PERSPECTIVE PLAN FOR DEVELOPMENT OF TAWANG RIVER BASIN

Cumulative Impact Assessment of Proposed Hydel Power Projects, Determination of Basin Carrying Capacity, and Landscape Level Biodiversity Management Plan

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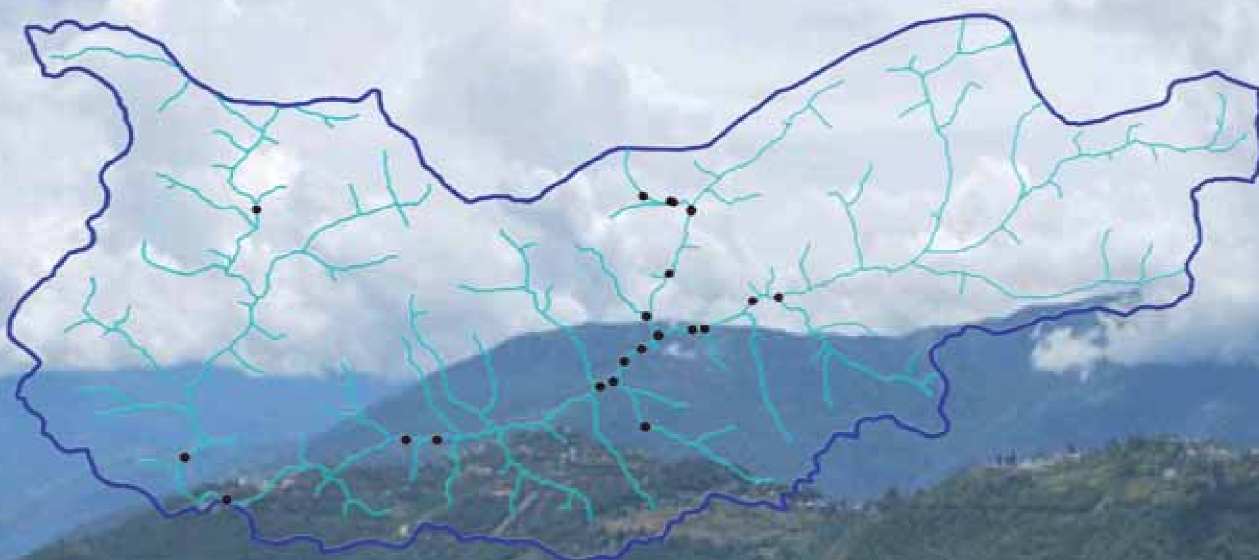

Department of Botany
North-Eastern Hill University, Shillong – 793 022

In association with

Indian Institute of Technology, Guwahati
WWF India, Tezpur
Foundation for Revitalization of Local Health Traditions (FRLHT), Bangalore

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Preparation of a River Basin Development Plan is a herculean task that involves several feeder studies such as impact assessment at individual project level and at cumulative level, determination of carrying capacity, environmental flow assessment, and biodiversity management plan. Each of this study is objective-specific and needs data and information from several scientific disciplines. In order to analyse the vast amount of data generated and integrate the findings for developing an effective basin level plan, involvement of a team of experts having long experience, expertise, and with a vision is a pre-requisite. Therefore, the cooperation and assistance of several organisations and experts is an indispensable part of such study. In the present study, we received excellent cooperation and assistance from several organisations and individuals for which we are grateful. It is not possible to name them all, but the following persons and organisations in particular have contributed immensely to successful completion of this study:

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ABBREVIATIONS

Abbreviation	Acronym
AAS	Atomic Absorption Spectrophotometry
ADIAC	Automatic Diatom Identification and Classification
AF	Atherkheit Fault
asl	Above sea level
BBM	Building Block Methodology
BDL	Below Detectable Limits
BEL	Bhilwara Energy Limited
BMCs	Biodiversity Management Committees
BMP	Biodiversity Management Plan
BNHS	Bombay Natural History Society
BOD	Biological Oxygen Demand
CAT	Catchment Area Treatment
CCA's	Community Conserved Areas
CEA	Cumulative Effects Assessment
CFL	Community Forest Land
CFU	Colony Forming Units
CHC	Community Health Center
CIA	Cumulative Impact Assessment
CITES	Convention on International Trade in Endangered Species
CPCB	Central Pollution Control Board
CPRs	Common Property Resources
CSR	Corporate Social Responsibility
CWC	Central Water Commission
dBA	Decibels Adjusted
DBE	Design Base Earthquake
DBH	Diameter at Breast Height
DEM	Digital Elevation Model
DG	Diesel Generator
DO	Dissolved Oxygen
DPR	Detailed Project Report
DRDA	District Rural Development Agency
DSHA	Deterministic Seismic Hazard Analysis
DWC	District Working Committee
EAC	Expert Appraisal Committee
EBA	Ecosystem based approach
E-Flow	Ecological Flow
EHZ	Eocene Hinge Zone
EIA	Environmental Impact Assessment
EMP	Environmental Management Plan
ENM	Ecological Niche Modeling
FAC	Forest Advisory Committee
FCC	False Color Composite
FDAs	Forest Development Agency(s)
FGDs	Focus Group Discussions
FRL	Full Reservoir Level
FRLHT	Foundation for Revitalization of Local Health Traditions
GEF's	Global Environment Facility's
GIS	Geographic Information System
GLoF	Glacial Lake Outburst Flood
GPP	Grass Primary Productivity
GRBMP	Ganga River Basin Management Plan
GSI	Geological Survey of India

Abbreviation	Acronym
GWh	Gigawatt Hours
HEC	Hydrologic Engineering Centre
HEP	Hydro Electric Project
HH	Household
HRT	Head Race Tunnel
I-AIM	Institute for Ayurveda and Integrated Medicine
IAS	Invasive Alien Species
IAY	Indira Awas Yojana
IBA	Important Bird Area
IBEF	India Brand Equity Foundation
IC	Installed Capacity
ICFRE	Indian Council for Forestry Research and Education
IIT	Indian Institute of Technology
IMD	Indian Meteorological Department
IPD	Integrated Power Developers
ISI	Indian Statistical Institute
IUCN	International Union for Conservation of Nature
IVI	Importance Value Index
IWDP	Integrated Wasteland Development Programme
IWR	Institute for Water Resources
JFMC	Joint Forest Management Committee
kWh	Kilowatt-Hour
LAMP	Large and Multi-purpose Cooperative Society
LPC	Land Possession Certificate
LPG	Liquefied Petroleum Gas
MAST	Marine Science and Technology
MBT	Main Boundary Thrust
MC	Mago Chu
MCE	Maximum Credible Earthquake
MCT	Main Central Thrust
MDDL	Minimum Drawdown Level
MFT	Main Frontal Thrust
MGH	Mago Chu Project Site
MG-NREGA	Mahatma Gandhi National Rural Employment Guarantee Act
MoA	Memorandum of Association
MoEF & CC	Ministry of Environment, Forests & Climate Change
MoU	Memorandum of Understanding
MT	Mishmi Thrust
MU	Mukto
MW	Mega Watt
NABARD	National Bank for Agriculture and Rural Development
NAP	National Agriculture Policy
NAP	National Afforestation Programme
NBWL	National Board for Wildlife
NEHU	North-Eastern Hill University
NEP	National Environment Policy
NER	North Eastern Region
NE–SW	North East-South West
NFP	National Forest Policy
NGO	Non-Governmental Organization
NHPC	National Hydroelectric Power Corporation
NPP	Net Primary Productivity
NRHM	National Rural Health Mission
NRRP	National Rehabilitation and Resettlement Policy

Abbreviation	Acronym
NRSA	National Remote Sensing Agency
NTFP's	Non Timber Forest Products
NTU	Nephelometric Turbidity Unit
NW	North West
NWG	New Melling Project Site
NWP	National Water Policy
PAFs	Project Affected Families
PGA	Peak Ground Acceleration
PHC	Primary Health Centre
PHDP	Public Health Delivery Plan
PMGSY	Pradhan Mantri Gram Sadak Yojana
ppm	Parts per million
ppt	Parts per thousand
PSHA	Probabilistic Seismic Hazard Analysis
QPM	Quality Planting Material
R&D	Research and Development
R&R	Rehabilitation & Resettlement
RAS	River Analysis Software
RCC	Reinforced Concrete Cement
RGB	Red Green Blue
RHO	Rho Project Site
RRP	Rehabilitation and Resettlement Policy
SACON	Salim Ali Centre for Ornithology and Natural History
SAP	Strategic Action Programme
SCIA	Standardized Cumulated Project Effect Index
SDI	Social Development Index
SEA	Socio Economic Assessment
SEI	Socio-Economic index
SEIAA	State Environmental Impact Assessment Authority
SEW	Southern Engineering Works
SGDs	Small Group Discussions
SGSY	Swarnajayanti Gram Swarozgar Yojana
SHGs	Self Help Groups
SO_2	Sulphur-Di-Oxide
SOC	Soil Organic Carbon
SPCB	State Pollution Control Board
SPV	Special Purpose Vehicle
ST	Scheduled Tribe
TDA	Trans-boundary Diagnostic Analysis
TDF	Tribal Development Fund
TDS	Total Dissolved Solids
TKN	Total Kjeldahl Nitrogen
TOR	Terms of Reference
TRB	Tawang River Basin
TRBDA	Tawang River Basin Development Authority
TRBDF	Tawang River Basin Development Fund
TRBDP	Tawang River Basin Development Plan
TRBL	Tawang River Basin Landscape
TRB-PA	Tawang River Basin Project Area
TRL	Twang River Landscape
TRT	Tail Race Tunnel
UF	Unclassed Forest
UNEP	United Nations Environment Programme
UTM	Universal Transverse Mercator

Abbreviation	Acronym
VECs	Valued Environmental and Social Components
VFMC	Village Forest Management Committee
VOC's	Volatile Organic Compounds
VU	Vulnerable
WGS	World Geographic System
WHC	Water Holding Capacity
WHP	Worker Health Program
WII	Wildlife Institute of India
WPA	Wildlife Protection Act
WWF	World Wide Fund

EXECUTIVE SUMMARY

I INTRODUCTION

Among the major sources of energy production such as hydropower, nuclear and thermal, hydropower is the least polluting source of power generation. The contribution of non-renewable energy sources such as wind, solar and tidal being insignificant, today hydropower seems to be the preferred source of power generation in India. Although construction of Hydro Electric Projects (HEPs) is essential to generate electricity for the development of the northeastern region, the prime victim of this development will be the biodiversity rich forests and mountain ecosystems.

A total of 13 HEPs with total capacity of about 2809.10 MW have been planned in Tawang River Basin (TRB) in Arunachal Pradesh including three projects of over 500 MW capacity, seven projects of less than 100 MW capacity and three projects of less than 50 MW capacity (Table 0.1 and Figure 0.1).

Table 0.1: Details of the proponents of the 13 HEPs planned to be constructed in TRB

Name of project	Name of implementing agency	Revised/proposed capacity (MW)	Elevation (m asl)
Tsa chu– I	Energy Development Co. Ltd., Faridabad	43.00	3295
Tsa chu– I Lower	Energy Development Co. Ltd., Faridabad	77.20	3190
Tsa chu– II	Energy Development Co. Ltd., Faridabad	67.00	3000
Thingbu chu	Arunachal Pradesh Mega Power Projects Pvt. Ltd., New Delhi	60.00	2800
New Melling	Sew Energy Ltd., Hyderabad	90.00	2730
Mago chu	Sew Energy Ltd.	96.00	2472
Nykcharong chu	Sew Energy Ltd.	96.00	2470
Rho	Sew Energy Ltd.	93.00	2240
Tawang–I	NHPC Ltd., Faridabad	600.00	2092
Tawang–II	NHPC Ltd., Faridabad	800.00	1536
Nyamjang chu	NJC Hydro Power Ltd. (Bhilwara Energy Ltd., Noida)	780.00	2115
Paikangrong chu	SMJ Consultants Pvt. Ltd., New Delhi	2.40	2150
Jaswantgarh Stage– I	SMJ Consultants Pvt. Ltd., New Delhi	4.50	3357
Total	**6**	**2809.10**	

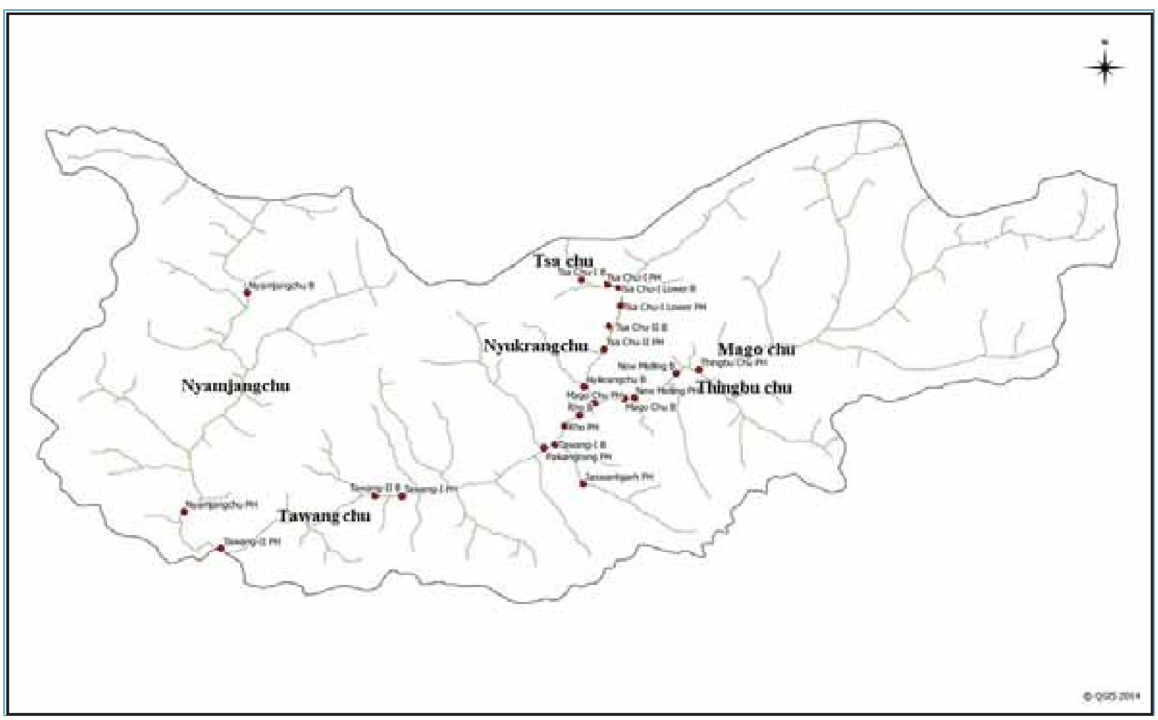


Figure 0.1: Proposed locations of the HEPs in TRB

No human population or habitation will be displaced due to implementation of the proposed HEPs since all the projects are run–of–the–river schemes, and do not involve the creation of reservoir. However, the unique biodiversity, undisturbed high forests, and rich cultural diversity of TRB will be affected if these projects are implemented. The destruction of habitats of the threatened and endemic flora and fauna of the basin may have detrimental impact on already dwindling populations of these floral and faunal elements.

On the other hand, the developmental needs of the region which have been hitherto neglected might be taken care of as an ancillary benefit if these projects are taken up. However, the environmental damage to be caused by such projects cannot be undermined. Therefore, a balanced approach needs to be worked out with an aim to optimize power production with minimum environmental damage. This approach has to be at a basin scale considering all the proposed projects, rather following a single project approach.

While considering the accordance of forest clearance for Tawang–I and Tawang–II projects, the Forest Advisory Committee (FAC) of the Ministry of Environment, Forests & Climate Change (MoEF & CC), Government of India desired that the Government of Arunachal Pradesh should conduct a study on TRB with the following objectives:

1. To assess the impact of thirteen HEPs planned in the basin, ancillary industries/activities, including influx of migrant workers, displacement of local ST population etc., on local ecology and biodiversity.
2. To assess the ecological water flow at different places along Tawang river and its tributaries.
3. To prepare a biodiversity management plan at the landscape level for the river basin.
4. To prepare a 15-20 years perspective plan for the cumulative development of the TRB.
5. To assess carrying capacity of TRB.

The Government of Arunachal Pradesh commissioned North–Eastern Hill University (NEHU), Shillong to conduct the above study based on the recommendation of the 'Technical Committee' of Government Arunachal Pradesh. A Memorandum of Association (herein after referred as MoA) was signed between the NEHU and Government of Arunachal Pradesh to complete the study.

The scope of the study as mentioned in the MoA in TRB include:

1. **Impact Assessment of Individual projects:** Geology and geomorphology, seismicity, hydro–meteorology, land use/land cover, vegetation and soil environment, floral and faunal elements, aquatic ecology and water quality, fish and fisheries, air pollution, socio–cultural and economic profile, prediction of impacts both cumulative as well as at individual project level. More specifically, the overall impact of the projects on hydrology, biodiversity, ecology of the area especially the river ecosystems and the vegetation in the adjoining land area was to be assessed. The impact of the projects on livelihood including displacement of the people and consequent pressures on the environment has to be adequately assessed and addressed.
2. **Cumulative Impact Assessment:** Cumulative Impact Assessment (CIA) study for TRB.
3. **Assessment of E–Flow:** An assessment of minimum ecological water flow at different places along Tawang river and its tributaries was to be made. The parameters of all the projects have to be adjusted to ensure this ecological water flow.
4. **Assessment of Carrying Capacity:** The carrying capacity of the river basin in terms of water resources, forest resources, biodiversity and human population was to be assessed.
5. **Twenty Year Perspective Development Plan:** Since a large numbers of projects are planned on the river system, a perspective development plan for the entire river basin was to be prepared. A proper disaster management plan keeping in view all the projects also needs to be prepared.
6. **Landscape Level Biodiversity Management Plan:** A landscape level biodiversity management plan was to be prepared for the entire river basin keeping in mind the possible damage to the biodiversity of the basin and ensure the future conservation.

As per TOR, NEHU involved IIT Guwahati, WWF Tezpur, I–AIM (FRLHT), the local institution NERIST, and experts representing alumni/former faculty of WII, ISI, SACON, GSI and ICFRE. Expert advice from senior government officials was taken wherever required.
The study began on 1st June, 2013 and the fieldworks continued till 31st July, 2014. The study was conducted with active participation of different stakeholders in TRB such as Tawang district administration, Zila parishad, political leaders, village council headmen and other villagers, and knowledgeable personalities, officials of Government of Arunachal Pradesh, and 4 developers representing 10 proposed hydel power projects. Since there was very little data available on TRB, and considering the large scale data requirement to complete the study, it was essential to involve a large number of subject–specific experts. Therefore, 54 experts were involved to accomplish the task through collecting primary field data over a period of 14 months. In fact, it was not an easy task given the complexity of geo–climatic and socio–political dynamics of TRB. The methodological challenges for

each component of the study particularly, assessment of cumulative impact, E–flow and carrying capacity added to the challenges and uncertainties of data generation. Because of the non–availability of existing data for most of the aspects, and to have the best possible assessment, 'holistic approach' was adopted to accomplish E–flow, CIA, and carrying capacity assessment. The approach and methods followed for each component of the study are given in Table 0.2.

Table 0.2: Approach and methods followed for each component of the study

Component of the study	**Section in the report**	**Approach**	**Methods**
Impact assessment for individual projects	II	Holistic	Domain–specific methods for baseline data generation, impact prediction, and mitigation
Cumulative impact assessment	III	Multi–level approach: Basin level, project level, and socio–economic level	Network analysis, matrices, GIS, mathematical impact models, mathematical indexing, check-listing and expert consultations
E–flow	IV	Holistic	Building block: Ecosystem structure, function and services, hydrology and hydraulics, biodiversity, livelihood, and cultural
Carrying capacity assessment	V	Multi–criteria: Basin zonation, population influx, forest loss, minimum river flow (e–flow) and free–flow river length, combined environmental index	Statistical models, indices, GIS, and trend analysis
20–year perspective development plan	VI	Integrated and strategic approach	Stakeholder consultations, analysis of data generated for situation assessment, formulating the vision, developing the basin strategies, and detailing the implementation
Landscape level biodiversity management plan	VII	Species–specific, ecosystem, and landscape level approach	Domain–specific methods followed by geospatial methods for landscape level planning

In addition to the components/sections listed in Table 0.2, 'Introduction to the study and TRB', 'Conclusions and Recommendations', and 'Detailed data and Annexures' have been presented in sections I, VIII and IX, respectively.

II IMPACT ASSESSMENT FOR INDIVIDUAL PROJECTS

Of the 13 proposed projects, Detailed Project Reports (DPR) for 7 projects viz. Nyamjang chu, Tawang–I, Tawang–II, Mago chu, Nykcharong chu, Rho, and New Melling have been prepared. The location data of barrage and power house sites of the projects, for which DPRs were not available, were given by the Department of Power, Government of Arunachal Pradesh. The EIA/EMP reports for 6 projects are now available, of which 3 projects viz., Nyamjang chu, Tawang–I and Tawang–II have been cleared by the MoEF & CC, Government of India. In order to have a comparative environmental baseline data for 13 projects, data on the following aspects were collected using uniform methods for all the projects.

Box 0.1: List of potentially impacted physical, biological and social environmental parameters considered for scoping.

PHYSICAL ENVIRONMENT	
Air	• Changes in ambient levels and ground level concentrations due to emission from point, line and area sources. • Effect on soils, materials, vegetation, and human health. • Impact of emissions from DG sets used for power generation during construction phase, on the vegetation and air environment
Noise	• Changes in ambient noise levels due to different sources. • Effect on fauna and human health.
Geomorphology	• Slope destabilization due to construction of barrage, powerhouse and ancillary infrastructure.
Soil	• WHC, Bulk density, Porosity, SMC, pH, Conductivity, NH_{4+}–N, NO_3–N, TKN, Available phosphorous, Total phosphorous, SOC, Ex. K, Ex. Mg, Ex. Ca, Soil microbial biomass–C, Soil microbial biomass–N, Fish diversity, Periphyton richness, Soil faunal density, Soil erosion
Water	• Changes in water quality: Temperature, Turbidity, pH, Electrical Conductivity, Total dissolved

	solids, Practical salinity, Total alkalinity, Total hardness, Chloride, Ca_2^+, Mg_2^+, K^+, Na^+, TKN, NH_4^+ N, NO_3–N, Total phosphorus, Dissolved oxygen, Total Coliforms • Impact on fish fauna • Impact of sewage disposal • NPP
Land use/ land cover	• Changes in land use and drainage pattern. • Changes in land quality including effects of waste disposal. • River banks and their stability. • Impact due to submergence • Impact due to construction during construction phase: Forest area loss, Carbon stock loss
BIOLOGICAL ENVIRONMENT	
Ecosystem Diversity	• Habitat fragmentation and destruction due to construction activities. • Deforestation and loss of plant species. • Impact on flora due to decreased flow of water. • IAS invasion
Plants	• Impact on threatened species, endemic species, if any.
Animals	• Impact on animal species due to deforestation and land clearing • Impact on animal distribution, migration routes, if any, • Impact on fauna (including aquatic species, fish) due to decreased flow of water. • Impact on breeding and nesting grounds, if any. • Periphyton and Zooplankton density
HUMAN ENVIRONMENT	
Existing development infrastructure	• Impact of increased traffic. • Downstream impact on water, land and human environment due to drying up of the river at least 10 km downstream of the barrage(s).
Socio–economic profile	• Impact on the local community including demographic changes. • Impact on economic status. • Impact on human health. • Positive as well as negative impacts likely to be accrued due to the proposed HEPs and ancillary activities are to be listed.
Culture/ religious profile	• Impact on holy places and tourism.
Resource use	• Dependency of villagers on spring water
Traditional Knowledge System	• Impact on the traditional knowledge system

However, the data on seismicity, geological features, and dam-break analysis were reviewed in the available EIA reports and it was decided that no fresh study would be conducted for these attributes as most of these attributes would be similar for all the projects in the basin. Moreover, given the geomorphological features of high Himalayas, location of the villages at a significant height from the river bed, and the pollution-free environment, it was agreed that the need for dam-break and air pollution modelling is insignificant for TRB.

The possible impacts common for all the projects and project-specific impacts were identified and mitigation measures were suggested which are summarized in Box 0.2.

Box 0.2. Possible impacts common to all the projects and project–specific impacts and suggested mitigation measures

I. POSSIBLE IMPACTS ON ECOSYSTEMS

Impact on river ecosystem and associated faunal diversity

- Regulating the normal water flow may affect the downstream river ecosystem as a whole, and the habitat and food regime of faunal species in particular.
- Polluting the river system during the construction phase through disposing solid wastes and other concrete materials into the river.
- Pollution may cause reduction in abundance of several faunal species of river ecosystem.
- Increase in air pollution level during project construction phase
- Impacts on terrestrial and aquatic ecosystems due to increased human interferences during project construction and operation phases.

Mitigation

Adopting strict management and regulatory options for pollution. E–flow needs to be adjusted to minimize the impact on river ecosystem and the faunal species. Minimum acceptable free-flow length between the two successive projects is to be maintained.

Impact of muck generated through the construction of tunnels and the impact of muck disposal on land and water resources

- Loss of habitats along the river systems including the alteration of hydraulics and hydrology of the river.
- Construction of very long retaining wall to store the muck dumps along the river system will restrict the normal movement of mammal species, as well as access to the river water resources.
- Runoff from the muck dumps will contaminate the land and water resources of the river system.
- Creation of muck dumping yards and disposal sites would damage the existing plant species.

Mitigation

In view of the above impacts, appropriate technical and structural interventions are needed. While constructing the disposal and storing structures, the factors described above should be kept in mind. While using the muck dumps, it has to be made mandatory to keep the disposal limit within the capacity of the site so that the muck does not spill into the river bed.

Impacts of noise due to drilling, tunnelling, blasting and vehicular movements on the faunal groups

- Changes in the normal behavior due to restrictions in normal movement, feeding and resting activities of major faunal groups of the project area.
- Possible permanent exodus of some affected larger territorial faunal species from the project area.
- The noise and associated ground vibration would impact the lower vertebrates mainly ground dwelling, specifically burrowing and reptilian species.

Mitigation

The use of high–tech equipments would minimize noise levels. Adoption of suitable managerial, ecological and technical interventions would minimize the impact of noise pollution.

Unregulated vehicular movement in the forest areas, and its impacts on faunal groups i.e., mortality due to accidents on the road, pollution load on the roadside plants, and soil compaction

- Road killings: Mostly herpetofauna (amphibians and reptiles) and smaller mammals are vulnerable to get killed by the vehicles while crossing the roads.
- Frequent movement of vehicles leading to collision of bird species may reduce species richness and abundance in the habitats along the road side.
- Compaction of soil: Movement of heavy vehicles would lead to soil compaction in the project areas leading to alteration of soil physico–chemical properties.
- Movement of vehicles for construction works would increase the pollution load on roadside plants leading to the loss of plant diversity and productivity.

Mitigation

The appropriate measures to minimize this impact would include, strict management decisions on regulated vehicular movement.

Influx of population and pressure on the local natural resources

- Clearing of land and vegetation cover for labour settlements.
- Cutting of wooden poles from the forest area for the construction of temporary sheds.
- Cutting of trees from the forest area to meet their fuel wood needs, and risk of their involvement in illegal activities like poaching/ hunting of animals.

Mitigation

Very strict managerial role is suggested to minimize the above impacts on forest and associated floral and faunal species of TRB.

Invasion of alien plant species

- Reduced flow in the downstream areas would increase the areas under invasive alien species (IAS).

Mitigation

The existing identified IAS should be weeded out and adequate measures should be taken to avoid import of new IAS through appropriate quarantine measures. An appropriate policy to regulate the introduction of IAS needs to be formulated by the Government of Arunachal Pradesh.

II. POSSIBLE IMPACTS ON FLORA AND FAUNA	
Acquisition of forest land and changing the land use for the proposed development activities and associated impacts of loss of habitats	• Loss of habitat: Due to diversion of forest land for the project activities including the construction of approach road, habitat conditions are altered resulting in deforestation, soil erosion and land degradation. • Changes in floral composition: Following removal of the forests for construction of various structures, the species composition of the altered habitat would change due to modified micro–environmental conditions. The pioneer species are likely to dominate the regenerating forests replacing the primary forest species. • Changes in faunal composition: The smaller groups of faunal species, which are potent indicators of habitat changes (e.g., butterflies, amphibians and reptiles), are likely to be more impacted than the larger faunal groups.
Mitigation	It is suggested that afforestation programmes using dominant native tree species and woody shrubs should be undertaken to compensate the floral and faunal losses in the project areas.
Impact	Construction activities would impact the terrestrial and aquatic plant and animal species having commercial importance and would have important livelihood implications.
Mitigation	The biodiversity management plan has described in detail the development of these resources to mitigate the impact.
Impact	Acquisition of forest land for the proposed project activities is expected to increase the resource dependency (timber, fire wood, fodder and grazing) on other adjoining forest lands, thereby impacting the overall floral and faunal diversity.
Mitigation	The activities planned under compensatory afforestation and Catchment Area Treatment (CAT) components should be adequate to mitigate this impact.
III. POSSIBLE IMPACTS ON THREATENED FLORAL AND FAUNAL SPECIES	
Impact	• Loss of specific habitats of the threatened floral and faunal species of the project area. • Habitat degradation and fragmentation will have significant impact on threatened floral and faunal populations.
Mitigation	It is important to follow specific management strategies suggested in the Biodiversity management plan which should minimise the impact on the identified floral and faunal species of Tawang River Basin Landscape (TRBL).
IV. POSSIBLE IMPACTS DUE TO SEISMICITY	
Impact	• Impacts due to seismicity
Mitigation	Safety criteria have been suggested to be followed in design of the barrage.
V. POSSIBLE IMPACTS ON HYDROLOGY AND WATER QUALITY	
Impact	• Impacts on hydrologic regime. • Impacts on water quality. • Increase in incidence of water–related diseases including water–borne and vector–borne diseases. • Effect on riverine fisheries including migratory fish species. • Impacts due to sewage generation from labour camps.
Mitigation	For fish migration, fish ladder at all the project sites should be a part of barrage design. Adequate E–flow must be ensured at all project sites, and regulatory steps to minimise the pollution close to zero discharge should be taken.
INDIVIDUAL PROJECT–SPECIFIC IMPACTS AND MITIGATION MEASURES	
1. Tsa Chu–I	
Impact	Being situated at very high elevation, the ecosystems are extremely fragile and difficult to recover and susceptible to hazards such as, high intensity landslides, soil erosion and GLoF.
Mitigation	Impacts being from natural origin, it is difficult to mitigate.
Impact	Close to hot spring and temple - a place of worship. Also close to *Chumbi Gyatsar* with high religious importance among the Monpa Buddhists.
Mitigation	Impacts cannot be mitigated. The project should not be undertaken.
2. Tsa Chu–I Lower and Tsa Chu–II	
Impact	High elevation ecosystems with high fragility, difficult to regenerate and reverse the degradation.
Mitigation	Specific sites for different project components should be selected in such a manner that no damage to forest and biodiversity is caused. No additional road construction should be permitted and the existing roads should be used without widening, and the transportation of machineries should be

	regulated with load limit. A sanctuary of at least 40 ha area should be established in the degraded areas surrounding the projects to conserve the biodiversity. Minimum free flow length between Tsa Chu-I Lower powerhouse site and Tsa Chu-II barrage site is to be maintained.
3. Thingbu Chu	
Impact	The proposed dam project would destroy substantial areas of land under forest and alter the river and adjoining ecosystems substantially. The identified site for the dam is highly unstable and landslide prone. Availability of water is too low for a HEP project.
Mitigation	Barrage construction must be avoided.
4. New Melling	
Impact	The right bank of the project site at New Melling is unstable and landslide prone.
Mitigation	Adequate measures to prevent landslide hazards should be taken.
Impact	Substantial areas near the proposed barrage site are the habitat for the edible algae (*Prasiola crispa*). The project would impact the survival and productivity of the species.
Mitigation	Adequate care must be taken to minimise the disturbance to the species' habitats and E-Flow should be adjusted accordingly.
5. Mago Chu	
Impact	Substantial areas near the proposed barrage site are the habitat for the edible algae (*Prasiola crispa*). The project would impact the survival and productivity of the species.
Mitigation	adequate care must be taken to minimise the disturbance to the species' habitats and E-Flow should be adjusted accordingly.
6. Nykcharong Chu and Rho	
Impact	The terrestrial ecosystems close to the barrage sites of both the projects have old growth broadleaved forests with high plant (*Cymbidium* spp.) and animal diversity (Arunachal Macaque). The construction activities may adversely impact the biodiversity and forest cover.
Mitigation	The construction activities should be planned in such a way that no existing forests and habitats of the biodiversity are destroyed. If required, the ancillary construction activities may be relocated to save the old growth forests (e.g., colony site of Rho project).
7. Tawang–I	
Impact	The proposed barrage might affect the existing tourist spot Nuranang falls, particularly during construction phase.
Mitigation	Adequate care must be taken to save this tourist place from the adverse impacts of barrage construction. The tourism interest should also be ensured during operational phase as well.
Impact	The villagers near the powerhouse site of Tawang–I project are afraid of losing their water sources due to tunnelling and underground powerhouse construction.
Mitigation	Drinking water sources for all the influenced villages must be ensured.
8. Tawang–II	
Impact	Due to high abundance of birds in this project sites, the project activities will adversely impact the bird populations.
Mitigation	The habitats for birds must be protected. The host plant species should be planted under various afforestation programmes, and artificial nest boxes must be installed in sufficient number as described in Section–VII. Although these measures are common to all the projects, Tawang–II project must make extra efforts in this regard in view of high abundance of birds.
9. Nyamjang Chu	
Impact	Possible submergence of pastureland near the barrage site might threaten the livelihood of pastoralist community.
Mitigation	The design of the barrage should be so adjusted that the pastureland does not come in the submergence zone. If it is unavoidable, an appropriate land must be procured in consultation with the pastoral communities of Zimithang village and provided to them. In addition, adequate compensation must be paid to them to neutralise this impact.
Impact	A *Hippophae* stand which is rare in distribution in Arunachal Pradesh would be destroyed at the barrage site.
Mitigation	At least 10 ha of *Hippophae rhamnoides* must be planted to compensate this loss.
Impact	The catchment area of Taksang chu in Panchen valley is rich in biodiversity/wildlife. If water from this tributary of Nyamjang chu is diverted, the availability of water for the wildlife could be crucial. Any disturbance to the catchment could affect the wildlife populations adversely.
Mitigation	Taksang chu should be allowed to flow freely.

Impact	Disturbing the lateral flow could affect the aquatic biodiversity in the downstream region which is critical for the livelihood of the people.
Mitigation	A number of villages in the downstream region of proposed Nyamjang chu barrage are dependent on river for fish. Therefore, adequate waterflow must be ensured for this downstream region. The lateral flow from 18 stream/streamlets must be allowed naturally. This would also help in maintaining the biodiversity in the downstream areas.
Impact	The proposed barrage site is close to the wintering habitat of the threatened black–necked crane. Therefore, it is very important to strictly adopt some mitigation measures for the protection of its wintering ground to ensure the long term survival of this endangered species.
Mitigation	The project proponent should take several mitigation measures to protect the habitat of the threatened bird. This should include a wide range of measures ranging from maintaining prescribed E–flow, restricting the construction activities during winter months and minimising the noise pollution. A detailed study on black-necked crane habitat requirement vis-a-vis E-Flow at Nyamjang Chu project barrage site should be undertaken by a competent national level institution such as WII, SACON or BNHS.

III CUMULATIVE IMPACT ASSESSMENT

The analysis of cumulative impacts at river basin level is important because in addition to the result of direct major impacts, significant environmental changes occur owing to accumulation of seemingly minor impacts over time and space. The cumulative impact could be linear, additive and synergistic depending upon the nature of the proposed project activities, future and past actions and their interactions. External environmental drivers and risk factors have additional aggravating impacts on the river basin.

In the process of assessing the cumulative impacts of the proposed 13 hydel power projects and related developmental activities on TRB, a holistic analysis approach was undertaken to characterize the potential impacts on Ecosystems, and Valued Ecosystem and Social Components (VECs). Subject-specific expertise, past experiences and examples from case studies, available literature and tools on the subject, extensive consultations with the stakeholders, and intensive field works were used to prepare this report, and arrive at an acceptable conclusion.

Two approaches viz., Basin and Project level approaches, were used to achieve strategic assessment of the cumulative impacts on TRB. Basin level cumulative impact analysis resulted in identification of the resources /attributes of the VECs most severely impacted and the corresponding impacts. This should be useful to address the impacts/issues at appropriate strategic level of implementation.

CIA index for each project was developed using 33 identified aspects under 6 selected VECs. The index was used to assess the relative contribution of the individual project to the cumulative impacts at basin level (Table 0.3).

Table 0.3: Environmental effects of different projects

Sl. No.	**Projects**	**Thingbu chu**	**New Melling**	**Mago chu**	**Nykcharong chu**	**Rho**	**Tsa chu-I**	**Tsa chu-I Lower**	**Tsa chu-II**	**Tawang-I**	**Tawang-II**	**Nyamjang chu**	**Jaswantgarh**	**Paikangrong chu**
	Aspects/Projects	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
1	Ecosystem structure, function and services	1.21	1	0.8	0.93	0.66	0.86	0.63	0.63	0.74	0.64	0.74	0.62	0.56
2	Biodiversity	0.96	0.68	1.02	0.48	1.04	0.85	1.24	0.67	0.91	0.53	0.77	0.62	0.24
3	Ecosystem vulnerability	0.94	0.93	0.86	0.94	1.06	0.8	0.8	0.91	1.06	0.91	0.4	0.2	0.2
4	Hydrology	1.62	1.19	1.27	0.65	0.62	1.2	0.75	0.59	0.77	0.59	0.75	0	0
5	Culture and livelihood	0.47	0.41	0.41	0.5	1.17	1.47	0.47	0.47	1.14	1.14	1.41	0.47	0.47
6	Dependency on natural resources	1.01	0.73	0.73	0.73	0.87	1.16	0.58	0.58	1.02	0.87	0.87	0	0.87
	SCIA	**1.03**	**0.82**	**0.85**	**0.71**	**0.9**	**1.06**	**0.74**	**0.64**	**0.94**	**0.78**	**0.82**	**0.32**	**0.39**

IV E-FLOW

Environmental flow of a river refers to the quantity, quality and timing of water needed to sustain aquatic and terrestrial ecosystems, and the related ecosystem services on which people depend on. Environmental flow assessment for TRB was done following building block method taking a holistic assessment approach. It comprises the following steps: (1) using a stakeholder consultation process to set objectives (thresholds) for the environmental conditions of the river, (2) assessing a modified flow regime that will meet those objectives, (3) using flow–dependent indicators and non-consumptive human requirements, as well as water quality metrics to identify water depths, velocities, river widths, and substrate types that will provide the required habitats and conditions. Such hydraulic requirements can be then converted to flow characteristics, and (4) identifying the critical components known as building blocks of the flow regime that govern environmental conditions. The Building Block Method followed in this study has identified six building blocks based on baseline data and expert opinion. The components are: (i) ecosystem structure, function, and services, (ii) river biodiversity, (iii) river hydraulics, (iv) cultural requirements, and (v) livelihood requirements. For river hydraulics, bed composition was considered as an indicator. Dead body disposal, and habitat requirement of the threatened bird - black-necked crane, also attached with religious belief in Buddhism, were two critical attributes for deciding the minimum flow depth width under the culture building block. Similarly water use, river resources, and edible algae were considered as major indicators for livelihood building block. The indicators for the ecosystem structure and function building block were: periphyton density, water quality, NPP, invasibility by IAS.

Analysis of hydrological parameters is a pre-requisite for E-Flow determination. The hydrological analysis of TRB included the following: (1) 90% dependable flow analysis, (2) lateral flow contribution analysis, (3) analysis of river cross sections, and (4) hydrodynamic modelling using HEC-RAS model. 90% dependable flow analysis showed that average lean flow at different project sites varied from 39 cumec to 1 cumec, whereas the variation in monsoon season ranged from 141 cumec to 4 cumec. Lateral flow contribution in the intermediate length during lean season for most of the projects was not significant, except the intermediate length in Tawang-I and Tawang-II. Hence, the contribution from lateral flow was not included in environmental flow assessment for any HEP. River cross section analysis showed that Tawang chu is a very shallow river with gravel, cobbles, few boulders as bed material. Flow depth and velocity measured at some of the project sites shows that flow depth ranges from 0.39 m to 1.23 m, and flow velocity ranges from 0.9 to 2.59 m/s. The flow width varies from 7 m to 26 m. The E-Flow requirement for each project site was assessed after extracting the average value of calculated flow depth, velocity, top width for each seasons through hydrodynamic modelling using HEC-RAS model. The recommended seasonal E-Flow requirements for all the studied HEPs are summarized in Table 0.4.

Table 0.4: Seasonal E–flow requirements for all the studied HEPs

Sl. No.	Name of HEP	Recommended environmental flow in discharge (cumecs)			Recommended environmental flow in percentage of 90% dependable flow		
		Lean	**Monsoon**	**Non–Monsoon**	**Lean**	**Monsoon**	**Non–Monsoon**
1	Tawang–II	10	26	13	25	18	20
2	Tawang–I	7.6	20	10	27	18	20
3	Rho	7.6	20	10	27	18	20
4	Nykcharong chu	6	13	10	30	30	27
5	Mago chu	5	10	8	70	20	53
6	New Melling	3	10	7	50	20	50
7	Tsa chu–I	5	10	6	25	25	17
8	Tsa chu–I Lower	5	10	6	25	25	17
9	Thingbu chu	1	2	1	100	30	100
10	Tsa chu–II	5	10	6	25	25	15
11	Nyamjang chu						

V CARRYING CAPACITY

Carrying capacity in the ecological context is defined as the threshold of stress below which populations and ecosystem functions can be sustained. As a method for evaluating cumulative effects, carrying capacity analysis serves to identify thresholds for the resources and systems of concern (as constraints on development), and provides mechanisms to monitor the incremental use of unused capacity.

The carrying capacity has been assessed taking a holistic approach by considering: (i) combined social and environmental impact threshold, (ii) human population influx threshold, (iii) E-Flow, (iv) free-flow river length, and (v) forest loss threshold. Since biodiversity in the forest area was the most dominant component of the total biodiversity of the basin, forest cover loss was used as the proxy indicator both for biodiversity and vegetation loss.

Given the ecological fragility and the resource limitation of TRB, it was essential to develop a future vision including the threshold limits for identified resources/parameters. Out of several parameters for which data were collected, the following parameters were identified as key indicators for determining carrying capacity of TRB: 1) upper elevation limit based on paraglacial deposits and location of the glaciers, (2) human population influx, (3) prescribed E-Flow based on availability of water at different points, (4) minimum acceptable free-flow length between the two successive projects, (5) forest/vegetation loss, and (6) combined socio-environmental index.

- 40 percent of the main river length should be free-flowing i.e, free of any projects.
- 66 percent of the total geographical area will be under forest cover.
- The total population of Tawang at any given point of time should not exceed 57,474 persons i.e., 15% more than the present population of 49,977 to protect the culture of ethnic community and maintain the demographic balance.
- No project above 3,200 m asl should be constructed.
- Minimum level of water flow must be maintained round the year to ensure the sustainability of the river ecosystem structure, function and services.
- Minimum acceptable free-flow length between the two successive projects is to be maintained.

The 'K' values for CIA index, population, E–Flow, free–flowing river length, and forest cover for TRB are 1.0 (0.84 + 95% confidence limit), 57,474 persons, 3 cumecs of water, 60 km (out of total 148 km of main river length), and 1,43,352 ha, respectively. The CIA index which was developed by combining several socio–environmental indicators was used to model the carrying capacity of TRB. The maximum carrying capacity value or the upper asymptote (K) was considered as CIA 1.0 (0.84 + 95% confidence limit). Thus, the projects falling below this value have been suggested to be allowed for project implementation. The name of these projects are Jaswantgarh Stage–I, Paikangrong chu, Nykcharong chu, Tawang–I, Tawang–II, Nyamjang chu, Rho, Mago chu, New Melling, Tsa chu-I Lower and Tsa chu-II (Figure 0.2). The remaining two projects viz., Tsa chu-I and Thingbu chu were above this value, and therefore are recommended for rejection.

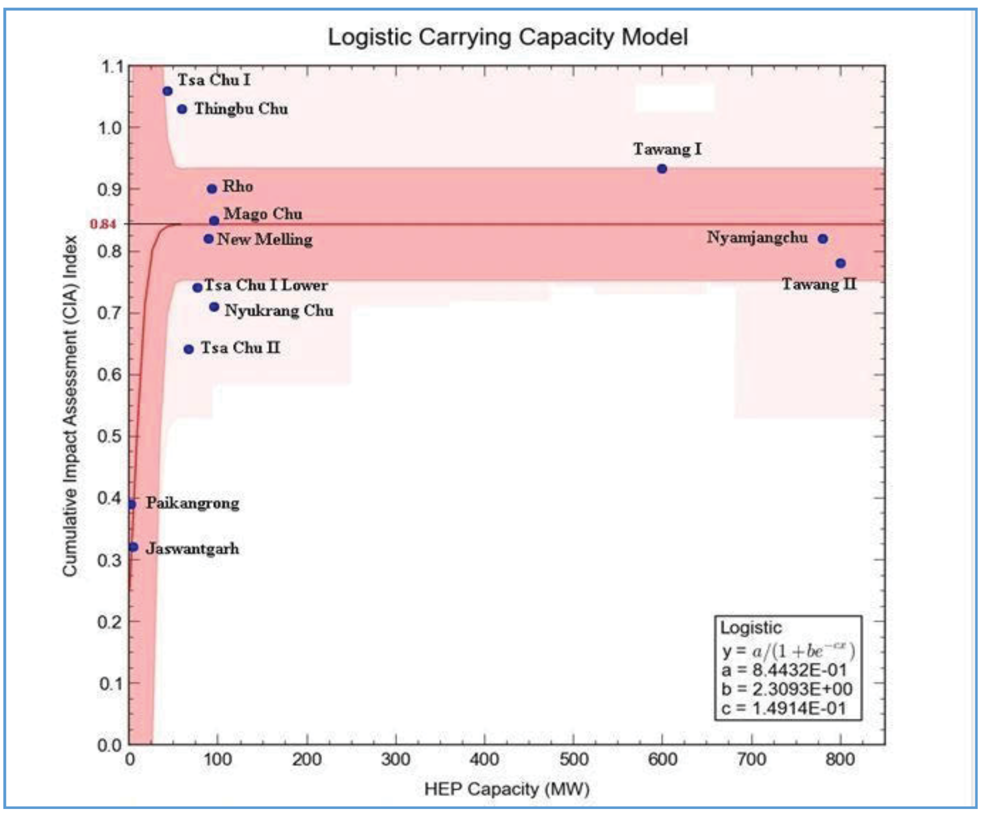


Figure 0.2: Acceptable projects within the maximum limit of carrying capacity 1.0 (0.84 + 95% confidence limit) based on CIA index.

Given the ecological fragility and the resource limitation of TRB, it will be detrimental to initiate all the proposed projects at a time. In order to keep the developmental activities within the carrying capacity of the basin, it is suggested that the projects falling within the carrying capacity limit as depicted in Figure 0.2, viz., Jaswantgarh Stage–I, Paikangrong chu, Nykcharong chu, Tawang–II, Nyamjang chu, Tawang–I, Rho, Mago chu, New Melling, Tsa chu-I Lower and Tsa chu-II may be taken up in two time phases. For diffusing the impact both spatial and temporal segregation (Figure 0.3) of the construction phase is suggested. While phasing several parameters were considered to minimize the impact. For instance, to maintain the influx of population within the carrying capacity limit, i.e., presumed to be 15% increase from the base population (Figure 0.4), the phasing resulted in keeping the total population size of TRB including the influx within the carrying capacity limit, which exceeded if all the projects are taken up together. Thus, the phasing was as follows:

Phase–I (0–5 years): Nykcharong chu, Tawang–I, Tawang–II, Nyamjang chu, Jaswantgarh Stage–I and Paikangrong chu.

Phase–II (5–10 years): Rho, Mago chu, New Melling, Tsa chu-I Lower, and Tsa chu-II.

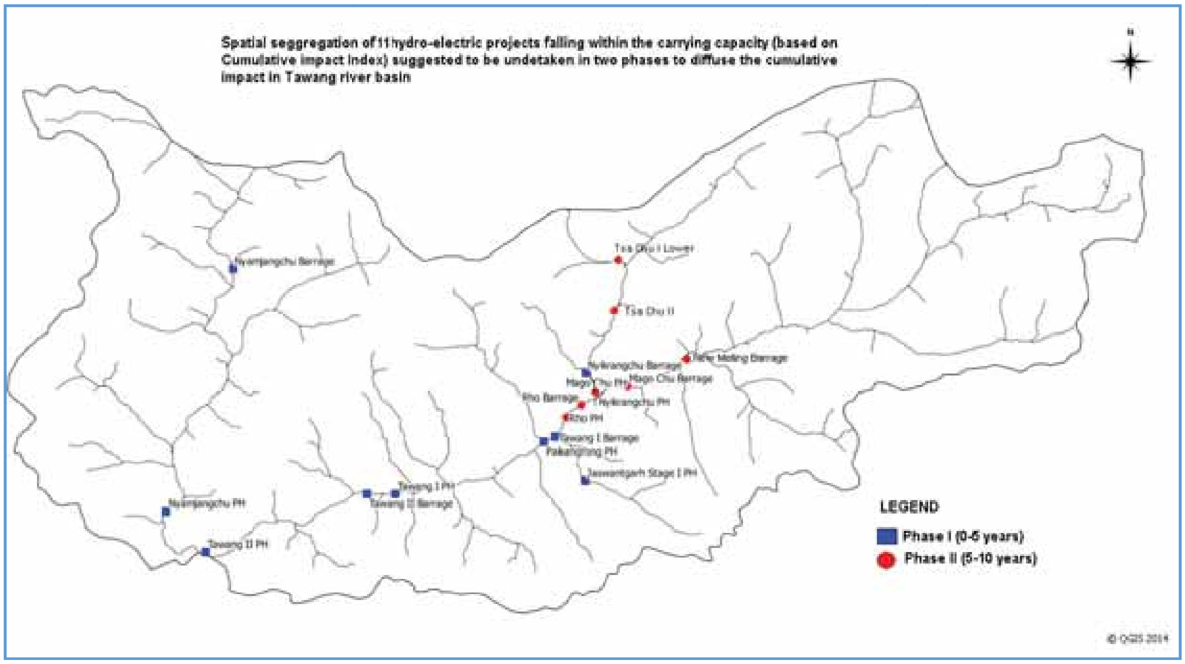


Figure 0.3: Spatial segregation of Phase–I and Phase–II projects in TRB

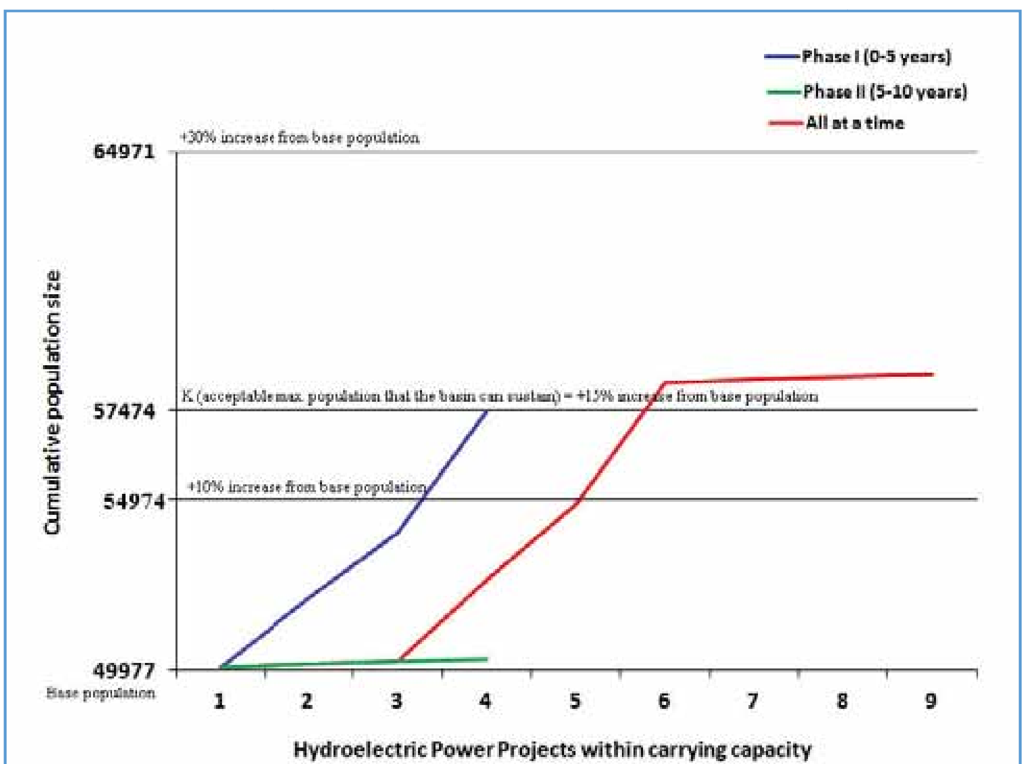


Figure 0.4: Analysis of carrying capacity of TRB considering human population growth as an indicator

VI DEVELOPMENT PLAN

The planning for hydropower development needs to evolve from a project-based approach to a more holistic one i.e., an approach incorporating river basin planning and integrating potential social and environmental issues across multiple projects and the entire river basin. Therefore, adequate and comprehensive planning is attempted to maximise the positive effects while minimizing the negative or adverse consequences of any development project. A balanced approach has been proposed for harnessing the hydropower energy and development needs of TRB with equal concern for environment as well as the well being of the population. Thus, the development plan for TRB has been prepared taking an integrated basin development approach to achieve the agreed vision and objectives through developing basin strategies and detailing the implementation. Achievement of the objectives would contribute to the socio-economic development and quality of life of the indigenous people of TRB.

Objectives and Scope of the Plan

1. To formulate a strategic hydropower integrated development plan of TRB in the context of existing policies and legislations.
2. To develop a clear-cut action agenda that reflect the aspirations of the people inhabiting the influence zone of proposed HEPs in TRB. This should be based on the ground reality relating to current scenario, the needs and requirements of the people of TRB.
3. To suggest appropriate institutional mechanism for plan implementation.
4. To emphasize the protection of environment, and conservation and development of forest and biodiversity in the face of adverse effects that arise out of HEP implementation.
5. To develop mitigation measures and management of disaster risk while also accentuate the need for preparedness if such events occur.

Strategic Process

The development plan was formulated for the development of TRB in 20 years. Because the development plan was related to HEPs, the scope of the plan was restricted to the influence zones of the 13 proposed HEPs. Thus, 46 villages falling within this zone were covered under the basin plan. The planning process outlined by Pegram et al. (2013) was adapted for strategizing the plan. Accordingly, the first stage in the process was to conduct the situation assessment to gain understanding of the current conditions as well as identify and prioritize key issues. The second stage was formulating the vision and goals to provide the long–term target for TRB development. The third stage was developing the basin strategies. Four strategic components that form the foundation of TRB development are: (i) Institutional, (ii) Development, (iii) Protection, and (iv) Disaster risk.

The fourth stage is detailing the implementation to define actions and give effect to the basin strategy. The activities as detailed under the four strategic components are as follows:

Institutional: Institutional management system was formulated wherein the Tawang River Basin Development Authority (TRBDA) was proposed to be constituted as an autonomous body by the state government. The TRBDA will be the implementing agency which would work closely with the HEP developers and collaborate with various existing institutions in TRB. In addition to implementing the Tawang River Basin Development Plan (TRBDP), TRBDA will also be entrusted with the responsibility to undertake regular monitoring of activities so that appropriate iterative and adaptive management can be done.

Development: The socio-economic and infrastructure development system focussed on community development of TRB. The current baseline scenario under each sector as well as the identified gaps in infrastructure, human resource and socio-economic requirements/issues, and aspiration of the people were considered while detailing the actions. The potential impacts that HEP implementation might result are also outlined under each sector and appropriate measures that the developer needs to follow were suggested. Subsequently, articulate plans/grants and schemes were proposed, and specified for the development of each infrastructure and socio-economic sector. The following R&R scheme and CSR activities were proposed:

- Land compensation for acquisition of private land.

- Compensation towards customary rights over community and UFs.

- School infrastructure development schemes: This includes setting up of schools at project sites, providing facilities to existing schools in affected and/or influenced villages, financial assistance for computer lab, furniture, library, books and laboratory.

- Merit scholarship scheme for different education levels (from Primary upto Graduate level).

- Salary support for teachers and staff to ensure qualified and adequate teaching manpower.

- Training grant for teachers and support staff.

- Exposure tours/visits for school students to technical institutions outside TRB.

- *Initiate Worker health program (WHP) and Public health delivery plan (PHDP):* For WHP, activities to be conducted are health education, prevention of diseases, rules and regulations, pre-employment screening, setting up of health centres at project sites. PHDP involves provision of health service in the affected and/or influenced villages and setting up of community health care centres and also providing adequate financial and technical support to the existing government health services such as appointing specialist doctors in district headquarters hospital and paramedical staff to run the equipments procured.

- *Road construction and network expansion scheme:* This includes providing road connectivity to affected and/or influenced villages, expansion of road network and access road to important locations such as agricultural land and farmland as desired by the people by providing RCC bridges and footpath wherever road is not feasible.

- Adopt sustainable transport system during construction phase to minimize adverse impacts on forests, environment and landscape.

- *Power supply scheme and power subsidies:* Power supply will be extended to the affected villages particularly the Project Affected Families (PAFs). These include 100 units of power free of cost to each family of PAFs every month for 10 years, and an additional 1% from the state governments share of 12% subject to condition and approval by the state government. The developers will also earmark 1% free power of the project capacity to local area development i.e., to TRBDA to be utilized for income generation and community welfare.

- *Water supply and irrigation schemes:* Provision of safe drinking water to the affected villages and PAFs, provision of storage tanks and pipelines to channelize water for irrigation and community use. Public drinking water facilities and school drinking water facilities.

- *Sanitation and solid waste management plan:* Provision of toilet at public locations and especially at workers camp and construction sites. Toilet to person ratio should not be more than 1:20.

- *Agricultural land compensation:* Appropriate and equitable compensation of agricultural land by land–for–land procedure, employment or financial compensation whichever feasible/desired by the PAFs.

- *Agriculture development package:* Financial allocation for *Jhum* land cultivation, agricultural land preparation grant for newly allotted agricultural land, training assistance for skill upgradation and technology adoption, provision of polyhouse/greenhouse, supply of QPM (quality planting material), setting up of Rural Bio–resource Complex (RBC) for value addition.

- *Veterinary assistance:* Assist in building manpower at existing veterinaries, if non–existence, to set up veterinaries at appropriate locations.

- *Livestock development:* Support for procuring additional livestock, construction of cattle shed and upgradation of milk storage and processing machineries, provision of feed and fodder to compensate for affected gazing and pasture land.

- *Grant for craft centres and skill development scheme:* Creation/upgradation of existing work shed including water supply, electricity, tools and machineries, development of training manual, support for procurement of raw materials etc. Establishment of small paper making unit, small scale food processing unit.

- *Compensation for horticultural land and horticulture development scheme:* Compensate affected horticultural land, financial assistance for procurement of seedlings.

- *Tourism development grant:* Construction of homestay and tourist lodge(s). Improvement and creation on new trekking trails and camping sites, souvenir shops, restaurants and food stalls etc.

- *Income generation scheme, subsistence grant and control of influx:* Provide financial assistance for diversifying income source, assistance to training for skill development and competency.

- *Electric crematorium:* In order to compensate the loss/damage of last rite sites, electric crematorium in all the affected villages will be provided.

Protection: The resource protection and conservation are other important aspects covered in the development plan. This includes the protection of environment, and plan for forest and biodiversity management and conservation. The following measures were proposed and recommended:

- *Public awareness programmes:* Providing financial assistance for social awareness and support.

- Adoption of strict rules and regulation during construction for protection of local environment including air, water and soil.

- *Soil and catchment area protection:* An appropriate plan has been outlined to check soil erosion and sedimentation which will be followed during construction phase.

- *CAT Plan:* CAT Plan will be initiated by all HEP developers and four key components were generalized to be followed viz., engineering measures, biological measures, infrastructure, and monitoring. Maintenance under CAT Plan would be for 3 years after construction/establishment, which may be extended whenever required.

- *Other environment management plans that will be taken up by developers include:* Muck management /disposal plan, water, air quality and noise environment management, water pollution control plans, environmental management in labour camp, environmental management in road construction, control of pollution from labour camps, reservoir rim treatment and soil erosion control, maintenance of air and water quality and noise level.

- *Forest and biodiversity conservation:* This includes afforestation programmes, habitat improvement and conservation for avifauna, fisheries, and black–necked crane, anti–poaching manpower and infrastructure. Many more ecosystem/landscape level plans have been suggested in landscape level biodiversity management plan.

Disaster risk: The disaster management system involves an area of planning that is focussed on the impacts of extreme or unplanned events, particularly around the mitigation and management of public safety and property risks associated with man–made disaster that can occur either relating to or due to hydropower structure and also with unexpected natural phenomenon. The following events were covered and their mitigation and management have been proposed.

- *Dam breakage:* This includes preventive measure, surveillance and evacuation plan. As such, the impact of dam breakage in TRB is minimum because all the proposed HEPs have barrage structure, and all the villages in the basin are located at least 600m above the river bed.

- *Un–regulated barrage water discharge:* Water discharge should be regulated, strong warning systems should be installed and disaster management cell should be constituted in each HEP.

- *Earthquake and landslide:* Seismic disaster management and safety measures were proposed. Landslide prevention and mitigation measures were also recommended.

- *GLoF:* Nine HEP sites were found to be vulnerable to GLoF. Effective management and mitigation plan for GLoF including inter–developer coordination have been proposed. Monitoring, early warning systems, mitigation and preparedness were outlined.

VII LANDSCAPE LEVEL BIODIVERSITY MANAGEMENT PLAN

Assessment of the status of biodiversity, and understanding their distribution in different landscape elements, and recommending effective conservation measures across the landscape are the main objectives of this BMP. The BMP has the following structure: (1) overview of biodiversity elements of TRB, (2) people–biodiversity relationships, (3) biodiversity and natural resource management systems, (4) landscape level impact assessment on biodiversity and mitigation measures, and (5) species–specific and landscape level biodiversity management plan.

The landscape of TRB is a mosaic of natural and man–made ecosystems situated in high Himalayan mountains. The natural ecosystems consist of primary sub–tropical forests, temperate forests, alpine scrubs/forests, alpine meadows, and wetland ecosystems. The secondary forest patches are found near human habitations and along the roads after the removal of primary forests. The man–made ecosystems are upland agroecosystems with millet, rice and maize crops along small terraces, and small horticultural gardens surrounding the homestead. The forest type in TRB change with elevation, and mainly composed of subtropical pine/broadleaved forests between 1000–1800 m elevation, temperate broad–leaved and conifer forests between 1800 to 3000 m, sub–alpine forests between 3000–4000 m and alpine forest/scrub >4000 m elevation.

Bird abundance is not very high as majority of the species (out of 241 species) were recorded to have less than 25 individuals. However, wintering habitat of black–necked crane in one of the proposed project areas needed a special habitat conservation plan. Six species of mammals reported in TRB are of high conservation significance as per IUCN listing, and relevant schedules of Wildlife (Protection) Act, 1972. Of these, Arunachal macaque and capped langur however, can be commonly seen. The herpetofauna of TRB is of very low conservation significance. Survey of butterflies covering three seasons in the entire TRB showed overall low species richness (42 species, 28 genera, 5 families), and none belongs to threatened category.

TRB is very rich in domesticated biodiversity and most of them are linked with the socio–economic–cultural system of the local communities. In fact, since time immemorial, the life of the Monpas, the dominant ethnic community in the basin, revolves around large varieties of crops, livestock and economically important non–timber plants available in their forest areas.

Since all the 13 HEPs are located at different elevations and across different rivers/tributaries confluencing into the main Tawang river, project–specific impacts in the upper reaches are likely to have cumulative impact on the basin. Based on the understanding of the nature of the proposed projects and associated activities, and existing biodiversity values assessed under baseline status survey in the project areas, the following possible cumulative impacts have been identified and evaluated for appropriate mitigation measures and management plans. The socio–cultural–spiritual needs of Monpas were also considered while developing the mitigation/conservation plan.

A total of 25 impacts of the proposed project activities have been identified at three levels, viz., (i) possible impacts on ecosystems i.e., on the river, riverine and adjacent terrestrial ecosystems, (ii) possible impacts on the biological elements i.e., the flora and fauna, and (iii) possible impacts on threatened floral and faunal species, and mitigation measures for each impact have been suggested. The mitigation plan for impacts on biological elements and ecosystems include: (1) Development of natural resources, and (2) Managerial, technical and legal interventions. Compensatory afforestation has been proposed to mitigate the loss of forest land. Mitigation plans for biological, managerial, technical and legal interventions have been proposed for sustaining ecological processes of the river ecosystem, maintenance of floral and faunal diversity, minimising the impact of muck dump yards on the river, floral and faunal species, controlling the impact of noise pollution on faunal groups, avoiding accidental road mortality due to vehicle pressures in the forest areas, and evading biotic pressures from labour force.

'Ecosystem based approach' (EBA) was considered as the strategy for developing the landscape level biodiversity management plan for TRB. Therefore, constituent ecosystems were identified for each landscape element and ecosystems were used as unit of planning for developing landscape level biodiversity management plan. Given the (1) wide altitudinal variation in TRB, and (2) varied landscape elements, the landscape level biodiversity management plan considered two layers of classification for developing the plan. TRB was classified into four climatic zones based on the elevation viz., montane sub–tropical (1000–1800 m), temperate (1800–3000 m), sub–alpine (3000–4000 m), and alpine (>4000 m). The dominant landscape elements at each climatic zone were represented by the combinations of different ecosystems such as forests, scrubland, cropland, wetlands, etc. based on the climatic zone. A landscape level management plan considering the above mentioned landscape matrix has been formulated with the following salient activities:

Net area of 1,94,986 hectares need to be established/maintained under the four climatic zones. The identified activities are: (1) Protection of existing dense forests as community conserved reserves, (2) Creation of 1km buffer forest on both sides of river/stream, (3) Area under scrubland to be afforested under aided natural regeneration (below 2500 m asl), (4) Creation of corridors for important wildlife, (5) Conservation/rehabilitation of Rhododendron scrubs (above 2500 m asl), and (6) Creation of a sanctuary of 40 ha area surrounding Tsa chu-I Lower project considering its location and availability of degraded lands surrounding the proposed barrage site (Tables 0.5 and 0.6).

Table 0.5: Biodiversity conservation activities suggested for TRBL

Biodiversity conservation activities	**Total area to be maintained (ha)**	**Existing cover (ha)**	**Net area to be established/ maintained (ha)**
Protection of existing dense forests as community conserved reserves (66% of total geographical area)	143352	80257.68	63094.32
Creation of 1km buffer forest on both sides of river/stream	94280.32	49479.84	44800.48
Area under scrubland to be afforested under aided natural regeneration (below 2500 m asl)	24641.92	11443.32	13198.6
Creation of corridors for important wildlife	1630.72	435.84	1194.88
Conservation/rehabilitation of Rhododendron scrubs (ha) (above 2500 m asl)	158822.4	86124.96	72697.44
Creation of a sanctuary of 40 ha area surrounding Tsa chu-I Lower project			40
Total			**195025.7**

Table 0.6: Area prescribed for different biodiversity conservation activities in forest ecosystems across different climatic zones in TRBL

Managing the existing biodiversity	**Montane sub–tropical**	**Temperate**	**Sub–alpine**	**Alpine**
Protection of existing dense forests as community conserved reserves (ha)	2642.04	25694.64	35961.12	15598.8
Protection of 1km buffer forest on both sides of river/stream including the creation of a new sanctuary (ha)	2642.04	25694.64	35961.12	7430.76
Protection of existing scrublands on 1km buffer of river/stream (ha)	4027.68	12641.04	23602.32	57337.9
Creation of corridors for important wildlife (ha)	53.76	1040	519.04	27.52
Conservation/rehabilitation of Rhododendron scrubs (ha)	NA	12641.04	23602.32	57337.9

The landscape level biodiversity conservation plan has taken into consideration traditional and contemporary knowledge systems and understanding on biodiversity and its varied elements. The plan has been participatory in nature ensuring meaningful engagement of local communities and other stakeholders in decision making as well as implementation of various strategies and actions. The suggested actions are in tune with local socio–cultural practices and belief systems. The plan recommends for creating an efficient and transparent organizational mechanism to coordinate and implement different measures and empowering local institutions and communities for adopting conservation friendly livelihood practices through capacity building. Following strategies and measures are suggested for long term biodiversity conservation in TRBL:

- Facilitate creation of biodiversity management committees (BMCs) in each village *Panchayat*.
- Filling the knowledge gap by undertaking comprehensive inventory and status survey of key taxonomic group; conduct research on structure, function, and interactions amongst and within ecosystems; monitor the status of ecosystems in the district; documenting traditional knowledge of

community through preparation of people's biodiversity register (PBR); and create a comprehensive, multi–layered biodiversity data base in GIS domain.

- Promoting *in–situ* conservation efforts through creation and support to the proposed high altitude biosphere reserve; expand network of community conserved areas; protection measures to biodiversity rich areas in influence zones of different projects; conservation and protection of other biodiversity rich areas; and conservation and protection of high altitude wetlands.

- Wildlife habitat improvement by regenerating and restoring degraded and open forest and pasturelands; removal/control of IAS; fire prevention; and education awareness.

- Regeneration of species of NTFP values.

- Establishment of natural resource based value addition facilities for livelihood improvement such as *Citronella*, plum, peach, pears, kiwi, pomegranate, gooseberry, walnut, broom grass, and Rhododendron flower.

- Orchid species conservation.

- Promote conservation friendly agro–pastoral system.

- Mitigate human–wildlife conflicts.

- Promote biodiversity and nature education/awareness programme.

- Promote infrastructure for eco–tourism development.
- Support to existing VFMCs, and

- Program implementation mechanism.

The species–specific conservation measures, particularly for the following threatened species/important faunal groups have been suggested:

1. **Alternate habitat including artificial nest boxes for avi–fauna:** Although applicable to all the recommended project sites, the high abundance of birds in Tawang–II project area necessitates to install at least 1500 nest boxes in the 1 km riverine buffer proposed to be created on both side of the river. Besides, it is also proposed to create special feeding habitats for birds at 4 to 5 different locations. Each such block shall be of 2 to 2.5 ha dimension and would provide different habitat types to cater to diverse avifauna. The existing herbaceous vegetation in all these blocks shall be kept intact and additional planting of 10–15 species of native plants for meeting diverse food needs (insects, fruits, seeds, and other vegetable elements) and nesting sites of avifauna shall be done. Very strong awareness programmes are necessary for the local villagers and schools in the nearby areas about the ecological role of bird community to enhance the ecosystem services and the benefits we gain from them.

2. **Protection of wintering habitat of black–necked crane by suggesting the following measures:** Considering the conservation importance of the species, the experts were unanimous to protect the habitat of the species. Appropriate E-Flow should be determined considering the protection of the habitat of the black-necked crane. In addition, the project proponents should strictly follow and adopt other mitigation measures as suggested to minimise the impact of noise pollution (drilling, blasting and tunnelling), water pollution, regulation of vehicle movements, and impacts from labour force.

3. **Conservation of Arunachal Macaque (*Macaca munzala*):** Though Arunachal macaque was sighted in 9 project areas, due to its endemic and threatened status, the following mitigation and management plans are suggested: (1) Awareness education programme, (2) Crop protection, (3) Habitat improvement, (4) Management oriented research programmes, and (5) Wildlife tourism.

4. **Conservation of Red Panda (*Ailurus fulgens*):** Even though, no sighting of red panda occurred during the study period, its presence in and around the Zimithang project area was confirmed based on the 2 stuffed animals collected from the riverside. Red panda subsists entirely on plant diet, predominately on higher altitude bamboo *Arundinaria maling*. They also feed on berries and fruits of

Sorbus cuspidata and *Sorbus microphylla*. With understanding of its habitat requirements and existing threats, it is very crucial to adopt some mitigation measures through management plans as suggested below to protect this threatened species. (1) Population status and assessment, (2) Habitat protection and restoration, and (3) Awareness and education programme.

5. **Conservation of butterfly species:** In TRB 42 species of butterflies were reported. This may be considered as low species richness. None of the species was under threatened categories of IUCN and WPA. Even then, adequate care should be taken to conserve their host plants in the forests.

6. **Conservation of herpetofauna:** The reported presence of four threatened reptiles viz., keeled box turtle –*Cuora mouhotii*, common mock viper –*Psammodynastes pulverulentus*, short–nosed vine snake –*Ahaetulla prasina* and red–necked keelback – *Rhabdophis subminiatus* in TRB indicates the need of taking conservation measures for this animal group.

7. **Conservation of Capped langur (*Trachypithecus pileatus*):** Capped langur was reported in one project area (Tawang–II) with 13 individuals. It is a vulnerable primate species listed in IUCN and also under the Schedule-I of WPA. Because Capped langur is very common across north–eastern states as reported from 18 protected areas, and due to its capability to use diverse habitats and food plants, the impact of project activities would be very minimal. Therefore, the mitigation plan as suggested for Arunachal macaque would also take care capped langur as well.

8. **Conservation of threatened plants:** There are quite a few threatened species of plants in the landscape which also have high use values for local communities. These species need to be propagated in natural conditions through aided natural regeneration efforts. However, in order to achieve the above, following needs to be done: (1) Standardization of propagation protocols and techniques for different species, (2) Develop nurseries to raise quality planting materials, (3) Threatened plant species distribution mapping for conservation, (4) Reintroduction of species in minimum 2 ha area of suitable natural habitats, and (5) Create *in–situ* germplasm bank. Out of the 10 identified threatened species, adequate distribution records for 4 species could be mapped viz., *Acer hookeri*, *Panax bipinnatifidus*, *Taxus wallichiana*, *Toricellia tillifolia* etc. The potential area distribution mapping for these 4 threatened species has been made using ecological niche modeling (ENM). These areas are also suitable for reintroduction of the species for their recovery. In addition to the above 10 species, 12 more species have been identified that show conservation concern needing further studies on their populations, species biology, and regeneration in nature. These species are: *Clethra delavayi, Fritillaria cirrhosa, Picrorhiza kurroa, Rhododendron anthopogon, Bergenia ciliata, Podophyllum hexandrum, Polygonum verticillatum, Cornus capitata, Botrychium virginianum, Pleione precox, Fraxinus griffithii,* and *Schizophragma heterophyllum*.

VIII CONCLUSION AND RECOMMENDATIONS

The draft report submitted to Government of Arunachal Pradesh on 25th September, 2014 was discussed with several stakeholders, and the report was finalized taking following points into consideration:

1. Many developers have redesigned the project, and also have changed the location of the project sites. When the study was started, these developers did not finalize their DPR. The data were collected from the sites as shown by the developers at the beginning of the study. The new sites/changed location of the project components were revisited, and the data were modified accordingly.
2. The data on dead body disposal, and dependency on natural resources including river were verified. Necessary corrections were made. Minor reorganization of VECs was done to give adequate emphasis on human dependency on natural resources.
3. The developer of Nyamjang chu joined the study late. The sites could be visited only for one season i.e., pre-monsoon season. In absence of the data for three seasons, it was not possible to conclude and recommend on all the aspects of the project. This was particularly important in determination of E-Flow. The expert team felt that the protection of the wintering habitat of the threatened black-necked crane could be a major deciding factor in determining the E-Flow for Nyamjang Chu project. However, during the present study the team could not directly observe or camera-trap the bird as winter season was already over by the time the developer joined the study. Therefore, E-Flow for Nyamjang Chu project could not be recommended. It is recommended that a national level institution having adequate expertise on black-necked crane such as WII, BNHS or SACON should be involved to recommend the E-Flow for Nyamjang Chu project vis-a-vis the

habitat protection of black-necked crane. The E-Flow recommended by the EIA committee of MoEF & CC for Nyamjang Chu project was used for calculating cumulative index at basin level.

4. Because of latitudinal difference between Eastern and Western Himalayas, the climatic and vegetation features at 2,500 m in the Western Himalaya are similar to those found at about 3,200 m elevation in the Eastern Himalayan mountains.
5. Based on the available imagery evidences duly supported by adequate ground truthing, it was concluded that paraglacial deposits (Ballantyne, 2002) are present in Tawang district above the elevation of 3,500 m a.s.l. Although winter snowline is at about 2,700-2,800 m a.s.l., the Himalaya in Tawang harbors considerable vegetation cover at this elevation and is relatively stable. Therefore, the snow cover at this elevation should not cause any disaster like paraglacial sediment outburst. Current glacial line in Tawang district is at an elevation of 5,000 m and above. A recent study in Sikkim Himalaya i.e., the glacial study available for the nearest area shows that the retreat rate of glaciers during 1976-2005 period was on an average 13.02 m per year (Raina, 2010). Thus, the glacial retreat in the last century should not be more than 1300 m. Since no glacier retreat data for Eastern Himalaya in Tawang is available, we considered the above mentioned rate of glacier retreat in Tawang district, and concluded that the glaciers were at least 3,700 m a.s.l. before 100 years. Therefore, the paraglacial deposit in no case was visible at or below 3,200 m asl.
6. Based on the above facts, it is recommended that no HEP should be constructed above 3,200 m. However, project-specific strict environmental safeguards/mitigation measures must be undertaken for the projects above 2,500 m elevation.
7. Considering the agreed mitigation measures as stated by the developers and public leaders, such as electric crematorium instead of dead body disposal in the river, creation of riverine green belt to reduce IAS invasion, reassessment of ecosystem structure and function vis-a-vis flow dynamics in different seasons, E-Flows for three seasons were recalculated.

Based on several rounds of brainstorming among the experts, and all the stakeholders as mentioned above, the following recommendations were made:

1. The projects above standardized cumulative impact assessment (SCIA) index value 1.0 i.e., 95 percent confidence band of the CIA index value of 0.84 would not be implemented. Under these criteria, Tsa chu-I and Thingbu chu should not be implemented.
2. The projects proposed above 3200 m asl should not be implemented in the river basin. Further, the projects above 2,500 m have to follow strict environmental safeguards and adopt specific mitigation measures, subject to fulfilling of other conditions.
3. The E-Flow as recommended in Table IV. 5.1 should be maintained by all the projects recommended viz., Nykcharong chu, Tawang-I, Tawang-II, Rho, Mago chu, New Melling, Tsa chu-I Lower and Tsa chu-II.
4. The recommended 9 projects and the 2 micro-hydels viz., Nykcharong chu, Tawang-I, Tawang-II, Nyamjang chu, Rho, Mago chu, New Melling, Tsa chu-I Lower, Tsa chu-II, Jaswantgarh Stage-I and Paikangrong chu should be implemented in two phases as follows: Phase-I (0-5 years): Nykcharong chu, Tawang-I, Tawang-II, Nyamjang chu, Jaswantgarh Stage-I and Paikangrong chu; and Phase-II (5-10 years): Rho, New Melling, Mago chu, Tsa chu-I Lower, and Tsa chu-II.
5. The following mitigation measures should be implemented to minimize the adverse impacts of the projects.

5.1 Adopting strict management and regulation options for pollution. E-Flow is needed to be adjusted to moderate the impact on faunal species during the construction phase.

5.2 While constructing the muck disposal and storing structures, the existing vegetation and the accessibility of wildlife to river water should be kept in mind and while using, it has to be made mandatory to keep the disposal limit within the capacity of the site so that the muck does not spill into the river bed.

5.3 High-tech equipments should be used to minimize noise levels. Suitable managerial, ecological and technical interventions should be adopted to minimize the impact of noise pollution.

5.4 Taking appropriate measures to minimize the death of wild animals due to increased vehicular traffic. Strict management decisions on regulated vehicular movement would reduce the accidental deaths.

5.5 Very strict managerial role in mitigation measures is suggested to minimize the impact of influx of population and pressure on local natural resources.

5.6 The existing identified IAS should be weeded out and adequate measures should be taken to avoid import of new IAS through appropriate quarantine measures. An appropriate policy needs to be formulated by the Government of Arunachal Pradesh.

5.7 Afforestation program using dominant native tree species and woody shrubs should be taken up to compensate for the floral losses in the project areas.

5.8 In view of the high impact on the terrestrial plant and aquatic plant and animal species having commercial importance, the development of these resources as described in the biodiversity management plan should be undertaken to mitigate the impact.

5.9 Activities recommended under compensatory afforestation and CAT should be adequate to mitigate the impact of resource dependency i.e., timber, fire wood, fodder and grazing, on other available forest lands.

5.10 Safety criteria are to be followed in design of the barrages to mitigate the possible impacts due to seismicity.

5.11 For fish migration, fish ladder at all the project sites should be a part of barrage design. Adequate E-Flow must be ensured at all project sites and regulatory steps to minimise the pollution close to zero discharge level should be taken.

5.12 Incorporation of the interventions suggested for mitigation, and prescriptions made in biodiversity and development plan at landscape/district levels, respectively should be made mandatory while according approval to individual projects. The specific activities recommended in the landscape level plan those fall within the 10 km radius of the respective projects should be taken up by the proponents.

The project-specific mitigation measures as detailed below should be implemented:

Tsa Chu-I Lower and Tsa Chu-II

- Minimum destruction to the terrestrial and aquatic ecosystems should be ensured during construction phase. Existing roads should be used for material transport with limited load, and new road construction is to be avoided.
- Cutting of trees is to be avoided and a sanctuary of 40 ha is to be created surrounding the project area (Tsa chu-I Lower barrage site) through tree planting to mitigate the diversion of forest land.

New Melling

- Adequate measures to be taken to prevent landslide hazards.
- Adequate care must be taken to minimise the disturbance to the river habitat of the edible aquatic algae (*Prisciola crispa*) and E-Flow recommended should be maintained to sustain the species.

Mago Chu

- Adequate care must be taken to minimise the disturbance to the river habitat of the edible aquatic algae (*Prisciola crispa*) and E-Flow recommended should be maintained to sustain the species.

Nykcharong Chu and Rho

- The construction activities should be planned in such a way that no existing forests and habitats of the biodiversity are destroyed. If required, the ancillary construction activities may be relocated to save the old growth forests (e.g., colony site of Rho project).

Tawang-I

- Care must be taken to save the tourist place i.e., Nuranang Falls from the adverse impacts of dam construction and also during operational phase.
- Drinking water sources for all the influenced villages must be ensured.
- Advanced and appropriate machineries should be used to minimize ground vibrations during construction phase.

Tawang-II

- The habitats for birds must be protected. The host plant species should be planted under various afforestation programmes, and artificial nest boxes must be installed in sufficient numbers. Although these measures are common to all the projects, Tawang-II project must make extra efforts in this regard in view of high abundance of birds.

Nyamjang Chu

- The information furnished by WWF and local people as well as secondary literature indicates that the barrage site is a wintering habitat of Black necked crane (BNC). However, there is difference of opinion about the actual location of the habitat of BNC vis-à-vis the barrage site/axis. Some experts claim that the entire river stretch adjacent to Zimithang town is the habitat of BNC. During the site visit of the present expert team during May, 2014, the developers of Nyamjang chu project and WWF personnel jointly showed the wintering habitat. Subsequently the Power department of Government of Arunachal Pradesh expressed its reservation about the location of wintering habitat of BNC shown during the aforesaid site visit. Since the developers joined the study only for one season i.e., pre- monsoon period, the team did not get an opportunity to observe the black necked crane wintering habitat directly or to camera trap it as winter season was already over by the time the developer joined the study. In absence of direct conclusive evidence, this study therefore, is not in a position to recommend the E-Flow as well as appropriate conservation measure for the threatened species. In view of this, we feel that there is a need to conduct an in-depth study on the black necked crane habitat vis-a-vis Nyamjang chu project by an independent institution having adequate expertise on black necked crane, such as WII, BNHS, or SACON.

The 20-year perspective development plan with a vision of 'Sustainable development of TRB' recommends the following actions under 4 basin strategies:

Basin Strategies	Activities recommended
Institutional	The autonomous body named as TRBDA is proposed to be constituted that will work closely with HEP developers in collaboration with the various existing TRB institutions for implementing the development plan.
Development	Articulate plans/schemes/grants for each infrastructural and socio-economic sector was formulated taking into account the current scenario and requirements of the communities. The following R&R scheme and CSR activities were proposed: • Land compensation for acquisition of private land. • Compensation towards customary rights over community and UFs • School infrastructure development schemes • Merit scholarship scheme for different education levels • Salary support for teachers and staff to ensure qualified and adequate teaching manpower • Training grant for teachers and support staff • Exposure tours/visits for school students to technical institutions outside TRB • Initiate Worker health program (WHP) and Public health delivery plan (PHDP) • Road construction and network expansion scheme • Adopt sustainable transport system during construction phase to minimize adverse impacts on forests, environment and landscape. • Power supply scheme and power subsidies • Water supply and irrigation schemes • Sanitation and solid waste management plan • Agricultural land compensation • Agriculture development package • Veterinary assistance • Livestock development • Grant for craft centres and skill development scheme • Compensation for horticultural land and horticulture development scheme • Tourism development grant • Income generation scheme, subsistence grant and control of influx • Electric crematorium • Value addition of NTFPs growing naturally such as *Citronella* • Large scale plantation of horticultural crops such as *Juglans regia* (Walnut) and *Punica granatum* (Pomegranate)
Protection	Protection of environment has been suggested, conservation of biodiversity was emphasized, and specific habitat improvement and conservation plans was made. The following protection measures are proposed and recommended: • Public awareness programmes • Adoption of strict rules and regulation during construction phase for protection of local environment including air, water and soil. • Soil and catchment area protection • CAT Plan • Other environment management plans viz., muck management /disposal plan, water, air quality and noise environment management, water pollution control plans, environmental management in labour camp, environmental management in road construction, control of pollution from labour camps, reservoir rim treatment and soil erosion control, maintenance of air and water quality and noise level.

	• Forest and biodiversity conservation
Disaster risk	Potential disaster risk associated with TRBL was identified and appropriate mitigation measures and management for each was proposed. The following actions were proposed: • Dam breakage: Preventive measure, surveillance and evacuation plan • Regulation of barrage water discharge • Seismic disaster management • GLoF: Monitoring, early warning systems, mitigation and preparedness

With the above recommendations, TRB would have the following scenario:

- The river basin would have at least 66% of its total geographical area under forest cover. Only 519.54 ha forest area will be diverted for construction of different project components.
- At least 40 percent of the main river length should be free-flowing i.e., free from any projects.
- A minimum distance of 1 km free-flowing river length between the two successive projects will be maintained.
- Being thinly populated, with a total population of 49,977, the influx of population in TRB at any given point of time would not exceed 15% of the original local population i.e., 57,474.
- Minimum level of water would flow in the river round the year required to maintain the river ecosystem structure, function and services, including flora and fauna in river, and the riverine and the adjacent terrestrial ecosystem structure and function.
- The seasonal flow dynamics of the river would be maintained, although at a much lower scale, to maintain the river ecosystem function and the adjoining riverine and terrestrial ecosystem functions. This would ensure the flow of existing ecosystem services, although in much reduced scale.
- All the existing forest/scrub areas should be managed and no more forests should be converted for other uses.
- The biodiversity present will be conserved in totality and not a single element of biodiversity would be lost.
- The air, water, and noise quality would be maintained well-below the permissible limit as notified by CPCB.
- Given the sensitivity and ecological fragility of the ecosystems above 3,200 m elevation in the Eastern Himalaya, no power projects would be undertaken beyond this elevation.
- Religious places or the stretches directly related to the sacred belief of the people will not be disturbed.
- No lateral flow or the adjoining ecosystems contributing to the lateral flow in the downstream region of the barrages would be disturbed.
- There will be a 1-km wide green corridor on the both sides of the river in the entire stretch of Tawang river beginning from the first barrage in the upstream region upto Bhutan border in the downstream area.
- All the well-vegetated forest areas are connected through wildlife corridors for their smooth migration.
- Establishment of well-designed HEPs i.e., design discharge based on actual water availability in a realistic manner, and allowing minimum level of E-Flow for the downstream river stretch for the sustenance of the river ecosystem. This would also ensure the continued dependency of people and wildlife on the river in the downstream area.
- Forest diversion per capita of power generation would be optimized.
- Substantial contribution by the power developers towards the socio-economic development of the river basin, particularly for those people whose lands would be acquired.
- Soil erosion and other hazards including future uncertainties due to climate change, earthquake and GLoF must be taken care of.
- Significant increase in employment opportunities and livelihood diversification.
- Improved quality of life through need-based intervention in education, health, road network, sanitation, and water supply.

All this would contribute towards sustainable development of TRB.

SECTION I

GENERAL INTRODUCTION

SUMMARY

Hydel is the least polluting source of power generation compared to other major sources of energy production such as nuclear and thermal. Although construction of Hydro Electric Project (HEP) is essential to generate electricity for the development of the north-eastern region, the prime victim of this development will be the biodiversity rich forests and mountain ecosystems.

A total of 13 HEPs with total capacity of about 2809.10 MW have been planned in Tawang River Basin (TRB) in Arunachal Pradesh including three projects of over 500 MW capacity, seven projects of less than 100 MW capacity, and three projects of less than 50 MW capacity.

With the implementation of these projects, no human population or habitation will be displaced since all the projects are run-of-the-river schemes, and do not involve the creation of reservoir. However, the unique biodiversity, undisturbed high forests, and rich cultural diversity of TRB are likely to be affected if these projects are implemented. The destruction of habitats of the threatened and endemic flora and fauna of the basin may have detrimental impact on the already dwindling populations of these floral and faunal elements. The developmental needs of the region which have been hitherto neglected might be taken care of as an ancillary benefit if these projects are taken up. However, the environmental damage to be caused by such projects cannot be undermined. Therefore, a balanced approach needs to be worked out with an aim to optimize power production with minimum environmental damage. This approach has to be at a basin scale considering all the proposed projects rather following single project approach.

While considering the accordance of forest clearance for Tawang-I and Tawang-II projects, the Forest Advisory Committee (FAC) of the Ministry of Environment and Forests, Government of India desired that the Government of Arunachal Pradesh should conduct a study on TRB with the following objectives:

1. To assess the impact of 13 HEPs planned in the basin, ancillary industries/activities, including influx of migrant workers, displacement of local ST population etc., on local ecology and biodiversity.
2. To assess the ecological water flow at different places along Tawang river and its tributaries.
3. To prepare a biodiversity management plan at the landscape level for the river basin.
4. To prepare a 15-20 years perspective plan for the cumulative development of the TRB.
5. To assess carrying capacity of TRB.

The Government of Arunachal Pradesh commissioned North-Eastern Hill University (NEHU), Shillong to conduct the above study based on the recommendation of the 'Technical Committee' of Government Arunachal Pradesh. A Memorandum of Association (herein after referred as MoA) was signed between the North-Eastern Hill University (NEHU) and Government of Arunachal Pradesh to complete the study.

The scope of the study as mentioned in the MoA in TRB include:

1. **Impact Assessment of Individual projects:** Geology and geomorphology, seismicity, hydro–meteorology, land use/land cover, vegetation and soil environment, floral and faunal elements, aquatic ecology and water quality, fish and fisheries, air pollution, socio-cultural and economic profile, prediction of impacts both cumulative as well as at individual project level. More specifically, the overall impact of the projects on hydrology, biodiversity, ecology of the area especially the river ecosystems and the vegetation in the adjoining land area was to be assessed. The impact of the projects on livelihood including displacement of the people and consequent pressures on the environment has to be adequately assessed and addressed.

2. **Cumulative Impact Assessment:** Cumulative Impact Assessment (CIA) study for TRB.

3. **Assessment of E-Flow:** An assessment of minimum ecological water flow at different places along Tawang River and its tributaries was to be made. The parameters of all the projects have to be adjusted to ensure this ecological water flow.

4. **Assessment of Carrying Capacity:** The carrying capacity of the river basin in terms of water resources, forest resources, biodiversity and human population was to be assessed.

5. **Twenty Year Perspective Development Plan:** Since a large numbers of projects are planned on the river system, a perspective development plan for the entire river basin was to be prepared. A proper disaster management plan keeping in view all the projects also needs to be prepared.

6. **Landscape Level Biodiversity Management Plan:** A landscape level biodiversity management plan was to be prepared for the entire river basin keeping in mind the possible damage to the biodiversity of the basin and ensure the future conservation.

As per TOR, NEHU involved IIT Guwahati, WWF Tezpur, I-AIM (FRLHT), and the local institutes NERIST, and NESAC. In addition, a large number of experts representing alumni/former faculty of WII, ISI, SACON, GSI, and ICFRE were involved. Expert advice from senior government officials was taken, wherever required.

The study began on 1st June, 2013, and the fieldworks continued till 31st July, 2014. The study was conducted with active participation of different stakeholders in TRB such as Tawang district administration, Zila parishad, political leaders, village council headmen and other villagers, and knowledgeable personalities, officials of Government of Arunachal Pradesh, and 4 developers representing 10 proposed hydel power projects. Since there was very little data available on TRB, and considering the large scale data requirement to complete the study, it was essential to involve a large number of subject-specific experts. Therefore, 54 experts were involved to accomplish the task through collecting primary field data over a period of 14 months. In fact, it was not an easy task given the complexity of geo-climatic and socio-political dynamics of TRB. The methodological challenges for each component of the study particularly CIA, e-flow and carrying capacity added to the challenges and uncertainties in data generation. Because of the non-availability of existing data for most of the aspects, and to have the best possible assessment, 'holistic approach' was adopted to accomplish e-flow, CIA, and carrying capacity assessment.

The proposed 13 projects in TRB were at different stages of development, when the current study began. While Nyamjang chu, Tawang-I and Tawang-II had got certain statutory clearances with finalised DPR and EIA reports, the remaining 10 projects did not even finalize their DPR when this study began. Therefore, changes in the location of various project components in respect of the latter 10 projects were inevitable. Incorporating these changes and considering the opinions of the officials of power department and Forest and Environment Departments of Arunachal Pradesh, Ministers and other people’s representatives at Itanagar, the draft report submitted on 25th September, 2014 was revised.

1.1 INTRODUCTION

Tawang, one of the 16 districts of the state is located in the extreme western corner of Arunachal Pradesh. It lies between 27°25’ and 27°45’N latitude and 91°42’ and 92°39’E longitude covering an area of 2,172 sq km. The district shares the boundary on the east with West Kameng district of the state, with Tibet (China) on the north, with Bhutan on west and south. The entire territory is mountainous with elevation ranging from 1000 m to about 6500 m along Tibet–China border. The geographical boundary of TRB in the Eastern Himalaya is almost identical with the administrative boundary of Tawang district in Arunachal Pradesh. Some portions of the basin boundary lie in Bhutan in the west and south, and in China in the north.

The name of Tawang is believed to have derived its name from the grandiose of Tawang Monastery perched on the edge of the ridge running along the western part of Tawang township. The popular interpretation is that the name “Tawang” was given by His Holiness the Mera Lama Lodre Gyatso. “Ta” means “Horse” and “Wang” means “Chosen”. As the legend goes, the site of the present Monastery is believed to have chosen by a horse owned by Mera Lama Lodre Gyatso. Mera Lama Lodre Gyatso was in search of an appropriate place to establish a monastery. Failed to locate an ideal site, he sat on prayer for a guidance of a divine power. As he opened his eyes after prayer, he found his horse missing. After searching, he found the horse on the top of the hill which was calm and quite. Believing it as a good omen, Mera Lama Lodre Gyatso decided to construct the monastery there with the help of people living across the land of Monpa in the later part of 17th Century as per the wishes of Fifth Dalai Lama.

Power Potential of North-Eastern India: The north-eastern region of India comprising the states of Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim and Tripura has large hydro-power potential. The region also has abundant resource of coal, oil and gas for thermal power generation. The north-eastern region has a hydro power potential of over 65,645 MW i.e. more than 50% of the country’s total hydro potential; but out of this only less than 2% (1116 MW) has so far been harnessed. The region has a reserve of 151.68 billion cubic feet of natural gas, which is capable of generating 7,500 MW of power for 10 years. In addition, the region has 864.78 million tonne of coal, compared to the country’s reserve of 186 billion tonne. With this reserve in the north-eastern region, approximately 240 MW power can be generated for a period of 100 years.

In spite of such large potential, the region ranks lowest in the country in terms of power generation and per capita energy consumption mainly due to lack of funding, inhospitable climatic conditions, remote location, and inaccessibility. However, with continuous improvement of infrastructure and communication facilities, the north-eastern region stands to become the powerhouse of India by utilizing its abundant power potential, especially in the hydel sector. The region offers a large potential in renewable energy, which is yet to be exploited. There is also an imbalance between hydel and thermal power, both in terms of generation and availability. The transmission and distribution sector is the weakest link of the electricity industry in the north-eastern region. Large transmission and distribution losses, estimated to be at over 40%, lower tariffs as compared to costs of generation, transmission and mounting losses of the state electricity boards are crippling the electricity sector of the region.
The Government of Arunachal Pradesh has so far (as on April, 2012) allotted about 140 HEPs with the total installed capacity (IC) of 41,500 MW that is to be developed on various rivers, rivulets and nalas in 7 major river basins (Table I. 1.1). The status of state-wise energy demand and energy generation in north-eastern region as per estimate of 2007-08 is shown in Table I. 1.2 indicating an overall energy deficit of 12.34%. Table I. 1.3 gives the peak load demand up to 2004-05 and projections for 2011-12 and 2016-17 in the region.

Table I. 1.1: Status of hydro electric potential development in north-eastern region (as on 01.10.2013)

Region/ State	Identified capacity as per reassessment study (MW)	Capacity under operation (MW)	Capacity under construction (MW)	Capacity under operation + under construction (MW)	Capacity yet to be taken up under construction (MW)
Meghalaya	2394	282	40	322	1976
Tripura	15	0	0	0.0	0
Manipur	1784	105	0	105	1656
Assam	680	375	0	375	275
Nagaland	1574	75	0	75	1377
Arunachal Pradesh	50328	405	2710	3115	46949
Mizoram	2196	0	60	60	2071
Total (NER)	**58971**	**1242**	**2810**	**4052**	**54304**

Table I. 1.2: Status of annual energy generation (Gwh) and demand in north-eastern region for 2007-2008

State	Energy demand	Estimated generation	Shortage/surplus (-/+)	% of value
Arunachal Pradesh	391	302	-89	-22.8
Assam	4816	4412	-404	-8.4
Manipur	530	01	-29	-5.5
Meghalaya	1620	1232	-388	-24
Mizoram	288	246	-42	-14.6
Nagaland	377	334	-43	-11.4
Tripura	777	686	-91	-11.7
North-eastern region	**8799**	**7713**	**(-) 1086**	**-12.34**

Table I. 1.3: Peak load demand and projections in north-eastern region

State	Peak load (MW)			Projected peak load	
	2003-04	**2004-05**	**2007-08**	**2011-12**	**2016-17**
Arunachal Pradesh	81	85	101	136	189
Assam	793	853	848	1423	2034
Manipur	189	208	119	406	651
Meghalaya	157	168	455	293	430
Mizoram	111	119	97	217	345
Nagaland	80	85	91	141	200
Tripura	193	211	171	396	616
North-eastern region	**1485**	**1601**	**1742**	**2789**	**4134**

An analysis of hydro power potential in each of the seven states revealed that nearly 87% of the hydro power potential of the region lies in Arunachal Pradesh followed by Meghalaya, Mizoram, Manipur and Nagaland (Table I. 1.4).

Table I. 1.4: Hydro power potential in north-eastern region

State	Potential assessed (MW)
Arunachal Pradesh	57002
Meghalaya	2394
Mizoram	2196
Manipur	1784
Nagaland	1574
Assam	674
Tripura	21
Total	**65645**

Source: *mdoner.gov.in*

International Relations and Hydropower Development in North-eastern India: The river systems of north-eastern region have linkages with its neighbouring countries–Tibet (China), Bhutan, Bangladesh, and Myanmar as trans-boundary or in some stretches as Border Rivers. The Brahmaputra originates in Tibet as the Tsangpo, and flows into India as the Siang (the Dihang) and joins the Bay of Bengal after traversing through Bangladesh. Some of the tributaries of the Brahmaputra also have catchment areas in Tibet/China. There are possibilities of utilizing the 'U' Bend (called the 'Big Bend') in the Tsangpo River (Brahmaputra) between Tibet (China) and Arunachal Pradesh in India for mega- scale hydropower development. A drop of about 3,000 m is available as Tsangpo flows at an altitude of 3,600 m and descends to Gelling in Arunachal Pradesh which could be utilized for generation of a very large amount of power. The river systems viz., Pagladia, Manas, Sankosh and Rydak and Torsa of Bhutan join the Brahmaputra from the north in Indian territory. There is an excellent ongoing co-operation between the two countries on the water resource development for hydropower generation. The Kolodyne river in Mizoram/Manipur flows into Myanmar. Under a MoU signed between India and Myanmar, NHPC completed the investigations on the 800 MW Tamanthi hydro project in Myanmar. Beginning of this cooperation would auger well for development of the potential on the border and trans-boundary rivers between the two countries. Development of north-eastern region's hydro power would also provide an opportunity for Bangladesh to avail hydro-electricity to support its grid and facilitate linking power grids of Bangladesh and India.

So the scenario in the region appears to be a win-win type, where the exploitation of the country's largest perennial water system is to be carried out to produce power for those parts of the nation that are continuously expanding and getting industrialized. Economic benefits for the north-eastern region through power export; flood control, not much direct displacement of local communities, employment generation and the end of militancy, may change the future of this hitherto isolated region.

Power Scenario of Arunachal Pradesh: As mention above, among the north-eastern states, Arunachal Pradesh is the richest in hydroelectric power potential. As per the preliminary basin study done by the Arunachal Pradesh Hydro Power Corporation, the total potential from major projects in the state is estimated to be about 57002 MW. Hydropower potential in Arunachal Pradesh is available in eight river basins, viz. Tawang, Kameng, Dikrong, Subansiri, Siang, Lohit, Dibang and Tirap. The state also has the highest number of high head mini and micro hydel projects in India. The abstract of hydro potential in the eight major river basins in the state are indicated in Table I. 1.5. The map showing all the river basins of Arunachal Pradesh is given in Figure I. 1.1.

Table I. 1.5: Abstract of hydro power potential of major river basins

Name of river basin	Probable hydro power potentials (MW)	Allotted hydro power potentials (MW)			Balance hydro power potential (MW)	Name of districts covered by the basin
		CPSU	Private	Total		
Tawang	2057	1500	482	1982	75	Tawang
Kameng	6183	1120	2482	3602	2581	West and East Kameng
Subansiri	12248	-	125	125	12123	Upper and Lower Subansiri and Kurung Kumey
Dikrong	410	110	90	200	210	Papum Pare
Siang	17308		5610	5610	11698	West, East and Upper Siang
Dibang	10977	7500	887	8387	2590	Dibang Valley and Lower Dibang Valley
Lohit	7679.50		5816.50	5816.50	1863	Anjaw and Lohit
Tirap	140	-	-	-	140	Changlang and Tirap
Total	**57002.50**	**10230**	**15492.50**	**25722.50**	**31280**	

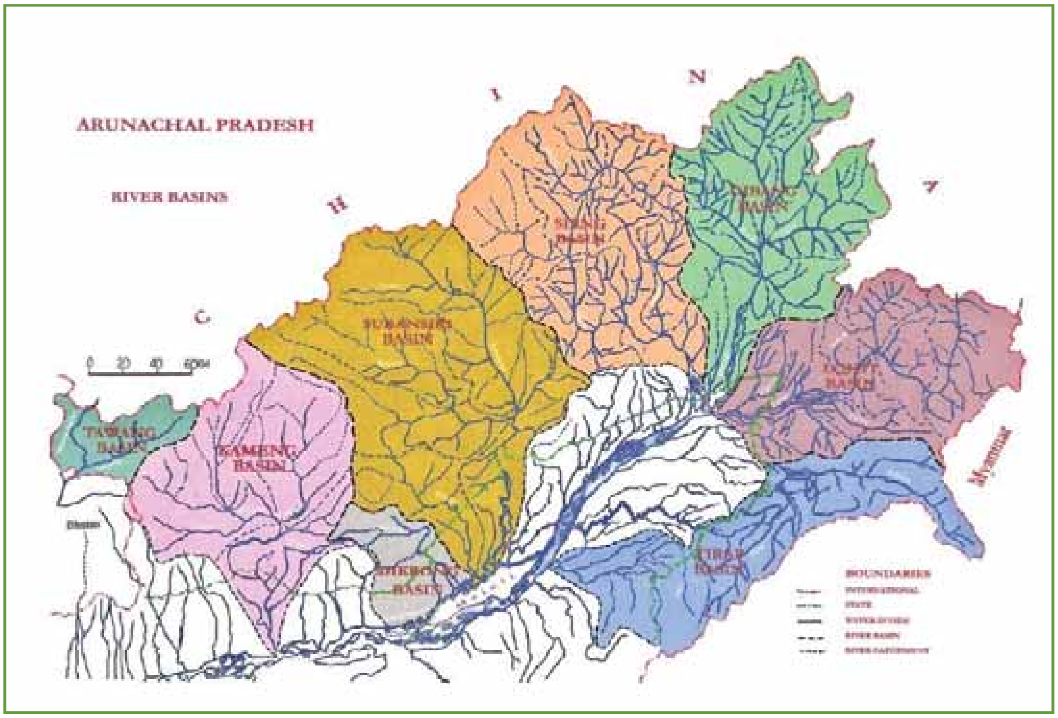


Figure I. 1.1: River basins of Arunachal Pradesh

The state has 63 small power plants ranging from 5 kW to 6,000 kW with a total installed capacity of 35 MW. Also, 94 diesel generating stations, ranging from 10 kW to 500 kW capacity, are functioning with a total capacity of 18.5 MW. The details of existing small power plants in Tawang district are indicated in Table I. 1.6.

Table I. 1.6: List of existing small hydel stations in Tawang district

Name of station	Installed capacity (in kW)	Year of commissioning
Kitpi Ph-I	1500	1977-78
BTK Camp	10	1995-96
Thongleng	10	1995-96
Nuranang	6000	1996-97
T. Gompa	50	2001-02
Dudunghar	30	2004-05

1.2 DETAILS OF THE PROPOSED PROJECTS

A total of 13 HEPs with total capacity of 2809.10 MW have been planned in eight rivers of TRB including three projects of over 500 MW capacity, seven projects of less than 100 MW capacity and three projects of less than 50 MW capacity (Table I. 1.7 and Figure I. 1.2).

Table I. 1.7: Details of the capacity and proponents of the proposed 13 HEPs in TRB

Sl. No.	Name of project	Address of agency	Revised/proposed capacity (MW)	Name of basin
1	Tsa chu-I	Energy Development Co. Ltd., Faridabad	43.00	Tawang
2	Tsa chu-I Lower	-do-	77.20	-do-
3	Tsa chu-II	-do-	67.00	-do-
4	Thingbu chu	Arunachal Pradesh Mega Power Projects Pvt. Ltd., New Delhi	60.00	-do-
5	New Melling	Sew Energy Ltd., Hyderabad	90.00	-do-
6	Mago chu	-do-	96.00	-do-
7	Nykcharong chu	-do-	96.00	-do-
8	Rho	-do-	93.00	-do-
9	Tawang-I	NHPC Ltd., Faridabad	600.00	-do-
10	Tawang-II	-do-	800.00	-do-
11	Nyamjang chu	Bhilwara Energy Ltd., Noida	780.00	-do-
12	Paikangrong chu	SMJ Consultants Pvt. Ltd., New Delhi	2.40	-do-
13	Jaswantgarh Stage-I	-do-	4.50	-do-
	Total	**6**	**2809.10**	**1**

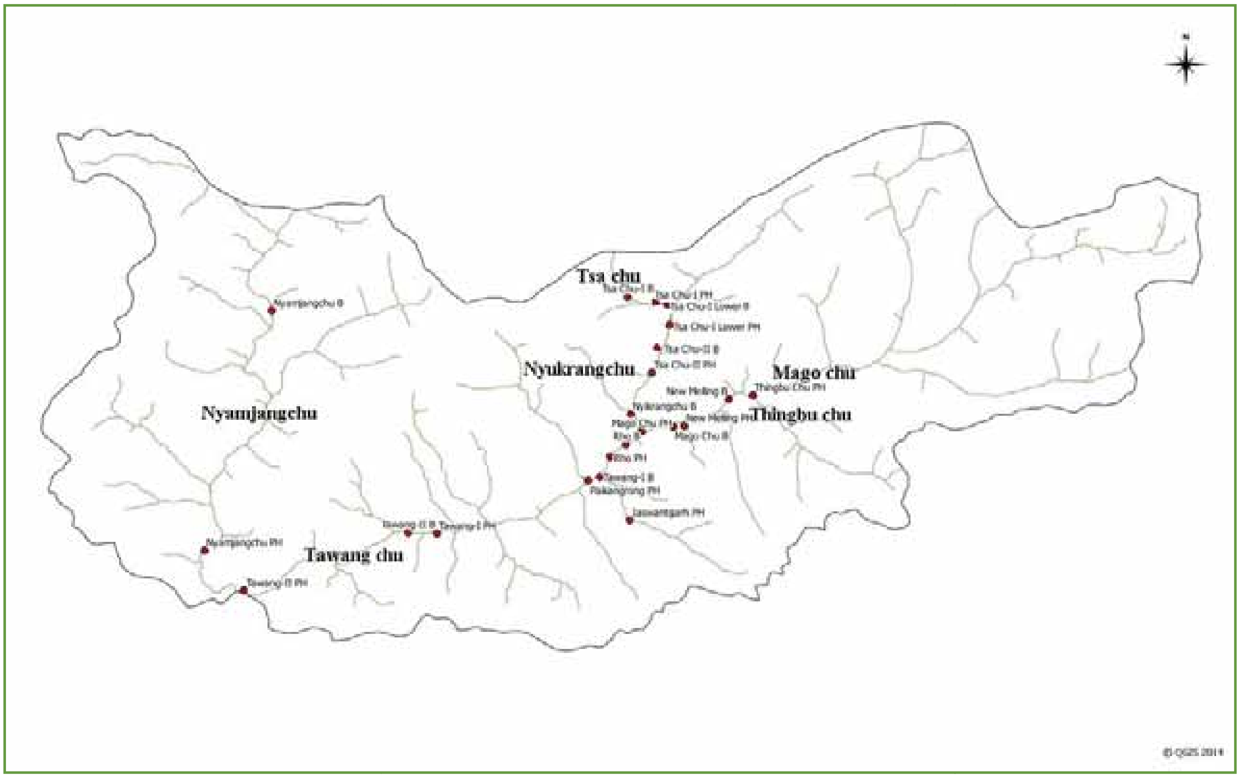


Figure I. 1.2: Proposed locations of the HEPs in TRB

Hydro-power Development Vis-à-vis Environment Degradation: It has been argued that among the major sources of energy production such as nuclear, thermal and hydel, hydel is the cleanest and least risk source of power generation. The contribution of non-renewable energy sources such as wind, solar and tidal being insignificant, hydel power seems to be the best preferred source of power generation. Although construction of HEPs is essential to generate electricity for the development of the region, the prime victim of this development will be the biodiversity rich forests and mountain ecosystems of the Himalayan state. The unique biodiversity, undisturbed high forests, rich cultural diversity of the state are going to be affected if these projects are implemented. The destruction of habitats of the threatened and endemic flora and fauna of Arunachal Pradesh would have an irreparable impact on already dwindling populations of these floral and faunal elements. While developmental needs of the region which has been hither to neglected might be taken care of as an ancillary benefit, if some of these projects are taken up, the environmental damage to be caused by such projects cannot be undermined. Therefore, a balanced approach needs to be worked out with an aim to optimize power production with minimum environmental damage. This approach has to be at a basin scale considering all the proposed projects rather following single project approach.

1.3 BACKGROUND OF THE STUDY

While considering the accordance of forest clearance for Tawang-I and Tawang-II projects, the Forest Advisory Committee (FAC) of the Ministry of Environment and Forests, Government of India desired that the Government of Arunachal Pradesh should conduct the studies in TRB with the following objectives:

1. To assess the impact of thirteen HEPs planned in the basin, ancillary industries/activities, including influx of migrant workers, displacement of local ST population etc., on local ecology and biodiversity.
2. To assess the ecological water flow at different places along Tawang river and its tributaries.
3. To prepare a biodiversity management plan at the landscape level for the river basin.
4. To prepare a 15-20 years perspective plan for the cumulative development of the TRB.
5. To assess carrying capacity of TRB.

The Government of Arunachal Pradesh commissioned North-Eastern Hill University (NEHU), Shillong to conduct the above studies based on the recommendation of the 'Technical Committee' of Government Arunachal Pradesh. A Memorandum of Association (herein after referred as MoA) was signed between the North-Eastern Hill University (NEHU) and Government of Arunachal Pradesh to complete the studies.

1.4 SCOPE OF THE STUDY

The scope of the study as mentioned in the MoA in TRB include:

Individual and Cumulative Impact Assessment Study: Geology and geomorphology, seismicity, hydro-meteorology, land use/land cover, vegetation and soil environment, floral and faunal elements, aquatic ecology and water quality, fish and fisheries, air pollution, socio–cultural and economic profile, prediction of impacts both cumulative as well as at individual project level. More specifically, the overall impact of the projects on hydrology, biodiversity, ecology of the area especially the river ecosystems and the vegetation in the adjoining land area was to be assessed. The impact of the projects on livelihood including displacement of the people and consequent pressures on the environment has to be adequately assessed and addressed.

Assessment of E-Flow: An assessment of minimum ecological water flow at different places along Tawang River and its tributaries was to be made. The parameters of all the projects have to be adjusted to ensure this ecological water flow.

Assessment of Carrying Capacity: The carrying capacity of the river basin in terms of water resources, forest resources, biodiversity and human population was to be assessed.

Landscape Level Biodiversity Management Plan: A landscape level biodiversity management plan was to be prepared for the entire river basin keeping in mind the possible damage to the biodiversity of the basin and ensure the future conservation.

Twenty Year Perspective Development Plan: Since a large numbers of projects are planned on the river system, a perspective development plan for the entire river basin was to be prepared. A proper disaster management plan keeping in view all the projects also needs to be prepared.

1.5 TOR OF THE STUDY

The TOR of the study as per MoA are:

- To prepare a 15-20 years perspective plan for the cumulative development of the TRB.
- To undertake a comprehensive study to assess the impacts of all HEPs planned in the basin, ancillary industries/activities, including influx of migrant workers, displacement of local ST population etc on local ecology and biodiversity.
- To prepare a biodiversity management plan at the landscape level for the river basin.

Some of the issues that are to be addressed in such a study are given here under:

- An assessment about minimum ecological water flow at different places along Tawang River and its tributaries. The parameters of all the projects have to be adjusted to ensure this ecological water flow.
- A study to assess the overall impact of the projects on hydrology, biodiversity, ecology of the area especially the Aquatic eco-systems of the river and the vegetation in the adjoining land area.
- The environmental impact of the projects planned in the river system on individual basis as well as on cumulative basis.
- A large number of projects are planned on the river system; a serious thought needs to be given to disaster management. A proper disaster management plan keeping in view all the projects needs to be prepared.
- The impact of the projects on livelihood including displacement of the people and consequent pressures on the environment has to be adequately assessed and addressed.
- The study team should comprise of the experts from the field of hydrology, ecology, wildlife, sociology, hydro power design engineers and disaster management. The experts from

Wildlife Institute of India, Dehradun, IIT, Guwahati, National Institute of Hydrology, Roorkee, Central Water Commission and reputed NGOs may be included for conducting the study. The team may also include the regional institutions as well as independent experts of national repute.

Organisations Involved in the Study: As per TOR, NEHU involved IIT Guwahati, WWF, I-AIM (FRLHT), and local organizations viz., NERIST and NESAC. The experts representing alumni/former faculty of WII, ISI, SACON, GSI and ICFRE were also involved. Expert advice from senior government officials was taken wherever required. A complete list of experts involved in the study is given at Appendix I.1.

Period of study: The study began on 1st June, 2013 and the fieldworks continued till 31st July, 2014. The study was conducted with active participation of different stakeholders in TRB such as Tawang district administration, Zila parishad, political leaders, village council headmen and other villagers, and knowledgeable personalities, district level officials of Government of Arunachal Pradesh, and 4 developers representing 10 proposed hydel power projects. Since there was very little data available on TRB, and considering the large scale data requirement to complete the study, it was essential to involve a large number of subject-specific experts. Therefore, 52 experts were involved to accomplish the task through collecting primary field data over a period of 14 months. In fact, it was not an easy task given the complexity of geo-climatic and socio-political dynamics of TRB. The methodological challenges for each component of the study particularly, CIA, e-flow and carrying capacity added to the challenges and uncertainties in data generation. Because of the non-availability of existing data for most of the aspects, and to have the best possible assessment, 'holistic approach' was adopted to accomplish e-flow, CIA, and carrying capacity assessment.

The proposed 13 projects in TRB were at different stages of development, when the current study began. While Nyamjang chu, Tawang-I and Tawang-II had got certain statutory clearances with finalised DPR and EIA reports, the remaining 10 projects did not even finalize their DPR when this study began. Therefore, changes in the location of various project components in respect of the latter 10 projects were inevitable. Incorporating these changes, and considering the opinions of the officials of power department and Forest and Environment Departments of Arunachal Pradesh, Ministers and other people's representatives at Itanagar, the draft report submitted on 25th September, 2014 was revised. A few field trips were also made to different project sites for verification of data on certain aspects before finalising the report i.e., the present version.

The report has been organised into six sections as follows:

Section	Aspect of study
I	General Introduction
II	Individual Project Impact Assessment
III	Cumulative Impact Assessment
IV	Assessment of E-Flow
V	Assessment of Carrying Capacity
VI	20 Years Perspective Development Plan
VII	Biodiversity Management Plan at Landscape Level
VIII	General Conclusion and Recommendations
IX	Data and appendices

2.1 INTRODUCTION

The boundary of TRB more or less matches with the Tawang district administrative boundary.

Importance of Tawang District/River Basin: The district was formed in October, 1984 by carving out certain areas from the existing West Kameng district of Arunachal Pradesh. The district has fascinating landscape with picturesque snow covered peaks of Himalayan ranges up to 6,500 m asl. Because of its beautiful landscape, Tawang is popularly known as 'The Hidden Paradise' or 'The Land of dawn–lit Mountains'. The Gudpi and Chong-chugmi mountain ranges, the Tawang chu river and the Tawang valley are indeed mesmerizing. There are beautiful natural lakes such as Sangetsar lake and PTso lake, which are known for scenic surroundings and habitats for rare avi-fauna e.g., snow pigeon and rare mammals e.g., musk deer.

Tawang is regarded as a historical centre of Buddhist culture. The world famous Tawang monastery, which is an important seat of Mahayana Buddhism is located here. It is the largest and second oldest in Asia being founded in the 17th century A.D. and bears long glorious history of over 400 years. It controls 17 Gompas in the region. The highlights of this monastery are the imposing three storied assembly hall and the 28 feet high golden statue of Lord Buddha. There is also a big library which has an impressive collection of ancient books and manuscripts. The famous Buddhist gold inscribed scriptures Kangyur and Tagyur are preserved here.

Another attraction in Tawang is the Urgyelling Monastery, which is considered sacred as it is the birthplace of Thangyang Gyatso, the sixth Dalai Lama, Bramadung chung, Sengsarbu Ani Gompa, Gyanggong Ani Gompa are also well known nunneries and monasteries with the Ani Gompa being one of the oldest in the country.

History of Tawang: The name 'Tawang' means the land of 'blessed horses'; it is also known by another Tibetan name, 'Galden Namgey Lhatse', which means a true name within a celestial paradise in a clear night. Prior to the construction of the Tawang Monastery, Tawang was traditionally inhabited by the Monpa people, who reigned over the Mon Kingdom that stretches from Tawang right up to Sikkim. The Mon kingdom later came under the control of neighbouring Bhutan and Tibet. Tawang Monastery was founded by the Merak Lama Lodre Gyatso in 1681 in accordance with the wishes of the 5th Dalai Lama, Ngawang Lobsang Gyatso. The sixth Dalai Lama, Tsangyang Gyatso, was born in Tawang. The monastery is of the Gelugpa sect is the largest Buddhist monastery in India. It is associated with Drepung Monastery in Lhasa.

Tawang was once a part of Tibet. In 1914 Tawang became a part of India. When McMahon Line was drawn in 1914, Tibet gave up several hundred square miles of its territory, including the whole of the Tawang region and the monastery to the British. It came under effective Indian administration on February 12, 1951 as a part of Kameng and Subansiri Frontier Division. Later on it was carved out of West Kameng district. India assumed sovereignty of the territory and established democratic rule. Elections are held regularly and democratic state legislature functions peacefully.

2.2 CLIMATE

The climate of TRB is monsoonal with distinct warm-wet and cold-dry seasons. Annual rainfall in the district during the year 2012 was 1782 mm most of which was received during April-May to September (Figure I. 2.1). The monsoon season sets in the end of May and it is over in September or early October. Winter starts in October with occasional rainfall/snowfall. January and February are the driest and coldest months when temperature drops below freezing point. The monthly maximum temperature varies between 9°C and 25°C, and mean monthly minimum from 1-12°C. The relative humidity is high throughout the year. The climate of the district is strongly influenced by the nature of its terrain. The mountain peaks are covered with perpetual snow. By and large TRB exhibits a mosaic of climatic zones varying from place to place mainly due to its geographical location i.e., elevation, and varied topography i.e., slope and aspect.

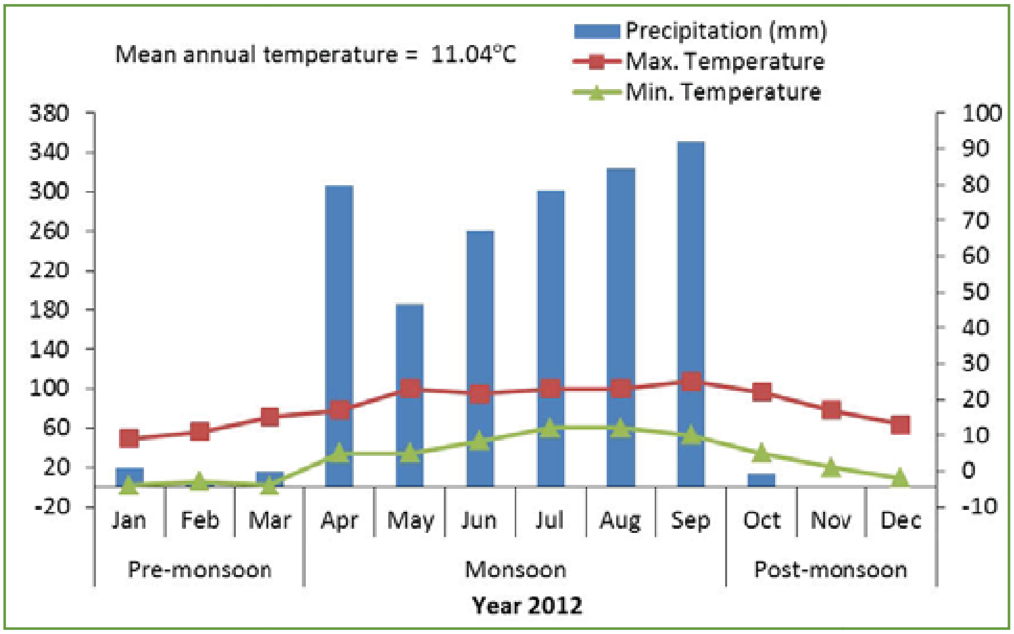


Figure I. 2.1: Monthly temperature and precipitation data in Tawang for the year 2012 (Source: http://tawang.nic.in/index.html).

Various climatic variables such as rainfall, temperature, wind direction and evapo-transpiration together with physiographic factors such as drainage pattern, slope and aspect factors play significant role in the Hydro-meteorology of a river basin. These hydro-meteorological parameters represent and exhibit the nature of environment of a river basin. Additionally, it also determines the setting up and viability of any development project and its management in river basins. It is also true in case of Himalayan mountainous regions. These mountainous areas are of paramount importance for the regions downstream.

On the basis of the monsoon, the year can be divided into two seasons viz. monsoon season (May to September) and non-monsoon (October to April). Monthly meteorological data is available at Bomdila and Tawang stations in and around the basin. The annual average humidity is 82.9% while month wise average ranges from 70.8% in the month of February to 87.8% in the month of July. Since the project areas are located in the valley, the humidity, therefore, is expected to higher than that of the values under discussion. Winter months measure low humidity while monsoon months record maximum humidity. Average minimum and maximum temperature of Tawang are-2.9°C to 31.1°C respectively.

January is the coldest month, when average temperature ranges between-0.1°C to 8.2°C while August is hottest month measuring temperature range of 11.3°C to 20.9°C. Average annual rainfall calculated from three rain gauge stations at Murga bridge, Yusum and Tawang is 2053 mm. At Yusum, maximum rainfall (569 mm) is received in the month of July, at Tawang maximum (386 mm) is received in the month of July, while at Murga bridge maximum (273.2 mm) is received in August. The annual precipitation received at Yusum (2665 mm) is higher than at Murga Bridge (1710 mm) and Tawang (1784 mm). Considerable portion of the basin receives precipitation in the form of snow. Snow accumulates during October to March, and it melts during April to July. No detailed data on the wind aspects are available; however, India Meteorological Department provided wind data for winter season. Average measured wind speed was 6.0 km/h while average wind direction was 228 deg.

2.3 GEOLOGY

The general lithostratigraphic succession has been worked out on the basis of order of superposition, lithological characteristics and grade of metamorphism:

Palaeo-Proterozoic: The oldest sequence presumably of late Archaean to Palaeo-Proterozoic age identified in Arunachal Pradesh includes a high grade politic and psammitic metasediments and intervening mafic bodies represented by sillimanite-kyanite bearing schists, gneisses and amphibolites respectively. There is no record of an earlier crust on which the sedimentation started in a basin developed in an extensional regime followed by mafic volcanism. An epeirogenic movement of short duration was responsible for the deposition of oligomictic conglomerate, persistent bands of quartzite and pelitic schists and limestone. Deposition of limestone with development of stromatolite in a photic zone is indicative of a stable condition during the later period with shallow marine/lacustrine environments.

SeLa Group: Se La Group is structurally the highest unit which is separated from the Dirang formation to the south by Main Central Thrust. This suite of medium to high grade rocks derived its name from the Se La pass in Kameng District. The predominance of migmatites and profuse intrusion of tourmaline granite characteristically differentiate this sequence from the underlying Dirang formation.

In the area around north of Tawang the rocks exposed include garnetiferous gneiss, sillimanite-kyanite-garnet bearing gneiss, migmatite, calc-gneiss/marble, staurolite bearing schist, tourmaline granite, quartzite and veins of pegmatite.

Structure of the Himalayan belt near north of Tawang: The Himalayan belt comprises several thrust bound litho tectonic units. In the area the most important structural unit is Main Central Thrust (MCT).

Main Central Thrust: This thrust separates the high grade metamorphics in the north from the epi to meso grade rocks of the lesser Himalayas to the south. The MCT separates the lesser Himalaya sequence from higher Himalaya. MCT is reported near Dirang and passes into Bhutan. Further, the Lumla formation comfortably lies above Sela group of rocks (GSI, Kumar, 1997). This formation appears to be in physical continuation of Jaishidanda formation of Bhutan Himalaya. There are many hot springs and they also fall in a linear or curvilinear fashion which shows that the area is geologically disturbed either by thrust/minor faults.

2.4 GEOMORPHOLOGY

The entire district is hilly and mountainous. Two third area of the district falls in the higher Himalayan zone and is covered by hard rock terrain. The highest mountain peak Kangte in the district has an altitude of 7,090 m. The northern part of the district is mostly devoid of vegetation due to heavy snowfall during winter season.

The prominent rivers are Tawang–chu and Nyamjang–chu. They enter the district from Tibet in the northeast and flow to Bhutan in southwest corner. The rivers and streams are mostly perennial. In the hilly terrain, the rivers have deep narrow gorges along their courses. Both the rivers are tributaries of the Manas River which is a part of the Brahmaputra River basin.

The drainage pattern is generally dendritic to sub–parallel in nature and follow the geomorphological trends of the hills and mountains. On the regional scale, the drainage pattern is angular to sub–angular. In the north–eastern part of Thingbu circle, the drainage pattern is sub–dendritic.

Geomorphology of the district may be divided into two major units as under:

- Denudo–structural hills: These are mainly comprised of metamorphites and some igneous intrusions with high hills and steep slopes between 2,100 and 6,800 m altitude. About 90% of the total geographical area of the district is occupied by this unit. This unit acts as run–off zone.

- Valley fills: Within the hill ranges, few valley fills occurs in limited area. These are covered by recent alluvium. This unit acts as good recharge zone for the rivers.

Being located in the high Himalayas, the topography of the entire basin is mountainous. In the higher reaches the slope often approaches 90°. However, most of the geographical area in the basin falls under moderately high slope category (31° to 44°) (Table I. 2.1 and Figure I. 2.2). In general, the major parts of the basin have alpine (939.30 sq.km), sub-alpine (692.11 sq.km), temperate (460.88 sq.km) and montane subtropical (79.71 sq.km) climate zones (Figure I. 2.3). Except 5 months of wet summers, even the temperate and montane subtropical climatic zones experience cold and humid climate in the remaining parts of the year.

Table I. 2.1: Slope of TRB

Class	Area (sq.km)	%
High (44° to 89°)	59.00	2.72
Moderately high (31° to 44°)	854.28	39.33
Moderately low (18° to 31°)	803.57	37.00
Low(Below 18°	455.16	20.96
Total	**2172.00**	**100.00**

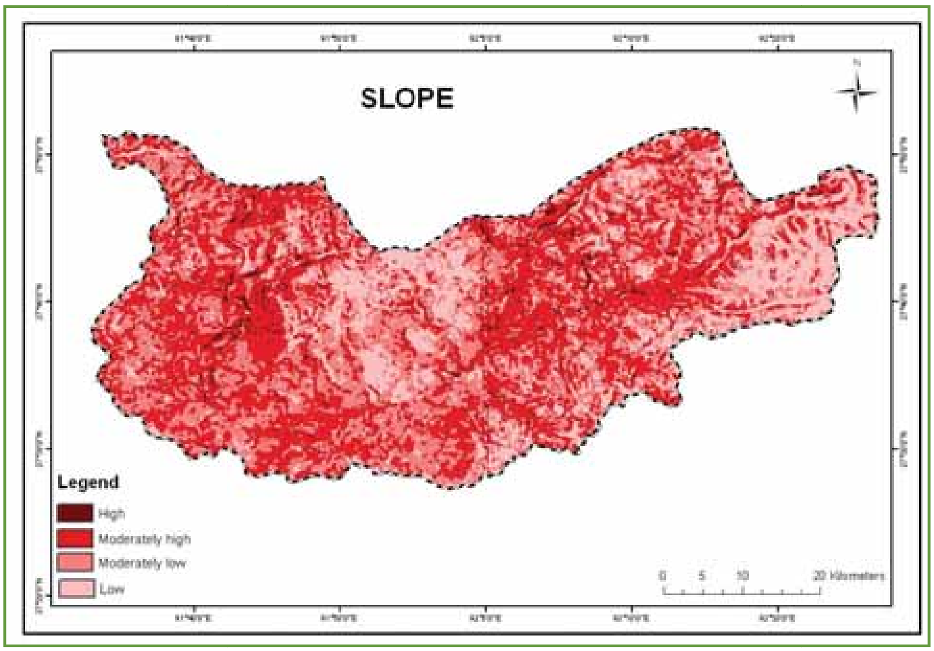


Figure I. 2.2: Slope map of TRB

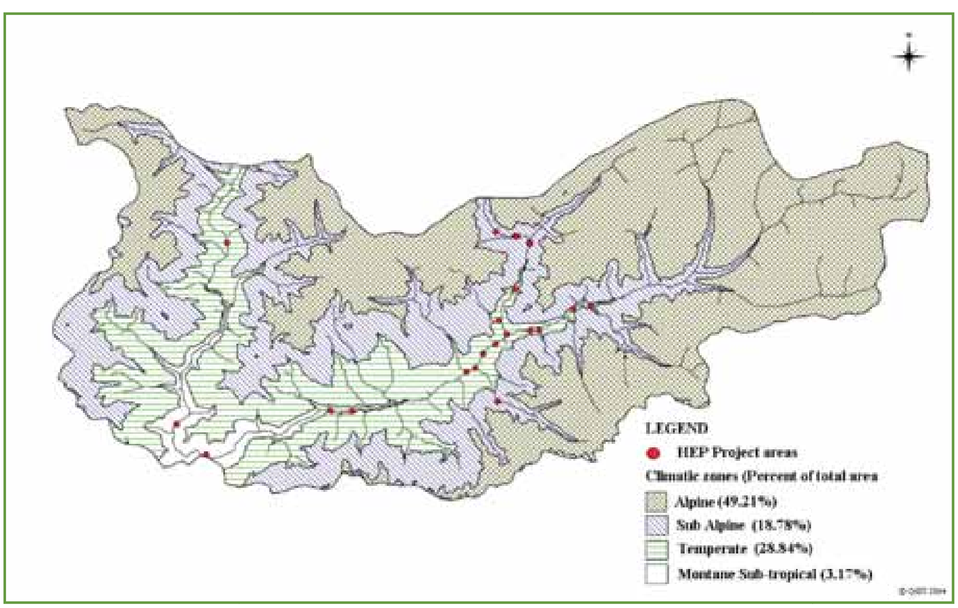


Figure I. 2.3: Broad climatic zones of TRB

In the Himalayan range it is better to describe Tibetan Himalaya in north and higher Himalaya in the south.

Tibetan Himalaya: This covers the north-western part of Arunachal Pradesh bordering Bhutan and Tibet and is represented by a NE-SW trending 30-40 km wide zone of high altitude, low relief, gentle slopes and sparse alpine type vegetation. The altitude, in general, ranges between 3,000 m and 7,089 m altitude. It comprises a part of the high grade schists and gneisses of the Sela Group, proterozoic sediments of Lumla Formation and a part of Tethyan sequence.

Higher Himalaya: This is bounded by the Tibetan Himalaya in the north and the lesser Himalaya in the south and the southern limit is generally defined by the Main Central Thrust in adjacent Bhutan. It has an ENE-WSW trend adjacent to Bhutan that changes gradually to NE-SW eastward. In general, the zone has a high relief around 6,000 m rugged topography with high ridges, precipitous slopes and narrow deep gorges. High ridges mostly remain snow clad; the precipitous slopes are occupied mainly by grasses and the valley and gorges by alpine type vegetation. Palaeoproterozoic high grade gneisses and schists are the major rock types exposed. The physiographic condition of a region is the outcome of actions of several geomorphic agents like water, glacier, wind etc. In the present study, various physiographic parameters were analyzed through remote sensing and GIS techniques. A database of different aspects was formulated for all constituent sub-watersheds of Tawang chu catchment.

Relief: The Tawang chu catchment area has been divided into 12 elevation bands. Among the high elevation classes, there are four classes above 4,000 m (4,000-4,400 m, 4,400-4,800 m, 4,800-5,200 m and 5,200-5,676 m) which are widely spread in the entire catchment. Together these elevation classes cover an area of 79,509 ha i.e., 43% of the entire catchment. These elevation classes are widely spread in the northern part of the catchment, in the Tibet part (based on ASTER DEM analysis)(Figure I. 2.4). Lower elevation classes are limited along the valleys of main channel of Mago chu, Tawang chu and Nyukcharong chu rivers.

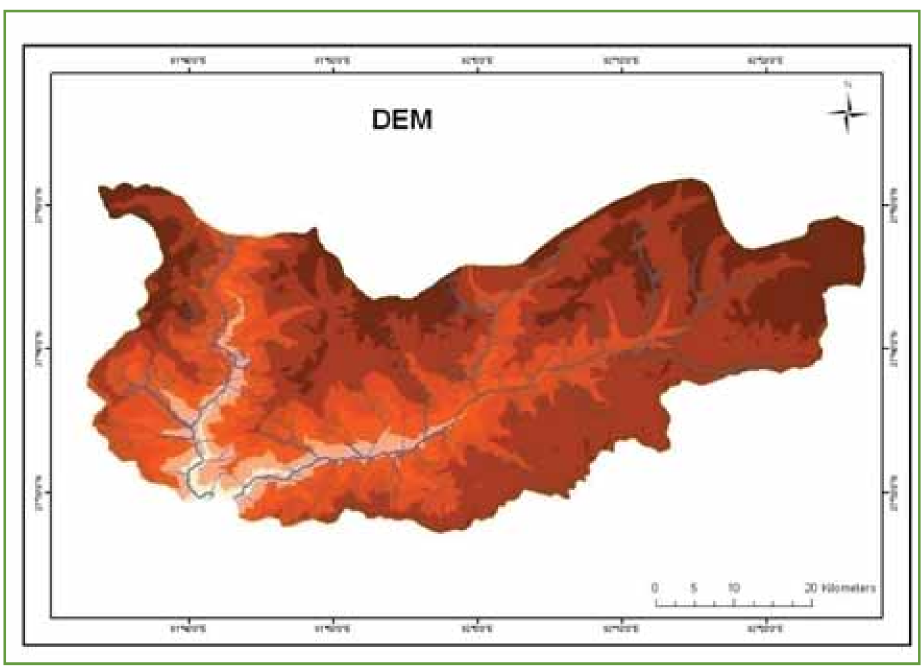
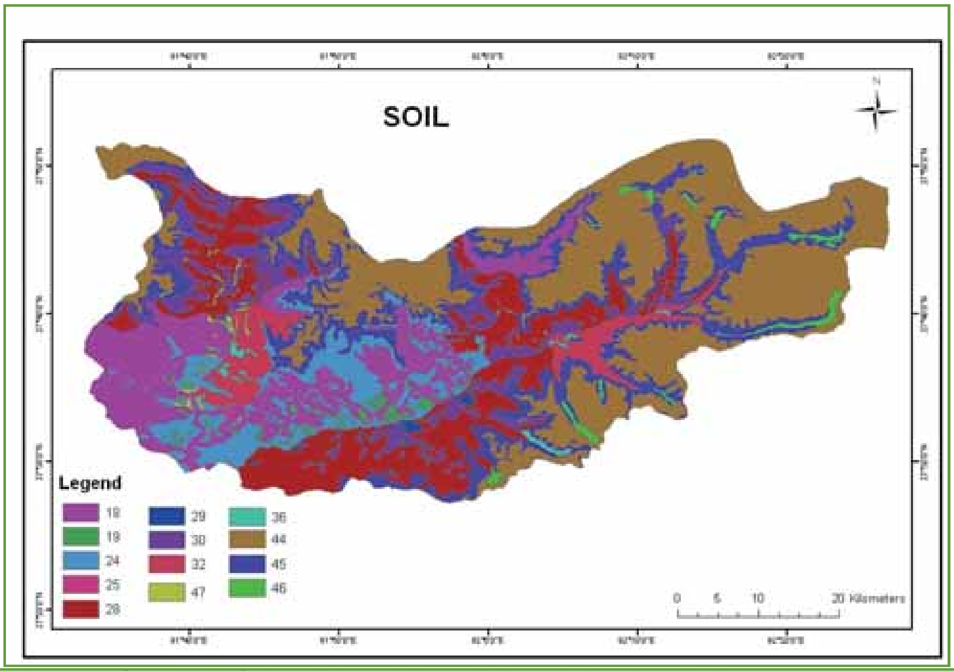


Figure I. 2.4: DEM showing the elevation profile of Tawang district

2.5 SOIL

The properties of soil vary widely in different parts of the basin (Figure I. 2.5). Soil in greater part of the district is red sandy and skeletal in nature. In the forested regions, the soil generally contains high humus and nitrogen due to thick forest cover. On the mountain soils slopes are relatively thin and poor in organic matter. The soil of this category is reddish in colour and acidic in nature. In the foothill areas the soil is alluvial, loamy or sandy loam mixed with gravel and pebble brought down by rain waters from high altitudes. The soil in the valley is clayey alluvium and is rich in organic content.

After climate, soil is the most important environmental factor that influence the growth and development of natural vegetation as well as the cultivated crops. Loss of soil cover through erosion or decline in its fertility level due to anthropogenic activities adversely affects both natural vegetation and crop productivity. Therefore, proper understanding of soil properties, their distribution and characterization are essential for optimizing land use and maintaining health of watershed. The present study has focused on the seasonal changes in the properties of soils at different places in vicinity of proposed project sites.



18		Slightly to moderately dissected, having slight to moderate erosion hazard, on very steep to steep side slopes, under dense forest
19		Slightly to moderately dissected, having severe erosion hazard, on very steep side slopes, under shifting cultivation
24		Slightly to moderately dissected, having severe erosion hazard, on very steep side slopes, having forest blanks
25		Severely dissected, having severe erosion hazard, on very steep slopes, under scrub
28		Slightly to moderately dissected, having moderate to severe erosion hazard, on steep side slopes with sparse tree cover
29		Slightly to moderately dissected, having moderate to severe erosion hazard, on very steep side slopes, under shifting cultivation and scrub
30		Slightly to moderately dissected, having severe erosion hazard on very steep side slopes, under forest blanks and scrub
32		Slightly to moderately dissected, having moderate erosion hazard, on very steep to steep side slopes, under dense forest
36		Slightly to moderately dissected, having severe erosion hazard, on very steep side slopes having forest blanks
37		Slightly to moderately dissected, having severe erosion hazard, on steep to very steep side slopes, under scrub
44		Rocky mountains under permanent snow cover; altitudes more than 3,500 m above msl
45		Rocky mountains, seasonally snow covered
46		Glacial valleys, mostly composed of snow, gravels, Pebbles and soils, brought down by sliding of snow

Figure I. 2.5: Soil map of Tawang district

Most of the soils in the river basin belong to Haplic Luvisols, Gelic Leptosols and Eutric Leptosols type (Figure I. 2.6).

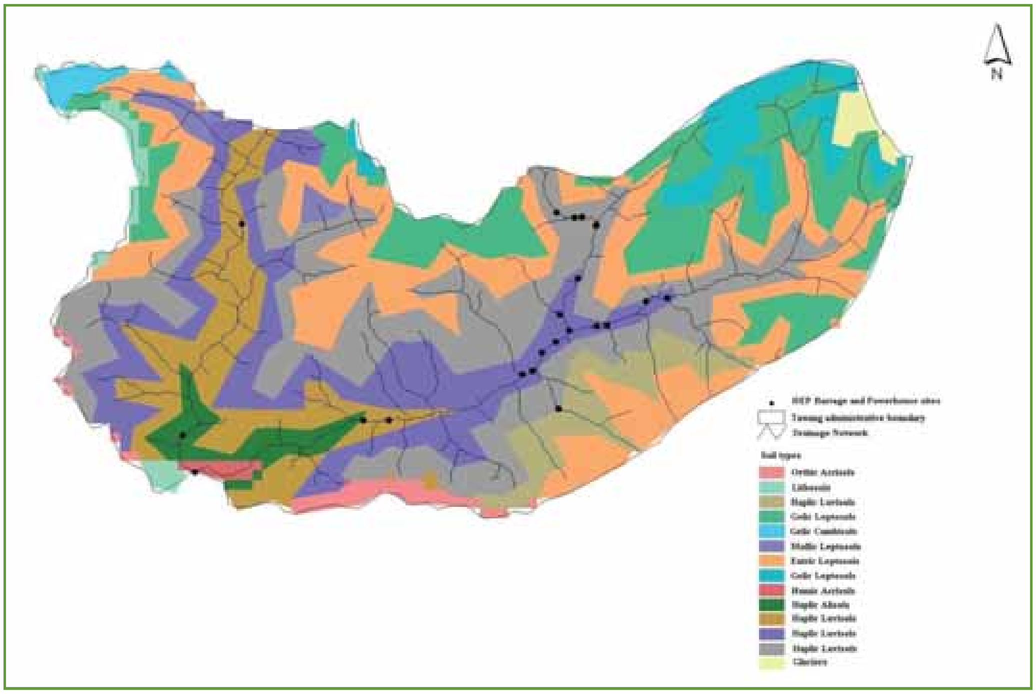
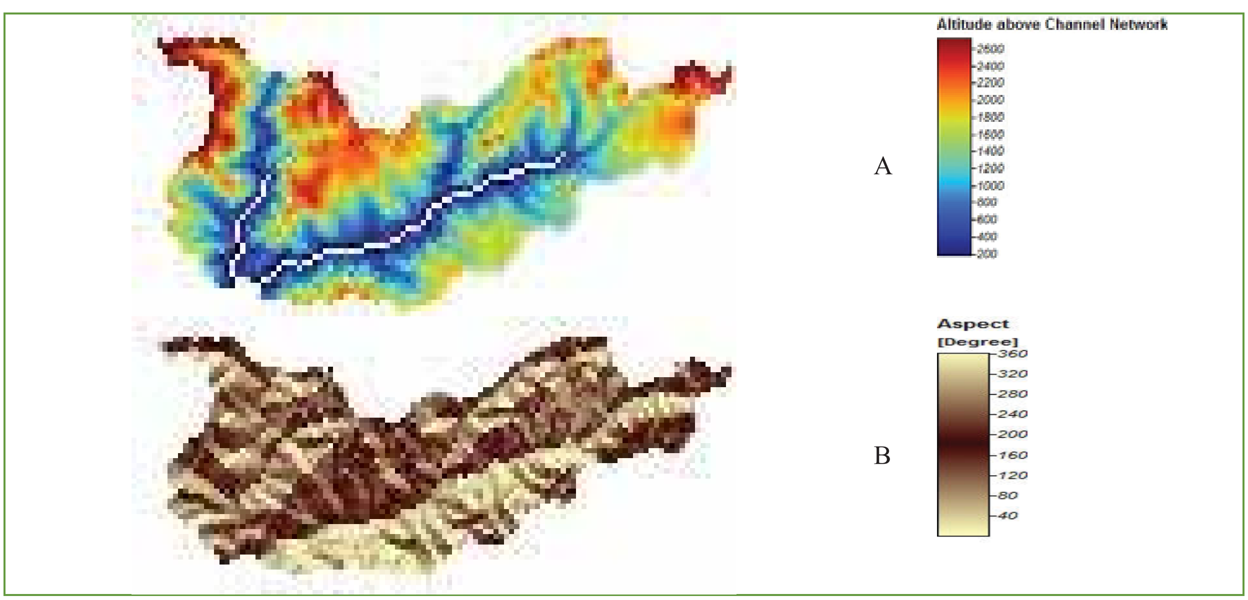


Figure I. 2.6: Map showing different soil types of Tawang district

2.6 HYDROLOGY

Various climatic variables such as rainfall, temperature, wind direction and evapo–transpiration together with physiographic factors such as drainage pattern, slope and aspect play significant role in the hydro-meteorology of a river basin. These factors are guided by geographical position and topography of the basin, which in turn controls the vegetation, rock and soil cover. The hydro-meteorological parameters in the mountainous river basins play significant role in assessing water discharge and forecasting catastrophe. Therefore these parameters are crucial in decision making for setting up and viability of any HEP and its management in the river basins. Therefore, hydro–meteorological parameters are needed to be studied in detail in the context of hydropower development (Figure I. 2.7).



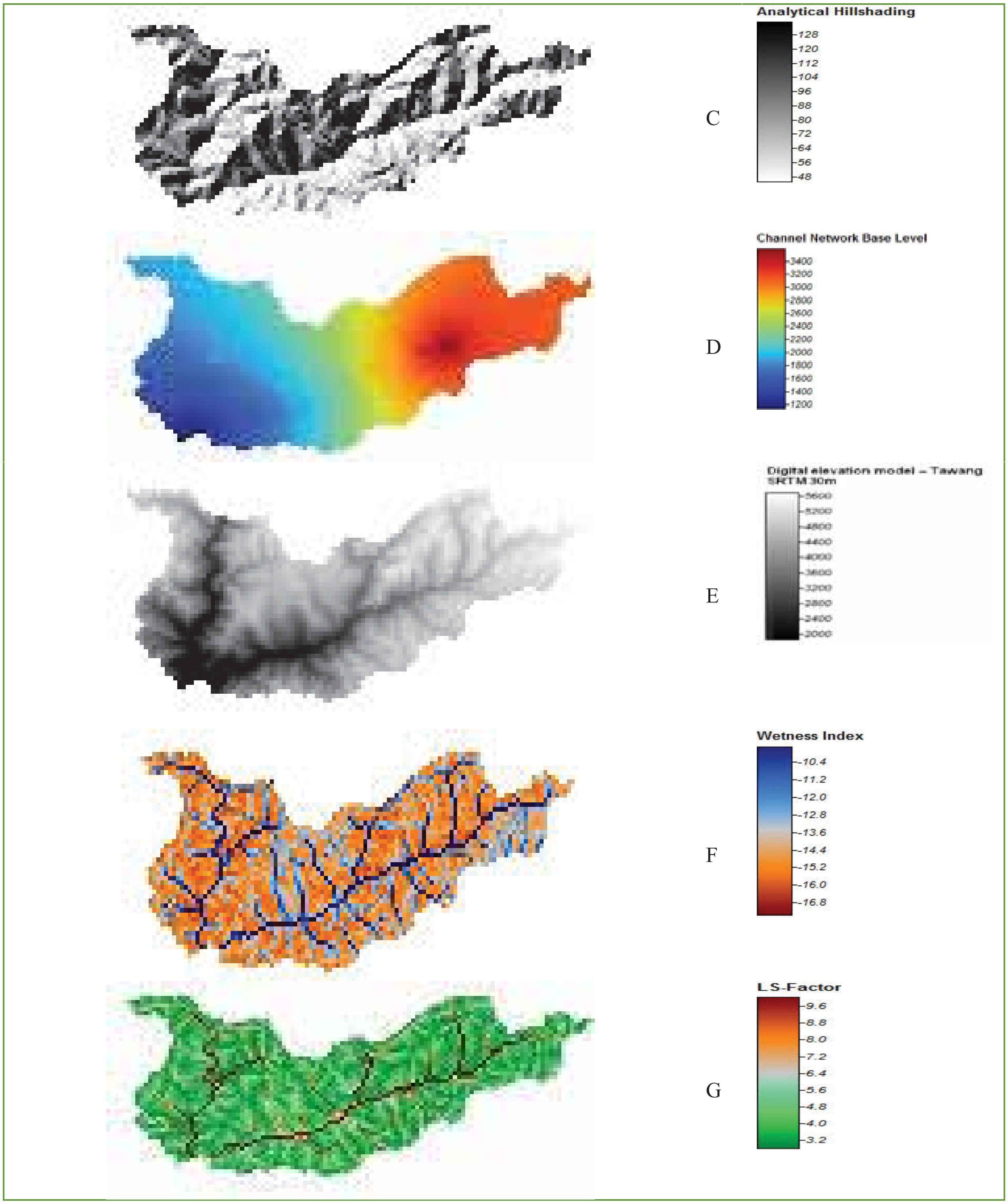


Figure I. 2.7: Hydrological variables of TRB (A-G)

Drainage Network: Tawang chu and Nyamjang chu are the two main rivers in Tawang basin (Figure I. 2.8). Tawang chu is the result of the confluence of Mago chu and Nyukcharong chu rivers at an elevation of 2,240 m. Nyukcharong chu originates from Tibet in the Eastern Himalayan ranges and flows towards southern direction and joins Seti chu after 52 km of travel in Tibet. It further flows southward direction and enters India after Shoe/Tsona chu joins it from left side at 3,060 m near Shyamdling. Mago chu originates in India at an elevation of 6,500 m. It traverses south-west and joins Nykcharong chu near Kyelatongbo. The river after confluence is known as Tawang chu. Tawang chu flows towards Bhutan through a narrow valley in most part of its length and crosses international boundaries after cruising in India for a distance of 45 km. The overall drainage network of the catchment area shows combination of dendritic, trellis and parallel drainage patterns. Several small and large lakes are located within the catchment area.

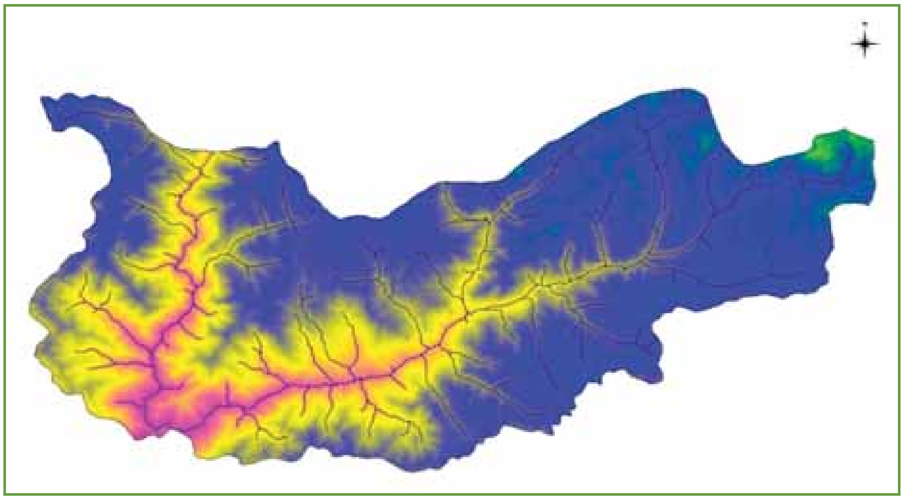


Figure I. 2.8: Drainage map of Tawang chu and Nyamjang chu in Tawang district

Water Discharge: The annual average of water discharge was recorded as 42.5 cumec at China Bridge increased to 89.0 cumec at barrage site in Tawang chu. For Mago chu the annual average of water discharge was 40.8 cumec. During the period of 17 years (CWC Classified Data, 1992-2008) maximum water discharge of 299.6 cumec was recorded in Tawang chu river at CWC gauge site in Yusum village in August, 2007. The maximum and minimum 10-daily average discharge was 299.6 cumec in the mid August, 2007 and 28.2 cumec in the beginning of February, 1998 respectively. The average run-off coefficient at Murga bridge (near barrage site) for the period of 2000-2007 was computed to be 0.60, which measures 0.63 after deducing the snowmelt contribution.

Gradient Profile: The longitudinal profile of the Tawang chu including its headwater, where the river is known as Shoe chu in Tibet covers a distance of about 140 km between 4,700 m elevation in the north and 2,060 m elevation at the proposed barrage site of Tawang-I project at the existing powerhouse site of Nuranang chu. At the central part of the profile major tributary streams meet the main river. In this stretch the river spans an elevation of 2,000 m in 47 km travel. Thus, the gradient of Tawang chu in this stretch is 1:23.5. The Mago chu travels for 45.65 km within the elevation range of 2,400 to 5,100 m. This channel has the gradient of 1:16.91. One of the prominent knick points observed along Mago chu lies at 75 km from the headwater region. Here, the water elevation in the river drops down from 3900 to 3500 m in a span of about one km distance. Another knick point was observed near the confluence of Tawang chu and Mago chu. The presence of knick points indicates major structural discontinuity across the stream. Steep gradients was also observed at Nuranang chu (1:7.34) and Nyukcharong chu (1:12.83).

2.7 LANDUSE LAND COVER

The land use and land cover of Tawang district includes forest land, scrubland, waterbody, croplands, grasslands, builtup area and snow and ice (Table I. 2.2 and Figure I. 2.9). About 39.3% of the land is covered by forest land. Significant area of 103,325.4 ha is covered under scrubland occupying 42.4% of the total area. Area under waterbody and snow and ice covers about 12.3% (29,934.56 ha) and 4.8% (11,622.53 ha) of the total area, respectively. Cropland and builtup area accounts for only 0.3% of the total area.

Table I. 2.2: Area under various landuses in Tawang district

Class	Area (ha)	%
Forest	95840.78	39.3
Scrubland	103325.4	42.4
Waterbody	29934.56	12.3
Croplands	735.12	0.3
Grasslands	1658.228	0.7
Builtup area	799.92	0.3
Snow and ice	11622.53	4.8
Total	**243916.54**	**100**

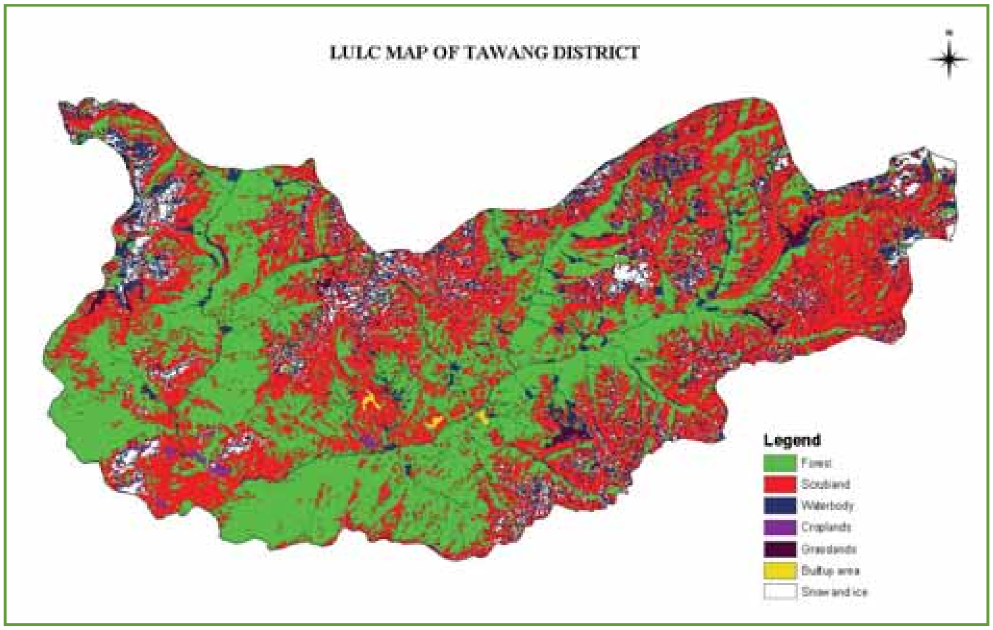


Figure I. 2.9: Landuse land cover of Tawang district and proposed project locations with their influence zone

2.8 VEGETATION

The first account of Botanical exploration in Tawang region could be traced to the 20th Century with the publication of 'A sketch of the vegetation of Aka Hills' based on the collections of Bor (1931–1934) which enumerates 1549 species of flowering plants, 9 species of gymnosperms and 58 species of ferns and fern allies. The vegetation of TRB may be broadly grouped into the following major types based on elevation and their structural and compositional characteristics (Champion and Seth, 1968; Kaul and Haridasan, 1987) (Table I. 2.3).

Table I. 2.3: Classification of vegetation of TRB

Sl. No.	Broad climate type	Champion and Seth Code	Forest type	Elevation (m)
I	**Montane Sub-Tropical Forest**			**1000-1800**
		8/B/CI	East Himalayan sub-tropical wet hill forest	1000-1800
		9/CI	Eastern Himalayan sub-tropical pine forest	1200-1800
II	**Temperate Forest**			**1800-3500**
		11B/CI	East Himalayan wet temperate forest	2000-3000
		12/C3a	East Himalayan mixed coniferous forests	2000-3500
		12/C3b	*Abies* forest	2750-3000
		12/EI	Cypress forest	1800-2800
		12/ISI	Alder forest	1800-2200
		12/1S2	Riverine blue-pine forest	1800-3000
III	**Sub-Alpine Forest**			**3500-4000**
		14/C2	East Himalayan sub-alpine birch/fir forest	3500-4000
		14/1SI	*Hippophae* forest	3500-3750
		14/2SI	Sub-alpine blue-pine forest	3500-4000
		14/DSI	Sub-alpine pasture	3500-4000
IV	**Alpine Forest**			**4000-5500**
		15/CI	Birch-Rhododendron alpine scrub forest	4000-5500
		15/E2	Moist alpine dwarf Juniper scrub	4000-4250
		15/C3	Alpine pasture	4000-5500
		16/EI	Dry alpine dwarf Juniper scrub	4000-4900

1. Montane Sub-Tropical Forest

8/B/CI East Himalayan sub-tropical broad-leaved forest (1000-1800 m): These forests occur in and around 1000 m and extend up to 1800 m elevations. The canopy is comprised of *Alnus nepalensis, Macaranga denticulata, Castanea sativa, Engelhardtia spicata, Erythrina arborescens, Quercus glauca, Rhus succedanea, Schima wallichii*, *Ficus auriculata, Myrica esculenta*, etc. Medium sized evergreen tree species such as by *Ficus semicordata, Lophopetalum wightianum, Lyonia ovalifolia, Rhus chinensis, Saurauia punduana, Tetracentron sinense, Phyllanthus emblica*, *Rhus javanica, Torricellia tiliifolia* etc., constituted sub canopy layer. Understory consisted of shrubs such as *Artimisia nilagarica, Coriaria nepalensis, Elaeagnus parvifolia, Rubus ellipticus, Maesa indica* etc. and climbers. Epiphytes were abundant in the forest.

9/CI Eastern Himalayan sub-tropical pine forest (1200-1800 m): These forests occur in and around 1200 m and extend up to 1800 m elevations. The canopy is comprised of *Pinus roxburghii*, *Mallotus philippensis, Pyrus pashia, Syzygium cumini, Albizzia arunachalensis, Prunus cerasoides, Purus* sp., etc. Shrubs were represented by *Artimisia nilagirica, Coriaria nepalensis, Elaeagnus parvifolia, Rosa* sp., *Rubus ellipticus, Butea buteiformis* and *Viburnum erubescens*. The herbaceous layer constitutes of Climber and epiphytes are not common.

2. Temperate Forest

11B/CI East Himalayan wet temperate forest (2000-3000 m): These are mixed evergreen forests with moderate size trees occurring between 1800 and 3000 m altitude. In these forests important tree associates are *Acer campbellii, Lithocarpus pachyphylla, Prunus cerasoides, Quercus serrata, Rhododendron arboreum, Schima wallichii* and *Tetracentron sinense*. Shrubs are represented by *Berberis asiatica, Coriaria nepalensis, Elaeagnus parvifolia, Rosa brunonii, Rubus ellipticus* and *Viburnum erubescens*. Climber and epiphytes are not common.

12/C3a East Himalayan mixed coniferous forests (2000-3500 m): These are dense evergreen forests with dominance of oak and rhododendrons. In the upper ridges between 2300-3500 m elevations, silver fir (*Abies densa*) makes appearance as a dominant tree species. With the oak are mixed deciduous trees such as *Magnolia* sp., *Acer* sp., *Betula alnoides, Alnus nepalensis*, and others to a varying extent. There is usually gregarius undergrowth, usually of bamboo, and in its absence Rhododendron species and other evergreen shrubs such as *Berberis* sp., *Cotoneaster* sp., *Rhododendron* sp., *Salix* sp., *Thamnocalamus* sp. and *Viburnum* sp. These are laden with many epiphytic mosses and lichens.

12/C3b Abies forest (2750-3000 m): *Abies densa*, occur in remarkable pure stand, it is upto 20 m tall and attains girth of 2 m and in some places *Rhododendron, Lyonia, Litsea* species are also seen. Dense and almost impenetrable brakes with one or more species of *Arundinaria* and related genera, often practically with no other large woody plants. However there are often few *Rhododendron* and *Berberis* species seen as shrub component of this forest type. In the damper region there may be epiphytic moss. The herbaceous flora covers the soil wherever enough light penetrates. Transitions with scattered overwood are numerous.

12/EI Cypress forest (1800-2800 m): Typically very open forest of scattered tree on steep rocky ground with xerophytic shrubs and little grass, the trees being 10-25 m high and branchy to the base. It is capable, however, of excellent growth with a height up to 45 m and may form an uneven but fairly closed wood with a filling and second storey of oak and other evergreens, or more or less bamboo. Cypress forest is most frequently met with on limestone rocks which provide relatively dry soil conditions, particularly on screes of limestone shales. The trees comprised are those of *Cupressus, Quercus*, etc.

12/ISI Alder forest (1800-2200 m): Typically seen as pure stands of *Alnus nepalensis, Populus ciliata*, 20-30 m high, as a strip of varying width along stream sides, spreading out to larger areas, more or less deciduous. In the lower course of the stream where the fringe of Alder is the only remaining tree growth owing to cultivation, there is often an under growth of inedible or thorny shrubs comprising *Berberis, Rubus, Princepia* etc, whilst in the better wooded tracts progression starts early and other species, notably blue pine and other conifers, are usually present.

12/1S2 Riverine blue-pine forest (1800-3000 m): Irregular often dense stands of blue pine with occasional *Picea*, *Populus* and *Alnus* with little or no undergrowth at first, but often becoming more open with inedible or thorny shrubs, if grazed.

3. Sub-Alpine Forest

14/C2 East Himalayan sub-alpine birch/fir forest (3500-4000 m): These are forests which occur in the Eastern part of the Himalaya between 3500 and 4000 m. The forests comprise of trees such as *Abies densa, Juniperus, Larix griffithii, Betula utilis* etc. and small trees like those of *Rhododendron wightii, Salix*, etc. and shrubs such as *Rosa, Berberis, Spirea* etc. The herbaceous layer is comprised of *Polygonum* sp*., Potentilla* sp., *Primula* sp., *Fragaria* sp. etc.

14/1SI Hippophae forest (3500-3750 m): A more or less pure thicket of *Hippophae salicifolia* with some admixture or undergrowth of *Salix* sp*., Myricaria* sp., and occasional *Populus ciliata* at the lower elevation and tufts of grass and herbs such as *Thymus, Epilobium*.

14/2SI Sub-alpine blue-pine forest (3500-4000 m): These types of forest are represented by pure stands of *Pinus wallichiana* around 3500-4000 m, their seral status seems equally definite, regeneration only occurring where the progression is thrown back by new snow or earth slides, or sometimes fire; otherwise the fir gradually displaces it.

14/DSISub-alpine pasture (3500-4000 m): In this region the grasses predominates, namely, *Agropyrum longearistatum, A. semicostatum, Brachypodium sylvaticum, Bromus asper, B. japonicas, Dactylis* sp., *Festuca* sp., *Milium effusum, Oryzopis, Phleum, Poa* sp., etc.

4. Alpine Forest

15/CI Birch-rhododendron alpine scrub forest (4000-5500 m): In the Eastern Himalaya, this type forms a low evergreen forest almost entirely of species of Rhododendron but with some birch (*Betula utilis*) and other deciduous trees, so dense as to be difficult to penetrate, particularly in an uphill direction as owing to snow pressure, the stems all curve up from a more or less horizontal or downward bent base. Moss or fern covers the ground with varying amount of alpine shrubs such as *Sorbus, Viburnum, Gaultheria trichophylla, Rhododendron lepidotum, R. nivale,* flowering herbs like *Primula, Corydalis, Meconopsis* etc. and ferns. The birch may form almost pure stand above the last fir.

15/E2 Moist alpine dwarf Juniper scrub (4000-4250 m): These types of forest are dominated by *Juniperus communis* and *Juniperus wallichiana* at around 4000-4250 m.

15/C3 Alpine pasture (4000-5500): The alpine pasture medows are composed mostly of perennial mesophytic herbs, with very little grass. Conspicuous among the herbs are *Primula*, *Anemone, Fritillaria*, *Iris, Gentiana*, with many Ranunculaceae, Brassicaceae, Caryophyllaceae, and Asteraceae. This alpine pasture has a shorter snow free period.

16/EI Dry alpine dwarf Juniper scrub (4000-4900 m): In the eastern Himalaya *Juniperus recurva* (3000-4600 m.) and *J. recurva var. squamata* (4,300-4,900 m.) succeed *J.wallichiana* at about 4,300 m., especially on screes, and ascend upto 4,900 m. the association are purer at higher elevation.

2.9 ADMINISTRATIVE SETUP

Tawang is an administrative district in the state of Arunachal Pradesh and Tawang town is the district headquarter. The entire district is divided into 3 sub division with 10 circles and CD 3 blocks under them (Table I. 2.4). Besides being a tribal state, the Panchayati Raj Institution exists and functions in a three tier system with one Zilla Parishad at the top, 6 Anchal Samitis in the middle and 80 Gram Panchayats at the bottom level (Table I. 2.5).

Table I. 2.4: Administrative set-up showing the sub-division, circles, distance from Head Quarter, altitude and population in Tawang district

Sl. No.	Sub-Division	Circle	Distance from HQ. (km)	Head Quarter	Altitude (m)	Population as per census-2011		
						Persons	Males	Females
1	Tawang	Tawang	-	Tawang	3,025	19099	12463	6636
		Kitpi	25			2935	1411	1524
2	Jang	Jang	42			5480	3288	2192
		Mukto	58	Mukto	2,400	3655	1926	1729
		Thingbu	74	Thingbu	3,400	1592	939	653
		Bongkhar	75			1256	575	681
		Lhou	25			4029	2606	1423
3	Lumla	Lumla	50	Lumla	2,176	6171	3055	3117
		Zimithang	90	Zimithang	2,176	2926	1439	1487
		Dudunghar	78			2833	1449	1384
Total	**3**	**10**				**49976**	**29151**	**20826**

Table I. 2.5: Panchayat Raj Institution during the year 2011-12 in Tawang district

Sl. No	Institution	Total number	Total number of members
1	Gram Panchayat	80	298
2	Anchal Samitis	6	80
3	Zila Parishad		6

2.10 SOCIO–ECONOMIC PROFILE

According to Census, 2011, Tawang had population of 49,977 of which male and female were 29,151 and 20,826 respectively. There was a change of 28.40% in the population compared to population as per 2001. Population density is 23 people per sq. km. and the average literacy rate is 59 where male and female literacy rate are 67.54 and 46.53 respectively.

Monpa is the dominant tribe in Tawang. They are the followers of Buddhist ideals. Out of 163 villages in the district, Monpas inhabit 162 villages. Most of the people including the Monpa, Takpa and the Tibetans follow Tibetan Buddhist religion. Pre-Buddhist Bon and Shamanist influence is also evident. Festivals like Losar, Choskar, and Torgya are celebrated annually. The Dungyur is celebrated every three years of the Torgya. Both the Dungyur and Torgya festivals are celebrated at the Tawang Monastery with traditional gaiety and enthusiasm.

The economy of Tawang district is agrarian in nature with more than 80% of the population dependent on agriculture. The alpine and temperate agro climatic conditions of the district are conducive for certain agricultural activities. Wheat is the major food crop produced along with Rice, Maize and Millet. Other important crops of the district include potato, oil seeds and vegetables etc. Apple is introduced in Tawang and at present the district produces about one fourth of total production of apple of the state. As per the 2011-12 Census data, the total net area sown in the district is 4148 ha under agriculture and 3640 ha under horticulture (Table I. 2.6).

Table I. 2.6: Agriculture and horticulture during the year 2011-12 in Tawang district

Agriculture		Horticulture	
Net area sown	4148 ha	Area under horticulture	3604 ha
Estimate production of main crops		Estimate production of fruits	
Paddy (Rice)	1196.52 MT	Apple	4675 MT
Maize	1512 MT	Plum/Pear/Peach	120 MT
Wheat	1406.16 MT	Walnut	87.5 MT
Millet	1218 MT	Guava	160 MT
Potato	4550 MT	Orange	793 MT
Pulses	197 MT	Kiwi	2375 MT
Oil seeds	221 MT		
Area brought under permanent cultivation during the year	8 ha		

As of March 2009, Arunachal Pradesh had a total installed power capacity of 61.1 MW, all under the state power department. The state's share in the central sector capacity is around 120 MW, taking up the total power capacity available to Arunachal Pradesh to 180.1 MW. Renewable energy sources accounted for 79.5% of the total installed capacity. The Ministry of New and Renewable Energy controls this sector. The per capita consumption of electricity in Arunachal Pradesh was 297.7 kWh in 2005-06. Arunachal Pradesh has been focusing on developing its huge hydro power potential. The state has set up the Department of Hydro Power Development to oversee, coordinate and monitor hydro power development. The Government of Arunachal Pradesh has signed a memorandum of understanding (MoU) with central sector power generators and integrated power developers (IPD) for the development of 72 HEP plants, with an aggregate capacity of 25,722 MW IBEF (2010)

In villages, electricity is mainly used for domestic purposes only. Till 31-3-2012, about 7 towns and 238 villages have received electricity connection in Tawang district. The total consumption of electricity in the district is 6247.57 MWh (Table I. 2.7).

Table I. 2.7: Power distribution during the year 2011-12 in Tawang district

Sl. No.	Particulars		Unit
1	Electrical Division	1	No.
2	Electrical Sub-Division	3	Nos.
3	Electrical installed capacity	1275	KW
4	**Power generated**		
	Hydel	14539.687	MWh
	D.G. Set	275.719	MWh
	Total	**14815.41**	**MWh**
5	**Electricity consumed**		
	Domestic	3957.646	MWh
	Commercial	1096.974	MWh
	Industrial	4.234	MWh
	Public light (Street light)	275.624	MWh
	Non-residential	766.543	MWh
	Others	146.549	MWh
	Total	**6247.57**	**MWh**
6	Town Electrified as on 31-3-2012	7	Nos.
7	Village Electrified as on 31-3-2012	238	Nos.

The district has a good base of fishery and veterinary services. As on 2011-12, there are 4 Government fish farms, 4 fish breeding farm and 208 village fish ponds. Revenue earned under fishery was Rs. 52,000 (Statistical Abstract of Arunachal Pradesh, 2011-12). Under animal husbandry and veterinary department, there are 5 veterinary dispensaries, 11 veterinary aid centres, 8 cattle upgrading centre, 1 district diagnostic laboratory and 4 sheep and wood extension centre (Table I. 2.8).

Table I. 2.8: Fishery, animal husbandry and veterinary statistics during the year 2011-12 in Tawang district

Sl. No.	Fishery		Animal Husbandry and Veterinary	
1	Govt. fish farm as on 31-3-2012	4 Nos.	Veterinary dispensary	5 Nos.
2	Fish breeding farm as on 31-3-2012	4 Nos.	Veterinary aid centre	11 Nos.
3	Village fish pond as on 31-3-2012	208 Nos.	Cattle up-grading centre	8 Nos.
4	Area under paddy cum-fish culture	-	District diagnostic laboratory	1 No.
5	Water area developed	18.7 ha	Sheep wool extension centre	4 Nos.
6	Fingerlings distributed	59000 ha	Pig breeding farm	1 No.
7	Revenue earned (2011-12)	Rs. 52,000	District broiler farm	1 No.
8			Animals and birds treated	16239 Nos.
9			Castration performed	313 Nos.
10			Vaccination performed	11775 Nos.

The district has 78 primary schools, 40 middle primary schools, 7 secondary schools and 2 higher secondary schools. There is no college in the district. Historically education has been a laggard field in the entire state, schools coming into existence only at the start of 20th century. The total number of students both boys and girls were 10,116 and the total number of teachers including men and women were 615 (Table I. 2.9).

Table I. 2.9: Educational statistics during the year 2011-12 in Tawang district

Sl. No.	Particulars	Number
1	College	NIL
2	Higher Secondary school	2
3	Secondary School	7
4	Middle Primary School	40
5	Primary School	78
6	Pre-Primary School	-
7	Total Number of students	10116
	a) Boys	4466
	b) Girls	5650
8	Total number of teachers	615
	a) Men	401
	b) Women	214

Source: Statistical Abstract of Arunachal Pradesh, 2011-12

Tourism has grown rapidly in the recent years with eco and adventure tourism, cultural tourism, and religious tourism being the major areas of interest. The New Industrial Policy (Government of Arunachal Pradesh, 2008), encourages the development of tourism sector in areas such as tour operations, hotels and resorts. The number of foreign tourist visits in Tawang district has increased to 548 during the year 2011-12. The numbers of domestic tourists have also increased to 28770 during 2011-12 (Table I. 2.10). The popular tourist spots in Tawang district includes:

- *Tawang (547 km from Itanagar):* chugmi ranges and Twang chu river and valley; Tawang Monastery founded by Mera Lama Lodre Gyatso during 17th century, Nyamjang chu river and valley.
- *Urgyelling (4 km from Tawang):* Birth place of Thangyang Gyatso, Bramadug Chaung/Sengsarbu Ani Monastery, Gyanggong Ani Monastery, Nunneries.
- *Jaswantgarh (63 km from Tawang):* War memorial founded in memory of Martyrs of the 1962 India-China War.
- *Zimithang (94 km from Tawang):* Brokenthang waterfalls. Gorchan Chorten, Sarsang, Sandrukpen Monastery built in stone in the 17th to 18th century. It is believed that this stupa is the 2nd largest Buddhist stupa after Budhnath stupa in Asia.
- *Lumla (50 km from Tawang):* Nam-Tsering waterfalls.
- *Takstang (46 km from Tawang):* Sangatsar lake, home of snow pigeon and musk deer; Buddhist pilgrimage centre, where Guru Padma Sambhwa is reported to have offered prayers.
- *Nagula (28 km from Tawang):* Pangkeng lake, high altitude mountain pass.
- *Sela (80 km from Tawang):* High mountain ranges, Sela lake, Bangajang Monestery.
- *Jang (34 km from Tawang):* Nuranang waterfalls, Gorichan peak, proposed wild life sanctuary for protecting red panda and musk deer, Lhou-proposed reserved forest.

Table I. 2.10: Tourism statistics during the year 2011-12 in Tawang district

Number of tourist lodged in the district	3
Number of foreign tourist visited during the year 2011-12	548
Number of domestic tourist visited during the year 2011-12	28770

The number of state government run medical (Allopathic) institutions in the district is 22 including 1 District Hospital located at the urban area. There is no CHC or any referral centers in Tawang. The bed availability is very low in the district, with 47 beds in the District Hospital and 13 beds in the PHCs (Table I. 2.11). This is grossly inadequate when we compare with the norm of one hospital bed per 175-person norm laid down by the Bhore Committee in 1964, and which is regarded as a standard norm in the country. Thus, health infrastructure is exceedingly poor in the district.

Table I. 2.11: Medical and public health statistics during the year 2011-12 in Tawang district

1	**Total number of medical institution**	**19**
	a) Allopathic	22
	b) Homeopathic	1
	c) Ayurvedic	1
2	**Total number of beds installed**	**63**
	a) Urban area	47
	b) Rural area	13
3	**Total number of medical and para-medical personnel**	**44**
	a) Doctor	18
	b) Nurse	09
4	**Number of family welfare**	**01**
	Number of Clinic/Centre	
5	**Total number of patients treated**	**487886**
	a) Indoor patients treated	1312
	b) Outdoor patients treated	47476

2.11 EXISTING POLICIES, LEGAL AND INSTITUTIONAL/ADMINISTRATIVE FRAMEWORK

It is important, for the proposed projects, to identify applicable environmental regulations and legislations of the country which necessitate compliance in respect to its nature, type, scale, area and region of the proposed development.

Policy Framework: The National Environment Policy (NEP) (Government of India, 2006) is intended to streamline environmental concerns in all development activities. It is built on earlier policies for environmental management, viz., the National Forest Policy (Government of India, 1988), National Conservation Strategy and Policy Statement on Environment and Development (Government of India, 1992), Policy Statement on Abatement of Pollution (Government of India, 1992) and on some sector policies like National Water Policy (Government of India, 2012), National Agriculture Policy (Government of India, 2000), and National Population Policy (Government of India, 2000). The NEP is intended to be a guide to act in regulatory reforms, programmes and projects for environmental conservation and to review and enactment of legislation, by agencies of the central, state, and local Governments. The dominant theme of this policy is that while conservation of environmental resources is necessary to secure livelihoods and well–being of all, the most secure basis for conservation is to ensure that people dependent on particular resources obtain better livelihoods through their conservation.

The Tawang HEPs will adhere to all relevant policies and guidelines in general and the following policies, in particular.

i. National Forest Policy (NFP), 1988
ii. National Water Policy (NWP), 2002
iii. National Rehabilitation and Resettlement Policy (NRRP), 2007
iv. Rehabilitation and Resettlement Policy (RRP), 2008 of Govt. of AP

Legal Framework: The legal environmental framework stems from the national commitment to a clean environment, mandated in the Constitution in Articles 48 A and 51 A (g) and strengthened by judicial interpretation of Article 21. It is recognized that maintaining a healthy environment is not the state's responsibility alone, but also that of every citizen. The Ministry of Environment, Forests & Climate Change (MoEF & CC) is the nodal regulatory agency of the Central Government for planning, promotion, co–ordination and overseeing the formulation and implementation of environmental and forest policy, legislations and programmes. Regulatory functions like grant of Environment Clearance (EC), Forest Clearance (FC) are part of the mandate of this agency.

The Environment (Protection) Act, 1986 is the national umbrella legislation that provides a holistic framework for the protection and conservation of environment. The Act, its associated Rules and their subsequent amendments require for obtaining environmental clearances for new or expansion of river valley and HEPs as addressed under the Environmental Impact Assessment Notification, 2006 and require for submission of an Environmental Impact Assessment (EIA) report as one of the pre–requisites for EC.

Article 48A and 51A of Indian Constitution: As a sequel to the United Nations Conference on the Human Environment (1972), Indian Parliament in 1976 amended the Constitution of India by introducing articles 48A and 51A. These articles incorporated environmental concerns into the Directive Principles of state policy and postulated as a fundamental duty of all citizens to preserve and protect the environment.

Government of India Legislations: The applicable key laws and regulations of Central Government applicable to the project have been explained below:

a) Forest (Conservation) Act, 1980: The act pertains to the cases of diversion of forest area for non-forestry use. The process of obtaining forest clearance under this varies with the area of the forestland to be diverted.

If the area of forests to be cleared or diverted exceeds 40 hectares, the State Government/Union Territory Forest Department would forward the proposal with recommendations to MoEF & CC, Delhi.
If the forest land is between 5 and 40 hectares, the State Government/Union Territory Forest Department processes the proposal, but the permission is issued by MoEF & CC, Delhi.
If the forest land is less than or equal to 5 hectare, Regional Office of MoEF & CC is empowered to accord forest clearance.

As per Rule 6 of the Forest (Conservation) Rules, 2003, every user agency, who wants to use any forest land for non-forest purposes, shall make his proposal in Forms appended to it. Form 'A' is required for proposals seeking first time approval under the Act. Form 'B' is required for proposals seeking renewal of leases where approval of the Central Government under the Act had already been obtained earlier.

b) Wild Life Protection Act 1972: According to this Act, "wildlife" includes any animal, bees, butterflies, crustaceans, fish and moths; and aquatic or land vegetation which forms part of any habitat. In accordance with Wildlife (Protection) Amendment Act, 2002 "no alteration of boundaries/National Park/Sanctuary shall be made by the State Govt. except on recommendation of the National Board for Wildlife (NBWL)". This act has allowed the government to establish a number of National Parks and Sanctuaries over the past 25 years, to protect and conserve the flora and fauna of the State.

c) The Environment (Protection) Act, 1986: This act was passed as an overall comprehensive act "for protection and improvement of environment". According to this Act, the Central Government has the power to take all such measures as it deems necessary or expedient for the purpose of protecting and improving the quality of environment and preventing, controlling and abating environmental pollution. Under this act rules have been specified for discharge/emission of effluents and different standards for environmental quality. These include Ambient Noise Standard, Emission from Motor Vehicles, Mass Emission Standard for Petrol Driven Vehicles, General Effluent Standards, etc.

d) Water (Prevention and Control of Pollution) Act, 1974: This act makes provision for the establishment of the Central and State level Pollution Control Boards, whose responsibility includes managing water quality and effluent standards, as well as monitoring water quality, prosecuting offenders and issuing licenses for construction and operation of any facility. This will include generation of liquid effluent during construction of road from Civil Engineering activities or from domestic activities in workers colony. There are specific penalties for violation, which include imprisonment for responsible officials.

e) Air (Prevention and Control of Pollution) Act, 1981: This act empowers Central and State Pollution Control Boards for managing air quality and emission standards, as well as monitoring air quality, prosecuting offenders and issuing licenses for construction and operation of any facility. National ambient air quality standard for different regions e.g. industrial, residential and sensitive is notified under this act. Air quality during construction and operation phases, particularly for obtaining consent for establishment and operation of crushing plant, batching plant etc. will be done under this Act.

f) India Explosive Act 1984: This rules deals with use and storage of explosive for quarry blasting work.

g) Manufacture Storage and Import of Hazardous Chemical Rules 1989: This rules deals with storage of fuel oil, lubricants, diesel etc. at construction camp.

h) Mines and Minerals (Development and Regulation) Act, 1957: As per the act, "minor minerals" means building stones, gravel, ordinary clay, ordinary sand other than sand used for prescribed purposes, and any other mineral which the Central Government may, by notification in the Official Gazette, declare to be a minor mineral. Therefore, quarrying operation is covered under this act.

i) Contract Labor (Regulation and Abolition) Act, 1970: Engagement of labor and basic facility to be provided and labor license to be obtained.

j) The Child Labor (Prohibition and Regulation) Act (Government of India, 1986): Whereas it is expedient to prohibit engagement of child in factory, mining and similar other risky work and to make necessary provision for health, child's safety and services and facilities while engaging them in other work.

k) Ancient Monuments and Archaeological sites and Remains Act, 1958: Conservation of cultural and historical remains in India is covered under this act.

l) The Indian Fisheries Act, 1897: The Indian Fisheries Act, 1897 contains seven sections. Section 5 of the Act prohibits destruction of fish by poisoning waters.

m) Land Acquisition Act of 1894: This is a law in India that allows the government to acquire private land in those countries. "Land Acquisition" literally means the acquisition of land for some public purpose by a government agency from individual landowners, as authorised by the law, after paying a government-fixed compensation to cover losses incurred by landowners from surrendering their land to the concerned government agency.

n) The Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Act, 2013: In India, a new bill, Land Acquisition and Rehabilitation and Resettlement Bill has been passed by the Parliament in 2013 to repeal the Land Acquisition Act of 1894. This is the first National/ Central Law on the subject of Rehabilitation and Resettlement of families affected and displaced as a result of land acquisition. Only R & R provisions will apply when private companies purchase land for a project, and the same exceeds the area thresholds set by the State Governments for such purchase.

As per this Act, compensation will be given within a period of three months from the date of the award and R & R shall be completed six months prior to submergence in case of irrigation or hydel projects. Where an award has been made but the affected individuals have not accepted compensation or have not yet given up possession, and the proceedings have been pending for 5 years or more, provisions of the new law will apply.

o) The Scheduled Tribes and other Traditional Forest Dwellers (Recognition of Forest Rights) Act, 2006: This is an Act to recognize and vest the forest rights and occupation in forest land in forest dwelling Scheduled Tribes and other traditional forest dwellers who have been residing in such forests for generations but whose rights could not be recorded; to provide for a framework for recording the forest rights so vested and the nature of evidence required for such recognition and vesting in respect of forest land.

p) National Policy on Rehabilitation and Resettlement 2007: The provisions of this policy provide for the basic minimum requirements, and all projects leading to involuntary displacement of people must address the rehabilitation and resettlement issues comprehensively.

q) EIA Notification 2006: The Environment Impact Assessment (EIA) notification 2006, Ministry of Environment and Forests, Government of India, came into effect from 14th September 2006. It specifies the various development projects requiring prior clearance from Ministry of Environment, Forests & Climate Change (MoEF & CC). As per Schedule of the Notification; the HEP falls under Physical Infrastructure including Environmental Services and have been listed under item no. 1(c) –River Valley Projects.

The projects and activities under the Notification have been classified into two categories- Category A and Category B, based on the spatial extent of potential impacts on human health and on natural and man made resources. Project categorization for River Valley projects is as follows:

Project or Activity		Category with threshold limit	
		A	B
1(c)	River Valley projects	(i) ≥ 50 MW hydroelectric power generation; (ii) ≥10,000 ha. of culturable command area	(i) < 50 MW ≥25 MW hydroelectric power generation; (ii) < 10,000 ha. of culturable command area

Moreover any project or activity specified in Category B will be treated as Category A, if located in whole or in part with in 10 km from the boundary of:

1. Protected areas notified under the Wild Life (Protection) Act, 1972;
2. Critically polluted areas as notified by Central Pollution Control Board from time to time;
3. Eco-sensitive areas as notified under section 3 of Environment Protection Act, 1986 such as Mahabaleshwar, Panchangi, Matheran, Pachmarhi, Dahanu, Doon Valley; and
4. Inter State boundaries and international boundaries.

Scope of EIA: If any project falls under Category 'A', Comprehensive EIA study need to be carried out and environmental clearance need to be obtained from Expert Appraisal Committee (EAC), MoEF & CC before start of any construction activity. Project falling under Category 'B', EIA study need to be carried out and environmental clearance need to be obtained from respective State Environmental Impact Assessment Authority (SEIAA) before start of any construction activity.

Government of Arunachal Pradesh Legislations: The applicable key laws and regulations of State Government applicable to the project have been explained below:

a) The Arunachal Pradesh (Land Settlements and Records) Act, 2000: This is an act to provide a comprehensive law for land revenue administration for the whole state of Arunachal Pradesh incorporating customary rights on the land and certain measures of land reforms. This Act in the history of Arunachal Pradesh is the first ever attempt to formalize the land and revenue administration.

b) Arunachal Pradesh (Land Settlement and Records) Rules 2002: This came into being on 20 July 2005. Under the provisions of the rules land settlement and records are proposed to be maintained. Those in actual possession/occupation of land, other than Government land, may be necessarily given Land Possession Certificate (LPC). The LPC is considered to be the authentic record for possession of land.

c) Hydro Power Policy 2008, Arunachal Pradesh: The State's Rehabilitation and Resettlement Policy, 2008 for the project affected people has been formulated on the lines of the National Rehabilitation and Resettlement Policy, 2007 providing greater benefits to the affected families in view of scarcity of non-forest land and overdependence of tribal populace on forests. The policy not only addresses the need for improving the living standards of displaced families and their welfare on sustained basis but also strives to minimize displacement, provide adequate compensation as also to facilitate harmonious relationship between the requiring body and the project affected families.

d) Arunachal Pradesh Rehabilitation and Resettlement Policy, 2008: In order to provide the adequate compensation to affected families and infrastructure facilities in the area, Arunachal Pradesh Government has formulated its own Rehabilitation and Resettlement policy (2008). The new policy supplements the existing National Policy on Rehabilitation and Resettlement (2007) with a few more definitions and compensatory provisions. The main objectives of the new Rehabilitation and Resettlement policy are to provide appropriate and adequate compensation to affected families against the diversion of land, especially forest land (Unclassified State Forest), to minimize the displacement, to provide adequate infrastructure facilities at rehabilitation site, to improve the living standard of affected zone and to facilitate the harmonious relationship between requiring body and inhabitants of affected zone. The tribal communities have strong reservations on the diversion of land under USF, over which they enjoy customary rights. The policy also emphasizes the Social Impact Assessment in case of the displacement of more than 20 families.

SECTION-II

INDIVIDUAL PROJECT IMPACT ASSESSMENT

SUMMARY

Of the 13 proposed projects, Detailed Project Reports (DPR) for 7 projects viz. Nyamjang chu, Tawang-I, Tawang-II, Mago chu, Nykcharong chu, Rho, and New Melling have been prepared. In those projects for which DPRs are not available, the locations of barrage and power house sites, given by the department of power (Thingbu chu, Paikangrong and Jaswantgarh)/developer (Tsa Chu-I, Tsa Chu-I Lower, and Tsa Chu-II) were considered. The EIA/EMP reports for 6 projects are now available, of which 3 projects viz., Nyamjang chu, Tawang-I and Tawang-II have been cleared by Ministry of Environment, Forests & Climate Change (MoEF & CC), Government of India. In order to have comparative environmental baseline data for 13 projects, data on the following aspects were collected using uniform methods for all the projects.

Box 0.1
List of potentially impacted physical, biological and social environmental parameters considered for scoping.

	Physical Environment
Air	• Changes in ambient levels and ground level concentrations due to emission from point, line and area sources. • Effect on soils, materials, vegetation, and human health. • Impact of emissions from DG sets used for construction power, if any, on the vegetation and air environment
Noise	• Changes in ambient levels and ground level concentrations due to point, line and area sources. • Effect on fauna and human health.
Geology	• Geological features such as fault zone, geological formations, and rock types.
Geomorphology	• Slope characteristics, glacial and fluvial features, and DEM.
Seismicity	• Seismic history and seismo–tectonic nature of the regional rock types in the area • Seismo-tectonic setup of the region, and earthquake data of IMD
Soil	• WHC, Bulk density, Porosity, SMC, pH, Conductivity, NH_{4+}-N, NO_3-N, TKN, Available Phosphorous, Total Phosphorous, SOC, Ex. K, Ex. Mg, Ex. Ca, Soil microbial biomass-C, Soil microbial biomass-N, Fish diversity, Periphyton richness, Soil faunal density
Water	• Changes in water quality: Temperature , Turbidity, pH, Electrical Conductivity, Total dissolved solids, Practical salinity, Total alkalinity, Total hardness, Chloride, Ca_2^+, Mg_2^+, K^+, Na^+, TKN, NH_4^+ N, NO_3-N, Total Phosphorus, Dissolved oxygen, Total Coliforms • Impact on fish fauna • Impact of sewage disposal • NPP
Climate	• Relating to future climate change
Land use/ land cover	• Changes in land use and drainage pattern. • Changes in land quality including effects of wastes disposal. • River banks and their stability. • Impact due to submergence • Impact due to construction during construction phase: Forest area loss, Carbon stock loss
	Biological Environment
Ecosystem Diversity	• Habitat fragmentation and destruction due to dam building activity. • Deforestation and loss of plant species. • Impact on flora due to decreased flow of water. • IAS invasion
Plants	• Impact on rare and endangered species, endemic species, if any.
Animals	• Impact on animal species due to deforestation and land clearing • Impact on animal distribution, migration routes, if any, • Impact on fauna (including aquatic species, fish) due to decreased flow of water. • Impact on breeding and nesting grounds, if any. • Periphyton and Zooplankton density
	Human Environment
Existing development infrastructure	• Impact of increased traffic. • Downstream impact on water, land and human environment due to drying up of the river at least 10 km downstream of the barrage (s).
Socio–economic profile	• Impact on the local community including demographic changes. • Impact on economic status. • Impact on human health. • Positive as well as negative impacts likely to be accrued due to the proposed HEPs and ancillary activities are to be listed.
Culture/ religious profile	• Impact on holy places and tourism.
Resource use	• Dependency of villagers on hill stream/spring water
Traditional Knowledge System	• Impact on the traditional knowledge system

However, the data on seismicity, geological features, and dam-break analysis were reviewed in the available EIA reports, and it was decided that no fresh study would be conducted for these attributes because most of these atttributes would be similar for all the projects in the basin. Moreover, given the geomorphological features of high Himalayas and the pollution-free environment, it was agreed that the need for dam-break and air pollution modeling is insignificant.

The possible impacts common for all the projects and project-specific impacts were identified and mitigation measures were suggested which are summarized below:

Possible impacts common to all the projects and project-specific impacts and suggested mitigation measures

I. POSSIBLE IMPACTS ON ECOSYSTEMS

1. Impact on river ecosystem and associated faunal diversity

- Regulating the normal water flow in the downstream may affect habitat and food regime of faunal species in the concerned river.
- Polluting the river system during the construction phase through disposing solid wastes and other concrete materials into the river.
- Pollution may cause reduction in abundance of several faunal species of river ecosystem.
- Increase in air pollution level during project construction phase
- Impacts on terrestrial and aquatic ecosystems due to increased human interferences during project construction and operation phases.

Mitigation: Adopting strict management and regulatory options for pollution. E–flow needs to be adjusted to minimize the impact on faunal species.

2. Impact of muck generated through the construction of tunnels and the impact of muck disposal on land and water resources

- Loss of habitats along the river systems including the alteration of hydraulics and hydrology of the river.
- Construction of very long retaining wall to store the muck dumps along the river system will restrict the normal movement of mammal species, as well as access to the river water resources.
- Runoff from the muck dumps will contaminate the land and water resources of the river system.
- Creation of muck dumping yards and disposal sites would damage the existing plant species.

Mitigation: In view of the above impacts, appropriate technical and structural interventions are needed. While constructing the disposal and storing structures, the factors described above should be kept in mind. While using the muck dumps, it has to be made mandatory to keep the disposal limit within the capacity of the site so that the muck does not spill into the river bed.

3. Impacts of noise due to drilling, tunnelling, blasting and vehicular movements on the faunal groups

- Changes in the normal behavior due to restrictions in normal movement, feeding and resting activities of major faunal groups of the project area.
- Possible permanent exodus of some affected larger territorial faunal species from the project area.
- The noise and associated ground vibration would impact the lower vertebrates mainly ground dwelling, specifically burrowing and reptilian species.

Mitigation: The use of high–tech equipments would minimize noise levels. Adoption of suitable managerial, ecological and technical interventions would minimize the impact of noise pollution.

4. Unregulated vehicular movement in the forest areas, and its impacts on faunal groups i.e. mortality due to accidents on the road, pollution load on the roadside plants, and soil compaction

- Road killings: Mostly herpetofauna (amphibians and reptiles) and smaller mammals are vulnerable to get killed by the vehicles while crossing the roads.
- Frequent movement of vehicles leading to collision of bird species may reduce species richness and abundance in the habitats along the road side.

- Compaction of soil: Movement of heavy vehicles would lead to soil compaction in the project areas leading to alteration of soil physico–chemical properties.
- Movement of vehicles for construction works would increase the pollution load on roadside plants leading to the loss of plant diversity and productivity.

Mitigation: The appropriate measures to minimize this impact would include, strict management decisions on regulated vehicular movement.

5. Influx of population and pressure on the local natural resources
- Clearing of land and vegetation cover for labour settlements.
- Cutting of wooden poles from the forest area for the construction of temporary sheds.
- Cutting of trees from the forest area to meet their fuel wood needs, and risk of their involvement in illegal activities like poaching/hunting of animals.

Mitigation: Very strict managerial role is suggested to minimize the above impacts on forest and associated floral and faunal species of TRB.

6. Invasion of alien plant species
- Reduced flow in the downstream areas would increase the areas under invasive alien species (IAS).

Mitigation: The existing identified IAS should be weeded out and adequate measures should be taken to avoid import of new IAS through appropriate quarantine measures. An appropriate policy to regulate the introduction of IAS needs to be formulated by the Government of Arunachal Pradesh.

II. POSSIBLE IMPACTS ON FLORA AND FAUNA

7. Acquisition of forest land and changing the land use for the proposed development activities and associated impacts of loss of habitats
- *Loss of habitat:* Due to diversion of forest land for the project activities including the construction of approach road, habitat conditions are altered resulting in deforestation, soil erosion and land degradation.
- *Changes in floral composition:* Following removal of the forests for construction of various structures, the species composition of the altered habitat would change due to modified micro–environmental conditions. The pioneer species are likely to dominate the regenerating forests replacing the primary forest species.
- *Changes in faunal composition:* The smaller groups of faunal species, which are potent indicators of habitat changes (e.g. butterflies, amphibians and reptiles), are likely to be more impacted than the larger faunal groups.

Mitigation: It is suggested that afforestation programmes using dominant native tree species and woody shrubs should be undertaken to compensate the floral and faunal losses in the project areas.

Impact: Construction activities would impact the terrestrial and aquatic plant and animal species having commercial importance and would have important livelihood implications.
Mitigation: The biodiversity management plan has described in detail the development of these resources to mitigate the impact.

Impact: Acquisition of forest land for the proposed project activities is expected to increase the resource dependency (timber, fire wood, fodder and grazing) on other adjoining forest lands, thereby impacting the overall floral and faunal diversity.
Mitigation: The activities planned under compensatory afforestation and catchment area treatment components should be adequate to mitigate this impact.

III. POSSIBLE IMPACTS ON THREATENED FLORAL AND FAUNAL SPECIES

Impact
- Loss of specific habitats of the threatened floral and faunal species of the project area.
- Habitat degradation and fragmentation will have significant impact on threatened floral and faunal populations.

Mitigation: It is important to follow specific management strategies suggested in the Biodiversity management plan which should minimise the impact on the identified floral and faunal species of TRB Landscape.

IV. POSSIBLE IMPACTS DUE TO SEISMICITY

Impact: Impacts due to seismicity

Mitigation: Safety criteria have been suggested to be followed in design of the barrage.

V. POSSIBLE IMPACTS ON HYDROLOGY AND WATER QUALITY

Impact

- Impacts on hydrologic regime.
- Impacts on water quality.
- Increase in incidence of water–related diseases including water–borne and vector–borne diseases.
- Effect on riverine fisheries including migratory fish species.
- Impacts due to sewage generation from labour camps.

Mitigation: For fish migration, fish ladder at all the project sites should be a part of barrage design. Adequate E–flow must be ensured at all project sites, and regulatory steps to minimise the pollution close to zero discharge should be taken.

INDIVIDUAL PROJECT–SPECIFIC IMPACTS AND MITIGATION MEASURES

1. Tsa Chu–I

Impact: *Being situated at very high elevation, the ecosystems are extremely fragile and difficult to recover and susceptible to hazards such as, high intensity landslides, soil erosion and GLoF.*

Mitigation: Impacts being from natural origin, it is difficult to mitigate.

Impact: *Close to hotspring and temple - a place of worship. Also close to Chumbi Gyatser with high religious importance among the Monpa Buddhists.*

Mitigation

Impacts cannot be mitigated. The project should not be undertaken.

2. Tsa Chu–I Lower and Tsa Chu–II

Impact: *High elevation ecosystems with high fragility, difficult to regenerate and reverse the degradation.*

Mitigation: Specific sites for different project components should be selected in such a manner that no damage to forest and biodiversity is caused. No additional road construction should be permitted and the existing roads should be used without widening, and the transportation of machineries should be regulated with load limit. A sanctuary of at least 40 ha area should be established in the degraded areas surrounding the projects to conserve the biodiversity.

3. Thingbu Chu

Impact: *The proposed dam project would destroy substantial areas of land under forest and alter the river and adjoining ecosystems substantially. The identified site for the dam is highly unstable and landslide prone.*

Mitigation: Barrage construction must be avoided.

4. Nykcharong Chu and Rho

Impact: *The terrestrial ecosystems close to the barrage sites of both the projects have old growth broadleaved forests with high plant (Cymbidium spp.) and animal diversity (Arunachal Macaque). The construction activities may adversely impact the biodiversity and forest cover.*

Mitigation: The construction activities should be planned in such a way that no existing forests and habitats of the biodiversity are destroyed. If required, the ancillary construction activities may be relocated to save the old growth forests (e.g., colony site of Rho project).

5. New Melling

Impact: *The right bank of the project site at New Melling is unstable and landslide prone.*

Mitigation: Adequate measures to prevent landslide hazards should be taken.

Impact: *Substantial areas near the proposed barrage site are the habitat for the edible algae (Presiola crispa). The project would impact the survival and productivity of the species.*

Mitigation: Adequate care must be taken to minimise the disturbance to the species' habitats and E-flow should be adjusted accordingly.

6. Mago Chu

Impact: *Substantial areas near the proposed barrage site are the habitat for the edible algae (Prasiola crispa). The project would impact the survival and productivity of the species.*

Mitigation: Adequate care must be taken to minimise the disturbance to the species' habitats and E-flow should be adjusted accordingly.

7. Tawang–I

Impact: *The proposed barrage might affect the existing tourist spot Nuranang falls, particularly during construction phase.*

Mitigation: Adequate care must be taken to save this tourist place from the adverse impacts of barrage construction. The tourism interest should also be ensured during operational phase as well.

Impact: *The villagers near the powerhouse site of Tawang–I project are afraid of losing their water sources due to tunnelling and underground powerhouse construction.*

Mitigation: Drinking water sources for all the influenced villages must be ensured.

8. Tawang–II

Impact: *Due to high abundance of birds in this project sites, the project activities will adversely impact the bird populations.*

Mitigation: The habitats for birds must be protected. The host plant species should be planted under various afforestation programmes, and artificial nest boxes must be installed in sufficient number as described in Section–VII. Although these measures are common to all the projects, Tawang–II project must make extra efforts in this regard in view of high abundance of birds.

9. Nyamjang Chu

Impact: *Possible submergence of pastureland near the barrage site might threaten the livelihood of pastoralist community.*

Mitigation: The design of the barrage should be so adjusted that the pastureland does not come in the submergence zone. If it is unavoidable, an appropriate land must be procured in consultation with the pastoral communities of Zimithang village and provided to them. In addition, adequate compensation must be paid to them to neutralise this impact.

Impact: *A Hippophae stand which is rare in distribution in Arunachal Pradesh would be destroyed at the barrage site.*

Mitigation: At least 10 ha of *Hippophae rhamnoides* must be planted to compensate this loss.

Impact: *The catchment area of Taksang chu in Panchen valley is rich in biodiversity/wildlife. If water from this tributary of Nyamjang chu is diverted, the availability of water for the wildlife could be crucial. Any disturbance to the catchment could affect the wildlife populations adversely.*

Mitigation: Taksang chu should be allowed to flow freely.

Impact: *Disturbing the lateral flow could affect the aquatic biodiversity in the downstream region which is critical for the livelihood of the people.*

Mitigation: A number of villages in the downstream region of proposed Nyamjang chu barrage are dependent on river for fish. Therefore, adequate waterflow must be ensured for this downstream region. The lateral flow from 18 stream/streamlets must be allowed naturally. This would also help in maintaining the biodiversity in the downstream areas.

Impact: *The proposed barrage site is close to the wintering habitat of the threatened black–necked crane. Therefore, it is very important to strictly adopt some mitigation measures for the protection of its wintering ground to ensure the long term survival of this endangered species.*

Mitigation: The project proponent should take several mitigation measures to protect the habitat of the threatened bird. This should include a wide range of measures ranging from maintaining prescribed E–flow, restricting the construction activities during winter months and minimising the noise pollution. A detailed study on black-necked crane habitat requirement vis-a-vis E-flow at Nyamjang Chu project barrage site should be undertaken by a competent national level institution such as WII, SACON or BNHS.

1.1 IMPORTANCE OF ENVIRONMENTAL IMPACT ASSESSMENT

Environmental Impact Assessment (EIA) is a process of evaluating the likely environmental impacts of a proposed project, taking into account inter-related socio-economic, cultural and human-health impacts, both beneficial and adverse. UNEP defines Environmental Impact Assessment (EIA) as a tool used to identify the environmental, social, and economic impacts of a project prior to decision-making. It aims to predict environmental impacts at an early stage in project planning and design, find ways and means to reduce adverse impacts, shape projects to suit the local environment, and present the predictions and options to decision-makers.

EIA studies comprise following steps: (i) Scoping, (ii) Baseline study, (iii) Environmental impact evaluation, and (iv) Mitigation measures including environmental management plan.

Out of these steps, scoping and baseline study are the most important components. Scoping highlights the significant environmental issues of the project with respect to its locality and regional environment. Baseline study is the study of the original status of the environment in the area before the project starts. This study serves the purpose of a base reference against which the changes due to implementation of the project are measured.

1.2 IMPORTANCE OF EIA FRAMEWORK

The present Environmental Impact Assessment has been undertaken under the broad framework of Environmental Impact Assessment Notification, 2006 under EPA, 1986.

The locations and the designs of the individual projects are described in this chapter.

2.1 TSA CHU-I

Tsa chu-I project is located at an elevation of about 3,350 m asl and 7.5 km downstream of the China border. Tsa chu–I has been proposed to produce 43 MW of electricity. The MoA was signed by the implementing agency Energy Development Co. Ltd., with the Government of Arunachal Pradesh on 10th January, 2009. The proposed barrage site is devoid of any vegetation and the land belongs to the villagers of Rho and Jangda which is about 110 km distance by road. The barrage site is located at N27°43'36" to E92°00'17", and powerhouse is located at N27°43'31.42" to E92°01'24.34" (Figures II. 2.1 and 2.2). The salient features of the proposed project is presented in Table II. 2.1.

Figure II. 2.1: Barrage site of Tsa chu–I

Figure II. 2.2: Powerhouse site of Tsa chu–I

Table II. 2.1: Salient features of the proposed Tsa chu-I HEP

LOCATION	
State	Arunachal Pradesh
District	Tawang
VDC	Tsa chu
River	Nykcharong chu
Hydrological Catchment	East Tawang /Tsa chu
Nearest Railway Station	Bhalukpong
Nearest Airport	Guwahati/Tezpur
HYDROLOGY	
Catchment Area up to Diversion (km^2)	1870
Snow-fed Area (from 5000m asl) (km^2)	665
Annual Average Rainfall (mm)	669
Annual Yield at 90% Dependability (mm)	266
Annual Inflow at 90% Dependability (mm^3)	1120.3
Annual Yield at 50% Dependability (mm)	381
Annual Inflow at 50% Dependability (mm^3)	1212.9
Design Discharge (90% Dependable Year) (m^3/s)	48.7
Environmental Flow (20% Avg. Lean Discharge) (m^3/s)	3.7
Standard Projected Flood SPF (m^3/s)	1982
Flood Discharge 100 Years Return Period (m^3/s)	1171
GLOF 100 year Return Flood (m^3/s)	1476
Atmospheric Temperature (Max /Min) (°C)	(29.9±5.4°/-8±2.2°)
Humidity (%)	70%
DIVERSION STRUCTURE	
Type	Ogee Weir
Location	$27^0$43'45.0768"N 92^0 0 ' 10.958"E
Location (km)	17+295
Full Reservoir Level FRL (m asl)	3295
Over Flown Crest Level (m asl)	3295
Non Over Flown Crest Level (m asl)	3302.5
River Bed Level (m asl)	3282
Weir Height (m)	13
Length at the top (m)	100
Width at the Top (m)	3
SPILLWAY	
Type of Gates	No Gate
Discharge Capacity (m^3/s)	3458
Width of Over flow Section (m)	100
Energy Dissipation System	Stilling Basin
Number of Flushing Gates	1
Type of Gate	Sluice Gate
Size of Gate (Width x Height)	5 m x 6 m
RESERVOIR	
Gross Capacity (m^3)	1,03,000
Submergence Area at FRL (km^2)	17,100
Live Capacity (mm^3)	1,01,411
Dead Storage Capacity (mm^3)	1,589
INTAKE	
Type	Rectangular
Invert Level (m asl)	3289
Size (Width x Height)	13 m x 6 m
Screen Width (m)	2 x 6
Screen Bar Width (mm)	10
Screen Bar Separation (mm)	30
HEAD RACE TUNNEL	
Length (m)	2522
Diameter (m)	5
Shape (m)	Horse Shoe
Capacity (m^3/s)	49
Slope (degree)	2.5
Invert Level at Inlet (m asl)	3285
Invert Level at Outlet (m asl)	3278.7
Number of Adits	1
Total Length of Adits	250
SURGE SHAFT	
Surge Shaft Location	$27^0$43'32.794"N $92^0$01' 40.372"E
Type	Simple Open Tank
Diameter (m)	10
Chamber Bed Level (m asl)	3277.7

Required Chamber Top Level (m asl)	3303
PENSTOCKS	
No of 1st Main	4
No of 2nd Main (= Branch)	1
Length of 1st Main (m)	141.7
Diameter of 1st Main (mm)	2000
Length of 2nd Main (m)	TBA
Diameter of 2nd Main (mm)	1000
POWERHOUSE	
Powerhouse Location	$27^0$43'30.749"N $92^0$01' 42.55" E
Powerhouse Location (km)	14+150
Powerhouse Size (Length/Width/Height) (m^3)	44/45/37
Machine Hall Floor Level (m asl)	TBA
Number and Type of Penstock Valves	(4+1) x Butterfly
Type of Turbines	FRANCIS
No of Turbines	4+1
Design Flow (m^3/s)	48.7
Flow per Turbine (m^3/s)	4 No. 12.2 1 No. 5
Design Net Head (m)	101.6
Installed Capacity (MW)	43
Installed Capacity per Unit (MW)	4 No. 10.75 1 No. 0.5 (Black Start)
TAILRACE (TRANSITION CHAMBER TSA CHU-I LOWER HEP)	
Minimum Tail Water Level (m asl)	3189.6
Normal Water Level (m asl)	3190
Maximum Tail Water Level (HQ100) (m asl)	3190.3
ENERGY GENERATION	
Annual Energy Generation (at T&G) (MU)	228.9
Design Energy at 95% Plant Availability (MU)	217.5
Plant Load Factor (PLF) (%)	61
Potential Exploited (PE) (%)	93
SWITCHYARD	
Type	Outdoor Type
No. and Size of Switch Yard (Width x Height) m^2	TBA
TRANSMISSION LINE	
Voltage Level (kV)	132
Length (km)	TBA
Sub-station	TBA
Feeding Point	TBA
PROJECT COST	
Civil Works (Rs. In Lakh)	TBA
E & M Works (Rs. In Lakh)	TBA
Interest and Escalation Costs during construction (Rs. In Lakh)	TBA
Total Project Cost (Rs. In Lakh)	TBA
Costs per MW Installed (Rs. In Lakh)	TBA
CONSTRUCTION PERIOD	
Duration of Construction Period	TBA

TBA- To be assessed

The proposed Tsa chu-I HEP will require a total of 10 ha for construction of different project components. Of the total area, 2.75 ha of forest land will be diverted for construction purposes (Table II. 2.2).

A

B

Figure II. 2.3: Location of Chumbi gyatsar in Tsa chu-I area [A], close view of the same [B]

Table II. 2.2: Land requirement for construction of various components under the proposed Tsa chu-I HEP site

Components	**Area (ha)**
Reservoir	2.75
Diversion weir	1.20
Adit	0.50
Portal	1.00
Power house and TRT	1.00
Penstock	0.25
Muck dumping	1.00
Common colony land for P/H	1.20
Surge Shaft	0.10
Road	1.00
Total area	**10.00**
Forest area to be diverted	**2.75**

2.2 TSA CHU-I LOWER

Tsa chu-I Lower project with a proposed capacity of 77.20 MW has been planned to be constructed in the downstream of Tsa chu-I powerhouse site. This is to be implemented by Energy Development Co. Ltd. The MoA with Government of Arunachal Pradesh was signed on 27th August, 2010 for implementation. The barrage site is located at 27°43'32.41" N and 92°01'50.82" E at an elevation of 3190 m (Figure II. 2.4). Powerhouse is located at 27°42'35.18" N and 92°02'6.24" E (Figure II. 2.5). The salient features of the proposed project are provided in Table II. 2.3.

Figure II. 2.4: Barrage site of Tsa chu–I Lower

Figure II. 2.5: Powerhouse site of Tsa chu–I Lower

Table II. 2.3: Salient features of the proposed Tsa chu-I Lower HEP

LOCATION	
State	Arunachal Pradesh
District	Tawang
VDC	Tsa chu
River	Nykcharong chu
Hydrological Catchment	East Tawang /Tsa chu
Nearest Railway Station	Bhalukpong
Nearest Airport	Guwahati/Tezpur
HYDROLOGY	
Catchment Area up to Diversion (km^2)	1876
Snow fed Area (from 5000 m) (km^2)	655
Annual Average Rainfall (mm)	640
Annual Yield at 90% Dependability (mm)	331

Annual Inflow at 90% Dependability (mm^3)	994.5
Annual Yield at 50% Dependability (mm)	453
Annual Inflow at 50% Dependability (mm^3)	1145.6
Design Discharge (90% Dependable Year) (m^3/s)	48.7 (from Tsa chu-I HEP) 3 (From Nykcharong chu Diversion)
Environmental Flow (20% Avg. Lean Discharge) (m^3/s)	3.7 (at Tsa chu-I HEP)
Standard Projected Flood SPF (m^3/s)	1790
Flood Discharge 100 Years Return Period (m^3/s)	1423
GLOF 100 year Return Flood (m^3/s)	1453
Atmospheric Temperature (Max /Min) (°C)	(29.9±5.4°/-8±2.2°)
Humidity (%)	70%
DIVERSION STRUCTURE	
Type	Barrage
Location	$27^0$43'32.41" N $92^0$01' 50.82" E
Location (km)	14+015
Full Reservoir Level	3190 m
Overflow Crest Level	3190 m
Non-Overflow Crest Level	3197 m
River Bed Level	3180 m
Barrage Height	12 m
Length at the top	110 m
Width at top	3 m
SPILLWAY	
Type of Gate	No Gate
Discharge Capacity	3458
Width of Overflow Section	100 m
Energy Dissipation System	Stilling basin
No. of Flushing Gate	1
Type of Gate	Sluice Gate
Size of Gate	5 x 6 m
RESERVOIR	
Gross Capacity (m^3)	103000
Submergence area at FRL (m^2)	17100
Live Capacity (m^3)	101411
Dead Storage Capacity	1589
INTAKE	
Type	Rectangular
Inver Level	3172.5 m
Size Capacity	13 x 6 m
Screen Width	2 x 6 m
Screen Bar Width	10 mm
Screen Bar Separation	30 mm
HEAD RACE TUNNEL	
Length (m)	1460
Diameter (m)	4
Shape (m)	Horse Shoe
Capacity (m^3/s)	52
Slope (degree)	2.5
Invert Level at Inlet (m asl)	3172.50
Invert Level at Outlet (m asl)	3170.82
SURGE SHAFT	
Surge Shaft Location	$27^0$42 '46.058" N $92^0$01' 58.58" E
Type	Simple Open Tank
Diameter (m)	8
Chamber Bed Level (m asl)	3170.87
Required Chamber Top Level (m asl)	3214.45
PENSTOCKS	
No of 1st Main	1
No of 1st Main (Branch)	4
Length of Main (m)	336
Diameter of Main (mm)	3,500
POWERHOUSE	
Powerhouse Location	$27^0$42' 38.84" N $92^0$02' 6.745" E
Powerhouse Location (km)	11+470
Powerhouse Size (Length/Width/Height) (m3)	86.4 m x 28.82 m x 38 m
Machine Hall Floor Level (m asl)	3020.69
Number and Type of Penstock Valves	(4+1) x Butterfly
Type of Turbines	FRANCIS
No of Turbines	4+1

Design Flow (m^3/s)	51.7
Flow per Turbine (m^3/s)	4 No 12.93; 1 No. 5.2
Design Net Head (m)	171
Installed Capacity	77.2
Installed Capacity per Unit (MW)	4 No. 19.3 1 No. 0.5 (Black Start)
TAILRACE	
Minimum tail water level (m asl)	3014
Normal water level (m asl)	3015
Maximum tail water level (HQ100) (m asl)	3020.6
ENERGY GENERATION	
Annual Energy Generation (at T&G) (MU)	406.1
Design Energy at 95% Plant Availability (MU)	385.8
Plant Load Factor (PLF) (%)	60
Potential Exploited (PE) (%)	95
SWITCHYARD	
Type	Outdoor Type
PROJECT COST	
Civil Works (Rs. In Lakh)	19092
E & M Works (Rs. In Lakh)	6708
Interest and Escalation Costs during construction (Lakh)	15802.5
Total Project Cost (Rs. In Lakh)	41602.5
Costs per MW Installed (Rs. In Lakh)	9.675
CONSTRUCTION PERIOD	
Duration of Construction Period	48

The proposed HEP will require a total forest area of 9.35 ha for construction of different project components (Table II. 2.4).

Table II. 2.4: Land requirement for construction of various components under the proposedTsa chu-I Lower HEP site

Components	Area (ha)
Weir	0.30
Surge shaft	0.10
Powerhouse and TRT	0.70
Muck dumping	2.00
Common colony land for P/H	2.00
Project roads	2.50
HRT potal	0.75
Total area	**9.35**
Forest area to be diverted	**9.35**

2.3 TSA CHU-II

Tsa chu-II project has been planned in the downstream of Tsa chu-I Lower powerhouse site and has a proposed capacity of 67 MW. The MoA was signed by the implementing agency Energy Development Co. Ltd., with the Government of Arunachal Pradesh on 10th January, 2009. The barrage site is located at N 27°42'50.68" to E 92°02'13.36" (Figure II. 2.6) and powerhouse site is located at N 27°40'14.06" to E 92°01'19.28". The salient features of the proposed project are provided in Table II. 2.5.

Figure II. 2.6: Barrage site of Tsa chu–II

Table II. 2.5: Salient features of the proposed Tsa chu-II HEP

LOCATION	
State	Arunachal Pradesh
District	Tawang
VDC	Tsa chu
River	Nykcharong chu
Hydrological Catchment	East Tawang/Tsa chu
Nearest Railway Station	Bhalukpong
Nearest Airport	Guwahati/Tezpur
HYDROLOGY	
Catchment Area up to Diversion (km^2)	2024
Snow fed Area (from 5000m asl) (km^2)	685
Annual Average Rainfall (mm)	640
Annual Yield at 90% Dependability (mm)	455
Annual Inflow at 90% Dependability (mm^3)	1194.05
Annual Yield at 50% Dependability (mm)	592
Annual Inflow at 50% Dependability (mm^3)	1292.67
Design Discharge (90% Dependable Year) (m^3/s)	57.3
Environmental Discharge (20% of Average Lean Discharge) (m^3/s)	3.9 + 30% Monsoon Flow
Standard Projected Flood SPF (m^3/s)	2012
Flood Discharge 100 Years Return Period (m^3/s)	1361
GLOF 100 year Return Flood (m^3/s)	1428
Atmospheric Temperature (Max /Min) (°C)	(24±1.1°/-4±1.2°)
Humidity (%)	70%
DIVERSION STRUCTURE	
Type	Ogee Weir
Location	27^{0}41'10.183"N 92^{0}01' 39.33"E
Location (km)	8+360
Full Reservoir Level FRL (m asl)	2860
Over Flown Crest Level (m asl)	2860
Non Over Flown Crest Level (m asl)	2867.5
River Bed Level (m asl)	2852.3
Height (m)	8.7
Length at the top (m)	80
Width at the Top (m)	3
SPILLWAY	
Type of Gates	No Gate
Discharge Capacity (m^3/s)	1639
Width of Over flown Section (m)	57
Energy Dissipation System	Stilling Basin
Number of Flushing Gates	1
Type of Gate	Sluice Gate
Size of Gate (m Width x m Height)	7 x 7
RESERVOIR	
Gross Capacity (m^3)	14,000
Submergence Area at FRL (m^2)	450

Live Capacity (m^3)	13,554
Dead Storage Capacity (m^3)	446
INTAKE	
Type	Rectangular
Invert Level (m asl)	2853
Size (m Width x m Height)	15 x 7
Screen Width (m)	7
Screen Bar Width (mm)	10
Screen Bar Separation (mm)	30
HEAD RACE TUNNEL	
Length (m)	1910
Diameter (m)	5
Shape (m)	Horse Shoe
Capacity (m^3/s)	58.8
Slope (degree)	2.5
Invert Level at Inlet (m asl)	2853
Invert Level at Outlet (m asl)	2845.06
SURGE SHAFT	
Location	$27^0$40 '17.198"N $92^0$01' 9.988" E
Surge Shaft Location	TBA
Type	Simple Open Tank
Diameter (m)	12
Chamber Bed Level (m asl)	2843.75
Required Chamber Top Level (m asl)	2865.55
PENSTOCKS	
No of 1st Main	4
No of branch	4
Length of 1st Main (m)	261.5
Diameter of 1st Main (mm)	3.5
POWER HOUSE	
Powerhouse Location	$27^0$40' 8.796"N $92^0$01' 9.178" E
Powerhouse Location (km)	5+970
Powerhouse Size (Length/Width/Height) (m^3)	(86.5 x 24 x 38)
Machine Hall Floor Level (m asl)	2702.3
Number and Type of Penstock Valves	(4+1) x Butterfly
Type of Turbines	FRANCIS
No of Turbines	5 (4+1 Black Start) 2 @ Dam Toe
Design Flow (m^3/s)	46; 22.47 @ Dam Toe
Flow per Turbine (m^3/s)	4 No. 11.5; 1 No. 4.6; 2 No. 11.3 @ Dam Toe
Design Net Head (m)	161.7 10.4 @ Dam Toe
Installed Capacity (MW)	65 @ PH 2 @ Dam Toe 67 (Total)
Installed Capacity per Unit (MW)	4 No. 16.25; 1 No. 0.5 (Black Start); 2 No. 1 (Dam Toe)
TAILRACE	
Minimum tail water level (m asl)	2694.5
Normal water level (m asl)	2695
Maximum tail water level (HQ100) (m asl)	2700.7
ENERGY GENERATION	
Annual Energy Generation (MU)	355.23 (PH) 6.6 (Dam Toe) 361.83 (Total)
Design Energy at 95% Plant Availability (MU)	337.47 (PH) 6.27 (Dam Toe) 343.74 (Total)
Plant Load Factor (PLF) (%)	62 (PH) 39 (Dam Toe)
Potential Exploited (%)	98 (PH) 100 (Dam Toe)
SWITCHYARD	
Type and Size	Outdoor Type
No. and Size of Switch Yard (m Width x m Height)	TBA
TRANSMISSION LINE	
Voltage Level (kV)	132
Length (km)	TBA
Sub-station	TBA
Feeding Point	TBA
PROJECT COST	
Civil Works (Rs. In Lakh)	26876
E & M Works (Rs. In Lakh)	10452
Interest and Escalation Costs during construction (Rs. In Lakh)	29136
Total Project Cost (Rs. In Lakh)	66464
Costs per MW Installed (Rs. In Lakh)	992
CONSTRUCTION PERIOD	
Duration of Construction Period	26876

TBA – To be assessed

The proposed HEP will require a total forest area of 17.64 ha for construction of different project components (Table II. 2.6).

Table II. 2.6: Land requirement for construction of various components under the proposed Tsa chu-II HEP site

Components	Area (ha)
Reservoir	0.20
Diversion weir	1.00
HRT potal	1.00
Penstock	0.74
Powerhouse	1.00
Surge shaft	0.10
Muck dumping	4.00
Common colony land for P/H	1.60
Road	8.00
Total area	**17.64**
Forest area to be diverted	**17.64**

2.4 THINGBU CHU

Thingbu chu project with a proposed capacity of 60 MW was to be implemented by Arunachal Pradesh Mega Power Projects Private Limited. The MoA was signed with Government of Arunachal Pradesh on 10th August, 2009. The powerhouse site is located at 92.1° E and 27.65° N (Figure II. 2.7).

Figure II. 2.7: Powerhouse site of Thingbu chu

2.5 NEW MELLING

SEW Energy Ltd. signed an MoA with Government of Arunachal Pradesh for developing New Melling hydro electric project on 2nd March, 2009 for installed capacity (IC) of 60 MW. The installed capacity of 90 MW was subsequently approved by Central Electricity Authority (CEA) on 31st January, 2014. The selected scheme comprises a medium head peaking power project with a 22 m high (from river bed) Barrage as the diversion structure and an underground water conductor system. The powerhouse site is located on the right bank of Mago chu about 4.26 km upstream of the confluence of Mago chu and Nykcharong chu. The New Melling HEP envisages utilization of water of Mago chu, a tributary of Tawang chu, for power generation in a run–of–river type development, harnessing a gross head of 218.678 m. The project with a proposed installation of 90 MW (3x30 MW) would afford an annual energy generation of

433.01 GWh. The barrage site is located at 27°39'0.39" N and 92°04'55.02" E and power house is located at 27°37'52.5" N and 92°03'23.4" E (Figures II. 2.8 and 2.9).

Figure II. 2.8: Barrage site of New Melling

Figure II. 2.9: Powerhouse site of New Melling

The project envisages construction of a barrage located at 2 km upstream of New Melling village. The barrage height is 22 m from river bed level and the length is of 47.8 m. The power house is located at approximately 4 km downstream of barrage site. The proposed project envisages power generation of 90 MW. The salient features of the proposed project are given in Table II. 2.7.

Table II. 2.7: Salient features of the proposed New Melling HEP

LOCATION		
State	:	Arunachal Pradesh
District	:	Tawang
River	:	Mago chu
Nearest Airport	:	Guwahati
Nearest rail head	:	Nagaon
BARRAGE		
Latitude	:	27^0 39' 0.39" N
Longitude	:	92^0 04' 55.02" E
POWER HOUSE		
Latitude	:	27^0 37' 52.5" N
Longitude	:	92^0 03' 23.4" E

HYDROLOGY		
Catchment area at Barrage site	:	805 sq km
Design Flood	:	2469 m^3/sec (SPF)
GLOF	:	1330 m^3/sec
Diversion Flood (1: 25 yr monsoon flood)	:	349 m^3/sec
RESERVOIR		
Full Reservoir Level (FRL)	:	El 2730.0 m
Minimum Drawdown Level (MDDL)	:	El 2720.0 m
Gross storage at FRL	:	0.39 M cum
Live storage	:	0.328 M cum
Area under Submergence at FRL	:	4.55 ha
DIVERSION STRUCTURE		
Type	:	Barrage
Length at top	:	47.8 m
Top of Barrage	:	EL 2732.0 m
SPILLWAY		
No. of Barrage bays and opening size	:	4 Nos. (9.2 m (w) x 6.0 m (h) each)
Crest Level	:	El 2710 m
Design Flood (SPF)	:	2469 cumecs
Size of stop log gate (1 set)	:	9.2 m (w) x 11.054 m (h)
Size of radial gate (6 nos.)	:	9.2 m (w) x 6.8 m (h)
DESILTING BASIN		
Number	:	Two
Size/Shape	:	14.0 m (W) x 19 m (H), Dufor type
Length	:	60 m
Trash rack at inlet (4 sets for each basin)	:	2.50 m (w) x 18.50 m (h)
Inlet discharge	:	26.80 cumecs each
Size of Stoplog gate opening (4 nos.)	:	6.0 m (w) x 18.5 m (h)–2 nos. at each Inlet
SILT FLUSHING DUCT		
Number	:	Two combined into one
Size of Duct upto silt flushing gate	:	Varies from 0.5 m (w) x 0.8 m (h) to 0.9 m (w) x 1.2 m (h), L = 65.0 m
Size of Duct after Junction upto outlet	:	1.30 m (w) x 1.6 m (h), L = 20 m
Silt flushing discharge	:	3.5 cumecs through each duct
INTAKE		
Number	:	Two
Invert level	:	El 2713.5 m
Design Discharge	:	23.3 cumecs each
Intake gate (2 nos.)	:	3.0 m (w) x 4.0 m (h)
CUT AND COVER DUCT		
Number	:	Two
Size	:	3.0 m
Shape	:	D-shape
Length	:	32.34 m/56.15 m
Invert level	:	EI 2713.5 m
Design discharge	:	23.3 cumecs each
FEEDER TUNNELS		
Number	:	Two
Size	:	3.0 m
Shape	:	D–shape
Length	:	38 m
Design discharge	:	25.47 cumecs each
Velocity	:	2.89 m/s
HEAD RACE TUNNEL		
Number	:	One
Size	:	4.5 m
Shape	:	Modified Horse–Shoe shape
Length	:	3128 m
Design discharge	:	46.6 cumecs
Velocity	:	2.9 m/s
SURGE SHAFT		
Number	:	One
Type	:	Restricted Orifice Type
Size	:	6.5 m diameter
Orifice diam.	:	2.0 m
Height	:	50 m
Top EL	:	EL 2756 m
Tunnel invert	:	EL 2699.5 m
Size of gate opening (1 no.)	:	3.4 m (w) x 3.4 m (h)
Maximum surge level	:	EL 2754.3 m
Minimum surge level	:	EL 2709.1 m
PRESSURE SHAFT/TUNNEL		

Main Pressure shaft/tunnel		
Numbers	:	One
Size and Length	:	3.4 m diameter, 240.7 m long
Pressure tunnel after 1st bifurcation		
Numbers	:	Two
Size and Length	:	2.8 m diameter, 20.5 m long
	:	2.0 m diameter, 35.5 m long
Pressure tunnel after 2nd bifurcation		
Numbers	:	Two
Size and Length	:	2.0 m diameter, 30.5 m long
	:	2.0 m diameter, 24.5 m long
POWER HOUSE		
Type	:	Underground
Installed capacity	:	90 MW
Number of units	:	3 x 30 MW
Power house cavern size (LxWxH)	:	87 m x 19 m x 38.5 m
Type of turbine	:	Vertical axis Francis turbine
C.L. of turbine	:	El 2502.7 m
Rated Head	:	211.65 m
Transformer cavern size (LxWxH)	:	40 m x 15.0m x 19.0 m
No. and Type of Transformers	:	3 Nos., 3 Phase, 40 MVA
DRAFT TUBE GATE CHAMBER		
Type	:	Underground
Size (L x W x H)	:	37.0 m x 6.0 m x 8.0 m
Size of gate opening (3 nos.)	:	4.6 m (w) x 2.5 m (h)
TAIL RACE TUNNEL		
Type	:	Modified Horse Shoe Shape
Size	:	5.0 m diam.
Length	:	257.0 m
Design Discharge	:	46.6 cumecs
River Bed Level	:	El 2506 m
Minimum TWL	:	El 2506.24 m
Normal TWL	:	El 2508 m
Maximum TWL	:	El 2512 m
Number and Size of TRT gate opening (1 no.)	:	5.0 m (w) x 5.0 m (h)
POWER GENERATION		
Installed capacity	:	90 MW (3 x 30 MW)
Annual energy generation		
i) 90% dependable year with 100% machine availability	:	438.32 GWh
ii) 90% dependable year with 95% machine availability	:	433.01 GWh
Plant Load Factor		
i) 90% dependable year with 100% machine availability	:	55.6 %
ii) 90% dependable year with 95% machine availability	:	54.92 %
COST ESTIMATES and FINANCIAL ASPECT (Rs. Crores)		
Civil and HM Works	:	480.14
Electro Mechanical Works	:	158.22
Sub Total	***:***	***638.36***
Interest during construction	:	149.85
Escalation	:	143.54
Financing cost	:	6.27
Total (Generation)	***:***	***938.02***
TARIFF (With 13% free power)		
Tariff for first year	:	Rs. 5.6/kWh
Levellised Tariff	:	Rs. 4.73/kWh
PRE–CONSTRUCTION PERIOD	:	**18 months**
CONSTRUCTION PERIOD	:	**3.5 years**

The proposed HEP will require a total of 25.69 ha for construction of different project components. Of the total area approximately 15 ha of forest land will be diverted for construction purposes (Table II. 2.8).

Table II. 2.8: Land requirement for construction of various components under the proposed New Melling HEP site

Sl. No.	Description	Left Bank	Right Bank	Total area (ha)	River	Road
1	Muck Dump Yard-1		1.54	1.54		
2	Muck Dump Yard-2		3.14	3.14		
3	Facility Area-1		1.86	1.86		0.13 Road 0.06 Nalla
4	Facility Area-2		0.30	0.30		
5	Facility Area-3		0.21	0.21		

6	Labour Colony-1		0.58	0.58		
7	Labour Colony-2		0.20	0.20		
8	Labour Colony-3		0.15	0.15		
9	Labour Colony-4		0.32	0.32		
10	Stack Yard-1		2.19	2.19		0.12 Road 0.07 Nalla
11	Stack Yard-2		0.88	0.88		0.22 Road
12	Quarry-1		0.30	0.30		
13	Quarry-2		0.50	0.50		
14	Proposed Roads	0.06	2.88	2.94		
15	Switch Yard		0.30	0.30		
16	Magazine		0.21	0.21		
17	Reservoir	1.16	0.82	1.98	2.25	0.30 Road-R/B
18	Barrage, Desilting and Feeder Tunnels	0.97	1.05	2.02	0.48	0.09 Road-R/B
19	Portal of Adit to Mat		0.18	0.18		0.01 Nalla
20	Portal of Adit to Surge		0.05	0.05		
21	Portal of Adit to PH		0.08	0.08		
22	Replacement Road		0.49	0.49		
23	Surge Shaft Area		0.50	0.50		
Total Surface Area (ha)		***2.19***	***18.73***	***20.92***	***2.73***	
Notional Area for Underground Works						
24	Head Race Tunnel		2.30	2.30		
25	Power House, Surge, Shaft, Adits, Mat, TRT		2.47	2.47		
Total Underground Area			***4.77***	***4.77***		
Grand Total Area				**25.69**	**2.73**	
Total Surface area for Acquisition				**20.92 ha**		
Notional area for U/G works				**4.77 ha**		

2.6 MAGO CHU

SEW Mago chu Power Corporation Pvt. Ltd., a SPV of SEW Green Energy Ltd., proposes to develop 96 MW hydropower project on Mago chu in Tawang district of Arunachal Pradesh. The MoA was signed with the Government of Arunachal Pradesh on 21st February, 2008. The intake and HRT are proposed on the right bank of Mago chu. The powerhouse will be constructed underground on the right bank of Mago chu about 200 m upstream of confluence of Mago chu and Nyukcharong chu. The Mago chu HE Project envisages harnessing a gross head of 199.68 m (at FRL). The project with a proposed installation capacity of 96 MW. The barrage site is located at 27°37′42.3″N and 92°02′32.7″E. Powerhouse is located on the right bank of Mago chu about 200 m upstream of the confluence at 27°37′ 27.6″N and 92°00′53.8″E (Figures II. 2.10 and 2.11).

Figure II. 2.10: Barrage site of Mago chu

Figure II. 2.11: Powerhouse site of Mago chu

The project envisages construction of a barrage located 3.2 km upstream of confluence of Mago chu and Nyukcharong chu. The barrage site is located in a relatively wide valley with steep rock abutments. The proposed project envisages power generation of 96 MW. The salient features of the proposed project are given in Table II. 2.9.

Table II. 2.9: Salient features of the proposed Mago chu HEP

LOCATION		
State	:	Arunachal Pradesh
District	:	Tawang
River	:	Mago chu
Nearest Airport	:	Guwahati
Nearest rail head	:	Nagaon
BARRAGE		
Latitude	:	27^{o} 37′ 42.3″ N
Longitude	:	92^{o} 02′32.7″ E
POWERHOUSE		
Latitude	:	27^{o} 37′ 27.6″ N
Longitude	:	92^{o} 00′ 53.8″ E
HYDROLOGY		
Catchment area at Barrage site	:	830 sq km
Design Flood	:	2452 m3/sec (SPF)
GLOF	:	1252 m3/sec
Diversion Flood (1: 25 yr monsoon flood)	:	357 m3/sec
RESERVOIR		
Full Reservoir Level (FRL)	:	El 2472.0 m
Minimum Drawdown Level (MDDL)	:	El 2460.0 m
Gross storage at FRL	:	0.332 M cum
Live storage	:	0.257 M cum
Area under Submergence at FRL	:	2.42 ha
DIVERSION STRUCTURE		
Type	:	Barrage
Length at top	:	47.8 m
Top of Barrage	:	EL 2474.0 m
SPILLWAY		
No. of barrage bays and opening size	:	4 Nos. (9.2 m (w) x 6.8 m (h) each)
Crest Level	:	El 2453 m
Design Flood (SPF)+GLoF	:	2452 cumec
Size of stop log gate (1 set)	:	9.2 m (w) x 11.054 m (h)
Size of radial gate (4 nos.)	:	9.2 m (w) x 6.8 m (h)
DESILTING BASIN		
Number	:	Two
Size/Shape	:	14.0 m(W) x 19 m(H), Dufor type
Length	:	70 m
Size of stop log gate opening (4 nos.)	:	6.0m (w) x 17.0m (h) – 2 nos. at each Inlet

Coarse Trashrack (2 Nos.)	:	6.0m (w) x 14.0m (h)
SILT FLUSHING DUCT		
Number	:	Two combined into one
Size of duct upto sluice valve		Varies from 0.5m (w) x 1.0m (h) to 0.9m (w) x 1.4m (h), L = 55.0 m
Size of duct after junction upto outlet		1.50m (w) x 1.75m (h), L = 20 m
Silt flushing discharge		4.23 cumec through each duct
INTAKE		
Number	:	Two
Invert level	:	El 2453.25 m
Intake gate (2 nos.)		3.5m (w) x 4.5m (h)
FEEDER TUNNELS		
Number	:	Two
Size	:	3.5 m
Shape	:	D–shape
Length	:	38 m
Design discharge	:	28.2 cumec each
Velocity	:	2.58 m/s
HEAD RACE TUNNEL		
Number	:	One
Size	:	4.8 m
Shape	:	Modified Horse–Shoe shape
Length	:	2773 m
Design discharge	:	56.4 cumec
Velocity	:	3.08 m/s
SURGE SHAFT		
Number	:	One
Type	:	Restricted Orifice Type
Size	:	7.0 m diameter
Orifice diam.	:	2.1m
Height	:	85 m
Top EL	:	EL 2510.0 m
Tunnel invert	:	EL 2420.30 m
Size of gate opening (1 no.)	:	3.7m (w) x 3.7m (h)
Maximum surge level	:	EL 2505.14 m
Minimum surge level	:	EL 2428.02 m
PRESSURE SHAFT/TUNNEL		
Main Pressure shaft/tunnel		
Numbers	:	One
Size and length	:	3.7 m diameter, 250.4 m long
Pressure tunnel after 1st bifurcation		
Numbers	:	Two
Size and length	:	3.0 m diameter, 22.5 m long 2.2 m diameter, 43.5 m long
Pressure tunnel after 2nd bifurcation		
Numbers	:	Two
Size and length	:	2.2 m diameter, 30 m long 2.2 m diameter, 20 m long
POWERHOUSE		
Type	:	Underground
Installed capacity	:	96 MW
Number of units	:	3 x 32 MW
Powerhouse cavern size (LxWxH)	:	87 m x 19 m x 38.5 m
Type of turbine	:	Vertical axis Francis turbine
C.L. of turbine	:	El 2265.5 m
Rated head	:	186.75 m
Transformer cavern size (LxWxH)	:	60 m x 14.0m x 19.0 m
No. and type of transformers	:	3 Nos., 3 Phase, 40 MVA
DRAFT TUBE GATE CHAMBER		
Type	:	Underground
Size (L x W x H)	:	37.0 m x 6.0m x 8.0 m
Size of gate opening (3 nos.)	:	4.6m (w) x 2.5m (h)
TAIL RACE TUNNEL		
Type	:	Modified Horse Shoe Shape
Size	:	5.5 m diam.
Length	:	62.0 m
Design discharge	:	56.4 cumec
River bed level	:	El 2265.0 m
Minimum TWL	:	El 2270.01 m
Normal TWL	:	El 2272.32 m
Maximum TWL	:	El 2278.50 m

Number and size of TRT gate opening (1 no.)	:	5.5m (w) x 5.5m (h)
POWER GENERATION		
Installed capacity	:	96 MW (3x32 MW)
Annual energy generation		
i) 90% dependable year with 100% machine availability	:	405.83 GWh
ii) 90% dependable year with 95% machine availability	:	404.42 GWh
Plant Load Factor		
i) 90% dependable year with 100% machine availability	:	48.26%
ii) 90% dependable year with 95% machine availability	:	48%
COST ESTIMATES AND FINANCIAL ASPECT (Rs. Crores)		
Civil works	:	453.65
Electro mechanical works	:	158.38
Sub Total	***:***	***612.03***
Interest during construction	:	129.47
Escalation	:	131.47
Financing cost	:	6.15
Total (Generation)	***:***	***879.12***
TARIFF		
With 12% free power		
Tariff for first year	:	Rs. 5.73/kWh
Levellised Tariff	:	Rs. 4.98/kWh
PRE–CONSTRUCTION PERIOD	**:**	**18 months**
CONSTRUCTION PERIOD	**:**	**3.5 years**

The proposed HEP will require a total area of 31.23 ha for construction of different project components. Of the total area about 5 ha of forest land will be diverted for construction purposes (Table II. 2.10).

Table II. 2.10: Land requirement for construction of various components under the proposed Mago chu HEP site

Sl. No.	Surface Area	Area in hectares					
	Description	**Left bank**	**Right bank**	**Total**	**River**	**Nalla**	**Total**
1	Labour colony-1		0.51	0.51			0.51
2	Reservoir colony (FRL-2472m)	0.51	0.72	1.23	1.25		2.48
3	Head works-Intake, desilting basin portal of adit to HRT	1.00	0.65	1.65	0.53		2.18
4	Replacement road near barrage		0.71	0.71			0.71
5	Approach road to barrage left bank	0.21	0.06	0.27	0.07		0.34
6	Facility area-1	1.58		1.58		0.04	1.62
7	Portal of adit to HRT		0.08	0.08			0.08
8	Muck dump yard-1		2.00	2.00			2.00
9	Stack yard-1		1.52	1.52			1.52
10	Approach road to stack yard-1		0.14	0.14			0.14
11	Approach road to surge shaft		0.32	0.32			0.32
12	Approach road to adits to surge shaft and HRT		0.31	0.31			0.31
13	Labour colony-2		0.90	0.90			0.90
14	Facility area-2		0.20	0.20			0.20
15	Quarry area-1		0.25	0.25			0.25
16	Facility area-3		0.64	0.64			0.64
17	Pothead yard		0.16	0.16			0.16
18	Approach road to MATm TRT and Adit Portal of valve chamber		0.50	0.50			0.50
19	Surge Shaft		2.20	2.20			2.20
20	Approach road to Magazine		0.15	0.15			0.15
21	Magazine		0.25	0.25			0.25
22	Facility area-4	0.11		0.11			0.11
23	Quarry area-2	0.50		0.50			0.50
24	Stack yard-3	0.86		0.86			0.86
25	Muck dump yard-2	0.90		0.90			0.90
26	Approach road to Muck dump yard-3	0.83		0.83		0.01	0.84
27	Labour colony-3	0.10		0.10			0.10
28	Labour colony-4	0.50		0.50			0.50
29	Stack yard-4	0.47		0.47			0.47
30	Muck dump yard-3	3.24		3.24			3.24
31	Permanent colony	1.50		1.50			1.50
	Total area	**12.31**	**12.27**	**24.58**	**1.85**	**0.05**	**26.48**
	Notional Area for underground Works						
32	Head Works-Feeder Tunnels, Adits to HRT, GOC			1.34			

33	Head Race Tunnel			1.90			
34	Adit to Head Race Tunnel			0.05			
35	Power House, surge shaft, pressure shaft, penstock, main access tunnel, TRT, Adits to power House, Pressure shaft and surge shaft			1.46			
	Sub-total area			**4.75**			
	Total area			**29.33**	**1.85**	**0.05**	**31.23**
	Total Surface area for acquisition			**24.58 ha**			
	Notional area for U/G works			**4.75 ha**			

2.7 NYKCHARONG CHU

SEW Energy Ltd. entered into MoA with Government of Arunachal Pradesh on 21st February, 2008 for developing Nykcharong chu HEP. The location at 1.5 km upstream of the China bridge is the barrage site i.e., diversion structure. The intake and HRT are proposed on the left bank of Nykcharong chu. The powerhouse is located near the confluence of Nykcharong chu and Mago chu. The Nykcharong chu HEP envisages utilization of water of Nykcharong chu, a tributary of Tawang chu, for power generation in a run–of–river type development harnessing an average gross head of 199.12 m. The project is with a proposed installation of 96 MW capacity. The barrage site is located at latitude 27°38'21.3'' N and longitude 92°00'20.9'' E. The powerhouse is located on the left bank of Nykcharong chu about 200 m upstream of the confluence at Latitude: 27°37'27.6'' N and Longitude: 92°00'50.5'' E (Figures II. 2.12 and 2.13).

Figure II. 2.12: Barrage site of Nykcharong chu

Figure II. 2.13: Powerhouse site of Nykcharong chu

The project envisages construction of a 22 m high barrage located 2.3 km upstream of confluence of Mago chu and Nykcharong chu (Table II. 2.11).

Table II. 2.11: Salient features of the proposed Nykcharong chu HEP

ACCESSIBILITY	
State	Arunachal Pradesh
District	Tawang
River	Nykcharong chu
Nearest Airport	Guwahati
Nearest rail head	Nagaon
GEOGRAPHICAL LOCATION	
Barrage	Latitude: 27^o 38'21.3" N Longitude: 92^o 00'20.9" E
Powerhouse	Latitude: 27^{0}37'27.6''N Longitude: 92^{0}00'50.5''E
HYDROLOGY	
Catchment area at Barrage site	2040 sq km
Design Flood SPF	2857 m^3/sec (SPF)
GLoF	1426 m^3/sec
Diversion Flood (1: 25 yr monsoon flood)	650 m^3/sec
RESERVOIR	
Full Reservoir Level (FRL)	El 2470.0 m
Minimum Drawdown Level (MDDL)	El 2460.0 m
Gross storage at FRL	0.106 M cum
Live storage	0.09 M cum
Area under Submergence at FRL	1.71 ha
DIVERSION STRUCTURE	
Type	Barrage
Length	74.2 m
Top of Barrage	EL 2472.0 m
SPILLWAY	
No. of Barrage bays	6 Nos.
Opening size	(9.2 m (w) x 6.0 m (h) each)
Crest Level	El 2450.0 m
Design Flood (SPF+GLoF)	4837 cumec
Size of stoplog gate (1 set)	9.2m (w) x 9.51m (h)
Size of radial gate (6 nos.)	9.2 m (w) x 6.31 m (h)
INTAKE	
Number	Two
Invert level	El 2452.25 m
Size of emergency gate opening (2 nos.)	3.5m (w) x 3.5m (h)
Size of service gate opening (2 nos.)	3.5m (w) x 3.5m (h)
Trash rack (6 sets)	2.7m (w) x 6.85m (h)
FEEDER TUNNELS	
Number	Two
Size	3.5 m
Shape	D– shape
Length	317m/264.4m
Design discharge	27.53 cumec each
Velocity	2.52 m/s
DESILTING CHAMBERS	
Number	Two
Size/Shape	10.0 m(W) x 12.5 m(H), Dufor type
Length	200 m
Size of gate opening (2 nos.)	3.5m (w) x 3.5m (h)
SILT FLUSHING TUNNEL	
Number	Two combined into one
Size of Duct up to Gate Chamber	Duct –1.25m (w) x 1.25m (h) in 2.5 m dia. D–shaped Tunnel
Size of SFT after Gate Chamber up to junction	Channel –2.0m (w) x 1.0m (h) in 2.5 m dia. D–shaped Tunnel
Size of SFT after Junction up to portal	Channel –2.0m (w) x 1.5m (h) in 2.5 m dia. D–shaped Tunnel
Service Gate (2 nos.)	1.25 m x 1.25m (w x h)
Emergency Gate (2 nos.)	1.25 m x 1.25m (w x h)
Length up to Gate Chamber	86 m/54m
Length from Gate Chamber up to Junction	32 m/26m
Length after junction up to portal	28m
Silt flushing discharge	4.13 cumec each
LINK TUNNEL TO HRT	
Number	Two

Size	3.5 m
Shape	D– shape
Length	91 m
Design discharge	27.53 cumec each
HEAD RACE TUNNEL	
Number	One
Size	4.8 m
Shape	Modified Horse–Shoe shape
Length	1271 m
Design discharge	55.06 cumec
Velocity	2.54 m/s
SURGE SHAFT	
Number	One
Type	Restricted Orifice Type
Size	7.0 m diameter
Orifice dia	2.3m
Height	62.0 m
Top EL	EL 2496.5 m
Tunnel invert	EL 2430.0 m
Size of gate opening (1 no.)	3.7m (w) x 3.7m (h)
Maximum surge level	EL 2494.7 m
Minimum surge level	EL 2436.7 m
PRESSURE SHAFT/TUNNEL	
Main Pressure shaft/tunnel	Numbers–One Size–3.7 m diam. Length–211.7 m
Pressure tunnel after 1st bifurcation	Numbers–Two Size–3.0 m diam. and 2.2 m diam. Length–20.5m and 49 m
Pressure tunnel after 2nd bifurcation	Numbers–Two Size–2.2 m diam. and 2.2 m diam. Length–34.5m and 40.3 m
POWERHOUSE	
Type	Underground
Installed capacity	96 MW
Number of units	3 x 32 MW
Powerhouse cavern size (LxWxH)	87 m x 19m x 37.5 m
Type of turbine	Vertical axis Francis turbine
C.L. of turbine	El 2265.5 m
Rated Head	191.12 m
Transformer cavern size (LxWxH)	60 m x 14.0m x 19.0 m
No. and Type of Transformers	3 Nos., 3 Phase, 40 MVA
POTHEAD YARD	
Type	Surface
Size	20 m x 57 m
DRAFT TUBE GATE CHAMBER	
Type	Underground
Size (L x W x H)	37.0 m x 6.0mx 8.0 m
Size of gate opening (3 nos.)	4.6m (w) x 2.5m (h)
Draft tube length (up to gate)	49.5 m
TAIL RACE TUNNEL	
Type	Modified Horse Shoe Shape
Size	5.5m diam.
Length	119.0 m
Design Discharge	55.06 cumec
River Bed Level	El 2265.0 m
Minimum TWL	El 2268.59 m
Normal TWL	El 2270.87 m
Maximum TWL	El 2277.60 m
Number and Size of TRT gate opening (1 no.)	5.5m (w) x 5.5m (h)
Type of Gate	Vertical lift gate
POWER GENERATION	
Installed capacity	96 MW (3x32 MW)
Annual energy generation with plant load factor	

Parameters	**Annual energy generation**	**Plant load factor**
90% dependable yr. with 100% machine availability	473.24 GWh	56.27%
90% dependable yr. with 95% machine availability	466.12 GWh	55.43%

COST ESTIMATES AND FINANCIAL ASPECT (Rs. in crores)	
Civil Works	549.53
Electro Mechanical Works	152.18
Sub Total	***701.71***
Interest during construction	155.55

Escalation	131.67
Financing cost	6.97
Total (Generation)	***995.90***
TARIFF (With 12% free power)	
Tariff for first year	Rs. 5.32/kWh
Levellised Tariff	Rs. 4.66/kWh
PRE–CONSTRUCTION PERIOD	**16 months**
CONSTRUCTION PERIOD	**42 months**

The proposed HEP will require a total of 34.53 ha for construction of different project components. Of the total area, approximately about 5 ha of forest land will be diverted for construction purposes (Table II. 2.12).

Table II. 2.12: Land requirement for construction of various components under the proposed Nykcharong chu HEP site

Sl. No.	Surface Area	Area in hectares				
	Description	**Left bank**	**Right bank**	**River**	**Nalla**	**Total**
1	Labour colony	2.09				2.09
2	Reservoir area (FRL-2470m)	0.10	0.61	0.86	0.06	1.63
3	Headwork area, intake etc.	3.44	2.51	0.62	0.22	6.79
4	Facility area-1		0.34			0.34
5	Quarry area-Right bank		0.05			0.05
6	Muck Dump Yard-1		1.17			1.17
7	Stack yard-1		1.48			1.48
8	Magazine		0.21			0.21
9	Residential area-1		1.01		0.03+0.04 =0.07	1.08
10	Facility area-2		1.21		0.02+0.03 =0.05	1.26
11	Quarry area-Left bank	0.25				0.25
12	Muck Dump Yard-2	0.55				0.55
13	Stack yard-2	0.37				0.37
14	Residential area-2	1.41				1.41
15	Muck Dump Yard-3		3.32			3.32
16	Approach road to barrage bottom-Left bank	0.80		0.01		0.81
17	Approach road to barrage top and labour colony-Right bank		0.37			0.37
18	Approach road to adits to surge and HRT	0.73				0.73
19	Approach road to surge shaft	0.69				0.69
20	Surge shafts, portals of adits to surge shaft and HRT	1.93				1.93
21	Facility area-3	0.72				0.72
22	Residential area-3	0.50				0.50
23	Port head yard area	0.45				0.45
24	Approach road to magazine	0.33				0.33
	Sub Total	**14.36**	**12.28**	**1.49**	**0.40**	**28.53**
	Notional Area for Underground Works					
	Head works, area-feeder tunnels, desanding chambers, SFT Adits to DSC, GOCs etc	3.12				3.12
25	Power house, Adits and TRT	1.39				1.39
26	Head Race Tunnel	1.04				1.04
	Total Area	**5.55**				**5.55**
	Grand Total	**19.91**	**12.28**	**1.49**	**0.40**	**34.53**
	Total Surface area for acquisition		**26.64**			
	Notional area for U/G works		**5.55**			

2.8 RHO

The proposed Rho Hydro Electric Power (HEP) being developed by SEW Rho Power Corporation Pvt. ltd. is proposed on Tawang chu near Rho village in Tawang district of Arunachal Pradesh. The MoA between SEW and Govt. of Arunachal Pradesh was signed on 2nd March, 2009 for IC 60 MW. Rho HEP derives its name from Rho village located in the vicinity of the project. The project is envisaged as a run–of–the–river scheme in the upper reaches of Tawang chu. The barrage site is located at latitude 27°36’ 51.34” N and longitude 92°00’ 8.78” E. The IC of the project in Rho was approved by CEA for 93 MW (Table II. 2.13). Rho

HEP is located on Tawang chu about 1.4 km downstream of the confluence of Mago chu and Nykcharong chu (Figures II. 2.14 and 2.15).

Figure II. 2.14: Barrage site of Rho

Figure II. 2.15: Powerhouse site of Rho

Table II. 2.13: Salient features of the proposed Rho HEP

ACCESSIBILITY	
State	Arunachal Pradesh
District	Tawang
River	Tawang chu
Nearest Airport	Guwahati, Assam
Nearest rail head (Meter Gauge)	Bhalukpong (Arunachal Pradesh)
Nearest rail head (Broad Gauge)	Guwahati, Assam
GEOGRAPHICAL LOCATION	
Latitude	27^0 36’ 51.34” N
Longitude	92^0 00’ 8.78” E
HYDROLOGY	
Catchment area	2983 sq km
Standard Project Flood (SPF)	3904 m^3/sec
GLoF	1406 m^3/sec
Diversion Flood (1: 25 yr monsoon flood)	415 m^3/sec
RESERVOIR	
Full Reservoir Level (FRL)	El 2240.0 m
Minimum Drawdown Level (MDDL)	El 2232.0 m
Live storage	0.251 M cum

Area under Submergence at FRL	4.74 ha		
BARRAGE-SPILLWAY			
Top of Barrage	El. 2242.0 m		
Barrage Height above River Bed	26.0 m		
Barrage Length	155.0 m		
Length of Spillway	54.5 m		
Number of Bays	5 Nos.		
DESANDING CHAMBERS			
Type	Underground, Du four type		
Number	2 Nos.		
Shape & Size (W x H x L)	14.0 m x 18.8 m x 176.0 m		
HEAD RACE TUNNEL			
Shape & Size	Modified horse shoe, 6.0 m diam.		
Lining type & lining thickness	Concrete lined, 350 mm thick		
Length of head race tunnel	1552.06 m		
Design discharge	105.83 m^3/sec		
Flow through velocity	3.61 m/sec		
SURGE SHAFT			
Type	Underground, Restricted orifice type		
Diameter of surge shaft	16.0 m		
Diameter of orifice	2.7 m		
Surge Shaft top elevation	El. 2266.39 m		
PRESSURE SHAFT			
Type	Steel lined	Steel lined	Steel lined
Number	1	1	3
Diameter (m)	5.1	4.1	2.9
Maximum discharge (m^3/sec)	105.83	70.55	35.28
Length	135.41 m	2408 m	245.02 m
Steel liner grade	ASTM-537 Grade-II		
POWER HOUSE			
Type	Underground		
Size (W x H x L)	21.0 m x 95.0 m x 38.15m		
Number of units	3 units		
Rated capacity of each unit	31.0 MW		
Total installed capacity	93 MW		
Type of turbine	Vertical axis Francis		
Rated discharge for each unit	35.276 m^3/sec		
Net Head/Design head	96.33 m		
Erection bay elevation	El. 2134.90 m		
TRANSFORMER HALL/GIS CAVERN			
Type	Underground		
Size (W x H x L)	12.0 m x 22.0 m x 64.9 m		
Number of transformers	3 unit transforrmers & 1 spare transformer		
TAIL RACE TUNNEL			
Number	3 Nos.		
Length	30.0 m		
Shape & Size (W x H)	6.00 m x 3.50 m		
Shape & Size	Modified Horse Shoe, 6.0m diameter		
Length	248.74 m		
Outlet invert elevation	El. 2128.65 m		
POTHEAD YARD			
Type	Outdoor		
Size (W x L)	28.0 m x 56.0 m		
POWER GENERATION			
Generation in 90% dependable year	493.97 GWh		
Free Power to home State	13%		
COST ESTIMATION			
Civil Cost	611.69 Cr		
E & M Works	171.72 Cr		
Total Basic cost	783.41 Cr		
Escalation	203.03 Cr		
IDC and Financing charges	174.31 Cr		
Total Cost	**1160.75 Cr**		
Levelised Tariff	Rs.5.19/KWh		

The proposed HEP will require a total 35.86 ha of land for construction of different project components. Of the total area, approximately about 4 ha of forest land will be diverted for construction purposes (Table II. 2.14).

Table II. 2.14: Land requirement for construction of various components under the proposed Rho HEP site

Sl. No.	Surface Area	Area in hectares			
	Description	**Left bank**	**Right bank**	**Total**	**River**
1	Reservoir area (FRL-2240m)	0.67	0.89	1.56	2.78
2	Head works, intake, portals of adits to desanding chambers and HRT	2.04	2.44	4.48	0.99
3	Magazine area		0.20	0.20	
4	Facility area-1	1.59		1.59	
5	Quarry area-1	0.60		0.60	
6	Muck dump yard-1		1.35	1.35	
7	Silt flushing tunnel portal		0.71	0.71	
8	Project colony	0.65		0.65	
9	Labour colony-1	0.51		0.51	
10	Muck dump yard-2		0.31	0.31	
11	Surge shaft adit portal		0.31	0.31	
12	Stack yard-1		0.67	0.67	
13	Stack yard-2		0.13	0.13	
14	Valve chamber adit portal		0.14	0.14	
15	Muck dump yard-3		0.94	0.94	
16	Facility area-2		0.49	0.49	
17	Labour colony-2	0.39		0.39	
18	Pothead yard		0.35	0.35	
19	Portals of TRT &adit to power house		0.87	0.87	
19A	Portal for MAT		0.24	0.24	
19B	Facility area-3		0.51	0.51	
20	Quarry area-2		0.40	0.40	
21	Muck dump yard-4	3.00		3.00	
22	Approach road to MAT from Chhagar-Marmang road and Abutment	0.79	0.02	0.81	0.05
23	Permanent colony	0.75		0.75	
24	Approach road to barrage right bank-Left abutment	0.02	0.50	0.52	0.03
24A	Approach road to adits to power house		0.86	0.86	
24B	Approach road to TRT and quarry		0.26	0.26	
24C	Approach road to surge shaft		0.60	0.60	
24D	Approach road to valve chamber and dumping yard		0.30	0.30	
24E	Approach road pothead yard		0.56	0.56	
25	Replacement road	0.63		0.63	
26	Stack yard-4		0.75	0.75	
	Total area	**11.64**	**14.80**	**26.44**	**3.85**
	Notional area for underground works				
27	Head works-feeder tunnels desanding chambers, link tunnels adits to HRT, GOC, SFT.		3.93	3.93	
28	Power house, Surge shaft, pressure shaft, penstock, main access tunnel, TRT, adits to power house, pressure shaft and surge shaft		3.7	3.7	
29	Head Race Tunnel		1.79	1.79	
				9.42	
	Total area	**11.64**	**9.42**	**35.86**	**3.85**
	Total surface area for acquisition			**26.44**	
	Notional area for U/G works			**9.42**	

2.9 TAWANG-I

The barrage of the proposed Tawang–I HEP will be on Tawang river near the existing Nuranang chu powerhouse in Tawang district of Arunachal Pradesh. The total catchment area measures approximately, 2,937 sq km (27°30'00"–28°24'00" N latitude and 91°47'00"–92°28'00" E longitude). (Figures II. 2.16 and 2.17). The implementing agency NHPC signed the MoA with Government of Arunachal Pradesh on 24th June, 2007.

Figure II. 2.16: Barrage site of Tawang–I

Figure II. 2.17: Near powerhouse site of Tawang–I

Tawang–I HEP is a run of the river scheme, and envisages construction of 26 m high RCC raft with piers barrage across Tawang chu near Nuranang chu powerhouse, diverting the water through 13.987 km long head race tunnel for generation of 600 MW of power by utilizing maximum gross head of 543 m and constructing an underground powerhouse on right bank near village Yusum. Table II. 2.15 provides the salient features of Tawang–I project.

Table II. 2.15: Salient features of the proposed Tawang–I HEP

LOCATION	
State	Arunachal Pradesh
District	Tawang
River	Tawang Chu
Barrage Site	Near Nuranang Chu Powerhouse
Nearest BG rail head	Guwahati and Nagoan
Nearest airport	Guwahati and Tezpur
Latitude	27°35'20"
Longitude	91°59'03"
HYDROLOGY	
Catchment area	2937 sq km
Location of catchment	
Latitude	27°30'00" to 28°24'00"
Longitude	91°47'00" to 92°28'00"
Average annual rainfall (at Murga Bridge)	1710 mm
Maximum temperature	31.1°C
Minimum temperature	–2.9°C
Max 10 daily discharge	299.6 cumec
Min 10 daily discharge	28.2 cumec
RESERVOIR	
Full reservoir level (FRL)	EL 2090 m
Min. Draw Down Level (MDDL)	EL 2087 m

Gross Storage	
at FRL	167.2 Ham
at MDDL	131.43 Ham
Area Under	
Submerged at FRL	12.46 ha
STAGE DIVERSION	
Diversion Discharge	843 cumecs
No. of Stages	2 No.
Length of Dyke	390 m
Stage–I	390 m
Stage–II	250 m
Top of Dyke	El 2075 m
BARRAGE	
Type	RCC RAFTS WITH PIERS
Top Elevation	EL 2092 m
Crest Elevation	EL 2068 m
Downstream Floor Level	EL 2059 m
Length at top	130.5 m
Thickness of d/s Raft	6 m
Upstream Floor Level	EL 2066 m
Upstream Floor Thickness	2 m
Thickness of Pier	3.5 m
Height	26 m
SPILLWAY	
Design flood	4264 cumecs (excluding GLOF)
Type	Orifice type
Crest Elevation	EL 2068 m
Number (including one emergency bay)	9
Size (W x H)	9.5 x 14.75 m
Energy dissipation	Stilling Basin with end sill
INTAKE	
Invert level	EL 2074 m
Number	2
Size of gate opening (W x H)	5.5 x 5.5 m
Trash Rack	Inclined type
Size of Trash Rack (W x H)	10 x 10 m
DESILTING CHAMBERS	
Type	Dufour
Number	2
Size (W x H)	16 x 19 m
Length	350 m
Design discharge per chamber	70.00 cumecs
GOC Floor	EL 2095 m
Outlet Gate Size (W x H)	5.5 x 5.5 m
SILT FLUSIG TUNNELS	
Branch Tunnels	
Number	2
Shape and Size (W x H)	2.0 m x 1.5 m, D–Shape
No. of Gate in Each Tunnel	2 Nos. (One service and one emergency)
Size of Gate	2 m x 1.5 m
SFT Size and Shape	2 m x 35 m, D–Shape
HEAD RACE TUNNEL	
Number	1
Size	7.0 m
Shape	Horseshoe
Length	13.987 km
Design discharge	129.75 cumecs
Overload discharge	142.00 cumec
ADITS	
Length of Adit No. 1	275 m
Length of Adit No. 2	405 m
Length of Adit No. 3	395 m
Length of Adit No. 4	310 m
Length of Adit No. 5	465 m
Length of Adit No. 6	510 m
Inspection gate in Adit No. 1,3 and 6	2.0 x 2.0 m each
SURGE SHAFT	
Number	1
Type	Orifice type
Size	18 m
Shape	Circular
Top Elevation	EL 2150 m

Lower Expansion Gallery	6.5 dia D–shaped, 120 m long
Maximum Up Surge	EL 2147.6 m
Minimum Down Surge	EL 2030.0 m
Height	125 m
Gate Size	6.0 x 6.0 m
Gate Operation Chamber (LxWxH)	35 x 25 x 13 m
PRESSURE SHAFT/VALUE CHAMBER/PENSTOCK	
Number	1/3
Type	Underground, Steel lined
Shape	Circular
Diameter	6.0/3.4 m
Length (6.0 m Dia)	32 m
Length (3.8 m Dia)	1235.0 to 1280.0 m
VALVE CHAMBER	
Size (LxWxH)	80x11x20 m
MIV CAVERN	
Type	Sphreical
Diameter	2.3 m
POWERHOUSE	
Type	Underground
Installed Capacity	600 MW
Number of Units	3
Powerhouse cavern size (L x W x H)	148 x 22 x 54 m
Turbine Axis Elevation	EL 1541.0 m
Type of turbine	Francis Vertical Axis
Max. Gross Head	543.0 m
Max. Head loss	21.75 m
Rated Net Head	518.0 m
TRANSFORMER CUM GIS CAVERN CUM DRAFT TUBE GOC	
Cavern Size (L x W x H)	143 x 17.5 x 28.5 m
Draft tube gate	
Number	3
Size	4.0 x 4.2 m
TAILRACE TUNNEL	
Number	1
Size	7.0 m
Shape	Horseshoe
Length	1680 m
Design Discharge	129.75 cumec
Tailrace Surge Gallery	7.0 m dia D–shaped, 530 m long
HFL at TRT outlet	EL 1554.20 m
Max. TWL	EL 1549.0 m
Min. TWL (one unit running)	EL 1548.0 m
TRT outlet gate	
Number	2
size	3.25 x 7.0 (H) m
POTHEAD YARD	
Size	40 x 190 m
POWER GENERATED	
Installed Capacity	600 MW
Annual energy generation with 95% machine availability in 90% dependable year	2963.0 MU

The proposed HEP will require a total of 277.06 ha for construction of different project components, of which forest land requirement is 187.20 ha. However, of the total area approximately 38.96 ha of land with forest cover (as calculated from imageries) will be diverted for construction purposes (Table II. 2.16).

Table II. 2.16: Land requirement for construction of various components under the proposed Tawang-I HEP site

Sl. No.	Name of components	Area of land (ha)					
		Unclassified Forest	Community land forest cover	Private land forest cover	Sub-total	Community and private land without forest cover	Total
1	Reservoir area	5.00	2.50	-	***7.50***	5.00	***12.50***
2	Barrage complex including Barrage site colony	7.00	6.00	6.00	***19.00***	12.00	***31.00***
3	Quarry sites	3.00	2.87	-	***5.87***	3.93	***9.80***
4	Muck dumping areas	3.00	12.00	4.80	***19.80***	16.60	***36.40***
5	Adits and CFAs	14.50	21.10	19.00	***54.60***	4.20	***58.80***

6	Main Office and Colony site		12.00	-	***12.00***	5.00	***17.00***
7	PH complex including colony at PH	9.00	16.50	10.50	***36.00***	36.50	***72.50***
8	New Roads	8.00	1.00	8.48	***17.48***	6.63	***24.11***
	Total	**49.50**	**73.97**	**48.78**	**172.25**	**89.86**	**262.11**
9	Underground excavation	-	-	-	***14.95***	-	***14.95***
	Grand total	**-**	**-**	**-**	**187.20**	**-**	**277.06**

2.10 TAWANG-II

The Tawang–II HEP is proposed on the Tawang chu river near Kudung village in the Tawang district of Arunachal Pradesh. The total catchment area measures approximately, 3,419 sq km (27°32′48” N latitude and 91°41′57” E longitude) (Figures II. 2.18 and 2.19). The implementing agency NHPC signed the MoA with Govt. of AP on 24th June, 2007.

Figure II. 2.18: Barrage site of Tawang–II

Figure II. 2.19: Powerhouse site of Tawang–II

Tawang–II HEP envisages the construction of a 28 m high barrage to provide a gross storage of 72.17 ham at FRL. It involves a 16.00 km long head race tunnel, an under-ground powerhouse and 170 m long tail race tunnel. The area of the proposed reservoir is 6.19 ha. Total installed capacity of the project revised to 800 MW. The salient features of the project are given in Table II. 2.17.

Table II. 2.17: Salient features of the proposed Tawang–II HEP

LOCATION	
State	Arunachal Pradesh
District	Tawang
River	Tawang Chhu
Barrage Site	Kudung Village
Nearest BG rail head	Guwahati and Nagoan
Nearest airport	Guwahati and Tezpur
HYDROLOGY	
Catchment area	3419 sq km
Location of catchment	
Latitude	27°32'48" N
Longitude	91°41'57" E
Average annual rainfall (at Yusum site)	2665 mm
Maximum temperature	31.1°C
Minimum temperature	–2.9°C
Max 10 daily discharge	344.3 cumec
Min 10 daily discharge	38.2 cumec
RESERVOIR	
Full reservoir level (FRL)	EL 1536 m
Min. Draw Down Level (MDDL)	EL 1534 m
Gross Storage	
at FRL	72.17 Ham
at MDDL	60.32 Ham
Area Under submergence at FRL	6.19 ha
DIVERSION TUNNEL	
Number	One
Size	8.5
Shape	Horseshoe
Length	610 m
Diversion Capacity (Monsoon, 1:25 Year)	990 cumecs
Height of u/s Coffer Dam	15
Height of d/s Coffer Dam	7
DT Inlet gate	
Number	2
Size (W x H)	3.5 x 8.5 m
BARRAGE	
Type	RCC RAFTS WITH PIERS
Top Elevation	EL 1538 m
Crest Elevation	EL 1512 m
Downstream Floor Level	EL 1501 m
Length at top	124 m
Thickness of d/s Raft	5 m
Upstream Floor Level	EL 1510 m
Upstream Floor Thickness	2 m
Thickness of Pier	3.5 m
Height	28 m
SPILLWAY	
Design flood	5000 cumecs
Type	Orifice type
Crest Elevation	EL 1512 m
Number and Size of Spillway opening (including one emergency bay)	8
Size (W x H)	10 x 14.75 m
Energy dissipation	Stilling Basin eith end sill
INTAKE	
Invert level	EL 1520 m
Number	2
Size of gate opening (W x H)	6.5 x 6.5 m each
Trash Rack	Inclined type
Size of Trash Rack (W x H)	11 x 12.5 m each
DESILTING CHAMBERS	
Type	Dufour
Number	2
Size (W x H)	18 x 25 m
Length	420 m
Design discharge per chamber	101.75 cum
GOC Floor	EL 1541 m
Outlet Gate Size (W x H)	6.0 x 6.0 m
SILT FLUSIG TUNNELS	
Branch Tunnels	
Number	2
Shape and Size (W x H)	2.0 m x 1.5 m, D–Shape

No. of Gate in Each Tunnel	2 Nos. (One service and one emergency)
Size of Gate	2.0 m x 1.5 m
SFT Size and Shape	2.0 m x 3.5 m, D–Shape
HEAD RACE TUNNEL	
Number	1
Size	8.1 m
Shape	Horseshoe
Length	15.989km
Design discharge	190.67 cumecs
ADITS	
Length of Adit No. 1	312 m
Length of Adit No. 2	173 m
Length of Adit No. 3	364 m
Length of Adit No. 4	317 m
Length of Adit No. 5	391 m
Length of Adit No. 6	155 m
Inspection gate in Adit No. 1,3 and 6	2.0 x 2.0 m each
SURGE SHAFT	
Number	1
Type	Orifice type open to Surface
Size	20 m
Shape	Circular
Top Elevation	EL 1600 m
Upper Expansion Gallery	6.5 m dia D–shap, 150 m long
Upper Expansion Gallery	7.5 m dia D–shape, 150 m long
Maximum Up Surge	EL 1598.3 m
Minimum Down Surge	EL 1471.0 m
Height	131 m
Gate Size	5.0 X 5.0 m
PRESSURE SHAFT/VALUE CHAMBER/PENSTOCK From EL 1461.5 to EL 1296.0 m	
Number	2
Type	Underground, Steel lined
Shape	Circular
Diameter	5.0 m
Length up to Bifurcation	514.0 m
From EL 1296.0 to EL 1038.0 m	
Number	4
Type	Underground, Steel lined
Shape	Circular
Diameter	3.5 m
Length	621.0 to 698.0 m
VALVE CHAMBER (At EL 1296.0 m)	
Size (LxWxH)	104 x 12 x 20 m
MIV CAVERN	
Type	Sphreical
Diameter	2.5 m
POWERHOUSE	
Type	Underground
Installed Capacity	800 MW
Number of Units	4
Powerhouse cavern size (L x W x H)	190 x 22 x 56.0 m
Turbine Axis Elevation	EL 1038.0 m
Type of turbine	Francis Vertical Axis
Max. Gross Head	494 m
Rated Net Head	470 m
TRANSFORMER CUM GIS CAVERN CUM DRAFT TUBE GOC	
Cavern Size (L x W x H)	173 x 17.5 x 29.5 m
Draft tube gate	3.7 x 4.1
Number	4
Size	4.0 x 4.5 m
TAILRACE TUNNEL	
Number	1
Size	8.1 m
Shape	Horseshoe
Length	170 m
Design Discharge	190.67 cumecs
Tailrace Surge Gallery	7.0 m dia D–shaped, 300 m long
HFL at TRT outlet	EL 1058.25 m
Max. TWL	EL 1044.7 m
Min. TWL (one unit running)	EL 1043.0 m
TRT outlet gate	3.5 x 8.1 m (H)

Number	2
size	4.0 X 9.0 m (H)
POTHEAD YARD	
Size	40 x 210 m
POWER GENERATED	
Installed Capacity	800 MW
Annual energy generation in 90% dependable year	3622 MU

The proposed HEP will require a total of 237.88 ha for construction of different project components, of which forest land requirement is 116.62 ha. However, of the total area, about 28.93 ha land with forest cover (as assessed from the imageries) will be diverted for construction purposes (Table II. 2.18).

Table II. 2.18: Land requirement for construction of various components under the proposed Tawang-II HEP site

Sl. No.	Name of components	Area of land (ha)					
		Unclassified State Forest	Community land forest cover	Private land forest cover	Sub-total	Community and Private land without forest cover	Total
1	Reservoir area	-	4.19	-	***4.19***	2.00	***6.19***
2	Barrage complex	9.15	15.50	4.00	***28.65***	6.93	***35.58***
3	Quarry sites	-	6.95	-	***6.95***	6.00	***12.95***
4	Muck dumping areas	-	8.00	-	***8.00***	29.80	***37.80***
5	Adits and CFAs	1.00	8.50	1.50	***11.00***	9.95	***20.95***
6	Main Office and Colony site	10.00	7.85		***17.85***	22.15	***40.00***
7	PH Complex	-	5.50	-	***5.50***	27.50	***33.00***
8	New Roads	-	12.00	2.81	***14.81***	16.93	***31.74***
	Total	**20.15**	**68.49**	**8.31**	**96.95**	**121.26**	**218.21**
9	Underground excavation	-	-	-	***19.67***	-	***19.67***
	Grand total				**116.62**		**237.88**

2.11 NYAMJANG CHU

Nyamjang chu hydroelectric project is a run–of–the–river scheme with reservoir having diurnal storage on the river Nyamjang chu, barrage site being located near Zimithang town. The project is located at 91°43’37” E and 27°43’06” N in Tawang district of Arunachal Pradesh (Figures II. 2.20 and 2.21). The project will be implemented by NJC Hydro Power Ltd. (Bhilwara Energy Limited) with a proposed capacity of 780 MW. The MoA was signed with the Govt. of AP on 28th May, 2009. The salient features of the project are given in Table II. 2.19.

Figure II. 2.20: Barrage site of Nyamjang chu

Figure II. 2.21: Powerhouse site of Nyamjang chu

Table II. 2.19: Salient features of the proposed Nyamjang chu HEP

LOCATION		
State	:	Arunachal Pradesh
District	:	Tawang
River	:	Nyamjang chu
Vicinity	:	Tawang
Longitude at diversion site	:	91°43’37”
Latitude at diversion site	:	27°43’06”
HYDROLOGY		
Catchment area at diversion	:	2650 Sq. Km.
Catchment area Taksang chu	:	154 sq. km
Design Flood (Standard Project Flood)	:	3400 Cumecs
Design Discharge	:	87 Cumecs
BARRAGE		
Length of barrage	:	151.0 m
Embankment Length	:	89.0m
H.F.L	:	2114.90 m
F.R.L	:	2114.9 m
Average river bed level	:	2106.20 m
Max. height of barrage above Avg. River Bed Level	:	10.20 m
Bridge deck level	:	2116.40 m
Design Flood (SPF)	:	3400 Cumecs
SPILLWAY		
Type	:	Gated
No. of Bays	:	10 Nos.
Length of Bay	:	10.00 m
Sill level	:	2107.4 m
Size of gates	:	7.5m (H) x 10m (W)
Type of gate	:	Vertical lift gates
Energy Dissipation arrangement	:	Stilling Basin type
UNDERSLUICE		
Type	:	Gated
No. of Bays	:	3 Nos.
Length. of Bay	:	5.00 m.
Sill Level	:	2105.9 m
Size of gates	:	6.3m (H) x 5m (W)
Type of gates	:	Vertical lift gates
Energy Dissipation System	:	Stilling Basin.
HEAD REGULATOR		
Length	:	46 m
HFL	:	2114.90 m
FRL	:	2114.9 m
MDDL	:	2112.2 m
Sill level	:	2108.4 m
Bridge deck level	:	2116.4 m
No. of bays	:	8 Nos.
Length of bay	:	4.00 m
Size of gates	:	6.5 m (H) x 4.0 m (W)

Type of gates	:	Vertical lift gates
No. of silt excluder tunnels	:	8 Nos.
Size of silt excluder tunnels		0.75m (H) x 1.5m (W)
FEEDER CHANNEL		
Length	:	600 m
Total width	:	20.00 m
No. of channels	:	4 Nos.
Width	:	4.25 m
Height	:	6.00 m
Velocity of flow	:	2 m/s
DESILTING ARRANGEMENT		
Type	:	Surface basins Hopper type
No. and Size of desilting basin (LxBxH)	:	8 Nos., 150m x 10.50m x 19m
Particle size to be excluded	:	0.20 mm and above
Flow through velocity	:	0.2 m/s
Flushing velocity	:	4.5 m/sec.
Dia. of silt flushing Conduit	:	2.0 m
HEAD RACE TUNNEL		
Type and Size	:	Concrete Lined Circular Shaped, 6.20 m Finished Dia. 2.88 m/s
Velocity	:	23450.0m
Length	:	87 cumec.
Design discharge	:	1 in 145
Slope	:	
Taksang chu Scheme		
Diversion Weir Type	:	Trench Weir
Design Discharge	:	5 Cumec
Weir Elevation	:	El. 2160.0m
Desilting Chamber No. and Size	:	1 No.,55.0mx7.55mx4.5m
Silt Flushing Tunnel Dia, Length	:	2m, 165m
Vertical Drop Shaft Dia, Height	:	2m, 86m
Connecting Tunnel Dia., Length	:	2.5m, 177m
ADITS		
Type	:	D–Shaped
Adit No.–1	:	7.0mx5.0m, Length =450.0m
Adit No.–2	:	7.0mx5.0m, Length =322.0m
Adit No.–3	:	7.0mx5.0m, Length =460.0m
Adit No.–4	:	7.0mx5.0m, Length =655.0m
Adit No.–5	:	7.0mx5.0m, Length =439.0m
Adit No.–6	:	7.0mx5.0m, Length =476.0m
Adit No.–7	:	7.0mx7.0m, Length =436.0m
Adit No.–8	:	7.0mx5.0m, Length =1236.0m
Adit No.–9	:	7.0mx5.0m, Length =1088.0m
SURGE SHAFT		
Type	:	Open to sky, Restricted orifice type.
Size:	:	4.0m, 10.0m and 12.0m Dia.,
Height from Orifice Slab	:	234.0 m high.
Maximum Upsurge Level	:	2165.20 m
Minimum Downsurge Level	:	2052.42 m
Bottom Level	:	1931.40 m
Top Level	:	2171.40 m
PRESSURE SHAFT		
Type	:	Steel Lined
Size Main	:	2 No., 3.3m dia, each 2115.0 m long.
Unit Pressure Shaft	:	6 No, 2.0m dia, each 415.0 m long
Velocity	:	5.07 m/s
Type and thickness of steel liner	:	ASTM–A–537, CL–II and ASTM–A–517, Gr.–F, 20 mm to 65 mm thk.
Butterfly Valve Chamber	:	15.0m (H) x 10.0m (W) x 67m (L)
POWERHOUSE		
Type	:	Underground
Installed Capacity	:	780 MW (6 x 130 MW)
Size	:	166.2m (L) x 20m (W) x45.67m (H)
Maximum gross head	:	1057.40 m
Max Net head	:	1018.40 m
Min Net Head	:	1014.30 m
Rated Net head	:	1017.03 m
C/L of Turbine	:	1057.50 m
Erection bay floor level	:	1070.20 m
Crane beam level	:	1082.70 m
Maximum TWL	:	1054.0 m
Capacity of E.O.T crane	:	2 x 180 MT

TRANSFORMER CAVERN		
Size	:	216.95m (L) x16.3m (w) x27m (H)
TAILRACE TUNNEL		
Type	:	Circular shaped
Size	:	7.0m Dia., 1970.0m Long
Slope	:	1 in 722
Tail Race upstream Stoplog gate		
Type	:	Bulkhead
Size	:	4.0m (W) x 7.0m (H)
Tail Race Outfall/ End gate	:	
Type	:	Vertical Lift Gate
Size	:	7.0m (W) x 7.0m (H)
TURBINES		
No. and Type	:	6 No., Vertical Shaft Pelton.
Rated Power (at generator terminal)	:	780.0 MW
Rated net Head	:	1017.03 m
Rated discharge	:	87 cumec.
MAIN INLET VALVE (MIV)		
Type	:	Spherical valve
Diameter	:	2.0 m
GENERATOR		
Type	:	Synchronous Type
Number	:	6 Nos.
Rated Capacity	:	144.45 MVA
Nominal Active Power	:	130.0 MW
MAIN GENERATOR STEP UP TRANSFORMER		
No. of Single Phase Transformer	:	20 Nos.
Rated Output	:	54 MVA
Rated Voltage	:	13.8 KV/ 420 KV
Frequency	:	50Hz
Type of cooling	:	OFWF
GAS INSULATED SWITCHGEAR (GIS)		
Rated Voltage	:	420kV
No. of Bays	:	6 Transformer Bay, 1 Tie Bus Bay, One Line Transfer Bay, Two Outgoing Bay, and 2 Bus Reactor Bays
400kV Cable Tunnel		
Length	:	772 m
Shape and Size	:	D–shape, 5.10m (W) x 7.6 m (H)
POT HEAD YARD (400kV)		
Area	:	122.7m x 46.1m
Type	:	Surface at EL 1137.4m
ESTIMATED COST		
(Without Mega Power Status)	:	Rs. 6268.26 Crores
Completion Cost at May, 2010 price level (With Mega Power Status)	:	Rs. 6115.60 Crores
Completion Cost at May, 2010 price level		
POWER BENEFITS		
Gross Energy generation in 90% dependable year	:	3430.29MU
Design Energy generation in 90% dependable year (at 95% Plant Availability)	:	3366 MU
TARIFF		
(Without Mega Power Status)		
Levelised Tariff	:	Rs. 3.93/Kwh
First Year	:	Rs. 4.69/Kwh
(With Mega Power Status)		
Levelised Tariff	:	Rs. 3.83/Kwh
First Year	:	Rs. 4.57/Kwh
CONSTRUCTION PERIOD		
Construction Period (including 12 months for pre–construction activities)	:	74 months

The proposed HEP will require a total of 276.6 ha for construction of different project components. Of the total area about 50.92 ha of forest land will be diverted for construction purposes (Table II. 2.20).

Table II. 2.20: Land requirement for construction of various components under the proposed Nyamjang chu HEP site

Components	Area (ha)
Submergence	39.35
Upstream headworks	22.05
HRT	39.16
Adit	3.92
Tail race tunnel	1.34
GIB	0.33
MAT	0.52
Powerhouse	15.56
Surge shaft (equqlly in three villages)	0.59
Pressure shaft (equqlly in three villages)	2.69
Switchyard	0.68
Muck disposal	68.98
Colonies	7.00
Labour camps (equqlly in three villages)	3.00
Workshop, centerlised store and fabrication yard	4.00
Explosive magazines (2 nos) (%0-50)	1.50
Crusher, batching plant and aggregate storage (2 nos)(50-50)	12.00
Contractor colonies (temp)equally in three villages	4.00
Adit portals (1 to 9), TRT, cables tunnel portals (for cover)	0.42
Storage area at different works sites	2.00
Access road	41.53
Quarry	6.00
Total area (ha)	**276.60**
Forest area to be diverted (approx.)	**50.92**

2.12 PAIKANGRONG

Paikangrong is micro hydel project with a proposed capacity of 2.4 MW on the Paikangrong chu stream in TRB (Figures II. 2.22 and 2.23). The project was to be implemented by SMJ Consultants Pvt. Ltd., New Delhi. The MoA with Government of Arunachal Pradesh for implementing this project was signed on 28th August, 2009.

Figure II. 2.22: Barrage site of Paikangrong chu

Figure II. 2.23: Powerhouse site of Paikangrong chu

2.13 JASWANTGARH STAGE-I

Jaswantgarh Stage-I is a micro hydel project with a proposed capacity of 4.50 MW on Nuranang chu river in TRB. The project was to be implemented by SMJ Consultants Pvt. Ltd., New Delhi. The MoA with Government of Arunachal Pradesh for implementing this project was signed on 28th August, 2009.

3.1 INTRODUCTION

Since all the thirteen proposed projects in TRB were evaluated on all the aspects by a large group of 54 Scientists, a commonly agreed set of methods were finalized at the beginning. These methods particularly for collection of baseline data, and impact prediction for individual projects were followed for all the projects and are described in this chapter.

3.2 METHODS

The baseline data pertaining to vegetation, soil, and water were collected from the proposed barrage site, powerhouse site and other specific areas as per requirement for each of the proposed project during three seasons of the year 2013-14, i.e. Monsoon (May to September), Post-monsoon (October and November), and Winter (December to April) season beginning June, 2013, except Nyamjang chu where the study was carried out only for one season, i.e., rainy season of 2014. The measurement of air quality was carried out only in two seasons i.e., during pre-monsoon and post-monsoon seasons. However, air quality monitoring could not be undertaken at Nyamjang chu barrage site. The details of baseline data/information are enumerated in the following pages:

3.2.1 Geomorphology

The regional geology around the project area highlighting geomorphology, stratigraphy and structural features was based on the existing information on these aspects contained in Detailed Project Reports prepared by the respective developers (NHPC, 2010, SEW 2014, NJC Hydro Power Ltd. 2011) of the project as well as from the DEM (ASTER Data). In addition, the important parameters of seismicity were assessed using published literature on seismic history and seismo–tectonic nature of the regional rock types in the area. Seismo-tectonic setup of the region has also been described with the help of published literature (Kumar, 1997 besides referring to the 'Seismo-tectonic Catalogue of India and its Environments' published by Geological Survey of India (GSI publication 2000), and the earthquake data given by the India Meteorological Department (IMD).

3.2.2 Geology

Various physical features of Tawang district have been delineated at 1:50,000 scale using geographic projection system UTM; spheroid and datum used were WGS 84 with UTM zone 46N (Sarma *et al*., 2012). The sources for preparing soil, geology, river, road and landslide zonation were the maps published by State Remote Sensing Application Centre, Department of Science and Technology, Government of Arunachal Pradesh. The image features on the satellite data (Landsat 8, 2014) were interpreted to prepare land use/cover map using the various image elements like tone, texture, pattern, shape, size, shadow, location and association (Garg *et al*., 1988 and Lillesand and Kiefer, 1987). The relevant Survey of India Topographical maps were utilised for validation of the features prepared. The digital elevation and slope maps were delineated from the downloaded aster DEM. Intensive field survey was carried out for validation of the results. For the purpose of the objectives of the study an area was delineated taking 10 km radius from each site of the proposed hydroelectricity project. The GIS and image processing software used are ArcGIS 2010 and ERDAS IMAGINE 2011.

Weighted overlay analysis: For the preparation of accessibility the line features like fault line, river and road and point feature of landslide location were converted into polygon with desired distance from source. All the thematic features were converted into raster (Grid) with pixel size of 50 m x 50 m.

Integration of thematic layers was performed using weighted overlay analysis. Based on the contribution and understanding the behaviour of different thematic layers a weightage which is a qualitative assessment, has been given range on a scale of 1 to 9 depending on their overall vulnerability potential level. The influence percentage of each thematic layer has been assigned according to the contribution. All the thematic raster features with related item weight and integrated with one another through GIS (ArcInfo spatial analyst environment). As per this analysis, the total weightage of the final integrated grids were derived as sum of the weightage assigned to the different layers based on suitability in the present study, vulnerability mapping of various proposed hydroelectricity sites has been generated by integration of all above grid layers. The delineation has made by grouping the grids of final integrated layer into five vulnerable zones viz., high, moderately high, moderate, moderately low and low.

The seismicity analysis and the dam break analysis for the proposed 13 projects were not undertaken owing to the following reasons:

1. The detailed seismic studies undertaken by the respective project developers viz., NHPC, SEW and NJC Hydro Power Ltd., were credible and the predictions can in general be applicable to the entire basin.
2. The impact due to possible dam break is insignificant in the context of TRB as most of the villages are situated much above the river bed, and all the proposed projects are run-of-the-river scheme.

3.2.3 Land Use and Land Cover

Essentially two sources were identified to obtain landuse land cover. The first one is from the work already carried out by ISRO NMR NESAC. This was done on 1:50,000 scale using IRS/LISS 3 data of 2005-2006. The second source of information is through supervised classification of LANDSAT 8 data of December, 2013. Different band combinations were used to get desired features. The output of the supervised classification for each of the 13 project sites were taken in a buffer area of 10km radius from the project site. The classification scheme adopted was simplified and contains 7 classes. These are forest, Scrubland, Water-body, Grassland, Built-up area and Snow and Ice.

Land use and land cover mapping was carried out by standard methods by ground truthing, ground control point data collection and interpretation. Digital image processing of the satellite data and the analysis of interpreted maps were carried out using ERDAS Imagine 9.2 and QGIS for GIS analysis.

Base map preparation: The base map of the study area was prepared using Survey of India toposheet. The maps were geometrically corrected with WGS 84 datum and UTM projection. This was followed by field verification.

Ground truth collection: Intensive ground surveys were carried out in different seasons over the entire project areas during 2013 and 2014. GPS based observations were recorded as input for image interpretation.

3.2.4 Soil

To collect the baseline data for soil quality in the TRB, soil samples were collected during three seasons and analyzed. Among the physical parameters soil texture, moisture content, bulk density and water holding capacity were analyzed while chemical characteristics included pH, organic carbon, conductivity, exchangeable potassium, exchangeable calcium, exchangeable magnesium, ammonium and nitrate nitrogen, TKN, available phosphorus, total phosphorus, and soil microbial biomass-C and microbial biomass-N.

Physico–chemical properties: Soil samples were collected randomly from the surface soil layer (0–10 cm depth) during pre–monsoon, monsoon and post–monsoon/winter seasons, and were mixed thoroughly to obtain one composite sample. Sub–samples of field moist soil were taken

for analysis of soil moisture content and pH. The remaining soil was air dried, powdered, sieved (0.2 mm) and stored for the analysis of physical and chemical characteristics.
Soil texture was determined by the Buoycous hydrometer method (Allen *et al*., 1974). The soil was divided into 6 textural classes by using sieves of different mesh sizes *viz*. >2000 μm for gravel, pebbles, cobbles and boulders, 500–2000 μm for very coarse and coarse sand, 200–500 μm for medium fine sand, 50–200 μm for very fine sand and 20–50 μm for coarse and medium silt and >20 μm for fine silt and clay.

Soil moisture content (SMC) was determined by gravimetric method (Allen *et al*., 1974). Bulk density (BD) was estimated by gravimetric method (Allen *et al*., 1974). Porosity was calculated using bulk density data and Particle density value as 2.65 g cm^{-3}.

Water holding capacity (WHC) was determined by Keen's box method, using copper cups of 5.6 cm internal diameter and 1.6 cm height (Piper, 1942).

Soil pH was determined using a digital pH meter (Professional Meter PP–20, Sartorius) in a 1:2.5 w/v suspension of soil and deionized water (Anderson and Ingram, 1993).

Soil nutrient concentration: Soil organic carbon (SOC) was determined by colorimetric method (Anderson and Ingram, 1993). Transmittance was recorded at 600 nm using Spectrometer (Lambda–35, UV/VIS, Perkin Elmer, USA).

Ammonium nitrogen (NH_4–N) concentration was determined after extracting soil in 1.0 N KCl solution by indophenol–blue method (Allen *et al*., 1974). Transmittance was recorded at 625 nm, using Spectrometer (Lambda–35, UV/VIS, Perkin Elmer, USA).

Nitrate nitrogen (NO_3–N) concentration was determined following phenol–disulphonic acid method (Allen *et al*., 1974). Transmittance was recorded at 410 nm by using Spectrometer (Lambda–35, UV/VIS, Perkin Elmer, USA).

Soil available P was determined by shaking the soil samples with Bray–Kurtz P–1 extracting solution pH 2.6 (Bray and Kurtz 1945) and the extracts were analysed for P by the molybdenum–blue method (Allen *et al*., 1974).

Total Kjeldahl nitrogen (TKN) and total phosphorus (P) in soil were determined by Kjeldahl digestion of air–dried soil sample with conc. H_2SO_4 using Kjeltabs as catalyst followed by colorimetric analyses. TKN was analysed following Ammonium gas–diffusion technique and total P by vanado–molybdate method using the automated Spectrophotometric Flow Injection Analyser (FIAstar, Model 5000–Analyser, 5027–Sampler, AB, FOSS, Hoganas, Sweden).

Soil exchangeable potassium (K_{ex}) was determined using Flame Photometer (Model–1381E, ESICO) after extracting soil with ammonium acetate extractant at pH 7, by adding few drops of acetic acid or ammonium solution (Jackson, 1973).

Soil exchangeable calcium (Ca_{ex}) and magnesium (Mg_{ex}) were analysed by Atomic Absorption Spectrometer (Analyst, Model–200, Perkin–Elmer, USA) after extraction with ammonium acetate (pH 7) solution.

Soil microbial biomass: Microbial biomass carbon (C_{mic}) was determined from field moist soil by chloroform fumigation-extraction method (Brookes *et al*. 1985; Vance *et al*. 1987). After soil fumigation with $CHCl_3$ for 24 hrs, the organic C was extracted from unfumigated (extractable C) and fumigated samples with 0.5 M $K2SO_4$. The soil extracts were digested in a block digester at 150°C for 1 hr followed by titration with acidified ferrous ammonium sulphate, $Fe(NH_4)SO_4$.

The C_{mic} was calculated as the difference in organic C between the fumigated and unfumigated samples using the following formula:

$$C_{mic}\ (\mu g\ g{-}1) = (Cf{-}Cu) \times 2.64$$

Where, Cf = organic C concentration in fumigated samples Cu = organic C concentration in unfumigated samples.

Microbial biomass nitrogen (N_{mic}) was determined from the same soil extracts used for determination of C_{mic}. The fumigated and unfumigated soil extracts were digested at 220°C for 2 hrs in a block digester using a catalyst mixture composed of selenium powder, H_2O_2 and sulphuric acid. The digested samples were filtered and total N in the filtrates was determined by ammonia reduction technique using FIASTAR 5000 auto-analyzer (FOSS Tecator, Denmark). The N_{mic} was calculated by subtracting the total N in non-fumigated samples from total N in the fumigated samples using the following formula:

$$N_{mic}\ (\mu g g{-}1) = (Nf - Nu) \times 1.46$$

Where, Nf = Total N concentration in fumigated samples Nu = Total N concentration in unfumigated samples.

3.2.5 Water Quality

The water sampling was done at different locations to collect the baseline data for TRB (Figure II. 3.1). The sampling was done in three seasons (pre–monsoon, monsoon and winter), wherever possible. Physico–chemical parameters and biological parameters were studied to assess the water quality of the river.

Water temperature was recorded with the help of graduated mercury thermometer. Care was taken while measuring the temperature as it was recorded from surface, column and near the bottom of the river. An average value of these readings was calculated.

During the study period temperature, dissolved oxygen and turbidity were measured *in situ* with water proof multi stem thermometer ST–9239B, Lutron dissolved oxygen meter DO–5509, Eutech portable turbidimeter TN–100, respectively. Water samples were taken in polypropylene bottles and stored at 4^oC for subsequent analyses of pH, electrical conductivity, total dissolved solid and practical salinity with Sartorius professional meter PP–20.

Chemical parameters such as ammonia ($N{-}NH_4^+$), nitrites–nitrates ($N{-}NO_2/NO_3$), total phosphorus (TP) were measured, following standard techniques (APHA, 2012), using FIAstar™ 5000 system. Total alkalinity and chlorides (Cl^-) were measured by titrimetric method following standard techniques (APHA, 2012). Potassium (K^+) and sodium (Na^+) were measured with ESISCO microprocessor flame photometer 1381E. Total hardness was measured by calculation method through prior determination of Ca^{2+} and Mg^{2+} ions using FAAS following standard techniques (APHA, 2012).

Bacteriological determination of water quality: 500 ml of water samples were collected in a sterile bottle samples for enumeration of total coliform. Membrane filters (0.45 um cellulose acetate, Millipore Mf type) were placed on an absorption pad with 2.5 ml of m–Endo broth MF for total coliform, cultures were incubated at 35^oC for 24 h for total coliform bacteria (APHA, 2012).

Primary productivity: The periphyton primary productivity was determined by light and dark bottle method (Wetzel and Likens, 2000). The water samples were collected in light and dark BOD bottles. Three replicates were maintained for each sample. The experimental bottles were kept for 6 hours in the river from where the water samples were collected. Winkler's method was used for determination of oxygen in the light and dark bottles.

Following formula was used for calculation of periphyton primary productivity.

$$\text{Gross Primary Productivity (GPP) (mg C/m}^3\text{/hr)} = \frac{(O_2 \text{ content of light bottle} - O_2 \text{ content of dark bottle}) \times 0.375 \times 1000}{1.2 \times \text{Incubation hour}}$$

$$\text{Net Primary Productivity (NPP) (mg C/m}^3\text{/hr)} = \frac{(O_2 \text{ content of light bottle} - O_2 \text{ content of control bottle}) \times 0.375 \times 1000}{1.2 \times \text{Incubation hour}}$$


Location of Tsa Chu-I area


Garbage dumped directly at Tsa chu area


Water sample collection at Nykcharong chu powerhouse


Water sample collection at Thingbu chu barrage site


Water sample collection at Nyamjang chu barrage site


Water sample collection at Tawang chu barrage site

Figure II. 3.1: Photographs showing locations of water sample collection from different proposed HEP areas

3.2.6 Ambient Air Quality

The ambient air quality for parameters PM_{10} and $PM_{2.5}$ was monitored using Combo PM_{10} and $PM_{2.5}$ Sampler (Ecotech Model AAS, 271). A gaseous pollutants Sampler attachment (Ecotech Model AAS, 118) was used to monitor SO_2, NO_2, NH_3 and O_3 gases in the ambient air. The equipment was operated at the carefully selected locations in TRB to collect background representative concentrations of the said parameters covering landscapes having varied anthropogenic activities. Efforts were made to locate these stations in such a manner that the sampling stations cover the impact areas of all proposed hydroelectric projects. However, due to difficult terrain characteristics, logistic constraints and inclement climatic conditions, these sampling locations were occasionally shifted to other nearby/close locations. The details of these sampling locations together with dates of sampling, duration of sampling, latitude, longitude, elevation and location description are provided in Table II. 3.1 and Figure II. 3.2.

Table II. 3.1: Sampling locations in TRB for ambient air quality measurement

Sampling location	Sampling date	Sampling time	Latitude	Longitude	Elevation (m)	Description of sampling location
Khet bridge	12/12/13	09:40 am-06:00pm	27.546286°	91.856057°	1623	Valley, unpaved road side having thick vegetation with no habitation within 1 (one) km, little vehicular movement
Rho	13/12/13	08:50 am-04:50 pm	27.616942°	92.007358°	2265	Valley with good vegetation cover. Small habitation at 500 m above sampling location. Little vehicular movement
New Melling	04/03/14	09:30 am-06:10 pm	27.634935°	92.069664°	2650	Valley, under construction road and a quarry, small habitation, little vehicular movement
Thingbu chu	05/03/14	10:00 am-06:00 pm	27.653040°	92.095607°	2800	Valley with good vegetation cover, unpaved road. Little vehicular movement
Nuranang falls	06/03/14	09:45 am-06:25 pm	27.588138°	91.980700°	2110	Valley with fair vegetation cover and small habitation 200 meters from highway, 50-70 vehicles per day.
Jang	07/03/14	09:00 am-06:00 pm	27.581759°	91.981344°	2338	Highway side close to township, traffic density about 50-70 vehicles per day
Tsa chu	08/03/14	10:48 am-07:48 pm	27.722225°	92.013754°	3272	Snow covered valley, moist, canopy cover, small habitation, little vehicular movement
Tawang	10/03/14	08:00 am-06:00 pm	27.585399°	91.857015°	2973	Paved road near township, traffic density about 80-90 vehicles per day
Lumla	11/3/14	10:00 am-06:00 pm	27.531182°	91.722534°	2324	Mountain top with good vegetation cover, habitation at 1-1.5 km away
Jaswant-garh	12/3/14	09:30 am-05:30 pm	27.554821°	92.010049°	3345	Snow covered mountain on highway near army camp. Traffic density about 40-45 vehicles per day

Meteorological parameters viz., wind speed (km/h), wind direction, relative humidity (%) and ambient temperature (°C) were also recorded during ambient air quality monitoring at all the selected locations using hand held equipments. The methods used for sampling and analysis of PM_{10}, $PM_{2.5}$, SO_2, NO_2, NH_3 and O_3 are given in Table II. 3.2.

Table II. 3.2: Parameters used for air quality monitoring and methods followed for air sampling and analysis

Parameters	Sampling duration	Method of measurement	Concentration in ambient air		Detectable limit (µg/m^3)
			Industrial, residential, rural and other areas	Ecologically sensitive area (notified by Central Govt.)	
Particulate matter (Size less than 10µm) or PM_{10}, µg/m^3	8 hours	Gravimetric	100	100	
Particulate matter (Size less than 2.5µm) or $PM_{2.5}$, µg/m^3	8 hours	Gravimetric	60	60	
Sulphur-di-oxide (SO_2) µg/m^3	4 hours	Improved West and Gaeke	80	80	25-1050
Nitrogen-di-oxide (NO_2) µg/m^3	4 hours	Modified Jacob and Hochhesier (Na-Arsenite)	80	80	6-750
Ammonia (NH_3) µg/m^3	4 hour	Indophenol blue method	400	400	0.03
Ozone (O_3) µg/m^3	4 hour	Chemical Method	180	180	5

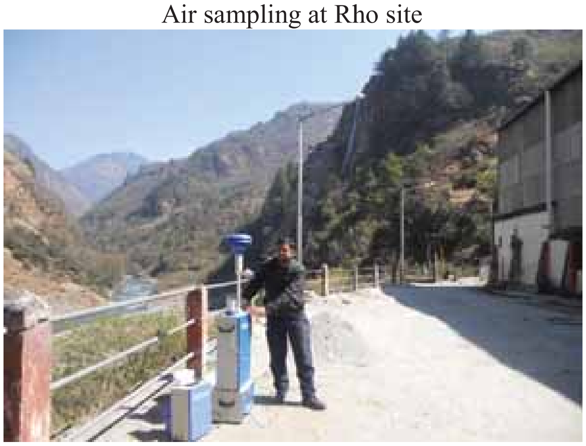
Source: Guidelines for the Measurement of Ambient Air Pollutants, Volume-II. Central Pollution Control Board, Ministry of Environment and Forests, Govt. of India, May, 2011. *NAAQS Monitoring and Analysis Guidelines Volume-II.*

Air sampling at Khet bridge site

Analysis of air samples at the site

Air sampling at Rho site

Air sampling at Thingbu chu



Air sampling at Nuranang Fall site

Air sampling at Tsa Chu-I

Air sampling at Lumla site

Air sampling at Jaswantgarh site

Figure II. 3.2: Photographs showing air sampling sites at different HEP areas of TRB

3.2.7 Noise

Noise levels were recorded using Lutron Make Noise Level Meter Model SL 4033 SD having range of 30-130 dB with 0.1 dBA resolution. The instrument was calibrated at National Physical

Laboratory, Delhi prior to its use in the field. The noise levels were recorded at the same locations as detailed in Table II. 1.

3.2.8 Vegetation Types

During the field visits to different sites in TRB in different seasons, types of vegetation and plant species composition observed at each site were documented. Besides primary surveys in the project sites (Figures II. 3.3 and 3.4), published literature and various floras were consulted to prepare an inventory of plant species growing at project sites. The forest vegetation of the river basin was broadly classified into four major types following Champion and Seth (1968) and Kaul and Haridasan (1987).

3.2.9 Plant Diversity

The plant diversity was classified into various plant groups such as tree, shrub, herb, climbers, orchids, pteridophytes, bryophytes, lichens, and fungi. The plant diversity survey in the project area was undertaken during three seasons (monsoon, post-monsoon, and winter) with the objectives of preparing a checklist of flora in the catchment areas, barrage, and powerhouse sites. The list included total plant diversity belonging to various groups as well as threatened, endemic and economically important plant species found in each project site.

3.2.10 Vegetation Analysis for Angiosperms and Gymnosperms

The plant community structure studies were carried out at three places viz., barrage site, powerhouse site and catchment area of each project site. The tree layer was analysed by sampling ten quadrats of 10 x 10 m size. The shrub layer (saplings and shrubs) was analysed by sampling ten quadrats of 5 x 5 m size randomly. For herb layer (herbs and seedlings of perennial species) ten quadrats of 1 x 1 m size were laid. IVI for herb and shrub was calculated based on density and frequency values. The optimal size and number of quadrats needed were determined using species area curve. Frequency and density of trees, shrubs and herbs were determined using the above mentioned quadrats.

Importance value index (IVI) of tree species were computed as sum of relative frequency, relative density, and relative dominance following the method outlined by Misra (1968). The index of diversity was computed by using Shannon–Weaver information index (Shannon–Wiener, 1963) as:

$$H = -\Sigma (n_i/n) \times \ln (n_i/n)$$

Where, n_i is individual density of a species and n is total density of all the species. Dominance index was calculated according to Simpson (1949). Evenness index was calculated according to Pielou (1969).

Biomass and carbon estimation of trees: Estimation of volume, biomass, and carbon stocks for trees and forests is a tedious process, and needs a lot of effort in terms of financial, technical, and human inputs. Allometric models allow the estimation of volume and biomass from easy-to measure parameters such as the diameter or tree height. The databases of tree allometric equations such as 'GlobAllomeTree' are of immense help in this aspect (Henry *et al*., 2013). In the present study, we used the 'GlobAllomeTree' database along with the 'Fantallometrik' software to calculate tree volume, biomass, and carbon stocks. This software integrates most of the allometric equations, allows their comparison and selection, and helps in making compartment-wise calculation for volume, biomass, and carbon stocks. It also allows insertion of new equations for updating the database. The 'Fantallometrik' software comprises 3 modules which are as follows:

Module 1: This is for comparison of allometric equations contained in the database or the ones provided by the user. In this module, the selection of equations can be made using a number of filters that includes the source, geographic location, mathematical forms, and sampling i.e. number, species etc.

Module 2: This is for assessment of volume, biomass, and carbon using selected allometric equations. In this module, statistical analysis and comparison of results obtained with the default data proposed by IPCC (2006) can be done.

Module 3: In this module, the user can insert new allometric equations in existing databases, or can create new databases for the allometric equations. All the three modules contain functions of quality control to facilitate the selection and verification of the calculations.

Data on diameter at breast height (DBH) of trees were recorded through direct measurements using a measuring tape. The DBH data of trees from various sites was used as input in the Fantallometrik software to estimate the biomass and carbon stocks for each site.

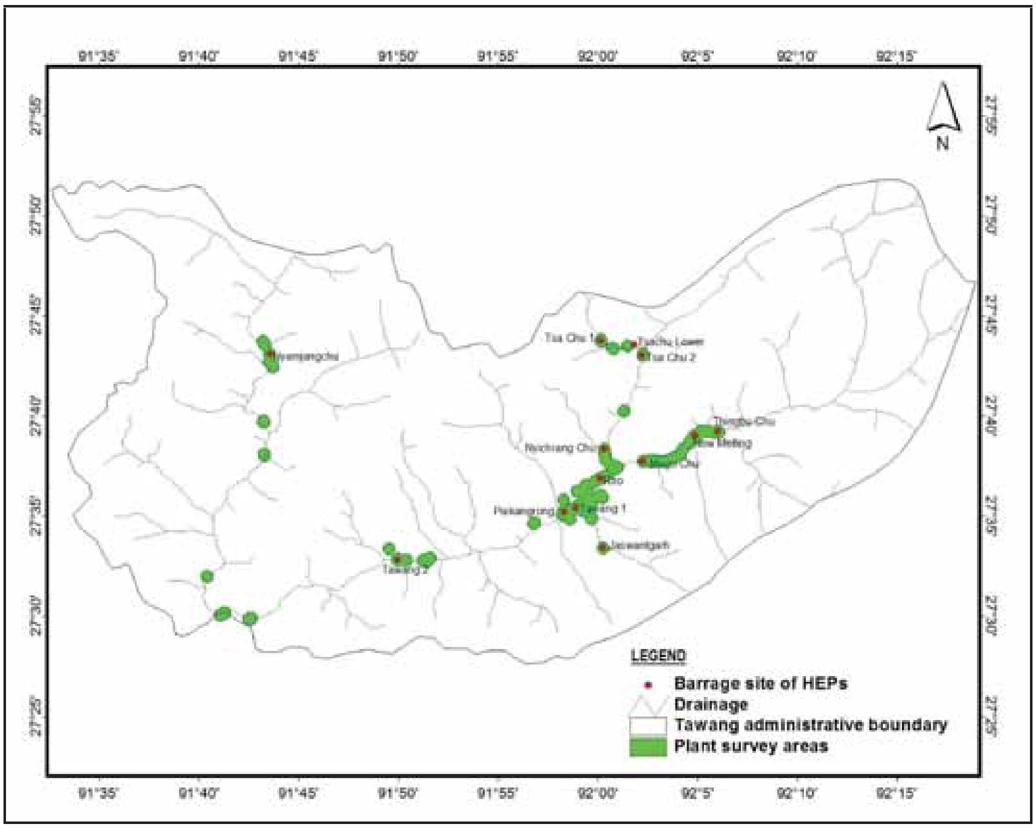
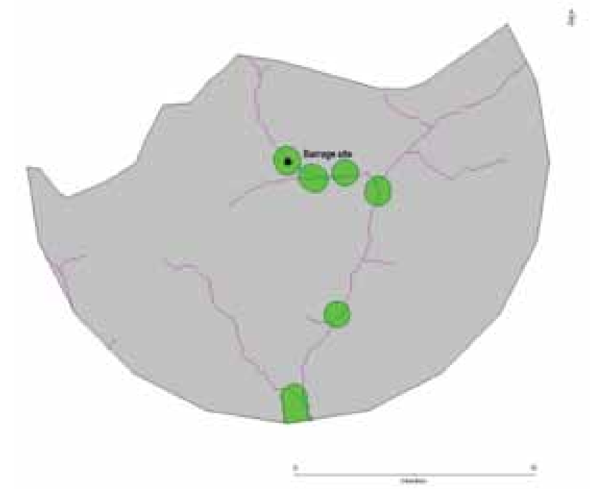
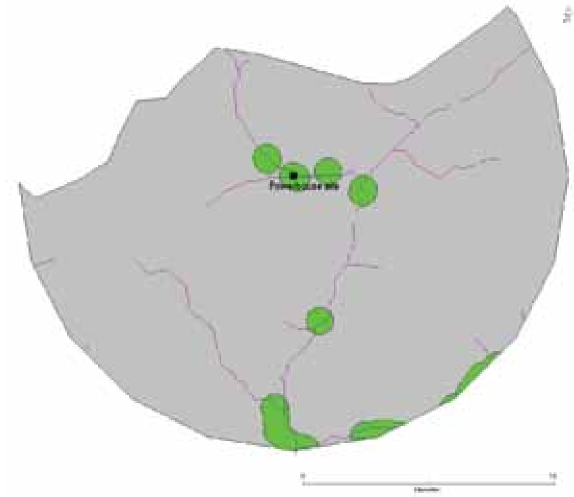


Figure II. 3.3: Map showing plant survey areas in 13 hydro-power project sites under TRB



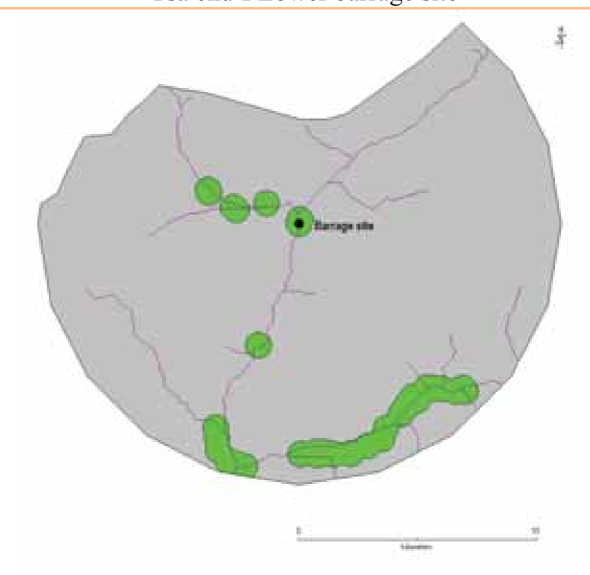
Tsa chu-I barrage site



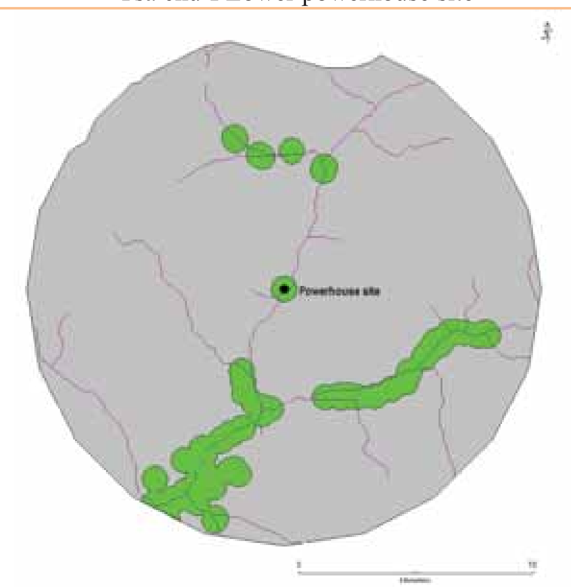
Tsa chu-I powerhouse site

Tsa chu-I Lower barrage site

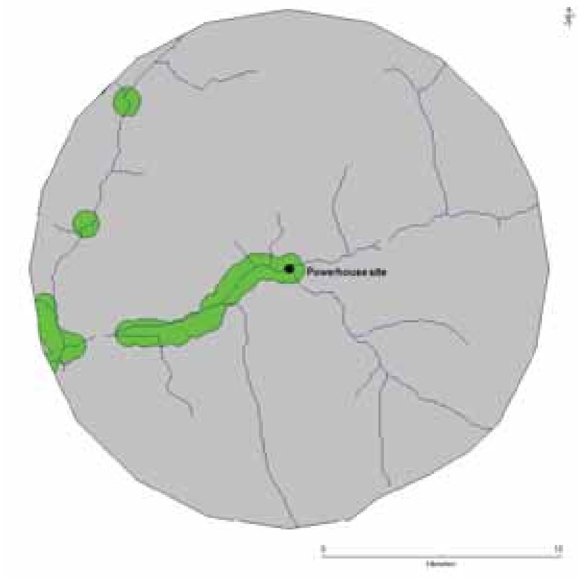
Tsa chu-I Lower powerhouse site



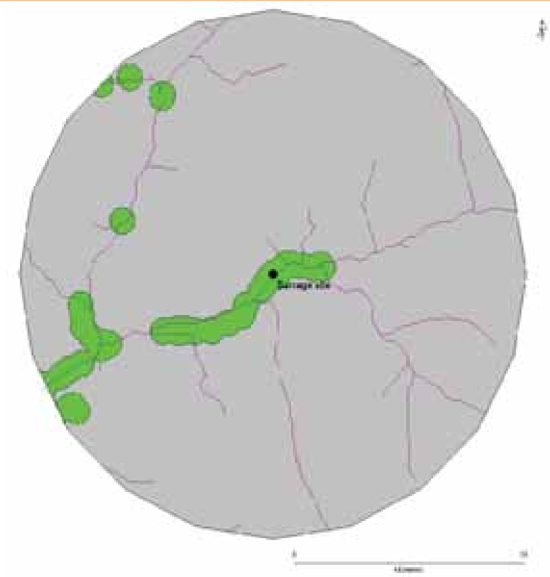
Tsa chu-II barrage site



Tsa chu-II powerhouse site



Thingbu chu powerhouse site



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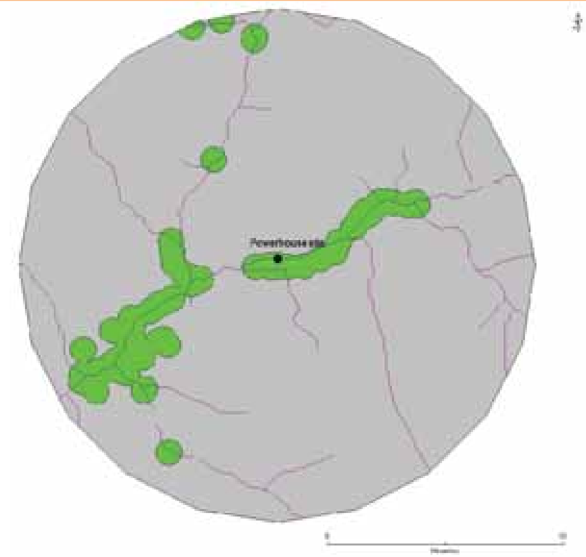

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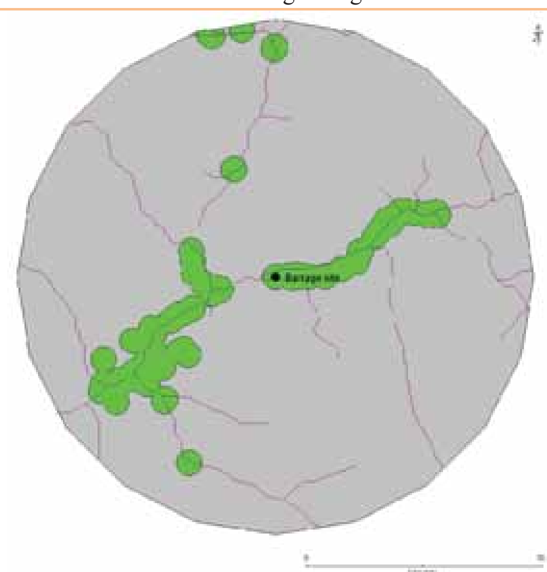
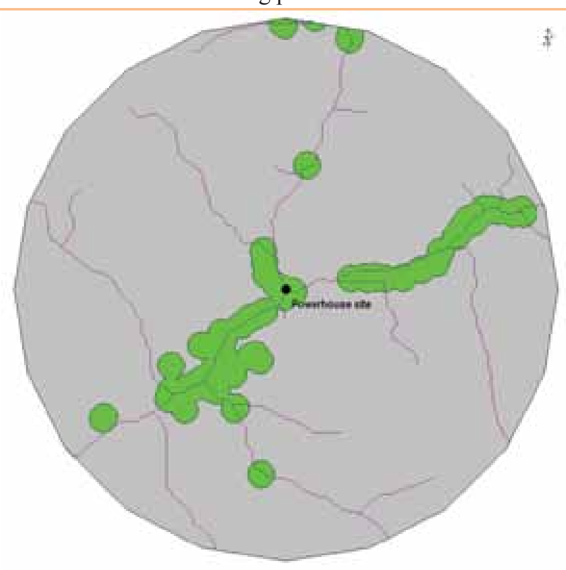


Mago chu barrage site



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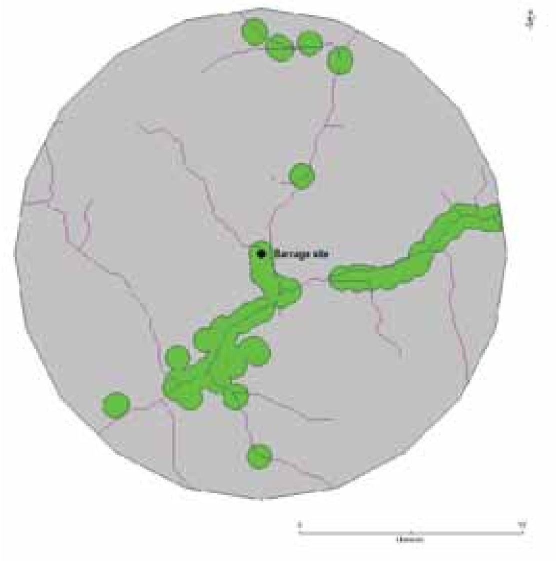

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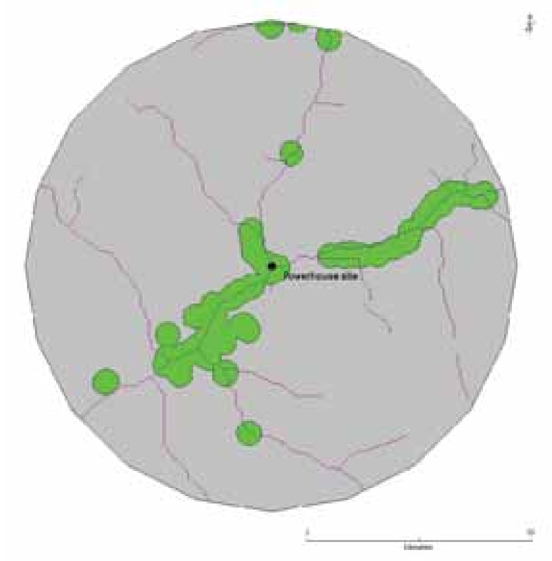

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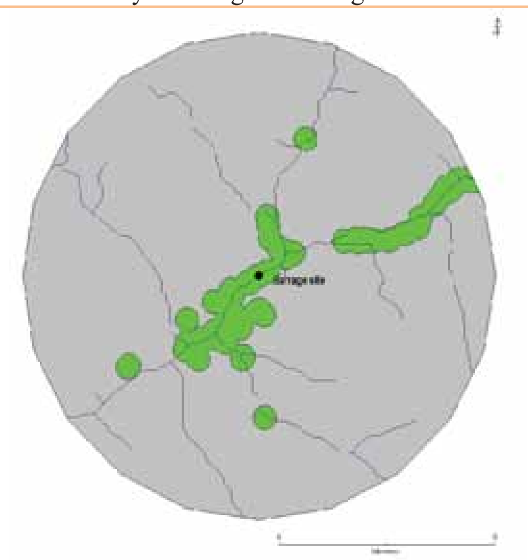

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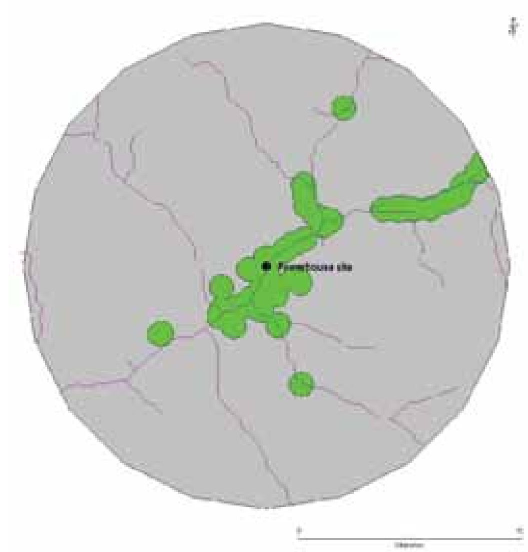
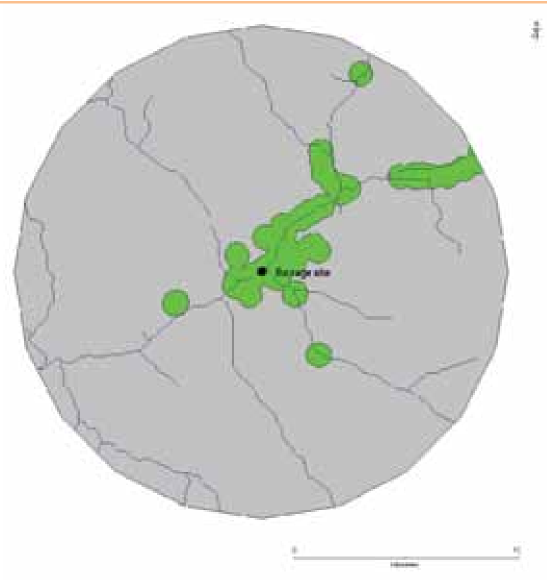
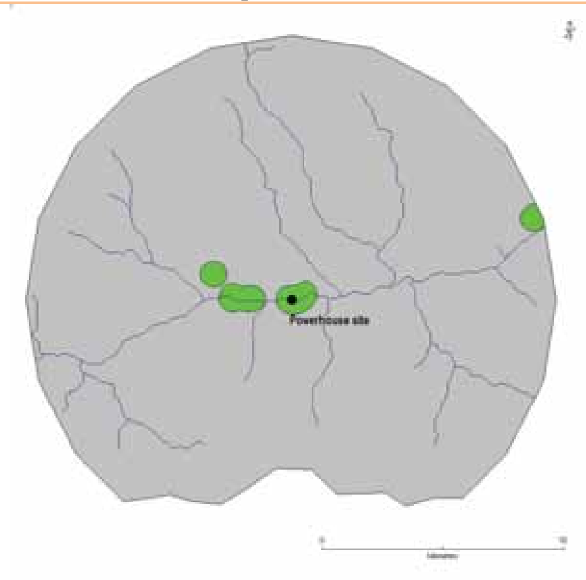


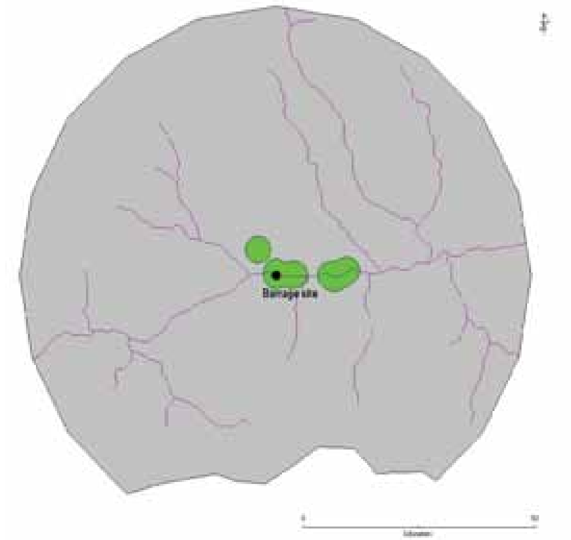
Rho powerhouse site



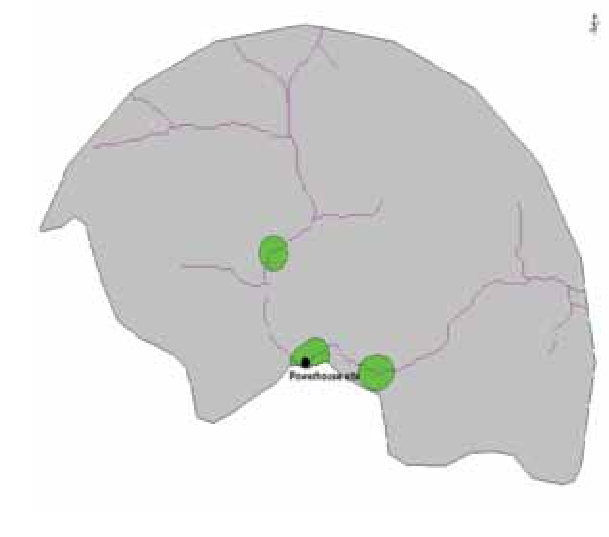
Tawang-I barrage site



Tawang-I powerhouse site



Tawang-II barrage site



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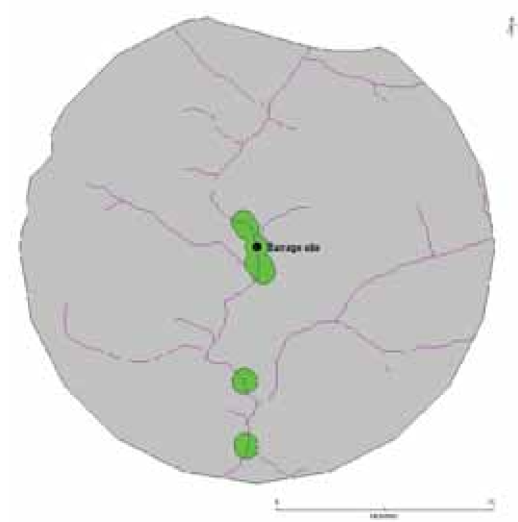
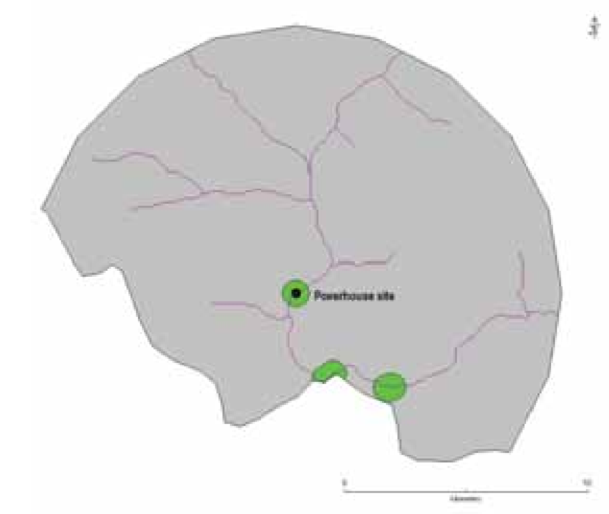
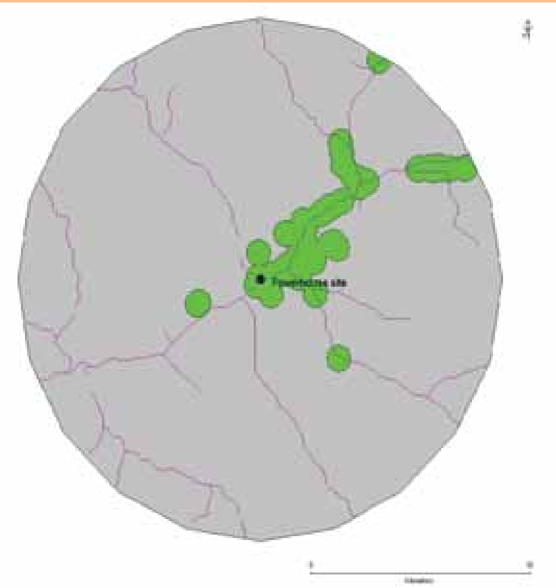


Nyamjang chu barrage site



Nyamjang chu powerhouse site



Paikangrong chu powerhouse site

Jaswantgarh Stage-I powerhouse site

Figure II. 3.4: Areas surveyed for plant diversity within 10 km radius

3.2.11 Phytoplankton/Periphyton

Collection: Periphytons were collected from the surface water by towing plankton net having mesh size of 45 µm. The collected samples were transferred into a 1 litre sample container which was washed thoroughly with field water.

Preservation: Samples that required later on counting were preserved immediately at the sampling site by adding Lugol's solution at a ratio of 1:100 (Vollenweider, 1969). This gave the sample a weak tea colour. The fixed samples were brought to the laboratory and allowed to stand for 24 to 48 hours without disturbance to allow the planktonic algae to settle down.

Enumeration: The preserved periphyton samples were collected through centrifugation. One ml of the concentrated sample was transferred into Sedgwick-rafter counting chamber with the help of a dropper. The counting chamber was covered with a thin cover slip, taking care to avoid trapping of air bubbles inside. The planktons were allowed to settle down for 15 minutes. Enumeration of the cells was done with the help of a tri-ocular light microscope (Olympus-BX41) and photographed by using a digital camera directly fitted to the microscope. Counting was carried out in replicates and the final result was expressed as number of cells/ml by following the formula mentioned below:

$$\text{Periphyton (cells/ml)} = \frac{NxCx1000}{LxDxWxSxV}$$

Where, N = Number of organisms counted in 1 ml of concentrated sample; C = Total volume of concentrated sample (ml); L = Length of strip of S-R Cell in which counting has been made (50 mm); D = Depth of strip in S-R Cell (1mm); W= Width of strip counted by Whipple grid, mm; S = Number of strips counted; V= Total volume of sample concentrated (ml)

Identification: Taxonomic identification was done with the help of floras and monographs. For non-diatomic algae, monograph of Tiffani and Britton (1952); Presscott (1982); Desikachary (1985) and John *et al*. (2002) were followed. For diatoms, monographs of Gandhi (1998) and Krammer and Lange-Bertalot (1986-1991) were followed and the taxonomy was updated using online database, Algae Base (Guiry and Guiry, 2012) and ADIAC (Automatic Diatom Identification and Classification) Diatom image database funded by the European Marine Science and Technology (MAST) programme.

3.2.12 Zooplankton

The zooplankton was sampled with a 40 cm long plankton net (net aperture 20 cm and mesh size 25 µm). For the quantification of zooplankton, 50 liters of water for each community is filtered at each site by using standard plankton net made up of fine silk cloth (mesh size 25 µm). The filtrate collected was preserved in the 4% formalin solution. The qualitative and quantitative analyses of zooplankton were undertaken by methods given in APHA (1995). The zooplankton was identified using Edmondson (1992) and Battish (1992). Community structure was calculated as per the results of analytical data.

3.2.13 Fish

Secondary information were collected from different published literature and cross checked during the field study. A common fishing method was used to catch fish. Fishing was carried out using caste net within the 10 km river stretch of proposed project area with the help of local fishermen for all the three seasons. In addition, hook and line methods were also used to land the fish. Identification of fishes was done using Talwar and Jhingran (1991).

3.2.14 Soil Fauna

Soil is a complex subsystem that influences primary productivity of terrestrial ecosystems and maintains biogeochemical cycles (Nannipieri *et al*., 2003). The varied and complex physical, chemical and biological interactions determine the composition and activity of the soil biota at a given site and time (Killham, 1994). Soil biodiversity refers to the variety of living organisms present in the soil. Biologically it is by far the most diverse part of the earth. The biodiversity in soils is several orders of magnitude higher than that of above ground (Heywood, 1995). Animal members of the soil biota are numerous and encompass a rich pool of species including representatives of all terrestrial phyla. A small fraction of rich organic soil can contain millions of organisms representing hundreds of different species including bacteria, fungi, protozoa, algae, nematodes, annelids and approximately 20 different lineages of Arthropoda, the most diverse phylum of living organisms (May,1988).

The soil fauna is characterized by the duration of presence animals and their activity in the soil system viz, transient species which live in the plant stratum but hibernate in the soil (e.g. coleoptera); temporary residents whose adults live above ground and lay eggs in the soil where the larvae feeds on organic decomposing debris (e.g. diptera); periodic residents living in the soil and only emerging to reproduce (e.g. dermaptera); and permanent residents carrying out their entire life cycle in the soil (e.g. collembola) (Wallwork, 1970). A common method of classifying soil fauna is by grouping them into four size classes on the basis of body length (van der Drift, 1951 cited from Wallwork, 1970):

- Microfauna (20μ to 200μ)
- Mesofauna (200μ to 2mm)
- Macrofauna (2mm to 20mm)
- Megafauna (>20mm).

Microarthropods fall under the mesofauna group according to the size classes described above. Mites and collembolans are the dominant groups among all microarthropods. They form a set of linkages in the food web in soil by feeding on microflora and microfauna, bridging a connection between mesofauna on the one hand and the microbes and microfauna on the other. In turn, they are the prey for macroarthropods such as spiders, beetles and ants forming a link between the mesofauna and the macrofauna.

Soil fauna, as a general rule play important roles in soil processes. They play crucial role in efficient nutrient cycling, decomposition of organic matter and maintenance of soil physical structure and processes that are key determinants of primary production, carbon storage and ecosystem function. These processes are the result of intricate ecological interactions among soil fauna, bacteria, fungi, plants, and the stratum of soil in which they are found (Moore *et al*., 1988, 1993).

The present investigation aimed at studying the biodiversity of soil arthropods in the proposed hydro-electric project sites. The sampling for faunal catch was carried out during three seasons as mentioned in the above sub-sections.

- Litter and soil samples were collected in three replicates at each sampling occasion in 5×5 cm^2 area from barrage and power house sites.
- The samples were tagged and sealed, transported to the laboratory and extracted for soil fauna for 48 hours using modified high-efficiency Tullgren extractor (Crossley and Blair, 1991).
- The extracted fauna were sorted, identified and counted. They were grouped into three categories: Collembola, Acarina and "Other arthropods".
- Identification of the fauna were done up to order following Borror and Delong (1971). The orders of Collembola and Acarina were identified to species and sub-order levels wherever possible.

The population counts of samples having size of 5×5 cm^2 were converted and presented as number/m^2.

3.2.15 Wildlife

Faunal biodiversity assessment involved intensive field surveys during three seasons viz., monsoon, post-monsoon, and winter. During the survey, data on baseline status of butterflies, herpetofauna, avifauna and mammalian fauna were collected. Based on these surveys, checklists of faunal groups for each project area were prepared.

All the 13 project areas were visited several times during May, 2013 and June, 2014. Since all the project areas were located at the bottom of narrow valleys with very steep hilly ridges, survey and quantification of biodiversity were mainly dependent on the accessibility and terrain conditions of each site. Since the nature of all the project sites/river basins are narrow, the impact of project related activities on biological attributes are likely to be restricted/distributed within the narrow stretch of 1-2 km along the river valleys from the periphery of dam sites. With this understanding, most of the areas were surveyed using the existing approach roads and human paths, which were walked and surveyed for biodiversity status assessment, specifically birds, butterfly, herpetofauna, and mammals (Figures II. 3.6 and 3.7).

Apart from this, Camera trapping exercise was undertaken for capturing faunal diversity in selected project sites (Figure II. 3.5). Local knowledge of the area was used to determine a few potential locations near the project sites for placement of the camera traps. 10 locations were selected with the best possible chances to encounter animals, and camera traps were deployed in these locations in 2 phases. The camera traps remained functional 24-hours a day. A minimum gap of 500 m was maintained between consecutive trap sites so that the possibility of capturing the same individuals can be avoided. The study period consisted of only 330 trap nights (total no. of camera traps × total no. of days of camera trapping). After completion of the whole exercise, the photographs obtained were downloaded and the data were analysed according to the animal species captured. Photo Capture Rate (PCR; Dutta *et al*. 2008) (No. of photos of a species/total trap nights × 100) was calculated for each species which gives an idea of the Relative Abundance Index (RAI) of a species.

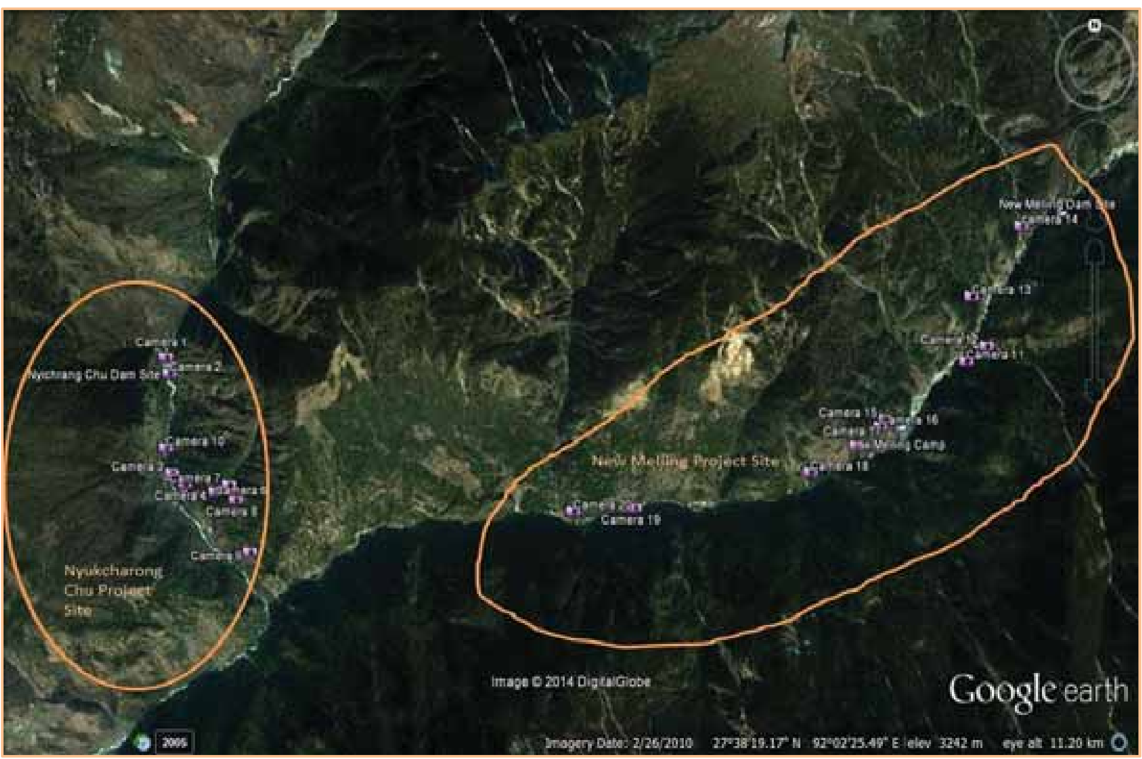


Figure II. 3.5: Map with some of the camera trap locations in TRB

Butterflies: Only inventory/listing was done for the butterflies through surveys along the line or road transects and opportunistic observations in each project area. This was used to provide information on presence and absence of differnt butterfly species in the project site based on field survey.

Herpetofauna: Considering the topography and presence of diverse microhabitats of the project area, different field methods were used to list and assess the status of herpetofauna. Opportunistic sampling through microhabitat search, quadrat, patch, and transect census sampling (Allison and Englund, 2005) and time constrained search method-micro habitat specific (Welsh, 1987) were adopted for amphibians and reptiles. The list of probable species of herpetofauna was prepared following Ahmed *et al.* (2009).

Aquatic birds: Total count or flock count method was adapted to assess the status of aquatic birds in selected larger water bodies existing in the project area (Sridharan, 1989; Bhupathy, 1991; Thompson, 2002 and Steinkamp *et al.*, 2003).

Terrestrial birds: Station index and perambulation techniques were used to assess the status of terrestrial birds (Hutto *et al*., 1986; Bibby *et al.,* 1992 and Rosenstock *et at*., 2002). Additional effort was made to locate/identify the presence of any breeding/nesting sites/roosting sites of avifauna.

Mammals: Status and distribution of different mammalian fauna were assessed using direct count covering all the terrestrial habitats of the project area following line transect/road count (Burnham *et al.,* 1980, Sale and Berkmuller, 1988 and Rodgers 1991). In addition, circular (25 m radius) plots were laid in each sampling location and searched for indirect evidences (pellets, dungs, droppings, scats and other tracks and signs) which provide relative abundance of mammalian fauna (Thompson *et al*., 1989; Henke and Knowlton, 1995 and Allen *et al*., 1996). In addition to direct quantification, presence of different faunal species was also established through interviewing the local people and project personnel those who are residing at hydel project sites for a long period. The help of pictorial representation was also taken to confirm the presence data.

Status of threatened fauna: List of threatened fauna of the project study area was prepared based on the primary field data collected. Baseline information was also reviewed for the status of the existing threatened species within the study area in accordance with the IUCN Red List and according to the schedules of the Wildlife (Preservation) Act, 1972.

All the nomenclature and scientific names have been referred from standard pictorial/field guides for different faunal groups (Birds: Ali, 2002; Rasmussen and Anderton, 2005; Mammals: Menon, 2003 and Prater, 2005).

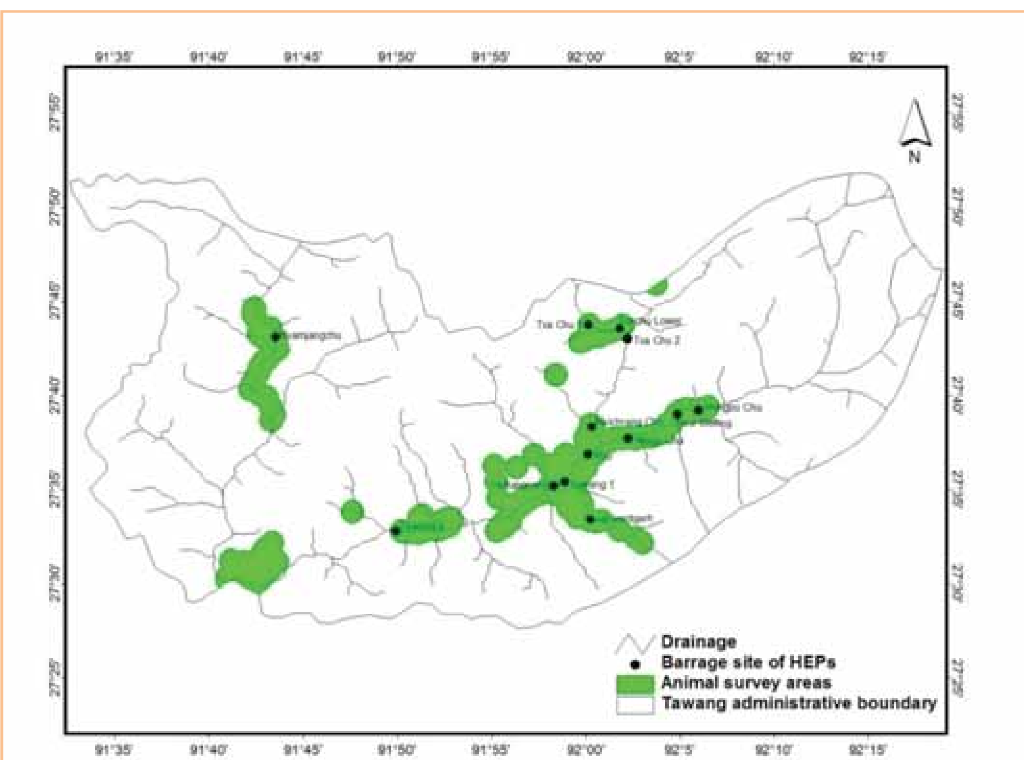
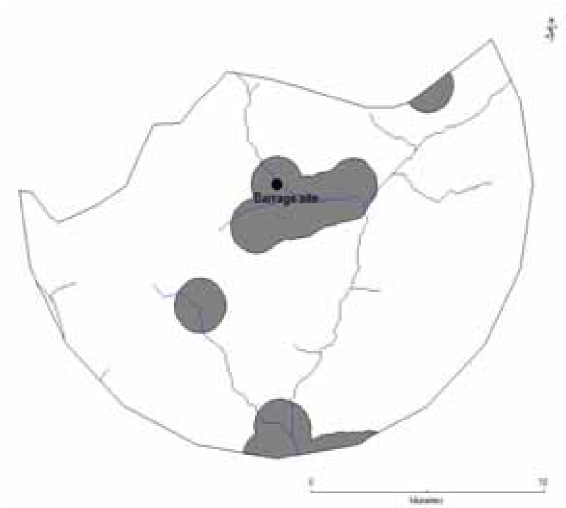
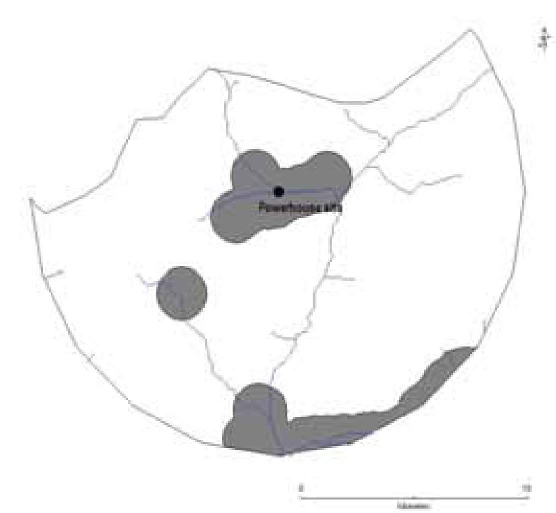


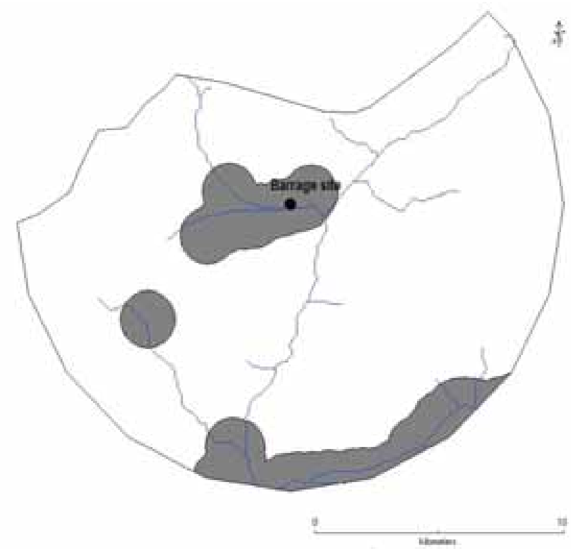
Figure II. 3.6: Map showing animal survey areas in 13 hydro-power project sites under TRB



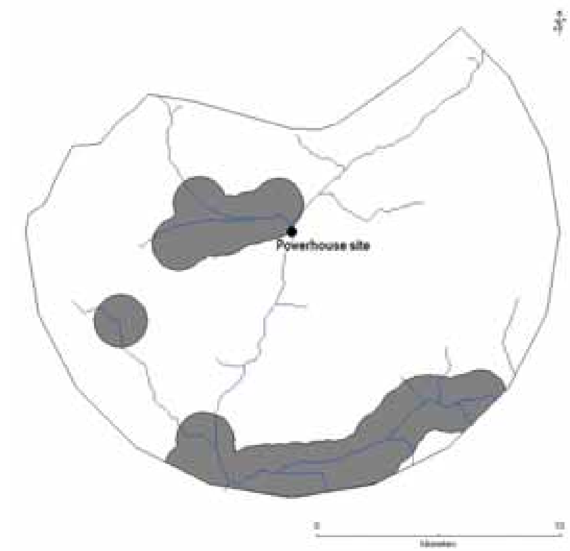
Tsa chu-I barrage site



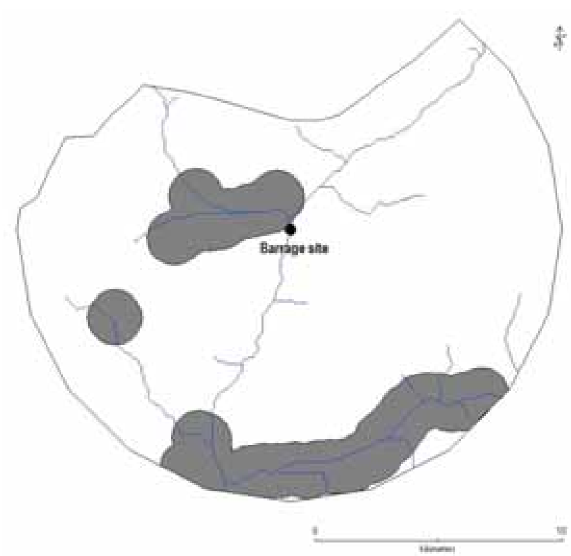
Tsa chu-I powerhouse site



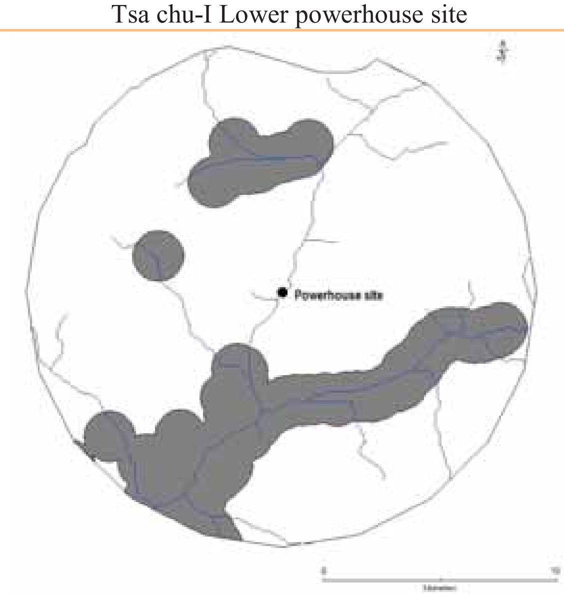
Tsa chu-I Lower barrage site



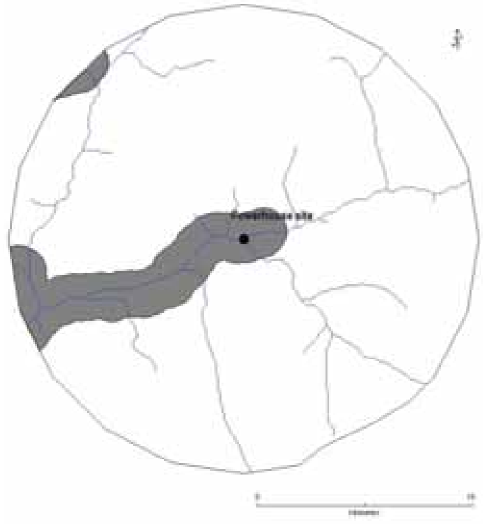
Tsa chu-I Lower powerhouse site



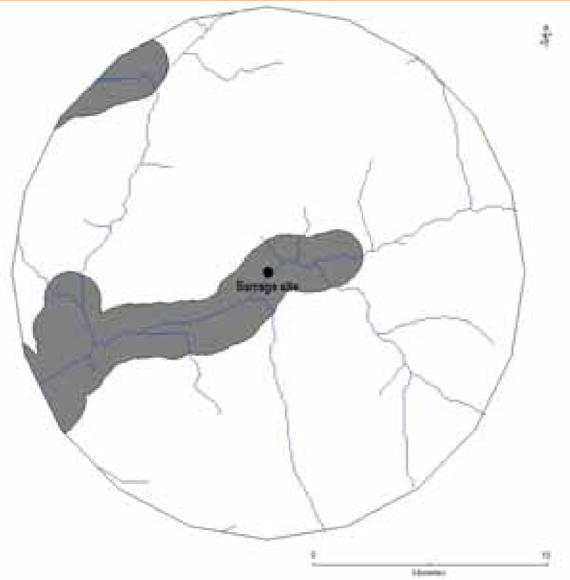
Tsa chu-II barrage site



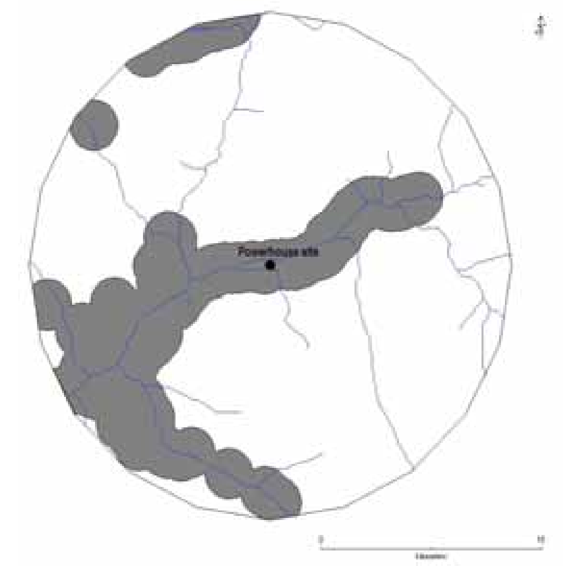
Tsa chu-II powerhouse site



Thingbu chu powerhouse site



New Melling barrage site



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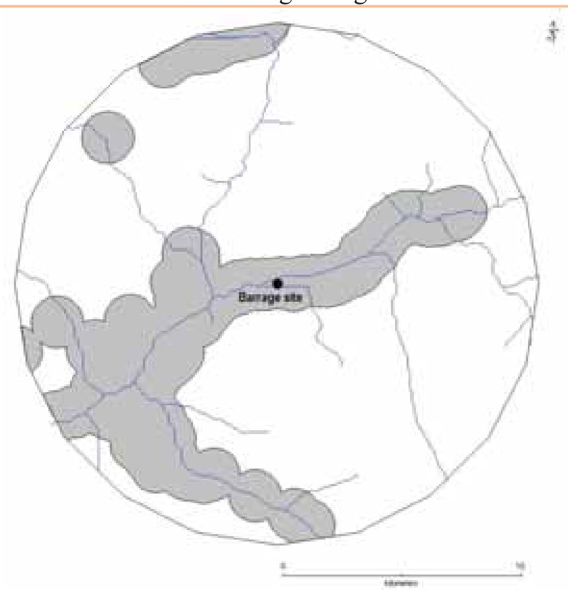

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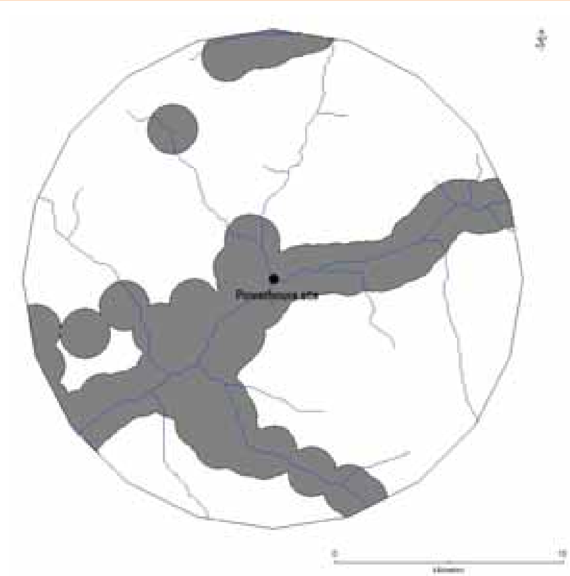
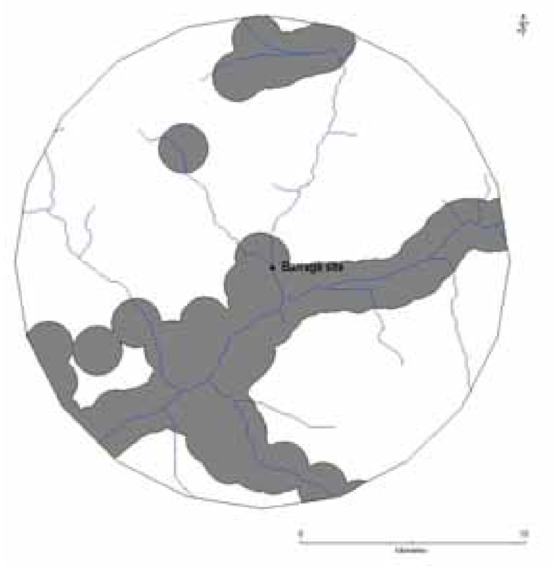
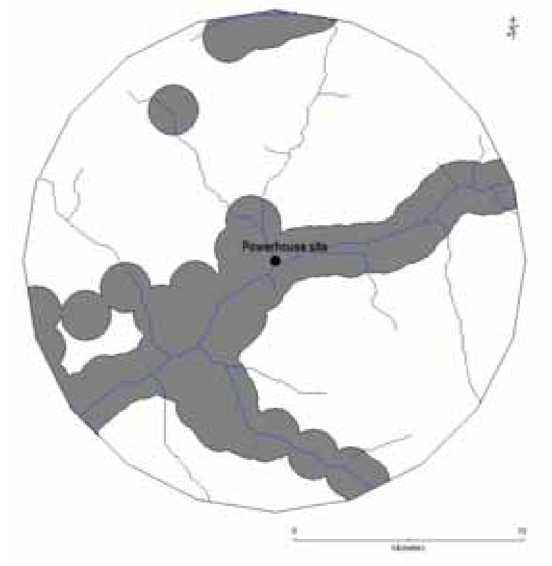


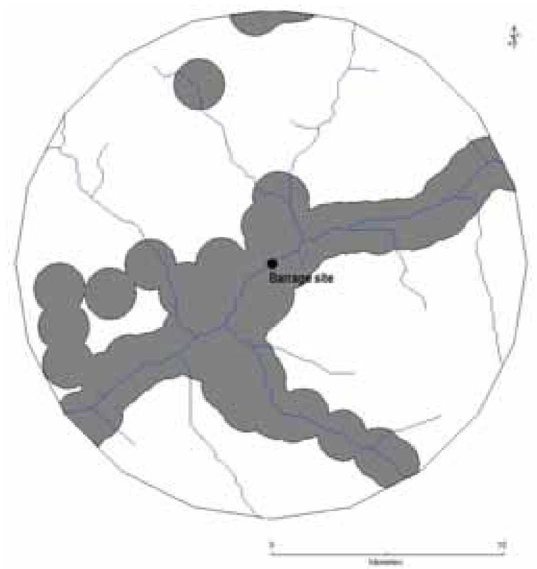
Mago chu powerhouse site



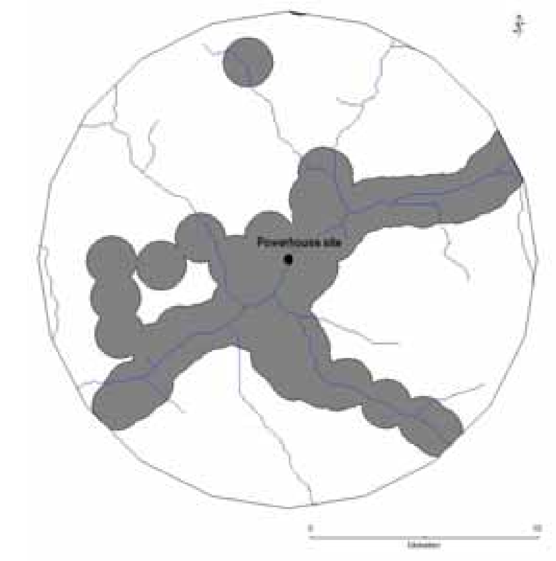
Nykcharong chu barrage site



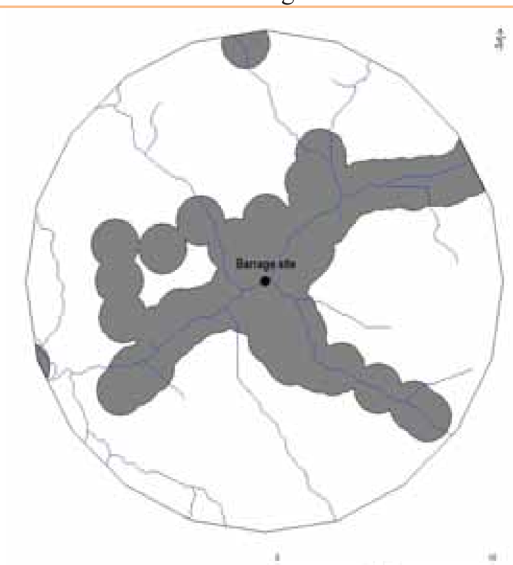
Nykcharong chu powerhouse site



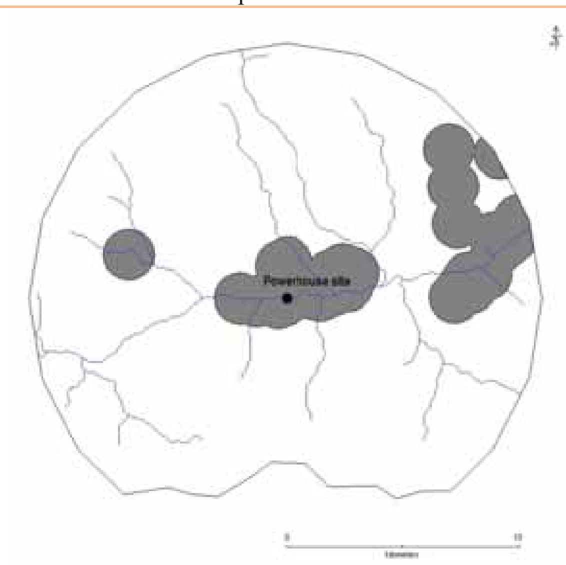
Rho barrage site



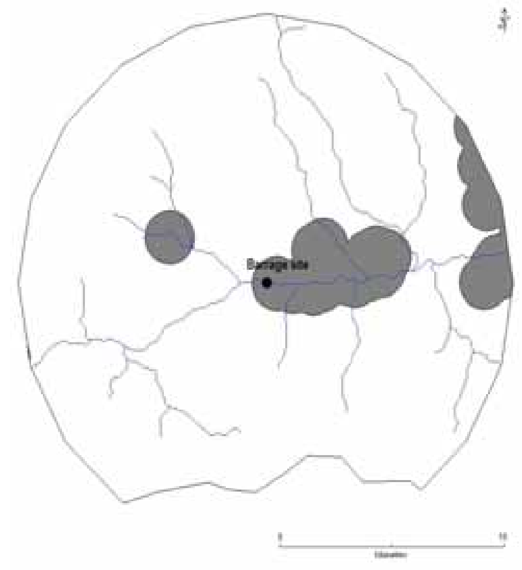
Rho powerhouse site



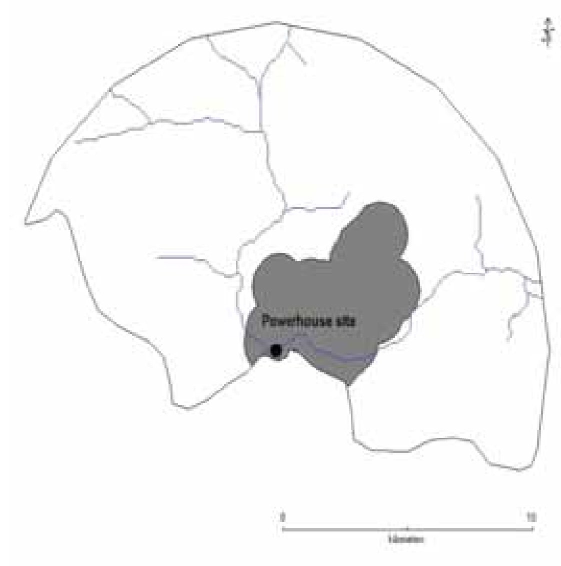
Tawang-I barrage site



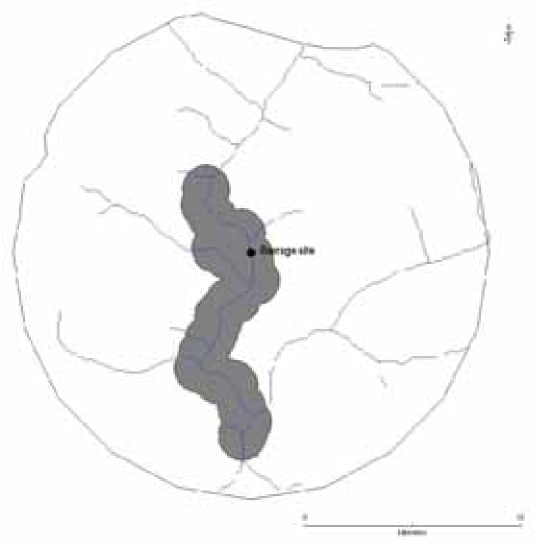
Tawang-I powerhouse site



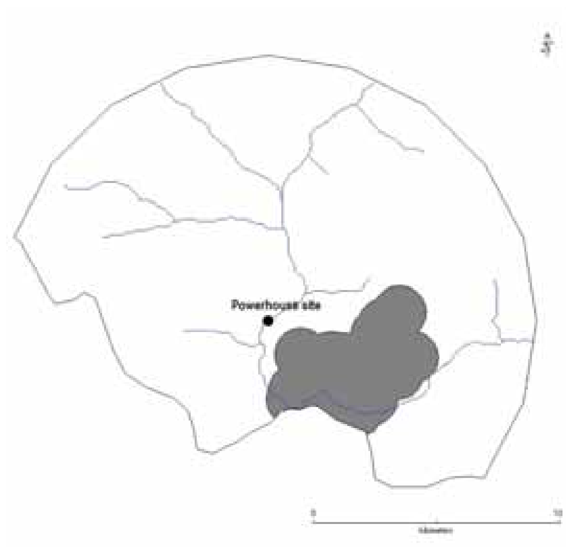
Tawang-II barrage site



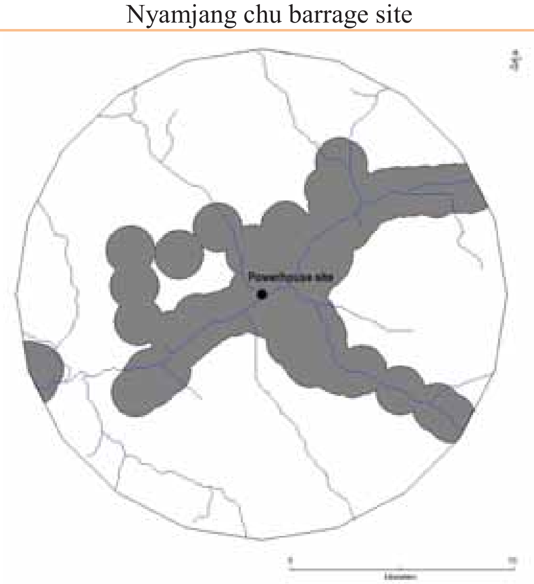
Tawang-II powerhouse site



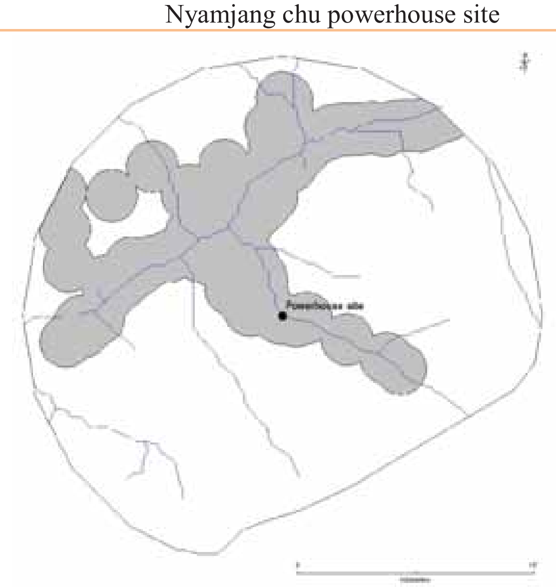
Nyamjang chu barrage site



Nyamjang chu powerhouse site



Paikangrong chu powerhouse site



Jaswantgarh Stage-I powerhouse site

Figure II. 3.7: Areas surveyed for faunal diversity within 10 km radius

3.2.16 Socio-Economic Analysis

A number of hydro-electric projects (HEPs) have been planned in the TRB of Arunachal Pradesh. The HEPs individually as well as collectively, and the ancillary industries/activities including influx of migrant workers are likely to impact negatively or positively the people living in the vicinity of the HEPs and the people living within the 10 km influence zone of the proposed projects in TRB.

In order to assess the impacts of HEPs, it is necessary to undertake comprehensive study to develop baseline data for the affected/influenced villages in the TRB. The socio-economic baseline data will be extremely important to evaluate the temporal impacts of the projects.

Socio–cultural and economic profile of people has emerged as a key issue in the environmental impact assessment of developmental projects. These are studied to develop sustainable strategy for the area, where the developmental projects would be executed. The present report addresses the socio-economic and cultural aspects of the people, mostly of Monpa tribe, to be affected by the execution of the 13 projects. The socio–cultural and economic aspects are, in general, divided into economy, demography, education, public and community services, fiscal, employment, religious and ethnic values and aspirations of people of the region. The affected persons are treated as stakeholders of the developmental activities, which include individuals, families, communities, or organizations. The baseline information on these aspects would be helpful in formulating suitable rehabilitation plan for the affected families of TRB projects in Tawang district of Arunachal Pradesh.

In this section, methods adopted to collect baseline data pertaining to the socio-cultural and economic aspects have been given.

a) Secondary sources: The secondary sources consulted were: Project related documents; District Statistical Handbook of Tawang district 2011-12; District Administration and Line Departments of Tawang District.

b) Primary sources: The Primary data was gathered by the following methods:

- Interviews with Tawang district Government functionaries.
- Interviews with the functionaries of the Panchayati Raj system and members of the respective Gram Sabhas.
- Interviews with functionaries of monastery, NGOs and social workers.
- Interviews with the functionaries of the Traditional Governance System.
- Interviews with adult men and women of the households (HHs).
- Focus group discussion (FGDs)/Small Group Discussion (SGDs) on selected topics.
- Field observations to capture status of Common Property Resources (CPRs) and private holdings.
- Relevant photographs/videos were taken in support of various kinds of data that has been collected.

c) Universe of the survey: It comprised of all the directly affected villages in the TRB and all HHs in the directly affected villages. Attempts were made to include, in the survey, a maximum number of villages falling within the 10 km radius of the HEPs.

d) Types of formats: Two types of formats were developed for the collection of the data: (i) Village level, and (ii) Household level.

Village level format: The parameters included were:

1) Administrative attributes of the village
2) Distance of the village from relevant locations
3) Type of village
4) Private land use pattern in the village
5) Demography and ethnic composition of the village

6) Literacy rate
7) Water sources in the village
8) Amenities in the village
9) Livestock holding
10) Traditional skills
11) Social institutions in the village
12) Dependence on river resources
13) Dependence on forest resources
14) Contribution of various occupations to the average annual village income
15) Average annual expenditure pattern of a family in the village
16) Sacred grooves and species
17) Occupational profile

Household level format: The attributes included were:

1) Name of the head of HH
2) Age; Gender
3) Ethnicity (ST/SC/Others)
4) Clan name
5) Demographic details of the family
6) Land holding pattern
7) Livestock holding
8) Traditional skills
9) Dependence on river resources
10) Dependence on forest resources
11) Water sources

e) Pre-testing of formats: The formats were pre-tested in a few villages of each of the two types of villages viz., influenced and affected. The inputs received were incorporated in the formats.

f) Capacity building of the research team: All the members of the research team were trained in various aspects of format filling, interview procedures, conduct of FGDs/SGDs, photographic documentation, and above all do's and don'ts especially focussing on respects for local cultures and people. This exercise was done in the field before the actual collection of data started.

g) Selection of villages and constrains in the field

- According to the data presented in Census of India 2011, TRB comprises 234 villages.
- In order to delineate the villages that will be impacted directly or indirectly, a 10 km radius was drawn from the power house/barrage axis, using satellite maps.
- Figure II. 3.8 shows that, in fact, all the villages of the TRB come under the influence zone of one or the other proposed HEPs.
- A careful examination of the locations and lifestyle of the various villages, and with consultation of key knowledgeable persons, it was seen that many villages had minimum dependence on the Tawang chu river resources. Therefore, these were excluded from the survey.
- Attempts were made to undertake baseline survey, among the remaining villages. However, a number of villages refused to participate in the survey due to various kinds of apprehensions about some of the proposed projects.
- Survey in some villages was also not possible due to repeated request for postponement of survey by the villagers, citing reasons of village household (HH) heads not being available. But, these could not always be complied with, in view of report submission deadlines.
- In Table II. 3.3 below are given the names and other details of all the villages included in the survey. It may be noted that many villages will be impacted by more than one HEP.

- As seen in the Table II. 3.3, the total numbers of HHs surveyed are 1917. From the Census of India 2011 data, it may be noted that the total number of HHs in Tawang district is 9477. Thus, 20.23% of HHs of the TRB have been covered in the survey. Altogether, field visits were made to 59 villages (25.21% villages of TRB) across the TRB. However, despite sustained efforts, villagers of 13 villages declined to participate in the survey (Table II. 3.4). Thus the total number of villages where both village and HH surveys were conducted reduced to 46. As noted earlier, there are 234 villages in TRB. The number of villages surveyed thus represents 19.66% of TRB villages. It may be noted that in addition to 46 villages, village level data could also be gathered for another nine villages. Thus village level data was available for 55 villages (23.5% of the villages in TRB). The village level data for 55 villages was used to develop cumulative socio-economic impacts.

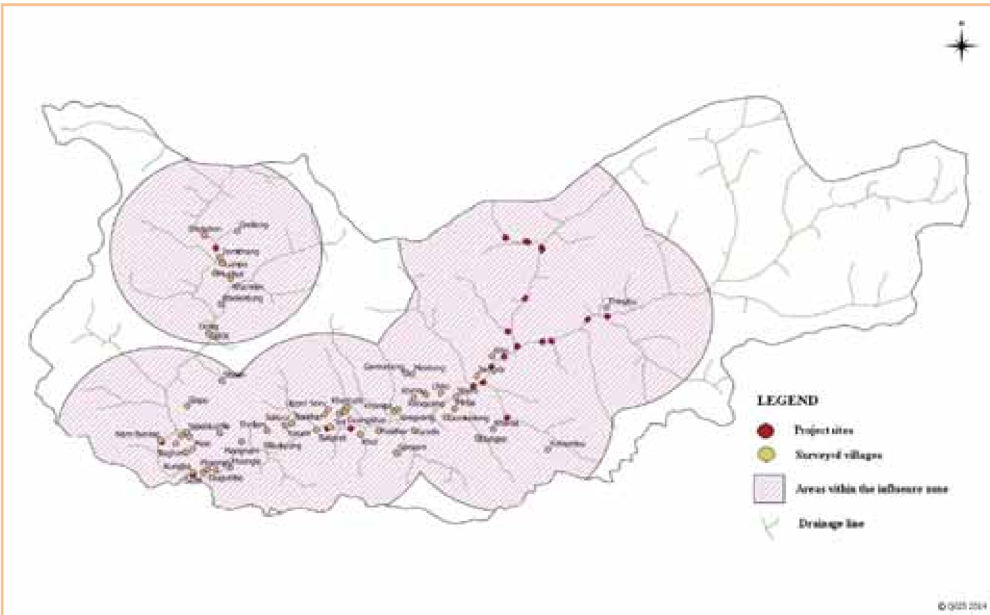


Figure II. 3.8: Name and location of surveyed villages in different hydropower projects sites of TRB

Table II. 3.3: List of surveyed villages in different hydropower projects sites of TRB

Sl. No.	Name of the village	Circle HQ	No. of HH covered
1	Nam Tsering	Dudunghar	52
2	Dungse	Jang	36
3	Yuthembu	Jang	98
4	Kharsa	Jang	107
5	Gemreteng	Lhau	9
6	Jangda	Lhau	99
7	Khamba	Lhau	36
8	Kregyang	Lhau	18
9	Menteng	Lhau	3
10	Rengyang	Lhau	26
11	Shyaro	Lhau	56
12	Baghar	Lumla	59
13	Dugumba	Lumla	15
14	Hoongla	Lumla	56
15	Kharteng	Lumla	107
16	Lumla	Lumla	57
17	Pharmey	Lumla	33
18	Phomang	Lumla	25
19	Poito	Lumla	22
20	Sazo	Lumla	45
21	Sherbang	Lumla	40
22	Thrillam	Lumla	35
23	Gomkelleng	Mukto	36
24	Mirba	Mukto	40
25	Gomkang	Tawang	12
26	Gyada	Tawang	11
27	Gyangkhar	Tawang	65

28	Khartuth	Tawang	28
29	Kudung	Tawang	33
30	Seru	Tawang	106
31	Teli	Tawang	35
32	Tsaikhar	Tawang	34
33	Yusum	Tawang	50
34	Thingbu	Thingbu	52
35	Rho	Thingbu	85
36	Dung	Zimithang	8
37	Gorsam	Zimithang	23
38	Kharman	Zimithang	44
39	Khelentung	Zimithang	35
40	Lumpo	Zimithang	49
41	Muchut	Zimithang	33
42	Zemithang	Zimithang	28
43	Brokenthang	Zimithang	15
44	BTK	Zimithang	24
45	Maio	Lumla	23
46	Yabab	Lumla	14
Total	**46**	**9**	**1917**

Table II. 3.4: List of surveyed villages who declined to participate in the socio-economic survey in TRB

Sl. No.	Name of the village	Circle HQ
1	Khirmu	Kitpi
2	Grelleng	Lhau
3	Lhau	Lhau
4	Buikyong	Lumla
5	Kungba	Lumla
6	Mangnam	Lumla
7	Sakyur	Lumla
8	Gispu	Lumla
9	Khet	Mukto
10	Paidhar	Tawang
11	Sakpret	Tawang
12	Shoksten	Zimithang
13	Shakti	Zimithang

h) Methods used in estimating monetary value of various resources

Selling price of domestic animals: After consultations with the Brokpa community in several villages, it was learned that there were standard rates for the different domesticated animal in Tawang district. These rates have been used to estimate the livestock asset of the surveyed villages. The selling price of different animals is given in Table II. 3.5.

Table II. 3.5: Selling price of different animals in surveyed villages

Animal	Selling price/animal (in Rupees)	
Mithun	40,000	
Cow	20,000	Average 25,000
Tzomu	30,000	
Goat	5,000	
Sheep	6,000	
Poultry	500	
Pig	25,000	
Pony	23,000	
Yak	25,000	
Others	15,000	

i) Estimation of village annual income: The methods used in estimating annual village income are described below.

- *Agriculture/Horticulture:* Out of the total agricultural/horticultural land holding, approximately, less than half is used for cultivation. The value of the produce per hectare is estimated as Rs. 20,000.

- *Animal Husbandry:* A major source of income of the villagers is animal husbandry. It is observed that at a given time about 40-50% of the milch animals yield milk. After detailed discussion carried out with the villagers, it was inferred that in a village an income of about Rs. 6,000 per animal per month is generated for about 9 months a year from the milch animals. Other animals like goat, sheep, pig, etc. are reared for meat. Accordingly, an estimate of total village income from animal husbandry has been made.

- *Traditional skills:* Those practicing weaving and other traditional skills contribute about Rs. 1.5 lakh/year.

- *Government service:* On an average, those employed as government servants earn Rs. 10,000/month.

- *Other sources of livelihood:* Other sources that contribute to the total village income are by artisans, self employed, contractors, businessmen, those gathering river resources (in particular sand and stone), Non-Timber Forest Produce (NTFP) etc.

Presentation of results of baseline socio-economic survey: The project-wise details of the socio-economic data gathered have been described individually in the following sections. The data has been described under two categories: (i) Village level profile, and (ii) HH level profile.

3.2.17 Cultural Analysis

The projects affecting the cultural life of the people were evaluated based on the following parameters:

i) Death ritual: In Monpa tribe, the dead body is disposed either by throwing it into the river after cutting it into pieces, or by burning, or by burying, or by keeping it in an isolated cave in the forest. However, the disposal in the river is the most common practice. Thus it necessitates a minimum level of water flow in the river.

ii) Place of worship: This includes the places of worships such as Gompas, and the places having religious connections e.g., origin of river Tsa chu through 108 holes located in the upstream of the proposed Tsa chu-I project site i.e. *Chumbi Gyatsar*.

iii) Totem worship: Birds or other animals having religious importance need to be conserved. Their habitats obviously would have cultural importance e.g., habitats of black neck crane in Nyamjang chu basin.

3.3 BASELINE DATA

The baseline data for all the 13 projects in TRB are provided in the following paragraphs.

3.3.1 TSA CHU-I

3.3.1.1 PHYSICAL ENVIRONMENT

Geomorphology

The project is located in sub–alpine zone of Himalayas. The river basin is narrow surrounded by steep to very steep slopes (Figure II. 3.9).

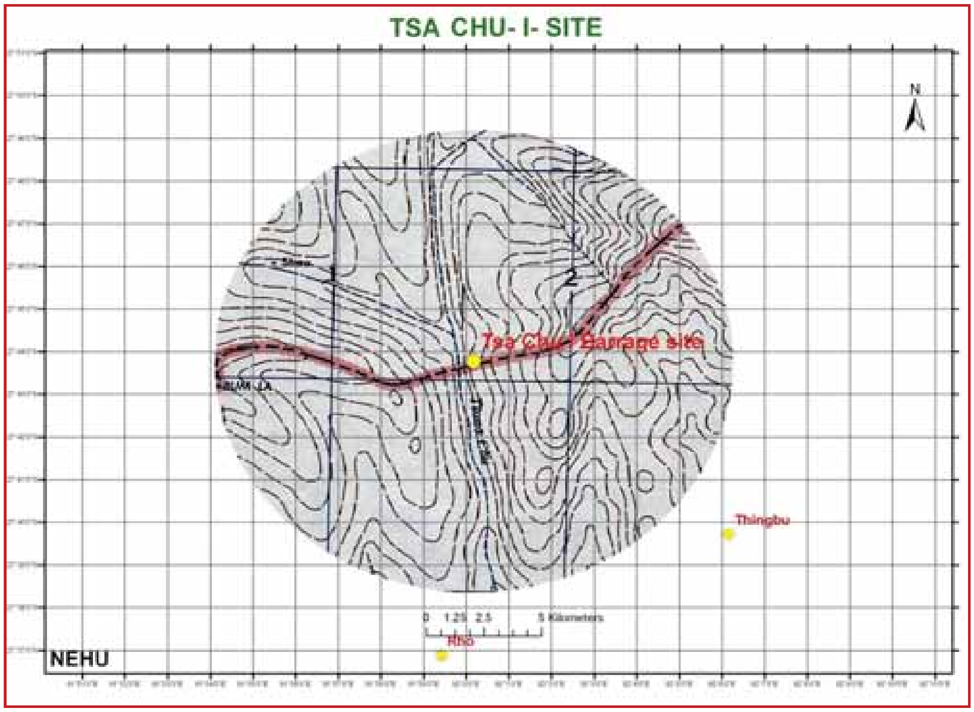


Figure II. 3.9: Contour map of Tsa chu–I HEP

Geology

Tsa chu–I project is located on calc. gneisses with pelitic schist here and there. Structurally the area is highly disturbed and the drainage is cutting perpendicular to the hill slope. Seismically it is active because of its nearness to the main central thrust (Figures II. 3.10 and 3.11). The area under various geological classes at barrage and powerhouse sites of Tsa chu–I HEP is presented in Table II. 3.6.

Table II. 3.6: Area under various geological classes in Tsa chu–I at barrage and powerhouse sites

Class	Barrage		Powerhouse	
	Area	%	Area	%
Snow covered area	32.37	15.62	19.19	8.96
Snow covered area	0.23	0.11	0.22	0.10
Snow covered area	44.55	21.50	57.52	26.87
Sela group (Structural hill)	48.20	23.26	47.55	22.21
Glacier	0.18	0.08	2.62	1.22
Glacier			0.17	0.08
Sela group (Structural hill)	0.04	0.02		
Volcanic sediment (valley)	0.66	0.32	0.62	0.29
Volcanic sediment (Structural hill)	79.07	38.16	79.00	36.91
Volcanic sediment (Structural hill)	1.91	0.92	7.17	3.35
Total	**207.20**	**100.00**	**214.04**	**100.00**

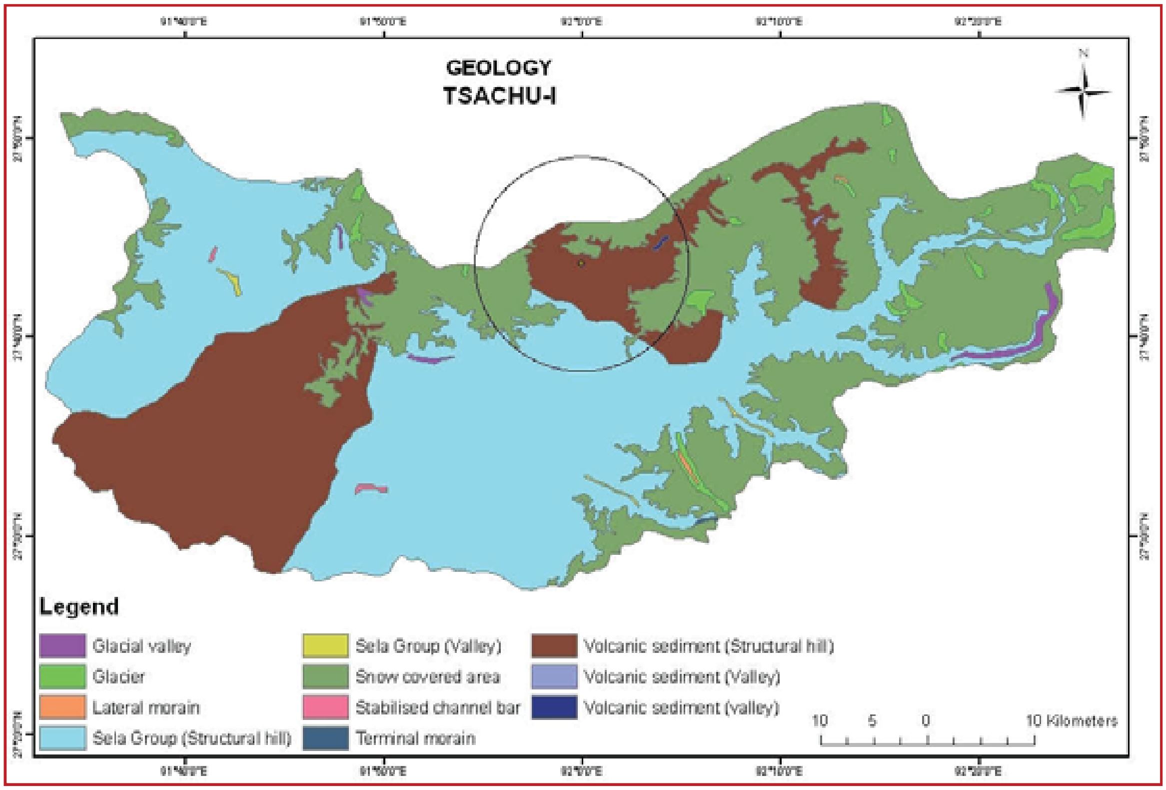


Figure II. 3.10: Geological map of TRB showing location of Tsa chu–I project site

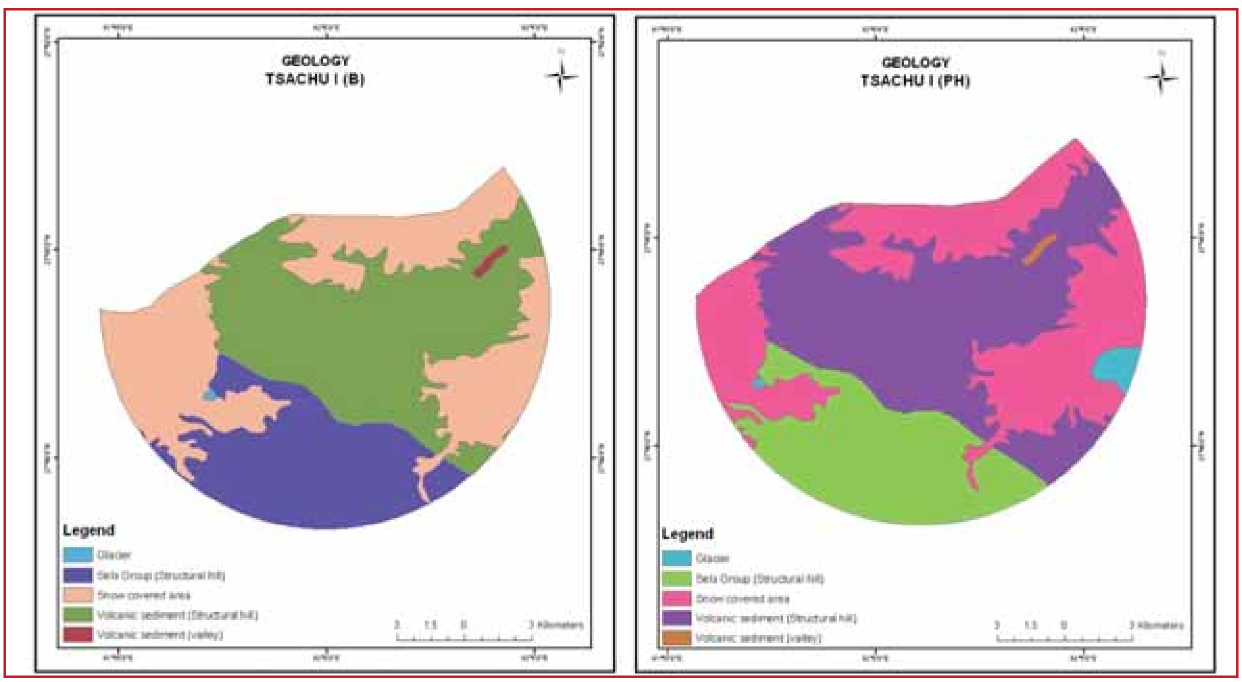


Figure II. 3.11: Geological map of Impact zone (10 km radius) of Tsa chu–I barrage and powerhouse site in Tawang river valley

Landuse and Land Cover

The total area within 10 km radius of Tsa chu-I HEP site is 24856.71 ha. Substantial areas of this 10 km radius falls in the Chinese territory (Figure II.3.12). Majority of the area is covered by scrubland which occupies about 47.51% (11809.7 ha) of the total area, followed by forest land which accounts for 35.18%. Grassland covers 7.0875 ha which is only 0.03% of the total project area followed by cropland which occupies only 7.3125 ha (0.03%). Waterbody constitutes around 12.94% of the total area. The total area occupied by snow and ice, and other builtup area constitutes 4.32% (Table II. 3.7).

Table II. 3.7: Landuse/land cover area of Tsa chu–I project site

Land category	Area (ha)	%
Forest	8744.22	35.18
Scrubland	11809.7	47.51
Waterbody	3215.52	12.94
Croplands	7.3125	0.03
Grasslands	7.0875	0.03
Builtup area	32.265	0.13
Snow and Ice	1040.6	4.19
Total	**24856.71**	**100.0**

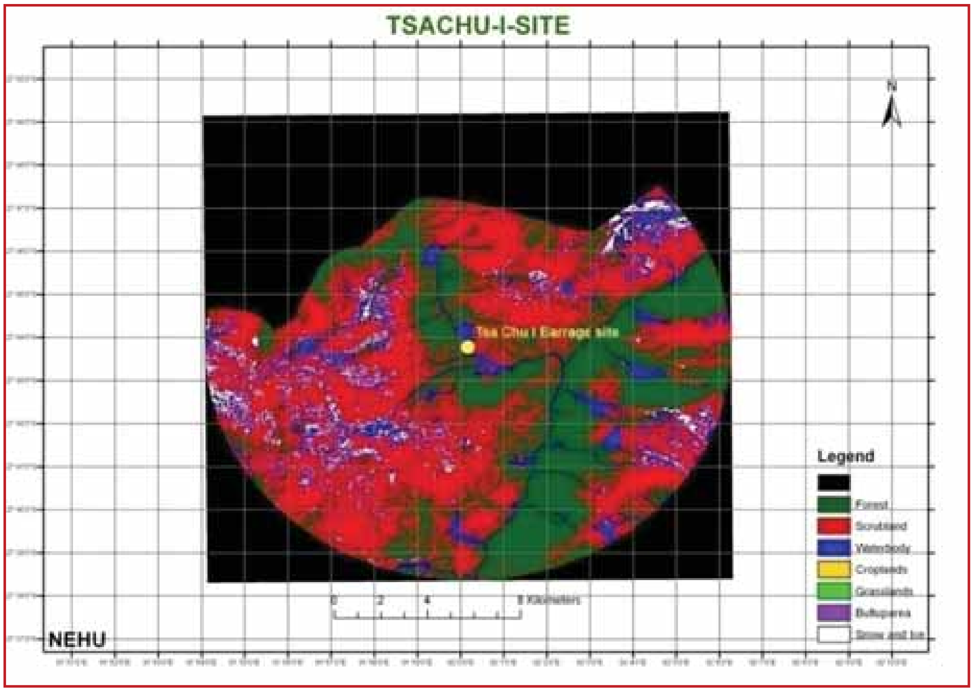


Figure II. 3.12: Landuse/land cover of Tsa chu–I project site

Soil

Soil at this site was sandy clay, acidic with high water holding capacity but poor in available phosphorus and organic carbon content (Table II. 3.8). NH_4^+–N, NO_3^-–N, and Ex. K concentrations were relatively higher than other sites in TRB (Table II. 3.9).

Table II. 3.8: Soil physical properties at Tsa chu–I site

Site	Texture	WHC (%)	Bulk density (g/cm³)	Porosity (%)
Barrage	Sandy clay	62.25	1.37	39.62
Powerhouse	Sandy clay	58.68	1.37	36.60

Table II. 3.9: Seasonal variation in soil physico–chemical properties at Tsa chu–I site

Parameters	Post–monsoon		Monsoon		Winter		Mean	
	B	PH	B	PH	B	PH	B	PH
SMC (%)	30	25	35	30.5	20	15	28	24
pH	5.2	5.4	5.5	5.5	5.1	4.7	5.3	5.2
Conductivity ($\mu S\ cm^{-1}$)	121	118	178	176	109	102	136	132
NH_4^+–N ($\mu g\ g^{-1}$)	330	320	34	330	300	300	323	317
NO_3^-–N($\mu g\ g^{-1}$)	41	51	53	54	32	32	42	46
TKN ($\mu g\ g^{-1}$) x10^3	0.900	0.890	1.200	1.170	0.760	0.770	0.950	0.940
Av.P ($\mu g\ g^{-1}$)	0.024	0.019	0.120	0.150	0.030	0.020	0.060	0.060
TP (%)	0.120	0.090	0.170	0.120	0.100	0.070	0.130	0.090
SOC (%)	0.008	0.007	0.009	0.008	0.006	0.005	0.010	0.010
Ex. K ($\mu g\ g^{-1}$)	501	753	639	802	398	489	513	681
Ex. Mg (%)	0.028	0.027	0.033	0.030	0.015	0.012	0.030	0.020
Ex. Ca (%)	0.269	0.268	0.290	0.285	0.176	0.172	0.250	0.240
Soil microbial biomass–C ($\mu g\ g^{-1}$)	24	22	17	14	23	23	21	20
Soil microbial biomass–N ($\mu g\ g^{-1}$)	13.0	15.0	9.5	10.7	17.2	16.5	13.2	14.1

(Note: Post–monsoon–October, Monsoon–July, Winter–December); B = Barrage, PH = Powerhouse

Soil Erosion Vulnerability

In the barrage site, out of a total area of 207.20 sq.km in Indian territory within the 10 km radius, 4.33% of soil erosion vulnerable areas fall under moderately high risk zone, 23.34% and 41.77% of the total area fall under low and moderately low vulnerable zones, respectively. The vulnerable area of soil erosion under moderate category was 30.57% (Table II. 3.10).

In the powerhouse site, out of the total area of 314.16 sq.km, only 0.02% area falls under high soil erosion vulnerable zone, and 4.73% falls under moderately high vulnerable zone. Only 18.93% of the total area is covered under low vulnerable zone, and 44.03% falls under moderately-low vulnerable zone. The soil erosion vulnerable area under moderate category covered about 32.29% of the total area. The spatial distribution map of soil erosion vulnerable areas under barrage and powerhouse sites of Tsa chu-I is given in Figure II. 3.13.

Table II. 3.10: Area under various soil erosion vulnerable zones in Tsa chu-I at barrage and powerhouse sites

Vulnerability	Barrage		Powerhouse	
	Area (sq. km)	**%**	**Area (sq. km)**	**%**
High	0.00	0.00	0.03	0.02
Moderately high	8.97	4.33	10.13	4.73
Moderate	63.34	30.57	69.12	32.29
Moderately low	86.54	41.77	94.24	44.03
Low	48.35	23.34	40.51	18.93
Total	**207.20**	**100.00**	**214.04**	**100.00**

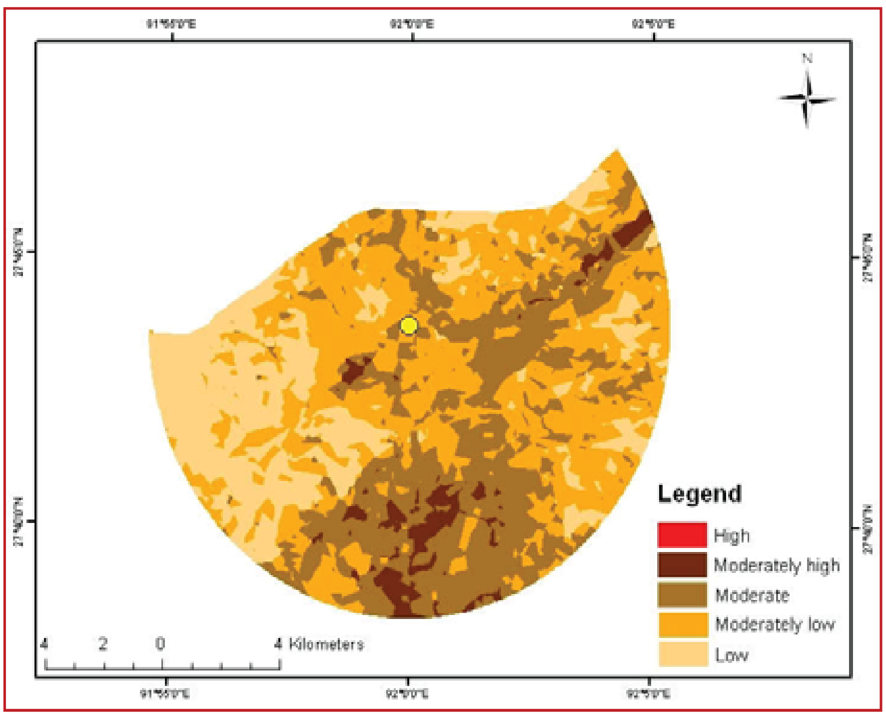


Figure II. 3.13: Spatial distribution of soil erosion vulnerable areas in Tsa chu–I at barrage site

Landslide and Erosion Vulnerability

The areas vulnerable to both landslide and erosion were worked out. The area under different landslide and erosion vulnerability classes in the barrage and powerhouse sites of Tsa chu–I is given in Table II. 3.11. In the barrage site, out of the total area of 207.2 sq.km, the low and moderately high vulnerable categories covered only 2.55% and 2.52% of the total area, respectively, and about 43.53% of the total area falls under moderate zone of vulnerability. The highest area of vulnerability falls under moderately low category which covers about 51.39% of the total area. Similarly, at powerhouse site, out of the total area of 214.04 sq.km, only 1.48% and 2.36% of the total area were covered under low and moderately high vulnerable categories, respectively, and about 41.65% of the total area falls under moderate zone of vulnerability. The highest area of vulnerability falls under moderately low zone which covers about 54.51% of the total area. The spatial distribution map of landslide and erosion vulnerability areas under barrage and powerhouse site of Tsa chu–I is given in Figure II.3.14.

Table II. 3.11: Area under various landslide and erosion vulnerability classes in Tsa chu–I at barrage and powerhouse site

Vulnerability	Barrage		Powerhouse	
	Area (sq.km)	**%**	**Area (sq.km)**	**%**
High	0.0	0.0	0.0	0.0
Moderately high	5.23	2.52	5.05	2.36
Moderate	90.20	43.53	89.15	41.65
Moderately low	106.49	51.39	116.66	54.51
Low	5.29	2.55	3.18	1.48
Total	**207.20**	**100.00**	**214.04**	**100.00**

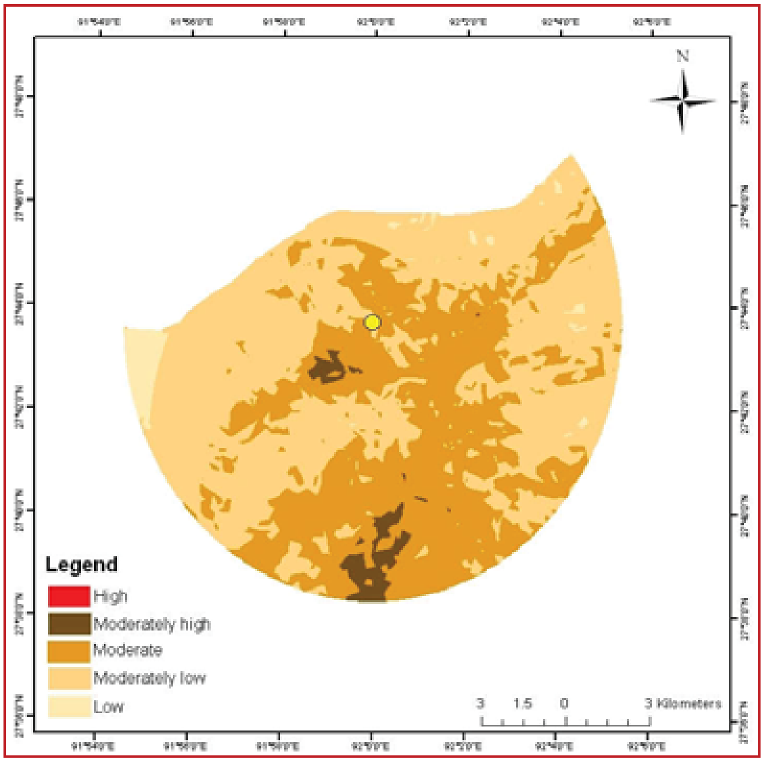


Figure II. 3.14: Area under various erosion and landslide vulnerability classes in Tsa chu–I at barrage site

Water

Seasonality was not prominent in the river water quality at Tsa chu-I site as indicated by several parameters, except temperature. Nine parameters out of the 20 analysed, showed peak during the monsoon season. Primary productivity and coliform count were high during this season compared to other two seasons. Total dissolved solids and electrical conductivity were much higher during post-monsoon compared to monsoon and winter seasons. DO and alkalinity were highest during winter. Concentrations of total Kjeldhal nitrogen (TKN), ammonium nitrogen (NH_4^+–N) and sodium (Na^+) were highest in the monsoon season as compared to the other seasons. Potassium (K^+), total phosphorus, and nitrate nitrogen concentration were highest during post-monsoon period (Table II. 3.12).

Table II. 3.12: Seasonal variation in physico-chemical and biological properties of water and river primary productivity at Tsa chu-I site

Parameters	Post-monsoon			Monsoon			Winter		
	B	**PH**	**Mean**	**B**	**PH**	**Mean**	**B**	**PH**	**Mean**
Temperature (˚C)	9.70	10.40	10.05	14.70	15.50	15.10	4.10	4.80	4.45
Turbidity (NTU)	0.59	0.62	0.60	0.50	0.57	0.53	0.55	0.58	0.57
pH	7.22	7.42	7.32	8.08	8.05	8.07	7.77	7.78	7.78
Electrical conductivity (µS/cm)	207	218.00	213	156	167.50	162	188	194.00	191
Total dissolved solids (mg/l)	103	108.50	105.75	81	86.50	83.75	97	100.00	98.50
Practical salinity (ppt)	0.12	0.12	0.12	0.09	0.10	0.10	0.11	0.11	0.11
Total alkalinity (mg $CaCO_3$/l)	32	34.00	33.00	28	30.00	29.00	44	48.00	46.00

Total hardness (mg/l)	25	25.85	25.48	38	38.84	38.65	40	42.26	41.21
Chloride (mg Cl^{-}/l)	10.99	11.17	11.08	12.99	12.99	12.99	5.99	5.99	5.99
Ca^{2+} (mg/l)	6.03	6.04	6.03	9.69	9.74	9.71	10.10	10.70	10.40
Mg^{2+}(mg/l)	2.44	2.62	2.53	3.46	3.53	3.49	3.63	3.78	3.70
K^{+} ppm	0.80	0.95	0.88	0.50	0.60	0.55	0.50	0.50	0.50
Na^{+} ppm	11.10	11.20	11.15	11.40	11.70	11.55	10.80	10.80	10.80
TKN (mg/l)	0.42	0.43	0.43	0.56	0.57	0.57	0.38	0.38	0.38
NH_4^{+} N (mg/l)	0.05	0.05	0.05	0.08	0.08	0.08	0.06	0.06	0.06
NO_3–N (mg/l)	0.35	0.35	0.35	0.12	0.13	0.13	0.16	0.18	0.17
Total phosphorus (mg/l)	0.10	0.10	0.10	0.08	0.08	0.08	0.06	0.06	0.06
GPP (mg C/cm^3/h)	0.42	0.36	0.39	0.39	0.43	0.41	0.21	0.21	0.21
NPP (mg C/cm^3/h)	0.10	0.10	0.10	0.23	0.27	0.25	0.10	0.10	0.10
Dissolved oxygen (mg/l)	11.70	11.65	11.68	10.20	10.05	10.13	12.60	12.40	12.50
Total coliforms (CFU/ml)	15	20.00	17.50	17	24.00	20.50	8	9.00	8.50

B: Barrage; PH: Powerhouse

Ambient Ambient Air Quality

Concentration of PM_{10} and $PM_{2.5}$: PM_{10} concentration at proposed Tsa chu–I site was 10.4 µg/m^3 while $PM_{2.5}$ concentration was below detectable limit (Table II. 3.13). The concentration of sulphur–dioxide (SO_2), nitrogen–dioxide (NO_2), ammonia (NH_3) and ground level ozone (O_3) at all the monitored locations were below detectable limits.

Table II. 3.13: Concentration of PM_{10} and $PM_{2.5}$ in ambient air at proposed Tsa chu–I HEP

Sampling location	Nearest project site covered	PM_{10} (µg/m^3)	$PM_{2.5}$ (µg/m^3)
Tsa chu–I	Tsa chu–I barrage site Tsa chu–I powerhouse site	10.4	BDL

Meteorological variables for Tsa chu–I HEP could be measured only at Tsa chu location (Table II. 3.14).

Table II. 3.14: Meteorological condition at proposed Tsa chu–I HEP

Sampling location	Nearest project component covered	Ambient temperature (°C) Min	Ambient temperature (°C) Max	Relative humidity (%)	Wind speed (range in km/hr)	Wind direction
Tsa chu–I	Tsa chu–I barrage site Tsa chu–I powerhouse site	02	06	42	1.8–2.5	SE

Noise Level: Noise level at barrage site of proposed Tsa chu–I HEP was 43.1 dBA at 4.00 PM and 44.6 dBA at 8.00 AM (Table II. 3.15).

Table II. 3.15: Noise level at proposed Tsa chu–I HEP

Sampling location	Nearest project site covered	Noise level (dBA) 8.00 AM	Noise level (dBA) 4.00 PM
Tsa chu–I	Tsa chu–I barrage site Tsa chu–I powerhouse site	44.6	43.1

3.3.1.2 BIOLOGICAL ENVIRONMENT

Vegetation Types

The project components of Tsa chu-I HEP are located in sub-alpine forest area. However, within 10 km radius of the proposed project, alpine rhododendron scrubs, and alpine pastures are also present.

14/C2 East Himalayan sub-alpine birch/fir forest (3500-4000 m): These are forests which occur in the Eastern Himalaya between 3500 and 4000 m. The important tree species are: *Abies densa, Juniperus* sp., *Larix griffithii, Betula utilis* etc. and small trees like those of *Rhododendron wightii, Salix* sp., etc. The dominant shrubs are: *Rosa* sp., *Berberis* sp., *Spirea* sp. etc. The herbaceous layer is comprised of *Polygonum* sp., *Potentilla* sp., *Primula* sp., *Fragaria* sp. etc.

14/DSI Sub-alpine pastures (3000-4000 m): The sub-alpine pastures are dominated by *Gentiana*, *Primula* and members of Asteraceae and Ranunculaceae.

15/CI Birch-rhododendron alpine scrub forest (4000-5500 m): In the Eastern Himalaya, this type forms a low evergreen forest with the species of *Rhododendron* and birch (*Betula utilis*). The dense scrub forest is difficult to penetrate. Moss and fern cover the ground with alpine shrubs such as *Sorbus, Viburnum, Gaultheria trichophylla, Rhododendron lepidotum, R. nivale,* and flowering herbs like *Primula, Corydalis, Meconopsis* etc.

15/C3 Alpine pastures (4000-5500 m): The alpine meadows mostly harbour perennial mesophytic herbs, with little representation of grass species. Conspicuous among the herbs are: *Primula*, *Anemone, Fritillaria*, *Iris,* and *Gentiana*. Many members of Ranunculaceae, cruciferae, Caryophyllaceae, and Asteraceae are also present. This alpine pasture has a short snow free period.

15/E2 Moist alpine dwarf Juniper scrub (4000-4250 m): These types of forests are dominated by *Juniperus communis* and *Juniperus wallichiana* at around 4000-4250 m. Beyond this elevation range, at 4300-4900 m elevation *Juniperus recurva* replaces *Juniperus wallichiana.*

Plant Diversity

The survey conducted at Tsa chu-I HEP sites resulted in the documentation of 83 plant species belonging to different groups at barrage and powerhouse sites, and catchment area. A complete list of plant species found in the study area representing different groups such as tree, shrub, herb, climbers, orchids, pteridophytes, bryophytes, lichens and fungi along with the family names is given in Appendix II.3.1 The number of plant species belonging to different groups is summarized in Table II. 3.16.

Table II. 3.16: Different groups of plant species present at Tsa chu-I HEP site

<table>
<tr><th rowspan="2">Sl. No.</th><th rowspan="2">Groups</th><th colspan="3">Number of species</th></tr>
<tr><th>Barrage site</th><th>Powerhouse site</th><th>Catchment area</th></tr>
<tr><td>1</td><td>Tree</td><td>6</td><td>6</td><td>6</td></tr>
<tr><td>2</td><td>Shrub</td><td>7</td><td>7</td><td>6</td></tr>
<tr><td>3</td><td>Herb</td><td>30</td><td>29</td><td>29</td></tr>
<tr><td>4</td><td>Climbers</td><td colspan="2">3</td><td>2</td></tr>
<tr><td>5</td><td>Orchids</td><td colspan="2">1</td><td>1</td></tr>
<tr><td>6</td><td>Pteridophytes</td><td colspan="2">9</td><td>5</td></tr>
<tr><td>7</td><td>Bryophytes</td><td colspan="2">4</td><td>4</td></tr>
<tr><td>8</td><td>Lichens</td><td colspan="2">5</td><td>4</td></tr>
<tr><td>9</td><td>Fungi</td><td>14</td><td>10</td><td>16</td></tr>
</table>

A large number of non-vascular epiphytes such as lichens, a variety of mosses and ferns cover large space on the bark of the trees with roots suspended in the air. At the barrage site, 6 tree, 7 shrub, and 30 herb species were recorded, and at the powerhouse site, 6 tree, 7 shrub, and 29 herb species were documented. From the project catchment area, 6 tree, 6 shrub, and 29 herb species were recorded. A total of 3 climber, 1 orchid, 9 pteridophyte, 4 bryophyte, 5 lichen and 14 fungus species were recorded from barrage and powerhouse sites. From the catchment area, 2 climber, 1 orchid, 5 pteridophyte, 4 bryophyte, 4 lichen, and 16 fungus species were recorded (Appendix II.3.2 and II.3.3).

Threatened and Endemic plant Species

During the survey, no threatened plant species was recorded at any of the HEP sites.

Economically Important Species/Plant Resources

The study area is rich in plant resources. A few of the important ones are listed in Table II. 3.17 under different resource groups.

Table II. 3.17: Economically important species/plant resources present at Tsa Chu-I HEP site

Sl. No.	Uses	Species name
1	Timber	*Abies densa, Larix griffithii*
2	Fuel	*Rhododendron* sp., *Abies densa*
3	Ornamentals and orchids	*Rhododendron* sp., *Primula* sp., *Satyrium* sp., *Begonia* sp., *Salix* sp.
4	Medicine and aromatics	*Panax* sp., *Aconitum* sp.

Vegetation Analysis for Angiosperms and Gymnosperms

The plant communities around Tsa chu-I including barrage and powerhouse sites, and catchment area were studied. At the study site, very low species richness was observed. It had 6 tree species, 7 shrub species, and 30 herbaceous species (Tables II. 3.18 and 3.19).

Table II. 3.18: Tree and shrub species recorded at barrage and powerhouse sites, and in catchment area of Tsa Chu-I

Trees	Shrub
Abies densa	*Berberis* sp.
Acer sp.	*Daphne papyracea*
Betula utilis	*Eleagnus parviflora*
Junipers sp.	*Pogostemon* sp.
Larix griffithiana	*Rosa* sp.
Rhododendron sp.	*Rubus ellipticus*
	Salix sp.

Table II. 3.19: Herbaceous species recorded at barrage and powerhouse sites, and in catchment area of Tsa Chu-I

Herbs		
Aconogonum alpinum	*Impatients* sp.	*Primula denticulata*
Ainsliaea sp.	*Leontopodium Stracheyi*	*Primula* sp.
Arisaema nepenthoides	*Meconopsis* sp.	*Prunella vulgaris*
Elsholtzia strolifera	*Panax bipinnatifidus*	*Rannunculus* sp.
Fragaria sp.	*Persicaria* sp.	*Rumex nepalensis*
Galinsoga parviflora	*Pilea umbrosa*	*Sambacus adnata*
Galium sp.	*Pogostemon* sp.	*Senecio cappa*
Gentiana capitata	*Polygonum hydropiper*	*Stellaria* sp.
Geranium nepalensis	*Potentilla cuneata*	*Swertia* sp.
Hemiphragma heterophyllum	*Pouzolzia* sp.	*Viola sikkimensis*

In general, species richness was high during monsoon season and low during winter season. Dominance of trees determined on the basis of importance value index is given in the Appendix II.3.4, II 3.7 and II.3.10. *Abies densa* was the dominant tree species at the barrage site, powerhouse site, and in the catchment area. Among shrubs, *Rosa* sp. was dominant at all the three sites. In case of shrubs and herbaceous species, dominance was determined on the basis of density only. The herbaceous community being mostly annual in nature, at a given site, different species were dominant in three different seasons.

The highest density of trees was recorded in the catchment area, while that for shrubs was at the powerhouse site (Appendix II. 3.5, 3.8 and 3.11). Density of herbaceous species varied widely among barrage site, powerhouse site, and catchment area. It was maximum during monsoon season and minimum during winter season at all the sites (Appendix II. 3.6, II.3.9 and II. 3.12).

Shannon diversity index for tree species in the community was highest in the catchment area (H'=1.71) followed in decreasing order by powerhouse site (H'=1.69) and barrage site (H'=1.64). For shrub species highest value was obtained at powerhouse site (H'=1.82) followed by barrage site (H'=1.78) and catchment area (H'=1.67) (Table II. 3.20 and 3.21).

Shannon diversity index for herbs ranged from 1.78-3.25. The highest value was recorded in the catchment area during monsoon season and lowest in powerhouse site during winter season. Overall, species diversity was highest in the catchment area.

Table II. 3.20: Species richness, diversity and dominance of trees and shrubs, and biomass and carbon stock of trees in the community at Tsa chu-I

Parameters	Barrage		Powerhouse		Catchment area	
	Tree	Shrub	Tree	Shrub	Tree	Shrub
Number of species	6	7	6	7	6	6
Density (ha^{-1})	470	1008	470	1056	590	976
Simpson index of dominance	0.22	0.80	0.2	0.81	0.2	0.79
Shannon index of diversity (H’)	1.64	1.78	1.69	1.82	1.71	1.67
Evenness index	0.92	0.85	0.94	0.88	0.96	0.89
Biomass (t/ha)	23.25		55.68		109.33	
Carbon (t/ha)	11.625		27.84		54.665	

Table II. 3.21: Species richness, diversity and dominance in herbaceous community at Tsa chu-I

Parameters	Barrage			Powerhouse			Catchment area		
	PM	M	W	PM	M	W	PM	M	W
Number of species	17	30	8	14	25	8	17	30	8
Density (ha^{-1})x10^3	92.4	186.4	48.4	81.2	162.8	51.6	92.4	198.4	48
Simpson index of dominance	0.92	0.95	0.79	0.91	0.94	0.78	0.92	0.95	0.80
Shannon index of diversity (H’)	2.70	3.23	1.82	2.51	3.03	1.78	2.68	3.25	1.86
Evenness index	0.88	0.84	0.77	0.88	0.83	0.74	0.86	0.85	0.80

PM: Post monsoon; M: Monsoon; W: winter

Phytoplankton/Periphyton

Eleven species of phytoplankton/periphyton were recorded from Tsa chu-I. The community was represented by 10 species of Bacillariophyceae and one species of Chlorophyceae. Species richness was highest at the project affected sites (barrage and powerhouse sites on the river) with 11 species and minimum of 5 species in the catchment area (upstream of barrage site). Phytoplankton/periphyton density was highest at the project affected sites (90 individuals/l) and lowest in the catchment area (35 individuals/l). Similarly, species diversity index was maximum (H’=2.05) at the project affected sites and minimum (H’=1.54) in the catchment area (Table II. 3.22).

Table II. 3.22: Density (Individuals/l), species richness and Shannon index of diversity (H’) of phytoplankton communities in river water at Project affected sites and in the catchment area of Tsa chu-I

List of species	Project affected area	Catchment area
Bacillariophyceae		
Achnanthidium rivulare	5	5
Amphora sp.	10	
Caloneis ventricosa	5	
Cymbella tumida	15	5
Encyonema minutum	10	10
Fragillaria sp.		5
Gomphonema olivaceoides	10	
Rhoicosphaenia sp.	10	
Synedra ulna		10
Thallassiosira sp.	10	
Chlorophyceae		
Spirogyra sp.	15	
Total density (Individuals/l)	**90**	**35**
Species diversity index	**2.05**	**1.54**
Species richness	**9**	**5**

NB: Blank cells indicate absence of phytoplankton species

Zooplankton

Study was conducted in two seasons in Tsa chu-I area, in which only 1 species, viz., *Alona affinis* from Cladocera and 3 species viz., *Keratella serrulata, Lecane closterocerca* and *Lecane flexilis* of Rotifera were recorded during monsoon period (Table II. 3.23). *Keratella serrulata,* a rare zooplankton species was recorded from the barrage site.

Table II. 3.23: Occurrence of species belonging to Cladocera and Rotifera during monsoon and winter seasons at Tsa chu-I site

Sl. No.	Taxa	Species	Season	
			Monsoon	Winter
1	Cladocera	*Alona affinis* (Leydig, 1860)	+	–
2	Rotifera	*Keratella serrulata* (Ehrenberg, 1838) *	+	–
3	Rotifera	*Lecane closterocerca* (Schmarda, 1859)	+	–
4	Rotifera	*Lecane flexilis* (Gosse, 1886)	+	–
Total	**2**	**4**	**4**	**0**

*Rare

Fish Fauna

No fish species could be located from Tsa chu-I project sites.

Soil Fauna

The seasonal variation in soil faunal diversity (Collembola, Acarina and other arthropods) and eveness in litter and soil layer is shown in Tables II. 3.24-3.26.

Table II. 3.24: Seasonal variation of soil faunal (Collembola, Acarina and other arthropods) diversity and equitability in litter and soil layer at Tsa chu-I site

Soil fauna	Diversity	Post-monsoon				Monsoon				Winter			
		Barrage		Powerhouse		Barrage		Powerhouse		Barrage		Powerhouse	
		Litter	Soil	Litter	Soil	Litter	Soil	Litter	Soil	Litter	Soil	Litter	Soil
Collembola	Dominance_D	0.22	0.28	0.16	0.22	0.13	0.22	0.14	0.16	0.25	1.00	0.50	0.33
	Shannon_H	1.56	1.33	1.91	1.56	2.05	1.56	2.08	1.89	1.39	0.00	0.69	1.10
	Evenness_e^H/S	0.95	0.95	0.96	0.95	0.97	0.95	0.89	0.94	1.00	1.00	1.00	1.00
Acarina	Dominance_D	0.22	0.28	0.16	0.22	0.13	0.22	0.14	0.16	0.25	1.00	0.50	0.33
	Shannon_H	1.56	1.33	1.91	1.56	2.05	1.56	2.08	1.89	1.39	0.00	0.69	1.10
	Evenness_e^H/S	0.95	0.95	0.96	0.95	0.97	0.95	0.89	0.94	1.00	1.00	1.00	1.00
Other Arthropods	Dominance_D	0.18	0.16	0.13	0.25	0.12	0.10	0.17	0.14	0.33	0.25	0.50	0.20
	Shannon_H	1.75	1.89	2.12	1.39	2.15	2.33	1.85	2.03	1.10	1.39	0.69	1.61
	Evenness_e^H/S	0.96	0.95	0.93	1.00	0.96	0.94	0.91	0.95	1.00	1.00	1.00	1.00

Table II. 3.25: Mean annual density (number/m^2) of soil fauna in litter and soil layer (0-5 cm) at Tsa chu-I site

Soil fauna	Site	Litter layer	Soil layer	Total
Collembola	Barrage	1164	836	**2000**
	Powerhouse	1018	1018	**2036**
Acarina	Barrage	886	343	**1229**
	Powerhouse	943	686	**1629**
Other Arthropods	Barrage	1127	1236	**2364**
	Powerhouse	1418	873	**2291**
Total fauna	**Barrage**	**3177**	**2415**	**5593**
	Powerhouse	**3379**	**2577**	**5956**

Table II. 3.26: Seasonal variation of soil fauna density (number/m^2) at barrage and powerhouse site of Tsa chu-I

Soil fauna	Site	Post-monsoon	Monsoon	Winter	Mean
Collembola	Barrage	4800	12400	4800	**7333**
	Powerhouse	6800	13200	2400	**7467**
Acarina	Barrage	2000	2400	400	**1600**
	Powerhouse	3200	5200	1200	**3200**
Other arthropods	Barrage	7200	16000	2800	**8667**
	Powerhouse	8400	14000	2800	**8400**

Wildlife

Butterflies: There were 15 species of butterfly belonging to 13 genera and four families. The family Pieridae dominaed the site with six species. None of these species belonged to threatened category (Table II. 3.27).

Table II. 3.27: Butterflies recorded in Tsa chu-I project area

Sl. No.	Family and common name	Scientific name	SAC-I
I.	**Papilionidae**		
1	Indian Purple Emperor	*Mimathyma ambica*	*
II.	**Pieridae**		
2	Spotless Grass Yellow	*Eurema laeta*	*
3	Small Grass Yellow	*Eurema brigitta rubella*	*
4	Indian Cabbage White	*Pieris canidia indica*	*
5	Plain Sulphur	*Dercas lycorias*	*
6	Green-veined White	*Pieris napi montana*	*
7	Spotted Sawtooth	*Prioneris thestylis thestylis*	*
III.	**Lycaenidae**		
8	Peablue	*Lampides boeticus*	*
9	Pale Hedgeblue	*Udara dilecta*	*
10	Large Hedgeblue	*Celastrina hugeli oreana*	*
11	Common Hedgeblue	*Acytolepis puspa gisca*	*
IV.	**Nymphalidae**		
12	Large Threering	*Ypthima nareda*	*
13	Glassy Tiger	*Graphium cloanthus*	*
14	Indian Tortoiseshell	*Aglais caschmirensis*	*
15	Chocolate Pansy	*Junonia iphita iphita*	*

Herpetofauna: No herpetofauna was encountered in Tsa chu-I project area during field survey. The probable list of amphibians and reptiles was prepared for this site following Ahmed *et al.* (2009) (Appendix II.3.167.).

Birds: The assessment of bird diversity carried out during monsoon and winter seasons in and around this project area revealed the presence of 46 terrestrial bird species that belonged to 31 genera and 17 families, and with a Shannon diversity (H') value of 2.9. This indicates a moderate level of species diversity. When seasonal status was compared, richness was higher during monsoon (35 species) than in winter, which might have been due to snowfall and less availability of food resources in the area during the winter. The abundance of birds was high during monsoon (Table II. 3.28).

Migratory status: The migratory and resident status of these bird species showed that most of the birds were residents (28 species) followed by 10 breeding visitors and eight winter visitors (Table II. 3.28).

Table II. 3.28: Status of birds recorded in Tsa chu-I project area

Details	Monsoon	Winter	Overall
Family	14	9	17
Genera	22	12	31
Species	35	15	46
Abundance	287	57	344
Diversity H'	2.5	2.5	2.9
Migratory Status			
Breeding Visitor	10	1	10
Isolated Record	0	0	0
Resident	20	12	28
Winter Visitor	5	2	8

Abundance status: The abundance status of birds was derived by classifying the abundance of bird species into five abundance category (Very Low = 1-25 birds, Low = 26-50, Moderate = 51-75, High = 76-100 & Very High = > 100 birds). The details of abundance status are given in the Table II. 3.29.

Table II. 3.29: Number of species and relative % of birds in different abundance classes

Abundance Class	No. of species	Relative %
Very Low: 1 –25 Birds	44	95.7
Low: 26 –50 birds	1	2.2
Moderate: 50–75 birds	0	0.0
High: 76-100 birds	0	0.0
Very High: > 100 birds	1	2.2
Total	46	100.0

Status of Foraging Guilds: In Tsa chu-I, five different foraging guilds were present, among which insectivore was dominant with 33 species followed by seven species of granivores, and other guilds were represented by less number of species (Table II. 3.30 and Annexure). This analysis also indicated low diversity of birds in the area.

Table II. 3.30: Status of foraging guild of birds recorded in Tsa chu-I project area

Foraging Guild	Post monsoon	Monsoon	Winter	Overall
Aquatic Feeder	-	0	0	0
Carnivore	-	2	1	3
Frugivore	-	0	0	0
Granivore	-	4	4	7
Insectivore	-	29	7	33
Nectarivore	-	0	0	0
Nucivore	-	0	1	1
Omnivore	-	0	2	2
Piscivore	-	0	0	0

Status of threatened species: The assessment of conservation status of birds in this project area showed that there was no threatened bird species (Appendix II.168).

Mammals: Surveys in and around Tsa chu-I project site revealed the presences of six mammalian fauna and each belonging to separate genus and family. This list consists of 2 ungulates and 4 carnivore species (Table II. 3.31 and Appendix II.169).

Abundance status: Among the six species, presence of five species was confirmed based on 15 indirect evidences. The Himalayan Stripped Squirrel *(Tamipos macclellandi*) and Himalayan goral (*Naemorhedus goral*) were the only two species sighted with one animal each. Presence of Wild pig (*Sus scrofa*) and Yellow-Throated Martin (*Martes flavigula)* were established on the basis of five and four evidences, respectively (Table II. 3.31). Occurrence of only six species with 15 evidences and two sightings of animals clearly showed the low potential of the project area to support the mammalian fauna. Further evaluation of species richness of the project area (six species) with the possible species (29 species) of Tawang district (Mishra *et al.* 2006) also revealed the low species richness, as the species recorded in the project area formed only 21.42% (Appendix II.169).

Status of threatened species: Except the Himalayan goral (*Naemorhedus goral)* which is Near Threatened (NT) according to IUCN Red List, rest of the five species of the project area fall under Least Concern (LC) of IUCN and Schedule II and III of WPA (1972) (Table II. 3.31) (Appendix II.169).

Table II. 3.31: Status of mammalian fauna reported in the Tsa chu-I project area

Sl. No.	Family/common name	Scientific name	Seasons			Overall	Conservation status	
			PM	M	W		IUCN	WPA
I.	**Bovidae**							
1	Himalayan goral	*Naemorhedus goral*		IE 1 A 1	IE 2	IE 3 A 1	NT	III
II.	**Suidae**							
2	Wild pig	*Sus scrofa*		IE 3	IE 2	IE 5	LC	III
III.	**Felidae**							
3	Jungle cat	*Felis chaus*			IE 2	IE 2	LC	II
IV.	**Mustelidae**							
4	Yellow Throated Martin	*Martes flavigula*		IE-2	IE2	IE 4	LC	II
V.	**Viverridae**							
5	Himalayan Palm Civet	*Paguma larvata*		IE 1		IE 1	LC	II
VI.	**Sciuridae**							
6	Himalayan Stripped Squirrel	*Tamipos macclellandi*		A1		A 1	LC	NE
	No of species			**5**	**4**	**6**		
	Total and types of records			**IE7 A 2**	**IE 8**	**IE 15 A 2**		

IE-Indirect Evidences A–animals sighted, W-Winter, PM-Post-monsoon, M-Monsoon, IUCN-Red List, WPA–Wildlife Protection Act, NT-Near threatened, LC-Least Concern, NE-Not Evaluated

Faunal status within 500 m of project affected area: This section revealed species richness status of selected faunal groups such as avifauna and mammal species reported within 500 m up and down streams of the barrage and powerhouse sites of the proposed project area. The species richness reported in these specific sites was evaluated based on subjective rating through estimating percent contribution with the overall species list of the project area. If the species richness of barrage and powerhouse sites contributes 25% of overall list it was categorized as low, > 25-50% as medium, >50-75% as high and above 75% as high species richness.

Status of avifauna: At Tsa chu-I Powerhouse site, bird species richness with 21 species is designated as medium species richness area, when compared with the overall list of 46 species reported for the entire project area (45.65%). There was no threatened species in the powerhouse site (Appendix II.170).

Status of mammals: Site specific evaluation of mammalian fauna within 500 m of up and down streams showed occurrence of only five species in the powerhouse site. Among the species only Hoary-bellied Himalayan Squirrel was recorded based on sighting of one animal, while presence of rest of the four species was ascertained based on seven indirect evidences. None of these species has been categorized under high conservation status of IUCN and WPA (1972) (Table II. 3.32). Overall, the powerhouse site of Tsa chu-I project did not have any mammalian fauna of high conservation significance.

Table II. 3.32: Status of mammalian fauna at barrage and powerhouse sites of the proposed Tsa chu-I project area

Sl. No.	Common name	Species name	Status		Conservation status	
			BS	PHS	IUCN	WPA
1	Himalayan goral	*Naemorhedus goral*	-	IE 1	NT	III
2	Wild pig	*Sus scrofa*	-	IE 2	LC	III
3	Jungle cat	*Felis chaus*	-	IE 2	LC	II
4	Yellow Throated Martin	*Martes flavigula*	-	IE 2	LC	II
5	Hoary-bellied Himalayan Squirrel	*Callosciurus pygerythrus*	-	A1	LC	NE
	Total no of species		**-**	**5**		
	Total no of evidences		**-**	**IE7, A I**		

IE-Indirect Evidences, A-No of Animals Sighted, BS-Barrage Site, PHS-Powerhouse Site, IUCN-Red List, WPA–Wildlife Protection Act, EN-Endangered, NT-Near threatened, LC-Least Concern.

3.3.1.3 SOCIO–ECONOMIC PROFILE

There are 4 villages falling within the 10 km influenced zone of Tsa chu–I project. Three villages namely, Rho, Tsa chu and Broxer fall under Thingbu circle and village Jangda falls in Lhau circle. There is currently no human settlement in the village of Broxer; while the inhabitants of Tsa chu are migrants and have no land holdings. Therefore, these two villages were not included in the baseline survey. The materials have been described separately for data gathered at the village level and at the HH level.

Village Level Survey

Profile of Surveyed Villages: From Table II. 3.33 it is seen that both Rho and Jangda fall under affected village category. Both the villages are situated at a considerable distance from Tawang River. Both Jangda and Rho villages are situated within 10 km radius of the barrage axis. The circle headquarters of the two villages are within 15 km distance. It is noteworthy that both the villages are located at a very long distance from the district headquarters; Jangda is located at a distance of 90 km and Rho at 93.6 km.

Table II. 3.33: Profile of the two surveyed villages

Sl. No.	Village	Circle	Distance of village (in km)			Category of village
			River/Tributary	Circle HQ	District HQ	
1	Rho	Thingbu	8	5	93.6	Affected
2	Jangda	Lhau	7	15	90	Affected

Private Landuse Pattern: In Table II. 3.34, details of private land holdings (in hectares) of the two surveyed villages are given. The total private land in the two villages is about 280 ha. Rho contributes to the maximum area being 160 ha and Jangda contributes to 120 ha of the total private land holding. In both the villages the proportion of agricultural land is greater than other land use types. 44% of total private land is under cultivation. Private forest land also contributes significantly (37%) to the total land holdings of the surveyed villages.

Table II. 3.34: Private landuse pattern and their percentage to total private land

Sl. No.	Village	Total private land (ha)	Forest cover (ha)	%	Agriculture (ha)	%	Horticulture (ha)	%	Habitation and HG (ha)	%
1	Rho	160	58	36	66	41	0	–	36	23
2	Jangda	120	45	38	57	48	0	–	18	15
	Total	**280**	**103**	**37**	**123**	**44**	**0**	**0**	**54**	**19**

Demography and Literacy Rate: From Table II. 3.35, the following main features emerge. The total number of HHs in the two villages is 184. The total population is 811 (393 males; 412 females). Out of the two surveyed villages, Rho has less number of females per 1000 males. The literacy rate in the two villages is less than 50%. Jangda has the least number of literates (30%). Literacy rate among males in Jangda is 30% and in Rho it is 58%. 23% of females in Rho are literate and in Jangda the rate is 41%. It is highly noteworthy that in Jangda, the literacy rate among female is considerably higher compared to males.

Table II. 3.35: Demography and literacy rate

Sl. No.	Village	Demography					% Literacy rate*		
		No. of HH	Male	Female	Total	Sex ratio (per 1000 males)	Male	Female	Total
1	Rho	85	150	136	**286**	907	58	23	**45**
2	Jangda	99	249	276	**525**	1108	30	41	**30**
	Total	**184**	**393**	**412**	**811**	**2015**	–	**75**	–

* After Census 2011

Number of Livestock: In Table II. 3.36 are given the details of livestock holding in the two surveyed villages. Altogether 8 different types of animals are domesticated in two surveyed villages. In both the surveyed villages, all the eight types of animals in varying proportions are maintained. Altogether 1508 animals are found in the two villages. Considerable inter–village variation is observed in total number of animals reared. It varied from 487 in Rho to 1021 animals in Jangda.

Table II. 3.36: Number of livestock

Sl. No.	Village	Cattle	Yak	Sheep	Goat	Pig	Pony	Poultry	Others	Total
1	Rho	255	49	85	68	14	6	7	3	**487**
2	Jangda	395	114	364	37	72	10	28	1	**1021**
	Total	**650**	**163**	**449**	**105**	**86**	**16**	**35**	**4**	**1508**

Total Estimated Value of Livestock: The monetary value of animals maintained by the inhabitants of the studied villages has been estimated separately for each animal and for each village (Table II. 3.37). The selling price of different animals was obtained from the knowledgeable persons in the villages. The detailed methodology used has been described in the Methodology section of the report. As expected, there is considerable intra and inter village variation in this respect. The monetary value of total animals numbering 1508 found in the two villages has been estimated as 261.40 lakh. The value varied from 89.87 lakh in Rho to 171.53 lakh in Jangda. In terms of relative contribution made by different animals to the total value, cattle and Yak together contributed over 203 lakh.

Table II. 3.37: Total estimated value of livestock

Sl. No.	Village	Total estimated value (Rupees in lakh)								
		Cattle	Yak	Sheep	Goat	Pig	Pony	Poultry	Others	Total
1	Rho	63.75	12.25	5.10	3.40	3.50	1.38	0.04	0.45	**89.87**
2	Jangda	98.75	28.50	21.84	1.85	18.00	2.30	0.14	0.15	**171.53**
	Total	**162.50**	**40.75**	**26.94**	**5.25**	**21.5**	**3.68**	**0.18**	**0.6**	**261.40**

Average Annual Earnings of the Village: The average annual family income varies from 2.5 lakh in Rho to 3.58 lakh in Jangda. The value of total earnings per year in the two villages is estimated at 567.20 lakh. The contribution made by animal husbandry to the total earnings, compared to the other resources, is maximum in both the villages. Of the total annual earnings, animal husbandry contributes 325.73 lakh (57%). Traditional skills and daily wage labour together contribute over 25%. It is highly noteworthy that agriculture contributes only 11% to the total annual village earnings (Table II. 3.38).

Table II. 3.38: Average annual earnings of the village

Sl. No.	Name of village	Total earnings/year (Rupees in lakhs)								Average family income (Rupees in lakhs)
		Agriculture	Animal husbandry	Horticulture	Traditional skills	Daily wages	Govt. service	Others*	Total	
1	Rho	33.00	105.19	0.00	25.00	34.43	9.00	6.30	**212.92**	2.50
2	Jangda	28.50	220.54	0.00	39.75	40.10	14.94	10.46	**354.28**	3.58
Total		**61.50**	**325.73**	**0.00**	**64.75**	**74.53**	**23.94**	**16.76**	**567.20**	**6.08**
%		**10.84**	**57.43**	**0.00**	**11.42**	**13.14**	**4.22**	**2.95**	**100.00**	

* Others include artisans, monks, self–employed, contractors, income from river resources and NTFPs etc.

Average Annual Expenditure Pattern of a Family: From Table II. 3.39, the data shows that average annual family expenditure in the surveyed villages varied from 1.58 lakh in Rho to 1.53 lakh in Jangda. In both the villages the maximum expenditure is incurred on health and education (0.48 lakh) followed by transport (0.40 lakh), clothings (0.35 lakh). The least expenditure is incurred on food and drinks in Jangda (about 0.30 lakh). It may be noted here that the high expenditure incurred on transport is because the markets, health facility and government setups are located at long distances from the villages and that there is no public transport system in the area. It is highly noteworthy that the estimated annual earnings per family in both the village is higher than that of average annual expenditure incurred by a family.

Table II. 3.39: Average annual expenditure pattern of a family in village

Sl. No.	Village	Expenditure/year (Rupees in lakh)				
		Food and drinks	Clothing	Transport	Education and health	Total
1	Rho	0.35	0.35	0.40	0.48	**1.58**
2	Jangda	0.30	0.35	0.40	0.48	**1.53**
	Total	**0.65**	**0.70**	**0.80**	**0.96**	**3.11**

Water Sources: In Table II. 3.40, data pertaining to the water resources available and their pattern of use in the two villages are presented. There are only two types of water resources, namely, hill stream/springs and tap water available in the two surveyed villages. Water from hill stream/spring(s) in both the surveyed villages is used for domestic purposes as well as for the domestic animals. Tap water is used for domestic purposes and for domestic animals in surveyed villages. It may be noted that the source of tap water in both the villages are hill stream/springs. Water from hill stream/springs is collected in tank(s) and through a network of pipes it is supplied to a cluster of HHs as a common facility.

Table II. 3.40: Water sources in the village

Sl. No.	Water sources	Uses	Rho	Jangda	Total
1	River	Drinking water	0	0	**0**
		Domestic use	0	0	**0**
		Livestock use	0	0	**0**
		Agriculture	0	0	**0**
2	Hill stream/spring	Drinking water	1	1	**2**

		Domestic use	1	1	**2**
		Livestock use	1	1	**2**
		Agriculture	0	0	**0**
3	Wells	Drinking water	0	0	**0**
		Domestic use	0	0	**0**
		Livestock use	0	0	**0**
		Agriculture	0	0	**0**
4	Ponds	Drinking water	0	0	**0**
		Domestic use	0	0	**0**
		Livestock use	0	0	**0**
		Agriculture	0	0	**0**
5	Tap water	Drinking water	1	1	**2**
		Domestic use	1	1	**2**
		Livestock use	0	0	**0**
		Agriculture	0	0	**0**

Amenities in the Villages: From Table II. 3.41, it is observed that Rho has a maximum number of amenities being 7/12 (58.3%) and the least 5/12 (42%) in Jangda. Both the villages have motorable road, electricity, School, Telephone/Mobile and TV/radio. It is highly noteworthy that none of the two villages have Traditional health healer, Fair price shop, Grocery shop, Post office and Bank.

Table II. 3.41: Amenities in the villages

Sl. No.	Amenities	Rho	Jangda	Total
1	Road connectivity	√	√	**2**
2	Health facility (PHC/sub–centre)	√		**1**
3	Traditional health healer			
4	Veterinary services	√		**1**
5	Electricity	√	√	**2**
6	Fair price shop			
7	Grocery shop			
8	Post office			
9	Bank			
10	School	√	√	**2**
11	Telephone/Mobile	√	√	**2**
12	TV/Radios	√	√	**2**
Total Amenities in the villages		**7**	**5**	**–**

NB: Blank indicates absent

Social Institutions: Both the surveyed villages have community hall and Gompa (Table II. 3.42). Anganwadi is present only in Jangda. Self Help Groups (SHGs) are absent in both the villages.

Table II. 3.42: Social institutions in the village

Sl. No.	Village	SHGs	Anganwadi	Community Hall	Gompa	Any Other	Total
1	Rho			√	√	√	**3**
2	Jangda		√	√	√		**3**
Total			**1**	**2**	**2**	**1**	**–**

NB: Blank indicates absent

Occupation Profile: Work force participation is detailed in Table II. 3.43. The total working population in the two villages comprises of 479 (36%) of total population. Jangda has higher working population (67%) than Rho (3%).

Table II. 3.43: Occupation profile of the village

Sl. No.	Name of village	Population			Workers			Main workers			Marginal workers			Non workers		
		T	M	F	T	M	F	T	M	F	T	M	F	T	M	F
1	Rho	652	403	249	21	8	13	10	7	3	11	1	10	16	4	12
2	Jangda	682	406	276	458	289	169	320	252	68	138	37	101	224	117	107
Total		**1334**	**809**	**525**	**479**	**297**	**182**	**330**	**259**	**71**	**149**	**38**	**111**	**240**	**121**	**119**

Source: Census 2011

Household Level Survey

Age of the Head of the Household: The age of head of HHs across the two surveyed villages varied from 24 to 92 years (Table II. 3.44). As expected and depending on the demographic structure of the villages, considerable variation has been observed between the villages in terms of the age of the Heads of HHs. The average age varied from 43 years in Rho to 55 years in Jangda (Table II. 3.45).

Table II. 3.44: Distribution of head of the HHs by age across two project villages

Sl. No.	Age class (years)	Rho		Jangda		Total	
		n	%	n	%	n	%
1	Upto 30	8	9	7	7	**15**	**8**
2	31–40	36	42	19	19	**55**	**30**
3	41–50	24	28	31	31	**55**	**30**
4	>50	17	20	42	42	**59**	**32**
	Total	**85**	**100**	**99**	**100**	**184**	**100**

Table II. 3.45: Minimum, maximum and average age of head of HHs across two project villages

Sl. No.	Village	Age range		Average age
		From	To	
1	Rho	24	78	43
2	Jangda	25	92	50

Gender of the Head of Households: Data on gender of the head of HHs in the two surveyed project villages is given in Table II. 3.46. As expected, in both the villages, the number of males exceeds that of females as head of HHs. Across the surveyed villages, 74% of heads were males. Interestingly in village Jangda, the female head of HHs also occur in substantial number being 34 %.

Table II. 3.46: Distribution of head of HHs by gender in two project villages

Sl. No.	Village	Male		Female		Total	
		n	%	n	%	n	%
1	Rho	72	85	13	15	**85**	**46**
2	Jangda	65	66	34	34	**99**	**54**
	Total	**137**	**74**	**47**	**26**	**184**	**100**

Ethnicity: Both the villages are inhabited by Monpa tribals.

Household Size: The HH size varies from one to nine across the two surveyed villages. There is vast variation between the two villages in terms of distribution of HH size. The average HH size varies from three in Rho to five in Jangda, and the average HH size across the surveyed villages is four (Tables II. 3.47 and 3.48).

Table II. 3.47: Distribution of HH size in two project villages

Sl. No.	HH size	Rho		Jangda		Total	
		n	%	n	%	n	%
1	1	9	11	5	5	**14**	**8**
2	2	8	9	11	11	**19**	**10**
3	3	22	26	6	6	**28**	**15**
4	4	39	46	13	13	**52**	**28**
5	5	4	5	14	14	**18**	**10**
6	6–8	3	4	39	39	**42**	**23**
7	9 and above	0	0	11	11	**11**	**6**
	Total	**85**	**100**	**99**	**100**	**184**	**100**

Table II. 3.48: Minimum, maximum and average HH size across three project villages

Sl. No.	Village	HH size range		Average HH size
		From	To	
1	Rho	1	7	3
2	Jangda	1	9	5
	Total	**1**	**9**	**4**

Education: Relevant data on education of the head of the HHs in the two project villages is presented in Table II. 3.49. It is highly noteworthy that a majority of the heads were illiterate. It was 85% in Jangda and 87% in Rho. Out of 184 Head of HHs, 158 (86%) were illiterate. There were only two head of HHs, one each in Rho and Jangda, who were Graduates.

Table II. 3.49: Distribution of education of head of HHs in two project villages

Sl. No.	Education	Rho		Jangda		Total	
		n	%	n	%	n	%
1	Illiterate	74	87	84	85	**158**	**86**
2	Primary	0	0	3	3	**3**	**2**
3	Upper Primary	2	2	5	5	**7**	**4**
4	Secondary	5	6	4	4	**9**	**5**
5	Higher Secondary	3	4	2	2	**5**	**3**
6	Graduation or above	1	1	1	1	**2**	**1**
	Total	**85**	**100**	**99**	**100**	**184**	**100**

Main Occupation of Household Heads: The main occupations of the head of HHs across the two villages are agriculture, labour, pastoralist and government service. Table II. 3.50 revealed the following main features:

Agriculture: About 52% of HHs in Jangda and 78% of HHs in Rho are engaged in agriculture.

Labour: Only in Jangda 15% of the heads of HHs reported labour as main source of income.

Pastoral: In Jangda 8% of the heads of HHs were engaged in livestock rearing.

Government service: Government servants were reported from the two villages. The number from Rho being 22% and in Jangda it was 10%. Government service constitutes 16% of the main occupation in surveyed villages.

Any other occupation: About 8% of heads of HHs in Rho and Jangda pursue other occupations.

Table II. 3.50: Distribution of head of HHs by main occupation in two project villages

Sl. No.	Main occupation	Rho		Jangda		Total	
		n	%	n	%	n	%
1	Farmer	66	78	51	52	**117**	**64**
2	Labour	0	0	15	15	**15**	**8**
3	Pastoral	0	0	8	8	**8**	**4**
4	Government Service	19	22	10	10	**29**	**16**
5	Any other	0	0	15	15	**15**	**8**
	Total	**85**	**100**	**99**	**100**	**184**	**100**

*any other category includes artisans, monks, self–employed, contractors, income from river resources and NTFPs etc.

Private Land Holding Pattern: The private land holding pattern in the two villages comprises of agricultural land, horticulture land, habitation and home garden land, and forest land. It may be noted here that a majority of the inhabitants of the concerned villages did not know actual area either in acres or hectares of all categories of land holdings. Therefore the area reported here should be considered as very rough estimates. Data pertaining to this aspect have been described below:

Agricultural land: Table II. 3.51 revealed that except 8 HHs (4.3%), all the remaining HHs (95.7%) in surveyed villages owned agricultural land in varying proportions. A majority of the HHs (64.1%) owned agri–land between 1–2 acres and only 19.6% of HHs owned more than 2 acres of agri–land.

Table II. 3.51: Distribution of agricultural land holding among surveyed HHs in the two project villages

Sl. No.	Class	Rho		Jangda		Total	
		n	%	n	%	n	%
1	0.0 acre	2	2	6	6	**8**	**4.3**
2	<1 acre	0	0	22	22	**22**	**12.0**
3	1–2 acre	64	75	54	55	**118**	**64.1**
4	>2 acre	19	22	17	17	**36**	**19.6**
	Total	**85**	**100**	**99**	**100**	**184**	**100.0**

Horticultural land: None of the HHs in the two villages owned horticultural land.

Habitation and home–garden land: Data presented in Table II. 3.52 reveal that only 3% of HHs in surveyed villages did not own any such land. A majority of HHs (68%) owned less than one acre of such land and 29 % of the HHs owned such land between 1–2 acres. It is highly noteworthy that unlike in many parts of northeast, the Monpas of surveyed villages do not have a strong tradition of raising home gardens.

Table II. 3.52: Distribution of habitation and home garden land among surveyed HHs in two project villages

Sl. No.	Class	Rho		Jangda		Total	
		n	%	n	%	n	%
1	0.0 acre	0	0	6	6	**6**	**3**
2	<1 acre	32	38	93	94	**125**	**68**
3	1–2 acre	53	62	0	0	**53**	**29**
4	>2 acre	0	0	0	0	**0**	**0**
	Total	**85**	**100**	**99**	**100**	**184**	**100**

Forest land: About 29 HHs (16%) in surveyed villages do not own private forest land. A majority of HHs (61%) owned such land between 1–2 acres. In Rho, it is noteworthy that 20% of HHs owned more than 2 acre of forest land (Table II. 3.53).

Table II. 3.53: Distribution of forest land holding among surveyed HHs in two project villages

Sl. No.	Class	Rho		Jangda		Total	
		n	%	n	%	n	%
1	0.0 acre	14	16	15	15	**29**	**16**
2	<1 acre	0	0	15	15	**15**	**8**
3	1–2 acre	54	64	59	60	**113**	**61**
4	>2 acre	17	20	10	10	**27**	**15**
	Total	**85**	**100**	**99**	**100**	**184**	**100**

Total land holdings: Tables II. 3.54–3.57 show that there are only 6 HHs (3%)–all in Jangda–that do not own any type of private land. Over three–fourth of the HHs (77%) owned more than 2 acres of total land. There is striking variation between the HH in a village as well as between villages in ownership of total land. For example, in Rho inter HHs holdings vary from 1 acre to 26 acres, whereas in Jangda it varies from 0.0–10.74 acre. In both the surveyed villages the proportion of agriculture land is greater than other types of land owned. The 184 HHs in the two villages owned total private land amounting to about 695 acres. Out of this Rho accounts for 57%. Agri–land accounts for 44% and forest land 37% of total land holding in the two villages.

Table II. 3.54: Distribution of total land holding among surveyed HHs in two project villages

Sl. No.	Class	Rho		Jangda		Total	
		n	%	n	%	n	%
1	0.0 acre	0	0	6	6	**6**	**3**
2	<1 acre	0	0	7	7	**7**	**4**
3	1–2 acre	10	12	19	19	**29**	**16**
4	>2 acre	75	88	67	68	**142**	**77**
	Total	**85**	**100**	**99**	**100**	**184**	**100**

Table II. 3.55: Minimum, maximum and average land holdings across two project villages

Sl. No.	Land type	Rho			Jangda		
		From	To	Average	From	To	Average
1	Agricultural land	0.00	12.00	1.94	0.00	6.00	1.42
2	Horticultural land	0.00	0.00	0.00	0.00	0.00	0.00
3	Habitation and home garden land	0.46	2.00	1.04	0.00	0.74	0.45
4	Forest land	0.00	12.00	1.69	0.00	4.00	1.13
5	Total land	1.00	26.00	4.68	0.00	10.74	3.00

Table II. 3.56: Number of HHs having land types in two project villages

Sl. No.	Land type	Rho		Jangda		Total	
		n= 85	%	n= 99	%	n= 184	%
1	Agricultural land	83	98	93	94	**176**	**96**
2	Horticultural land	0	0	0	0	**0**	**0**
3	Habitation and home garden land	85	100	93	94	**178**	**97**
4	Forest land	71	84	84	85	**155**	**84**

Table II. 3.57: Distribution of area (in acres) of land holding among HHs in two project villages

Sl. No.	Land category	Rho		Jangda		Total	
		Area	%	Area	%	Area	%
1	Agricultural land	165	41	141	47	**306**	**44**
2	Horticultural land	0	0	0	0	**0**	**0**
3	Habitation and home garden land	89	22	44	15	**133**	**19**
4	Forest land	144	36	112	38	**256**	**37**
	Total land	**398**	**100**	**297**	**100**	**695**	**100**

Livestock Holding: Data presented in Tables II. 3.58-3.60 in respect of distribution of livestock holding in the two surveyed villages revealed that altogether 8 different types of animals are domesticated in two surveyed villages (Table II. 3.58). In Rho and Jangda all the eight animals in varying proportions are maintained. The preferred animals in Rho are cattle, goat and sheep, whereas in Jangda in addition to these animals, 63% of HHs also rear pigs in appreciable numbers. Altogether 1508 animals are reared in the two villages (Table II. 3.59). Considerable inter–village variation is observed in total number of animals reared. It varied from 487 in Rho to 1021 animals in Jangda. Jangda alone accounts for 68% of all the animals found in the two surveyed villages. Three animals, viz., cattle (43%), sheep (30%) and Yak (11%) account for 84% of the total animals (1508). 29% of the HHs did not own any animals, whereas 29% HHs owned more than 10 animals (Table II. 3.60).

Table II. 3.58: Livestock holding by HHs in two project villages

Sl. No.	Livestock	Rho		Jangda		Total	
		n= 85	%	n= 99	%	n= 184	%
1	Cattle	30	35	92	93	**122**	**66**
2	Yak	5	6	25	25	**30**	**16**
3	Goat	17	20	22	22	**39**	**21**
4	Sheep	20	24	71	72	**91**	**49**
5	Pig	6	7	63	64	**69**	**38**
6	Pony	1	1	2	2	**3**	**2**
7	Poultry	2	2	13	13	**15**	**8**
8	Others	1	1	1	1	**2**	**1**

Table II. 3.59: Number of livestock among surveyed HHs in two project villages

Sl. No.	Livestock	Rho		Jangda		Total	
		n	%	n	%	n	%
1	Cattle	255	52	395	39	**650**	**43**
2	Yak	49	10	114	11	**163**	**11**
3	Goat	68	14	37	4	**105**	**7**
4	Sheep	85	17	364	36	**449**	**30**
	Pig	14	3	72	7	**86**	**6**
5	Pony	6	1	10	1	**16**	**1**
6	Poultry	7	1	28	3	**35**	**2**
7	Others	3	1	1	0	**4**	**0**
8	**Total**	**487**	**100**	**1021**	**100**	**1508**	**100**

Table II. 3.60: Distribution of total number of livestock in HHs of two project villages

Sl. No.	Range	Rho		Jangda		Total	
		n	%	n	%	n	%
1	0	48	56	5	5	**53**	**29**
2	1–5	9	11	25	25	**34**	**18**
3	6–10	11	13	33	33	**44**	**24**
4	>10	17	20	36	36	**53**	**29**
	Total	**85**	**100**	**99**	**100**	**184**	**100**

Traditional Skills: Data pertaining to this aspect is presented in Table II. 3.61. It is highly noteworthy that while in Tawang district at least 6 types of crafts are practiced (see Table II. 3.61). In the surveyed villages somewhat surprisingly only two types of crafts are being practiced. Only one HH in Jangda is engaged in wood carving. However, weaving is practiced in both the villages. It varies from 47% of HHs in Rho to 54% in Jangda. Overall 51% of the HHs practiced this craft. The craft is exclusively perused by women and they are highly skilled in weaving various types of garments which are primarily used at home.

Table 3.61: Distribution of various skills among surveyed HHs in two project villages

Sl. No.	Skills	Rho		Jangda		Total	
		n= 85	%	n= 99	%	n= 184	%
1	Wood carving	0	0	1	1	**1**	**1**
2	Thanka painting	0	0	0	0	**0**	**0**
3	Carpet making	0	0	0	0	**0**	**0**
4	Bamboo Utensils	0	0	0	0	**0**	**0**
5	Weaving	40	47	53	54	**93**	**51**
6	Paper making	0	0	0	0	**0**	**0**

River Resources: In Table II. 3.62 data gathered pertaining to the use of various river resources by the inhabitants of the two surveyed village is presented. The data revealed that only three river resources, viz., drinking water for domestic animals, sand and stone are used. About 71% of all the HHs use river water for domestic animals. In Jangda all the 99 HHs use sand and stone. These are used for self use as well as for selling. All the 184 HHs also use river for performing last rites of the dead. Although aquatic fauna is found in the river but there is a taboo among the Monpas for using this resource. It may be mentioned here that Rho and Jangda villages are common to at least 8 projects as either affected or influenced villages. Although the river dependency data at household/village levels are correct, the source of collection of these resources i.e. the exact name of the project site could not be ascertained. However, considering the distance from the villages to the proposed project sites, it may be safely concluded that the dependency on the river resources is minimum for Tsa Chu-I.

Table II. 3.62: Dependence on river resources among surveyed HHs in two project villages

Sl. No.	Nature of dependence	Rho		Jangda		Total	
		n= 85	%	n= 99	%	n= 184	%
1	Drinking water	0	0	0	0	**0**	**0**
2	Water for domestic use	0	0	0	0	**0**	**0**
3	Water for domestic animal	37	44	94	95	**131**	**71**
4	Aquatic fauna	0	0	0	0	**0**	**0**
5	Aquatic flora	0	0	0	0	**0**	**0**
6	Religious	85	100	99	100	**184**	**100**
7	Sand	0	0	99	100	**99**	**54**
8	Stones (boulders)	0	0	99	100	**99**	**54**

Forest Resources: The villagers of all the two villages are dependent in varying degrees of forest resources (Table II. 3.63). Altogether 12 forest resources are used in varying degrees in the two surveyed villages (Table II. 3.63). All the surveyed 184 HHs depend on four forest resources, viz., fuel wood, timber, water and stones. More than 50% of HHs also used forest resources for food (90%), grazing (71%), fencing (64%) and sand (64%). A few HHs also use forest for making handicrafts and for religious purposes. It is evident from above that forest resources contribute significantly to the livelihoods as well as the quality of life of a majority of the inhabitants of the surveyed villages. It may be mentioned here that Rho and Jangda villages are common to at least 8 projects as either affected or influenced villages. Although the forest dependency data at household/village levels are correct, the source of collection of these resources i.e. the exact name of the project site could not be ascertained. However, considering the distance from the villages to the proposed project sites, it may be safely concluded that the dependency on the forest resources is minimum for Tsa chu-I.

Table II. 3.63: Dependence on forest resources among surveyed HHs in two project villages

Sl. No.	Nature of dependence	Rho		Jangda		Total	
		n= 85	%	n= 99	%	n= 184	%
1	Fuel wood	85	100	99	100	**184**	**100**
2	Timber	85	100	99	100	**184**	**100**
3	Medicinal plants	0	0	0	0	**0**	**0**
4	Honey	0	0	0	0	**0**	**0**
5	Food	66	78	99	100	**165**	**90**
6	Edible oil	0	0	0	0	**0**	**0**
7	Ornamental	2	2	0	0	**2**	**1**
8	Religious	85	100	0	0	**85**	**46**

9	Fencing	19	22	99	100	**118**	**64**
10	Handicrafts	21	25	0	0	**21**	**11**
11	Thatching	0	0	0	0	**0**	**0**
12	Spices	0	0	0	0	**0**	**0**
13	Grazing	37	44	94	95	**131**	**71**
14	Hunting of wild animals	0	0	0	0	**0**	**0**
15	Fishes	0	0	0	0	**0**	**0**
16	Water	85	100	99	100	**184**	**100**
17	Stones	85	100	99	100	**184**	**100**
18	Sand	19	22	99	100	**118**	**64**
19	Dyes	0	0	0	0	**0**	**0**

Water Resources: In both the surveyed villages the main source of water for various usage are hill stream/springs. Without an exception, all the 184 HHs depend on hill stream/spring water for all their requirements. In the surveyed villages the hill stream/spring water is brought to houses by connecting pipes. Water storage tanks have also been installed in these villages and the HHs are connected to the tanks by pipes (Table II. 3.64). However, due to distance the dependency for water resource on Tsa chu-I project areas is minimum.

Table II. 3.64: Dependence on water resources among surveyed HHs in two project villages

Sl. No.	Nature of dependence	Rho		Jangda		Total	
		n	%	n	%	n	%
1	River	85	100	0	0	**85**	**46**
2	Hill stream/springs	85	100	99	100	**184**	**100**
3	Wells	0	0	0	0	**0**	**0**
4	Ponds	0	0	0	0	**0**	**0**
5	Hand pumps	0	0	0	0	**0**	**0**
6	Tap water	85	100	99	100	**184**	**100**

3.3.2 TSA CHU–I LOWER

3.3.2.1 PHYSICAL ENVIRONMENT

Geomorphology

The geomorphological conditions of Tsa chu-I Lower is the same as that of Tsa chu-I. The project is located in sub-alpine zone of Himalayas. The river basin is narrow and surrounded by steep to very steep slopes.

Geology

Tsa chu-I Lower project is located on calc. gneisses with pelitic schist. Structurally, the area is highly disturbed and the drainage is cutting perpendicular to the hill slope. Seismically, it is active because of its nearness to the main central thrust.

Soil

The soil was sandy loam and acidic with low water holding capacity and porosity (Table II. 3.65). Soil was poor in nitrate nitrogen, TKN, available-P, total-P, and soil organic carbon contents. Thus its fertility level was very low. These parameters also exhibited seasonal variation which is shown in Table II. 3.66.

Table II. 3.65: Soil physical properties at Tsa chu–I Lower site

Site	Texture	WHC (%)	Bulk density (g/cm³)	Porosity (%)
Barrage	Loamy sand	33.69	1.63	38.49
Powerhouse	Loamy sand	19.67	1.68	36.60

Table II. 3.66: Seasonal variation in soil physico–chemical properties at Tsa chu–I Lower site

Parameters	Post–monsoon		Monsoon		Winter		Mean	
	B	PH	B	PH	B	PH	B	PH
SMC (%)	30	25	35	31	16	20	27	25
pH	5.2	5.3	6.1	5.9	5.8	5.5	5.7	5.6
Conductivity ($\mu S\ cm^{-1}$)	129	131	190	182	85	80	135	131
NH_4^+–N ($\mu g\ g^{-1}$)	200	200	300	300	200	200	233	233
NO_3^-–N($\mu g\ g^{-1}$)	21	17	34	31	22	19	26	22
TKN ($\mu g\ g^{-1}$) x10^3	0.620	0.580	0.700	0.600	0.570	0.490	0.630	0.557
Av.P ($\mu g\ g^{-1}$)	0.060	0.070	0.120	0.130	0.040	0.050	0.073	0.083
TP (%)	0.110	0.150	0.140	0.200	0.100	0.170	0.117	0.173
SOC (%)	0.003	0.005	0.006	0.007	0.003	0.004	0.004	0.005
Ex. K ($\mu g\ g^{-1}$)	98	103	182	197	120	130	133	143
Ex. Mg (%)	0.009	0.010	0.011	0.013	0.007	0.009	0.009	0.011
Ex. Ca (%)	0.198	0.201	0.298	0.300	0.185	0.190	0.227	0.230
Soil microbial biomass–C ($\mu g\ g^{-1}$)	23	23	21	20	25	24	23	22
Soil microbial biomass–N ($\mu g\ g^{-1}$)	7.2	6.5	5.7	4.3	12.0	10.2	8.3	7.0

(Note:Post-monsoon: October, Monsoon–July, Winter–December); B = Barrage, PH = Powerhouse)

Water Quality

River water quality in Tsa chu–I lower was characterised by high turbidity and conductivity, greater amount of dissolved solids, and larger coliform count during the pre-monsoon period. Monsoon Season showed higher concentration of sodium (Na^+), total Kjeldhal nitrogen (TKN), ammonium nitrogen (NH_4^+N), chloride, and greater primary productivity. Like other sites, water temperature was high (15.5°C) during monsoon season and touched the lowest value (4.1°C) during winter months. Total alkalinity and salinity, Ca and dissolve oxygen concentration was high during winter period. Potassium (K^+), total phosphorus and nitrate nitrogen were high during post–monsoon period (Table II. 3.67).

Table II. 3.67: Seasonal variation in physico-chemical and biological properties of water and river primary productivity at Tsa chu-I Lower site

Parameters	Post–monsoon			Monsoon			Winter		
	B	PH	Mean	B	PH	Mean	B	PH	Mean
Temperature (˚C)	10.84	10.92	10.88	14.70	15.50	15.10	4.10	4.80	4.45
Turbidity (NTU)	0.63	0.63	0.63	0.50	0.57	0.53	0.55	0.58	0.57
pH	7.46	7.55	7.51	8.08	8.05	8.07	7.77	7.78	7.78
Electrical conductivity (µS/cm)	223	225.00	224	156	167.50	162	188	194.00	191
Total dissolved solids (mg/l)	110	112.60	111.40	81	86.50	83.75	97	100.00	98.50
Practical salinity (ppt)	0.12	0.12	0.12	0.09	0.10	0.10	0.11	0.11	0.11
Total alkalinity (mg $CaCO_3$/l)	34	34.00	34.00	28	30.00	29.00	44	48.00	46.00
Total hardness (mg/l)	26	26.23	26.17	39	39.25	39.18	42	42.52	42.46
Chloride (mg Cl^-/l)	11.17	11.17	11.17	12.99	12.99	12.99	5.99	5.99	5.99
Ca^{2+} (mg/l)	6.04	6.04	6.04	9.81	9.83	9.82	10.71	10.73	10.72
Mg^{2+}(mg/l)	2.68	2.71	2.70	3.55	3.57	3.56	3.80	3.82	3.81
K^+ ppm	0.95	1.10	1.03	0.60	0.70	0.65	0.50	0.60	0.55
Na^+ ppm	11.20	11.30	11.25	11.70	11.90	11.80	10.80	10.80	10.80
TKN (mg/l)	0.43	0.44	0.44	0.57	0.58	0.58	0.38	0.39	0.39
NH_4^+ N (mg/l)	0.05	0.06	0.06	0.09	0.09	0.09	0.06	0.06	0.06
NO_3–N (mg/l)	0.35	0.35	0.35	0.14	0.15	0.15	0.17	0.16	0.17
Total phosphorus (mg/l)	0.10	0.10	0.10	0.08	0.08	0.08	0.06	0.06	0.06
GPP (mg C/cm^3/h)	0.36	0.36	0.36	0.43	0.43	0.43	0.21	0.21	0.21
NPP (mg C/cm^3/h)	0.10	0.10	0.10	0.27	0.27	0.27	0.10	0.10	0.10
Dissolved oxygen (mg/l)	11.62	11.60	11.61	10.20	10.05	10.13	12.60	12.40	12.50
Total coliforms (CFU/ml)	18	15.00	16.50	14	16.00	15.00	7	17.00	12.00

Ambient Air Quality

Concentration of PM_{10} and $PM_{2.5}$: PM_{10} concentration at proposed Tsa chu-I Lower site was 4 µg/m^3while that of $PM_{2.5}$ was below permissible limit (Table II. 3.68). The concentration of sulphur-dioxide (SO_2), nitrogen-dioxide (NO_2), ammonia (NH_3), and ground level ozone (O_3) at all the monitored locations were below detectable limits.

Table II. 3.68: Concentration of PM_{10} and $PM_{2.5}$ in air at proposed Tsa chu-I Lower HEP area

Sampling location	Nearest project site covered	PM_{10} (µg/m^3)	$PM_{2.5}$ (µg/m^3)
Tsa chu	Tsa chu–I lower barrage site Tsa chu–I lower powerhouse site	10.4	BDL

Meteorological variables for Tsa Chu-I Lower HEP could be measured only at Tsa chu location, and are presented in Table II. 3.69.

Table II. 3.69: Meteorological conditions at proposed Tsa chu-I Lower HEP area

Sampling location	Nearest project sites covered	Ambient temperature (°c) Min	Ambient temperature (°c) Max	Relative humidity (%)	Wind speed (range in km/hr)	Wind direction
Tsa chu	Tsa chu–I lower barrage site Tsa chu–I lower powerhouse site	02	06	42	1.8–2.5	SE

Noise Level: Noise level at barrage site of proposed Tsa chu-I Lower HEP was 43.1 dBA at 4.00 PM and 44.6 dBA at 8.00 AM (Table II. 3.70).

Table II. 3.70: Noise level at proposed Tsa chu-I Lower HEP area

Sampling location	Nearest project component covered	Noise level (dBA) 8.00 am	Noise level (dBA) 4.00 pm
Tsa chu	Tsa chu–I lower barrage site Tsa chu–I lower powerhouse site	44.6	43.1

3.3.2.2 BIOLOGICAL ENVIRONMENT

Vegetation Types

The vegetation types at Tsa chu-I Lower project site were similar to the Tsa Chu-I project area.

Plant Diversity

Plant diversity survey conducted at Tsa chu-I Lower HEP sites resulted in 81 plant species belonging to different groups at barrage and powerhouse site, and the catchment area. A complete list of plant species found in the study area representing different groups such as tree, shrub, herb, climber, orchid, pteridophyte, bryophyte, lichen and fungi along with their family name is given in Appendix II.3. 14. The number of plant species belonging to different groups is summarized in Table II. 3.71.

Table II. 3.71: Different groups of plant species present at Tsa chu-I Lower HEP site

Sl. No.	Groups	Number of species		
		Barrage site	Powerhouse site	Catchment area
1	Tree	6	6	6
2	Shrub	7	6	5
3	Herb	27	27	29
4	Climbers	3		3
5	Orchids	1		1
6	Pteridophytes	10		8
7	Bryophytes	4		3
8	Lichens	6		5
9	Fungi	11	7	12

The forest structure of Tsa Chu-I Lower was similar with that of Tsa Chu-I site. At the barrage site, 6 tree, 7 shrub, and 27 herb species were recorded, and at the powerhouse site, 6 tree, 6 shrub, and 27 herb species were documented. In the project catchment area, 6 tree, 5 shrub, and 29 herb species were recorded. A total of 3 climber, 1 orchid, 10 pteridophyte, 4 bryophyte and 6 lichen species were recorded from barrage and powerhouse sites, and from the catchment area 3 climber, 1 orchid, 8 pteridophyte, 3 bryophyte, 5 lichen and 12 fungus species were recorded (Appendix II.3.15 and II.316).

Threatened and Endemic Plant Species

During the floristic survey, four threatened species were recorded at the HEP site. The species and family names and the threat status are presented in Table II. 3.72

Table II. 3.72: Threatened plants recorded at Tsa chu-I Lower project site

Species name	Family	Threat status	References
Aconitum heterophyllum	Ranunculaceae	EN	Walter and Gillet, 1998
Aconitum ferox	Ranunculaceae	EN	Walter and Gillet, 1998
Paris polyphylla	Trilliaceae	VU	CAMP and IUCN
Panax bipinnatifidus	Araliaceae	VU	CAMP, 2003

EN=Endangered; VU=Vulnerable

Economically Important Species/Plant Resources

The project area is rich in plant resources. A few of the important ones are listed in Table II. 3.73.

Table II. 3.73: Economically important species/plant resources recorded at Tsa chu-I Lower project site

Sl.No.	Uses	Species name
1	Timber	*Abies densa*
2	Fuel	*Rhododendron* sp., *Abies densa*
3	Ornamentals and orchids	*Rhododendron* sp., *Primula* sp., *Aster* sp., *Satyrium* sp., *Begonia* sp., *Salix* sp.
4	Medicine and aromatics	*Panax* sp., *Aconitum* sp., *Paris polyphylla*,

Vegetation Analysis for Angiosperms and Gymnosperms

The plant community around in the barrage and powerhouse sites, and catchment area of Tsa chu-I Lower project was composed of 6 tree species, 7 shrub species, and 32 herbaceous species (Tables II. 3.74 and 3.75).

Table II. 3.74: Tree and shrub species recorded in the barrage and powerhouse sites, and the catchment area of Tsa chu-I Lower project site

Trees	Shrub
Abies densa	*Berberis* sp.
Acer sp.	*Daphnae papyracea*
Betula utilis	*Eleagnus parviflora*
Junipers sp.	*Pogostemon* sp
Quercus sp.	*Rosa* sp.
Rhododendron sp.	*Rubus ellipticus*
	Salix sp.

Table II. 3.75: Herbaceous species recorded recorded in the barrage and powerhouse sites, and the catchment area of Tsa chu-I Lower project site

Herb		
Aconogonum alpinum	*Hemiphragma heterophyllum*	*Primula denticulata*
Aconitum heterophyllum	*Impatients* sp.	*Primula* sp.
Aconitum ferox	*Leontopodium Stracheyi*	*Prunella vulgaris*
Ainsliaea sp.	*Meconopsis* sp.	*Rannunculus* sp.
Arisaema nepenthoides	*Panax bipinnatifidus*	*Rumex nepalensis*
Elsholtzia strolifera	*Persicaria* sp.	*Sambacus adnata*
Fragaria sp.	*Pilea umbrosa*	*Senecio cappa*
Galinsoga parviflora	*Pogostemon* sp.	*Stellaria* sp.
Galium sp.	*Polygonum hydropiper*	*Swertia* sp.
Gentiana capitata	*Potentilla cuneata*	*Viola sikkimensis*
Geranium nepalensis	*Paris polyphylla*	

In general, species richness was high during monsoon season and low during winter season. *Abies densa* was the dominant tree species at the barrage and power site, and the catchment area. Among shrubs, *Rosa* sp. was dominant at all the sites i.e., at barrage site, at powerhouse site and other areas. The dominant herbaceous species differed between monsoon, post-monsoon and winter seasons (Appendix II.3.15 and II.3.26).

Highest density of trees and shrubs was recorded at the barrage site, while their density was lowest in the catchment area and powerhouse site. Shannon diversity index for tree species was highest for the catchment area (H'=1.68), followed by powerhouse site (H'=1.67) and barrage site (H'=1.50). Shannon diversity value for shrub species was highest for the barrage site (H'=1.68) followed by catchment area (H'=1.63) and powerhouse sites (H'=1.54) (Table II. 3.76 and II. 3.77) . Diversity index for herbaceous ranged from 3.09 to 1.59, where the highest value was obtained for the barrage site during monsoon season and lowest during the winter season for the catchment area. Overall, the plant communities near barrage site and catchment area had highest species diversity. However, seasonal variation in the diversity parameters was conspicuous for all three sites (Appendix II. 3.17–.3.25). High diversity and low dominance was the characteristic feature of all three sites.

Table II. 3.76: Species richness, diversity and dominance of trees and shrubs, and biomass and carbon stock of trees at Tsa chu-I Lower project site

Parameters	Barrage		Powerhouse		Catchment area	
	Tree	Shrub	Tree	Shrub	Tree	Shrub
Number of species	6	7	6	5	6	6
Density (ha^{-1})	510	960	580	784	620	880
Simpson index of dominance	0.2	0.80	0.28	0.77	0.2	0.77
Shannon index of diversity (H')	1.71	1.79	1.67	1.54	1.68	1.63
Evenness index	0.95	0.85	0.93	0.93	0.93	0.85
Biomass (t/ha)	105.3		98.15			
Carbon (t/ha)	52.65		49.08		65.2	

Table II. 3.77: Species richness, diversity and dominance in herbaceous community at Tsa chu-I Lower project site

Parameters	Barrage			Powerhouse			Catchment area		
	PM	M	W	PM	M	W	PM	M	W
Number of species	13	26	6	14	26	7	17	25	8
Density (ha^{-1})x10^3	80	186	35.6	87.6	168.4	43.2	90.4	162.4	50
Simpson index of dominance	0.90	0.94	0.74	0.91	0.94	0.75	0.92	0.94	0.79
Shannon index of diversity (H')	2.44	3.09	1.56	2.54	3.08	1.65	2.70	3.04	1.83
Evenness index	0.88	0.84	0.79	0.90	0.84	0.74	0.88	0.84	0.78

PM: Post monsoon; M: Monsoon; W: Winter

Phytoplankton/Periphyton

Nineteen species of phytoplankton/periphyton were recorded from Tsa chu-I Lower project sites. The community was represented by 2 species of Cyanophyceae, 16 species of Bacillariophyceae, and one species of Chlorophyceae. Species richness was highest at the project affected area with 19 species and minimum with 9 species at the catchment area. Phytoplankton/periphyton density was highest at project affected area (295 individuals/l) and lowest at the catchment area (70 individuals/l). Similarly, species diversity index was maximum (H'=2.69) at the project affected area and minimum (H'=2.11) at the catchment area (Table II. 3.78).

Table II. 3.78: Density (individuals/l), species richness and Shannon index of diversity (H') of phytoplankton community in river water at project affected area and catchment area of Tsa chu-I Lower HEP area

List of species	Project affected area	Catchment area
Cyanophyceae		
Aphanocapsa sp.	10	15
Oscillatoria sp.	25	
Bacillariophyceae		
Achnanthidium rivulare	5	5
Amphora sp.	15	
Caloneis ventricosa	5	
Cymbella delicatula	5	5
Cymbella tumida	15	5
Encyonema minutum	10	10
Fragillaria sp.	10	5
Gomphonema olivaceoides	5	
Hanzchia amphioxys	5	5
Meridion circulare	20	10
Navicula capitata	25	
Navicula cryptocephala	60	
Navicula cryptotenella	20	
Rhoicosphaenia sp.	10	
Synedra ulna	25	10
Thallassiosira sp.	10	
Chlorophyceae		
Spirogyra sp.	15	
Total density (Individuals/l)	**295**	**70**
Species diversity index	**2.69**	**2.11**
Species richness	**19**	**9**

NB: Blank cells indicate absence of phytoplankton species

Zooplankton

Zooplankton study was conducted during monsoon and winter seasons in Tsa chu-I Lower project area. In the survey, 1 species of Cladocera (viz., *Alona affinis*) and 3 species of Rotifera (viz., *Keratella serrulata, Trichocerca bidens* and *Lecane flexilis*) were recorded (Table II. 3.79). Two rare Zooplankton species viz., *Keratella serrulata* and *Trichocerca bidens* were recorded from the barrage site.

Table II. 3.79: Occurrence of species belonging to Cladocera and Rotifera during monsoon and winter seasons at Tsa chu-I Lower site

Sl. No.	Taxa	Species	Season	
			Monsoon	Winter
1	Cladocera	*Alona affinis* (Leydig, 1860)	+	–
2	Rotifera	*Keratella serrulata* (Ehrenberg, 1838) *	+	–
3	Rotifera	*Lecane closterocerca* (Schmarda, 1859)	+	–
4	Rotifera	*Trichocerca bidens* (Lucks, 1912) *	+	–
Total	**2**	**4**	**4**	**0**

* Rare

Fish Fauna

No fish was recorded from this site.

Soil Fauna

The seasonal variation in soil fauna diversity (Collembola, Acarina and other arthropods) and equitability in litter and soil layer is shown in Tables II. 3.80-3.82.

Table II. 3.80: Seasonal variation of soil fauna (Collembola, Acarina and other arthropods) diversity and equitability in litter and soil layer at Tsa chu-I Lower project sites

Soil fauna	Diversity	Post-monsoon				Monsoon				Winter			
		Barrage		Powerhouse		Barrage		Powerhouse		Barrage		Powerhouse	
		Litter	Soil	Litter	Soil	Litter	Soil	Litter	Soil	Litter	Soil	Litter	Soil
Collembola	Dominance_D	0.50	0.28	0.38	0.50	0.23	0.21	0.17	0.24	0.50	0.25	0.33	0.38
	Shannon_H	0.69	1.33	1.04	0.69	1.51	1.58	1.84	1.52	0.69	1.39	1.10	1.04
	Evenness_e^H/S	1.00	0.95	0.94	1.00	0.91	0.97	0.90	0.91	1.00	1.00	1.00	0.94
Acarina	Dominance_D	1.00	0.50	0.21	1.00	0.50	0.50	0.21	0.21	1.00	0.50	0.33	0.50
	Shannon_H	0.00	0.69	1.58	0.00	0.69	0.69	1.57	1.59	0.00	0.69	1.10	0.69
	Evenness_e^H/S	1.00	1.00	0.97	1.00	1.00	1.00	0.96	0.98	1.00	1.00	1.00	1.00
Other Arthropods	Dominance_D	0.50	0.17	0.18	0.13	0.50	0.17	0.12	0.10	1.00	0.33	0.12	0.50
	Shannon_H	0.69	1.79	1.75	2.11	0.69	1.79	2.21	2.37	0.00	1.10	2.16	0.69
	Evenness_e^H/S	1.00	1.00	0.96	0.91	1.00	1.00	0.91	0.97	1.00	1.00	0.97	1.00

Table II. 3.81: Mean annual density (number/m^2) of soil fauna in litter and soil layer (0-5 cm) at Tsa chu-I Lower project sites

Soil fauna	Site	Litter layer	Soil layer	Total
Collembola	Barrage	655	655	**1309**
	Powerhouse	873	618	**1491**
Acarina	Barrage	145	218	**364**
	Powerhouse	1127	291	**1418**
Other Arthropods	Barrage	327	545	**873**
	Powerhouse	2073	1164	**3236**
Total fauna	**Barrage**	**1127**	**1418**	**2546**
	Powerhouse	**4073**	**2073**	**6145**

Table II. 3.82: Seasonal variation of soil fauna density (number/m^2) at barrage and powerhouse site of Tsa chu-I Lower project sites

Soil fauna	Site	Post-monsoon	Monsoon	Winter	Mean
Collembola	Barrage	2800	9200	2400	**4800**
	Powerhouse	2400	11200	2800	**5467**
Acarina	Barrage	1200	1600	1200	**1333**
	Powerhouse	4400	9200	2000	**5200**
Other arthropods	Barrage	4000	4000	1600	**3200**
	Powerhouse	10400	20400	4800	**11867**

Wildlife

Butterflies: Studies on the diversity status of butterflies in Tsa chu-I Lower HEP area revealed the presence of 20 species belonging to 16 genera and four families. Nymphalidae was the dominant family with six species. These 20 species did not include any of the threatened species (Table II. 3.83).

Table II. 3.83: Butterflies recorded in Tsa chu-I Lower project area

Sl. No.	Family common name	Scientific name	Project area
I.	**Papilionidae**		
1	Common Peacock	*Papilio polyctor ganesa*	*
2	Paris Peacock	*Papilio paris paris*	*
3	Golden Birdwing	*Troides aeacus aeacus*	*
4	Common Bluebottle	*Graphium sarpedon sarpedon*	*
5	Indian Purple Emperor	*Mimathyma ambica*	*
II.	**Pieridae**		
6	Dark Jezebel	*Delias berinda*	*
7	Spotless Grass Yellow	*Eurema laeta*	*
8	Small Grass Yellow	*Eurema brigitta rubella*	*
9	Indian Cabbage White	*Pieris canidia indica*	*
10	Green-veined White	*Pieris napi montana*	*
III.	**Lycaenidae**		
11	Green Sapphire	*Heliophorus moore*	*
12	Common Flash	*Rapala nissa ratna*	*
13	Common Hedgeblue	*Acytolepis puspa gisca*	*

IV.	**Nymphalidae**		
14	Chestnut Tiger	*Parantica sita*	*
15	Eastern Comma	*Polygonia egea*	*
16	Large Silverstripe	*Argynnis children*	*
17	Glassy Tiger	*Graphium cloanthus*	*
18	Chocolate Pansy	*Junonia iphita iphita*	*
19	Banded Treebrown	*Lethe confusa*	*
20	Straight-banded Treebrown	*Lethe verma*	*

Herpetofauna: In Tsa chu-I Lower project area, the probable list of amphibians and reptiles was prepared following Ahmed *et al.* (2009) since the surveys carried out in three seasons did not result in reporting of any herpetofauna (Appendix II. 3.167).

Birds: The bird diversity assessment in and around the project area was carried out during Monsoon and winter seasons. The study revealed presence of 43 species of of terrestrial birds was 43 species belonging to 31 genera and 16 families. A diversity value (H') of 2.7 reflects moderate species diversity in the project area. Species richness was higher during monsoon season (31 species) than winter. Low species richness during winter might be due to snowfall and less availability of food resources in the area. However, the abundance of birds was also high during monsoon (Table II. 3.84).

Migratory status: The migratory and resident status of these bird species revealed that most of the birds were residents (23 species), followed by 7 breeding visitors, and 13 winter visitors (Table II. 3.84).

Table II. 3.84: Status of birds recorded in the Tsa chu-I Lower project area

Details	Post-monsoon	Monsoon	Winter	Overall
Family	–	13	9	16
Genera	–	22	12	31
Species	–	31	15	43
Abundance	–	307	57	364
Diversity H'	–	2.2	2.5	2.7
Migratory Status				
Breeding Visitor	–	6	1	7
Isolated Record	–	0	0	0
Resident	–	14	12	23
Winter Visitor	–	11	2	13

Abundance status: The abundance status of birds was derived by classifying the abundance of bird species into five abundance category (Very Low = 1-25 birds, Low = 26-50, Moderate = 51-75, High = 76-100 & Very High = > 100birds). The details of abundance status are given in Table II. 3.85.

Table II. 3.85: Number of species and relative % of birds in different abundance classes

Abundance class	No. of species	Relative %
Very low –1–25 birds	41	95.3
Low–26–50 birds	0	0.0
Moderate –50–75 birds	0	0.0
High–76-100 birds	1	2.3
Very high >100 birds	1	2.3
Total	**43**	**100.0**

Status of foraging guilds: In Tsa chu-I Lower project area, the birds were from five foraging guilds, among which insectivore were dominant with 31 species followed by six species of granivores (Table II. 3.8 and Annexure). This generally shows the low diversity of birds in this project area.

Table II. 3.86: Status of foraging guild of birds recorded in Tsa chu-I Lower HEP area

Foraging guild	Post monsoon	Monsoon	Winter	Overall
Aquatic Feeder	-	0	0	0
Carnivore	-	2	1	3
Frugivore	-	0	0	0
Granivore	-	3	4	6
Insectivore	-	26	7	31
Nectarivore	-	0	0	0
Nucivore	-	0	1	1
Omnivore	-	0	2	2
Piscivore	-	0	0	0

Status of threatened species: The assessment of conservation status of birds in this project area showed that there was no threatened bird species encountered during the field study (Appendix II. 3.171).

Mammals: Two surveys in and around the Tsa chu-I Lower project site revealed the presence of six mammalian fauna belonging to five families, and each species belonging to a separate genus. The recorded mammallian species comprised of two species each, beloning to ungulate, rodent, and carnivore (Appendix II.3. 172).

Abundance status: Among these six species, presence of five species was confirmed based on 14 evidences. The Himalayan Stripped Squirrel *(Tamipos macclellandi*) and Orange bellied Himalayan Squirrel (*Dremomys lokriah)* were the only two species sighted with one animal each. Presence of Wild pig (*Sus scrofa*) and Himalayan goral (*Naemorhedus goral*) were established based on the basis of five and four evidences respectively (Table II. 3.87). Occurance of only six species with 14 evidences and two sightings of animal clearly showed the low potential of the project area (six species) with the possible species (29 species) of Tawang district (Mishra *et al.,* 2006) also revealed the low species richness, as the species recorded in the project area formed only 21.42% (Table and Appendix II.3.172).

Status of threatened species: Except the Himalayan goral (*Naemorhedus goral)* which is Near Threatened (NT) according to IUCN Red List, the rest of the five species of the project area fall under Least Concern (LC) of IUCN and Schedule II and III of WPA (1972) (Table II. 3.87).

Table II. 3.87: Status of mammalian fauna reported in the Tsa chu-I Lower HEP area

Sl. No.	Common name	Scientific name	Seasons			Overall	Conservation status	
			PM	M	W		IUCN	WPA
I	**Bovidae**							
1	Himalayan goral	*Naemorhedus goral*		IE-1	IE 3	IE 4	NT	III
II	**Suidae**							
2	Wild pig	*Sus scrofa*		IE-3	IE 2	IE 5	LC	III
III	**Felidae**							
3	Jungle cat	*Felis chaus*		IE-2		IE 2	LC	II
IV	**Mustelidae**							
4	Yellow Throated Martin	*Martes flavigula*		IE–2	IE 1	IE 3	LC	II
V	**Sciuridae**							
5	Orange-Bellied Himalayan Squirrel	*Dremomys lokriah*		A 1		A 1	LC	NE
6	Himalayan Stripped Squirrel	*Tamipos macclellandi*		A1		A 1	LC	NE
	No of species			**6**	**3**	**6**		
	Total and types of records			**IE 8 A 2**	**IE 6**	**IE 14 A 2**		

IE–Indirect Evidences A–animals sighted, W-Winter, PM-Post-monsoon, M-Monsoon, IUCN-Red List, WPA–Wildlife Protection Act, NT-Near threatened, LC-Least Concern, NE–Not Evaluated

Faunal status within 500 m of project affected area: This section revealed species richness status of selected faunal groups such as avifauna and mammal species reported within 500 m up and down streams of the barrage and powerhouse sites of the proposed project area. The species richness reported in these specific sites was evaluated based on subjective rating through estimating percent contribution to the overall species list of the project area. If the species richness of barrage and powerhouse constitutes 25% of overall list it was categorised as low, > 25-50% as medium, >50-75% as high and above 75% as high species richness.

Status of avifauna: At Tsa chu-I Lower project site, the barrage and powerhouse sites were designated as medium species richness area comprising of 28 species of birds, when compared with the overall list of 43 species reported for the entire project area (65.11%). There were no threatened species in the powerhouse site (Appendix II.3.173).

Status of mammals: Site specific evaluation of mammalian fauna within 500 m of up and down streams showed occurrence of only four species in the barrage and powerhouse site. Himalayan goral was recorded on the basis of indirect evidences. Himalayan goral falls under NT category of IUCN, and the rests belong to LC category. Wildlife Protection Act (1972) showed that all these species were under schedule II and III (Table II. 3.88). Overall the of Tsa chu-I project site did not have any mammalian fauna of high conservation importance.

Table II. 3.88: Status of mammalian fauna at barrage and powerhouse sites of the proposed Tsa chu-I Lower HEP area

Sl. No.	Common name	Species name	Status	Conservation status	
			BS/PHS	IUCN	WPA
1	Himalayan goral	*Naemorhedus goral*	IE 4	NT	III
2	Wild pig	*Sus scrofa*	IE2	LC	III
3	Jungle cat	*Felis chaus*	IE 2	LC	II
4	Barking Deer	*Muntiacus muntjak*	IE 2	LC	II
	Total no of species		**4**		
	Total no of records		**IE 10**		

IE–Indirect Evidences, A–No of Animals Sighted, BS–Barrage Site, PHS–Powerhouse Site, IUCN-Red List, WPA–Wildlife Protection Act, EN-Endangered, NT-Near threatened, LC-Least Concern, NE-Not Evaluated

3.3.3.3 SOCIO–ECONOMIC PROFILE

There are 5 villages falling in the 10 km influence zone of the Tsa chu–II project. Four villages, namely, Thingbu, Rho, Tsa chu and Broxer fall under Thingbu circle, and the village Jangda falls under Lhau circle. Currently, there is no human settlement in the village Broxer; while the inhabitants of Tsa chu are migrants, and possess no land holdings. Therefore, these two villages were not included in the baseline survey. The materials have been described separately for the data gathered at the village level and at the HH level.

Village Level Survey

Profile of the Three Surveyed Villages: Out of the three villages, Rho and Jangda fall under the affected villages, while Thingbu is under influenced category (Table II. 3.117). All the three villages are situated at a considerable distance from the Tawang river. The village nearest to the river is Jangda, which is situated 7 km away, and the farthest village from the river is Thingbu, and the distance being 20 km. The circle headquarters of the three villages are within 15 km. All the three villages are located at a very long distance from the district headquarters.

Table II. 3.117: Profile of the three surveyed villages

Sl. No.	Village	Circle	Distance of village (in km)			Category of village
			River/ Tributary	Circle HQ	District HQ	
1	Rho	Thingbu	8	5	99.6	Affected
2	Jangda	Lhau	7	15	90	Affected
3	Thingbu	Thingbu	20	1	100	Influenced

Private Landuse Pattern: The details of private land holdings (in hectares) of the three villages are given in Table II. 3.118. The total private land in the three villages is about 340 ha. Rho has the maximum area of 160 ha, and Thingbu has only 60 ha. In all the villages, the proportion of agricultural land exceeds that of the other land use types. 49% of total private land is under cultivation. Private forest land also contributes significantly (33%) to the total land holdings of the villages.

Table II. 3.118: Private landuse pattern and their percentage to total private land

Sl. No.	Village	Total private land (ha)	Forest cover (ha)	%	Agriculture (ha)	%	Horticulture (ha)	%	Habitation and HG (ha)	%
1	Rho	160.00	58.00	36	66.00	41	0.00	–	36.00	23
2	Jangda	120.00	45.00	38	57.00	48	0.00	–	18.00	15
3	Thingbu	60.00	10.00	17	44.00	73	0.00	–	6.00	10
	Total	**340.00**	**113.00**	**33**	**167.00**	**49**	**0**	**–**	**60.00**	**18**

Demography and Literacy Rate: From Table II. 3.119, the following main features emerge. The total number of HHs in the three villages is 236. The total population is 1067 (528 males; 539 females). Except in Jangda, in other two villages the number of females per 1000 males is less. The literacy rate in all the three villages is less than 50%. Jangda has the least number of literates (30%). Among males, it varies from 30% in Jangda to 58% in Rho. In females, it varies from 23% in Rho to 41% in Jangda. It is highly noteworthy that in Jangda the literacy rate among females is considerably higher compared to males.

Table II. 3.119: Demography and literacy rate

Sl. No.	Village	Demography					% Literacy rate*		
		No. of HH	Male	Female	Total	Sex ratio (Per 1000 males)	Male	Female	Total
1	Rho	85	150	136	**286**	907	58	23	**45**
2	Jangda	99	249	276	**525**	1108	30	41	**30**
3	Thingbu	52	129	127	**256**	984	46	27	**39**
	Total	**236**	**528**	**539**	**1067**	**–**	**–**	**–**	**–**

*After Census 2011

Number of Livestock: The details of livestock holding in the three villages are given in Table II. 3.120. Altogether, 8 different types of animals are reared in the three surveyed villages. In Rho and Jangda, all the eight animals are reared in varying proportions. The pastoralist Monpas of Thingbu village primarily rear Yak. Altogether 2325 animals were recorded in the three villages. Considerable inter–village variation is observed in total number of animals reared. It varied from 487 in Rho to 1021 animals in Jangda.

Table II. 3.120: Number of livestock

Sl. No.	Village	Cattle	Yak	Goat	Sheep	Pig	Pony	Poultry	Others	Total
1	Rho	255	49	68	85	14	6	7	3	**487**
2	Jangda	395	114	37	364	72	10	28	1	**1021**
3	Thingbu	0	529	0	100	0	179	9	0	**817**
	Total	**650**	**692**	**105**	**549**	**86**	**195**	**44**	**4**	**2325**

Total Estimated Value of Livestock: The monetary value of animals maintained by the inhabitants of the studied villages have been estimated separately for each animal and for each village (Table II. 3.121). The selling price of different animals was obtained from the knowledgeable persons in the villages. The detailed methodology used has been described in the methodology section of the report. As expected, there is considerable intra- and inter-village variation in this respect. The monetary value of total animals numbering 2325 found in the three villages has been estimated as 440.87 lakh. The value varied from 89.87 lakh in Rho to 179.47 lakh in Thingbu. In terms of relative contribution made by different animals to the total value, cattle and Yak together contribute over 335 lakh.

Table II. 3.121: Total estimated value of livestock

Sl. No.	Village	Total estimated value (Rupees in lakh)								
		Cattle	Yak	Goat	Sheep	Pig	Pony	Poultry	Others	Total
1	Rho	63.75	12.25	3.40	5.10	3.50	1.38	0.04	0.45	**89.87**
2	Jangda	98.75	28.50	1.85	21.84	18.00	2.30	0.14	0.15	**171.53**
3	Thingbu	0.00	132.25	0.00	6.00	0.00	41.17	0.05	0.00	**179.47**
	Total	**162.50**	**173.00**	**5.25**	**32.94**	**21.50**	**44.85**	**0.23**	**0.60**	**440.87**

Average Annual Earning of the Village: The average annual family income varies from 2.5 lakh in Rho to 5.53 lakh in Thingbu (Table II. 3.122). Total annual earnings in the three villages is estimated as 854.89 lakh. Of the total annual earning, animal husbandry contributes the maximum i.e. 502.20 lakh (59%). Traditional skills and daily wage labour together contribute over 25%. It is highly noteworthy that agriculture contributes only 10% of the total annual village earning.

Table II. 3.122: Average annual earning of the village

Sl. No.	Name of village	Total earning / year (Rupees in lakh)								Average family income (Rupees in lakh)
		Agriculture	Animal husbandry	Horticulture	Traditional skills	Daily wages	Govt. service	Others*	Total	
1	Rho	33.00	105.19	0.00	25.00	34.43	9.00	6.30	**212.92**	2.50
2	Jangda	28.50	220.54	0.00	39.75	40.10	14.94	10.46	**354.28**	3.58
3	Thingbu	22.00	176.47	0.00	55.00	21.06	7.74	5.42	**287.69**	5.53
	Total	**83.50**	**502.20**	**0.00**	**119.75**	**95.59**	**31.68**	**22.18**	**854.89**	**11.61**
	%	**10**	**59**	**0**	**14**	**11**	**4**	**3**	**–**	**–**

* Others include artisans, monks, self–employed, contractors, income from river resources and NTFPs etc.

Average Annual Expenditure Pattern of a Family: The average annual family expenditure in the surveyed villages varies from 1.58 lakh in Rho to 1.53 lakh in the remaining villages. In all the villages, the maximum expenditure is incurred on health and education (0.48 lakh), followed by transport (0.40 lakh) and clothings (0.35 lakh). The least expenditure in all the three villages is incurred on food and drinks (about 0.30 lakh). It may be noted here that the high expenditure incurred on transport is because the markets, health facility and government setups are located at long distances from the villages, and that there is no public transport system in the area. It is highly noteworthy that the estimated annual earning per family in all the villages are higher than that of average annual expenditure incurred by a family (Table II. 3.123).

Table II. 3.123: Average annual expenditure pattern of a family in village

Sl. No.	Village	Expenditure/ year (Rupees in lakh)				
		Food and drinks	Clothing	Transport	Education and health	Total
1	Rho	0.35	0.35	0.40	0.48	**1.58**
2	Jangda	0.30	0.35	0.40	0.48	**1.53**
3	Thingbu	0.30	0.35	0.40	0.48	**1.53**
	Total	**0.95**	**1.05**	**1.20**	**1.44**	**4.64**

Water Sources: In Table II. 3.124, data pertaining to the water resources available and their pattern of use in the three villages have been presented. The data revealed that there are only two types of water sources available in each of the three villages, namely, hill stream/spring and tap water. Water from hill stream/spring in all the villages is used for domestic purposes. Tap water is used for domestic purposes and for domestic animals. It may be noted that the source of tap water in all the surveyed villages is hill stream/spring. Water from hill stream/spring is collected in tanks and through a network of pipes it is supplied to a cluster of HHs as a common facility.

Table II. 3.124: Water sources in the village

Sl. No.	Water sources	Uses	Rho	Jangda	Thingbu	Total
1	River	Drinking water	0	0	0	**0**
		Domestic use	0	0	0	**0**
		Livestock use	0	0	0	**0**
		Agriculture	0	0	0	**0**
2	Hill stream/spring	Drinking water	1	1	1	**3**
		Domestic use	1	1	1	**3**
		Livestock use	1	1	1	**3**
		Agriculture	0	0	0	**0**
3	Wells	Drinking water	0	0	0	**0**
		Domestic use	0	0	0	**0**
		Livestock use	0	0	0	**0**
		Agriculture	0	0	0	**0**
4	Ponds	Drinking water	0	0	0	**0**
		Domestic use	0	0	0	**0**
		Livestock use	0	0	0	**0**
		Agriculture	0	0	0	**0**

5	Tap water	Drinking water	1	1	1	**3**
		Domestic use	1	1	1	**3**
		Livestock use	0	0	0	**0**
		Agriculture	0	0	0	**0**

Amenities in the Villages: From Table II. 3.125, it is observed that Rho has a maximum number of amenities being 7/12 (58.3%) followed by Thingbu (50%), and the least (42%) are found in Jangda. All the villages have motorable road, electricity, School and TV/radio. It is highly noteworthy that none of the three villages have traditional health healer, fair price shop, grocery shop, post office and bank.

Table II. 3.125: Amenities in the villages

Sl. No.	Amenities	Rho	Jangda	Thingbu	Total
1	Road connectivity	√	√	√	**3**
2	Health facility (PHC/sub–centre)	√		√	**2**
3	Traditional health healer				
4	Veterinary services	√		√	**2**
5	Electricity	√	√	√	**3**
6	Fair price shop				
7	Grocery shop				
8	Post office				
9	Bank				
10	School	√	√	√	**3**
11	Telephone/mobile	√	√		**2**
12	TV/ radios	√	√	√	**3**
Total Amenities in the villages		**7**	**5**	**6**	**–**

NB: Blank indicates absent

Social Institutions: All the villages have community hall and Gompa (Table II. 3.126). Anganwadi is present in Jangda and Thingbu. SHGs are absent in all the villages.

Table II. 3.126: Social institutions in the village

Sl. No.	Village	SHGs	Anganwadi	Community hall	Gompa	Any other	Total
1	Rho			√	√	√	**3**
2	Jangda		√	√	√		**3**
3	Thingbu		√	√	√		**3**
Total			**2**	**3**	**3**	**1**	**–**

NB: Blank indicates absent

Occupation Profile: Work force participation is detailed in Table II. 3.127. The total working population in the three villages comprises of 714 (42%) of total population. Jangda has the highest working population (67%), and Rho has the least (3%).

Table II. 3.127: Occupation profile of the village

Sl. No.	Name of village	Population			Workers			Main workers			Marginal workers			Non workers		
		T	M	F	T	M	F	T	M	F	T	M	F	T	M	F
1	Rho	652	403	249	21	8	13	10	7	3	11	1	10	16	4	12
2	Jangda	682	406	276	458	289	169	320	252	68	138	37	101	224	117	107
3	Thingbu	363	225	138	235	161	74	234	161	73	1	0	1	128	64	64
	Total	**1697**	**1034**	**663**	**714**	**458**	**256**	**564**	**420**	**144**	**150**	**38**	**112**	**368**	**185**	**183**

Source: Census 2011

Household Level Survey

Age of the Head of the Household: The age of head of the HHs across the three surveyed villages varied from 20 to 99 years. The age of a majority of the head of HHs however was greater than 50 years (Table II. 3.128). Depending on the demographic structure of the villages, considerable variation was observed between the three villages in terms of the age of the Head of HHs. The average age varies from 43 years in Rho to 55 years in Thingbu (Table II. 3.129).

Table II. 3.128: Distribution of head of the HHs by age across three project villages

Sl. No.	Age class (years)	Rho		Jangda		Thingbu		Total	
		n	%	n	%	n	%	n	%
1	Upto 30	8	9	7	7	2	4	**17**	**7**
2	31–40	36	42	19	19	6	12	**61**	**26**
3	41–50	24	28	31	31	12	23	**67**	**28**
4	>50	17	20	42	42	32	62	**91**	**39**
	Total	**85**	**100**	**99**	**100**	**52**	**100**	**236**	**100**

Table II. 3.129: Minimum, maximum and average age of head of HHs across three project villages

Sl. No.	Village	Age range		Average age
		From	To	
1	Rho	24	78	43
2	Jangda	25	92	50
3	Thingbu	20	99	55

Gender of the Head of Households: Data on gender of the head of HHs in the three surveyed project villages is given in Table II. 3.130. In all the three villages, the number of males exceeds that of females as head of HHs. Across the surveyed villages, 74% of heads were males. In village Jangda, the female head of HHs also occur in substantial number being 34 %.

Table II. 3.130: Distribution of head of HHs by gender in three project villages

Sl. No.	Village	Male		Female		Total	
		n	%	n	%	n	%
1	Rho	72	85	13	15	**85**	**36**
2	Jangda	65	66	34	34	**99**	**42**
3	Thingbu	38	73	14	27	**52**	**22**
	Total	**175**	**74**	**61**	**26**	**236**	**100**

Ethnicity: All the three villages are inhabited by Monpa tribals.

Household Size: From Tables II. 3.131 and 3.132, in respect of the distribution of HH size in three project villages, the HH size varies from one to thirteen across the three villages. There is large variation between the three villages in terms of distribution of HH size. The average HH size varies from 3 in Rho to 5 in Jangda and Thingbu, and the average HH size across the surveyed villages is 4.

Table II. 3.131: Distribution of HH size in three project villages

Sl. No.	HH size	Rho		Jangda		Thingbu		Total	
		n	%	n	%	n	%	n	%
1	1	9	11	5	5	5	10	**19**	**8**
2	2	8	9	11	11	5	10	**24**	**10**
3	3	22	26	6	6	4	8	**32**	**14**
4	4	39	46	13	13	8	15	**60**	**25**
5	5	4	5	14	14	12	23	**30**	**13**
6	6–8	3	4	39	39	14	27	**56**	**24**
7	9 and above	0	0	11	11	4	8	**15**	**6**
	Total	**85**	**100**	**99**	**100**	**52**	**100**	**236**	**100**

Table II. 3.132: Minimum, maximum and average HH size across three project villages

Sl. No.	Village	HH size range		Average HH size
		From	To	
1	Rho	1	7	3
2	Jangda	1	9	5
3	Thingbu	1	13	5
	Total	**1**	**13**	**4**

Education: Relevant data on education of the head of the HHs in the three project villages is presented in Table II. 3.133. It is highly noteworthy that a majority of the heads were illiterate, varying from 85% in Jangda to 92% in Thingbu. Out of 236 Head of HHs, 206 (87%) were illiterate. There were only 2 head of HHs, one each in Rho and Jangda, who were graduates.

Table II. 3.133: Distribution of education of head of HHs in three project villages

Sl. No.	Education	Rho		Jangda		Thingbu		Total	
		n	%	n	%	n	%	n	%
1	Illiterate	74	87	84	85	48	92	**206**	**87**
2	Primary	0	0	3	3	0	0	**3**	**1**
3	Upper primary	2	2	5	5	1	2	**8**	**3**
4	Secondary	5	6	4	4	1	2	**10**	**4**
5	Higher secondary	3	4	2	2	2	4	**7**	**3**
6	Graduation or above	1	1	1	1	0	0	**2**	**1**
	Total	**85**	**100**	**99**	**100**	**52**	**100**	**236**	**100**

Main Occupation of Household Heads: The main occupation of the head of HHs across the three villages is agriculture, labour, pastoralist, and government service. Table II. 3.134 reveal the following main features:

Agriculture: It varies from zero in Thingbu to 78% in Rho. 50% of the surveyed head of HHs pursue agriculture.

Labour: Only in Jangda, 15% of the heads of HHs reported labour as main source of income.

Pastoral: 8% of the heads of HH heads in Jangda and 87% in Thingbu, were engaged in livestock rearing. In both the villages, the animal associated with this mode of occupation is Yak.

Government service: Government servants were reported from all the three villages and constitutes 15% of the main occupation in surveyed villages. The largest number is from Rho i.e. 22 percent, followed by Jangda (10%) and Thingbu (13%).

Any other occupation: 6% of heads of HHs in Rho and Jangda pursue other occupations.

Table II. 3.134: Distribution of head of HHs by main occupation in three project villages

Sl. No.	Main occupation	Rho		Jangda		Thingbu		Total	
		n	%	n	%	n	%	n	%
1	Farmer	66	78	51	52	0	0	**117**	**50**
2	Labour	0	0	15	15	0	0	**15**	**6**
3	Pastoral	0	0	8	8	45	87	**53**	**22**
4	Government service	19	22	10	10	7	13	**36**	**15**
5	Any other	0	0	15	15	0	0	**15**	**6**
	Total	**85**	**100**	**99**	**100**	**52**	**100**	**236**	**100**

*any other category includes artisans, monks, self–employed, contractors, income from river resources and NTFPs etc.

Private Land Holding Pattern: The private land holding in the three villages comprises of agricultural land, horticulture land, habitation, home garden, and forest land. It may be noted that a majority of the inhabitants of the surveyed villages did not know the actual area of land holding, either in acres or hectares. Therefore the area reported here should be considered as very rough estimates. Data pertaining to this aspect have been described below:

Agricultural land: An examination of the data given in Table II. 3.135 revealed that except 10 HHs (4.2%), all the remaining HHs (95.8%) in surveyed villages owned agricultural land in varying proportions. A majority of the HHs (54.7%) owned agri–land between 1–2 acres and only 27.5% of HHs owned more than 2 acres of agri–land.

Table II.3.135: Distribution of agricultural land holding among surveyed HHs in three project villages

Sl. No.	Class	Rho		Jangda		Thingbu		Total	
		n	%	n	%	n	%	n	%
1	0.0 acre	2	2	6	6	2	4	**10**	**4.2**
2	<1 acre	0	0	22	22	10	19	**32**	**13.6**
3	1–2 acre	64	75	54	55	11	21	**129**	**54.7**
4	>2 acre	19	22	17	17	29	56	**65**	**27.5**
	Total	**85**	**100**	**99**	**100**	**52**	**100**	**236**	**100**

Horticultural land: None of the HHs in the three villages owned horticultural land.

Habitation and home–garden land: Data presented in Table II. 3.136 reveal that only 5% of HHs in surveyed villages did not own any such land. A majority of HHs i.e., 72% owned less than one acre of such land, whereas nearly one–fourth of the HHs owned between 1–2 acre of land. It is highly noteworthy that, unlike in many parts of northeast, the Monpas of surveyed villages do not have a strong tradition of raising home gardens.

Table II. 3.136: Distribution of habitation and home garden land among surveyed HHs in three project villages

Sl. No.	Class	Rho		Jangda		Thingbu		Total	
		n	%	n	%	n	%	n	%
1	0.0 acre	0	0	6	6	6	12	12	**5**
2	<1 acre	32	38	93	94	45	87	170	**72**
3	1–2 acre	53	62	0	0	1	2	54	**23**
4	>2 acre	0	0	0	0	0	0	0	**0**
	Total	**85**	**100**	**99**	**100**	**52**	**100**	**236**	**100**

Forest land: About 42 HHs (18%) in surveyed villages do not own private forest land, whereas 53% of the total HHs owned such land between 1–2 acres. In Rho, it is noteworthy that 20% of HHs owned more than 2 acre of forest land (Table II. 3.137).

Table II. 3.137: Distribution of forest land holding among surveyed HHs in three project villages

Sl. No.	Class	Rho		Jangda		Thingbu		Total	
		n	%	n	%	n	%	n	%
1	0.0 acre	14	16	15	15	13	25	42	**18**
2	<1 acre	0	0	15	15	25	48	40	**17**
3	1–2 acre	54	64	59	60	12	23	125	**53**
4	>2 acre	17	20	10	10	2	4	29	**12**
	Total	**85**	**100**	**99**	**100**	**52**	**100**	**236**	**100**

Total land holdings: Data presented in Tables II. 3.138–3.141 shows that, there are only 6 HHs (3%) – all in Jangda–that do not own any type of private land, while over three–fourth of the HHs (77%) owned more than 2 acres of total land. There is a striking variation between the HH in a village, as well as between villages in ownership of total land. For example, in Rho inter-HHs land holdings vary from 1 acre to 26 acres, whereas in Thingbu it varies from 0.7–8.5 acre. In all the villages, the proportion of agri–land is greater than other types of land owned. The 236 HHs in the three villages owned total private land area of about 845 acres. Out of this, Rho accounts for 47% and Thingbu only 18%. Agri–land accounts for 49% of total land holding in the three villages, and that of forest land is 33% (Table II. 3.141).

Table II. 3.138: Distribution of total land holding among surveyed HHs in the three project villages

Sl. No.	Class	Rho		Jangda		Thingbu		Total	
		n	%	n	%	n	%	n	%
1	0.0 acre	0	0	6	6	0	0	6	**3**
2	<1 acre	0	0	7	7	11	21	18	**8**
3	1–2 acre	10	12	19	19	1	2	30	**13**
4	>2 acre	75	88	67	68	40	77	182	**77**
	Total	**85**	**100**	**99**	**100**	**52**	**100**	**236**	**100**

Table II. 3.139: Minimum, maximum and average land holdings across the three project villages

Sl. No.	Land type	Rho			Jangda			Thingbu		
		From	To	Average	From	To	Average	From	To	Average
1	Agricultural land	0.00	12.00	1.94	0.00	6.00	1.42	0.00	4.00	2.10
2	Horticultural land	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	Habitation and home garden land	0.46	2.00	1.04	0.00	0.74	0.45	0.00	1.00	0.28
4	Forest land	0.00	12.00	1.69	0.00	4.00	1.13	0.00	5.00	0.51
5	Total land	1.00	26.00	4.68	0.00	10.74	3.00	0.70	8.50	2.89

Table II. 3.140: Number of HHs having land types in the three project villages

Sl. No.	Land type	Rho		Jangda		Thingbu		Total	
		n= 85	%	n= 99	%	n= 52	%	n= 236	%
1	Agricultural land	83	98	93	94	50	96	**226**	**96**
2	Horticultural land	0	0	0	0	0	0	**0**	**0**
3	Habitation and home garden land	85	100	93	94	46	88	**224**	**95**
4	Forest land	71	84	84	85	39	75	**194**	**82**

Table II. 3.141: Distribution of area (in acres) of land holding among HHs in the three project villages

Sl. No.	Land category	Rho		Jangda		Thingbu		Total	
		Area	%	Area	%	Area	%	Area	%
1	Agricultural land	165	41	141	47	109	73	**415**	**49**
2	Horticultural land	0	0	0	0	0	0	**0**	**0**
3	Habitation and home garden land	89	22	44	15	15	10	**148**	**17**
4	Forest land	144	36	112	38	27	18	**282**	**33**
	Total land	**398**	**100**	**297**	**100**	**150**	**100**	**845**	**100**

Livestock Holding: Data presented in Tables II. 3.142-3.144 in respect of distribution of livestock holding in the three surveyed villages revealed that, altogether 8 different types of animals are reared in the three surveyed villages (Table II. 3.142). In Rho and Jangda, all the eight animals are maintained in varying proportions. All the HHs in Thingbu rear Yak and Pony in appreciable numbers, while only three HHs maintain poultry. The preferred animals in Rho are cattle, goat and sheep, whereas in Jangda in addition to these animals, 64% of HHs also rear pigs in appreciable numbers. All the 52 HHs in Thingbu own Yak.
Altogether, 2325 animals have been domesticated in the three villages (Table II. 3.143). Considerable inter–village variation is observed in total number of animals reared. It varied from 487 in Rho to 1021 animals in Jangda. Jangda alone accounts for 44% of all the animals found in the surveyed village. Three animals, viz, Yak (30%), cattle(28%) and sheep (24%) account for 82% of the total animals (2325). About 22% of the HHs did not own any animals, whereas 44% HHs owned more than 10 animals (Table II. 3.144).

Table II. 3.142: Livestock holding by HHs in the three project villages

Sl. No.	Livestock	Rho		Jangda		Thingbu		Total	
		n= 85	%	n= 99	%	n= 52	%	n= 236	%
1	Cattle	30	35	92	93	0	0	**122**	**52**
2	Yak	5	6	25	25	52	100	**82**	**35**
3	Goat	17	20	22	22	0	0	**39**	**17**
4	Sheep	20	24	71	72	52	100	**143**	**61**
5	Pig	6	7	63	64	0	0	**69**	**29**
6	Pony	1	1	2	2	52	100	**55**	**23**
7	Poultry	2	2	13	13	3	6	**18**	**8**
8	Others	1	1	1	1	0	0	**2**	**1**

Table II. 3.143: Number of livestock among surveyed HHs in the three project villages

Sl. No.	Livestock	Rho		Jangda		Thingbu		Total	
		n= 85	%	n= 99	%	n= 52	%	n= 236	%
1	Cattle	255	52	395	39	0	0	**650**	**28**
2	Yak	49	10	114	11	529	65	**692**	**30**
3	Goat	68	14	37	4	0	0	**105**	**5**
4	Sheep	85	17	364	36	100	12	**549**	**24**
5	Pig	14	3	72	7	0	0	**86**	**4**
6	Pony	6	1	10	1	179	22	**195**	**8**
7	Poultry	7	1	28	3	9	1	**44**	**2**
8	Others	3	1	1	0	0	0	**4**	**0**
	Total	**487**	**100**	**1021**	**100**	**817**	**100**	**2325**	**100**

Table II. 3.144: Distribution of total number of livestock in HHs of the three project villages

Sl. No.	Range	Rho		Jangda		Thingbu		Total	
		n	%	n	%	n	%	n	%
1	0	48	56	5	5	0	0	**53**	**22**
2	1–5	9	11	25	25	0	0	**34**	**14**
3	6–10	11	13	33	33	0	0	**44**	**19**
4	>10	17	20	36	36	52	100	**105**	**44**
	Total	**85**	**100**	**99**	**100**	**52**	**100**	**236**	**100**

Traditional Skills: Data pertaining to this aspect is presented in Table II. 3.145. It is highly noteworthy that, while in Tawang district at least 6 types of craft are practiced (see Table II. 3.145), in the surveyed villages only two types are practiced. Only one HH in Jangda is engaged in wood carving. However, weaving is practiced in all the three villages. It varies from 47% of HHs in Rho to 85% in Thingbu. Overall, 58% of the HHs practiced this craft. The craft is exclusively persued by women, and they are highly skilled in weaving various types of garments which are primarily used at home.

Table II. 3.145: Distribution of various skills among surveyed HHs in three project villages

Sl. No.	Skills	Rho		Jangda		Thingbu		Total	
		n= 85	%	n= 99	%	n= 52	%	n= 236	%
1	Wood carving	0	0	1	1	0	0	**1**	**0**
2	Thanka painting	0	0	0	0	0	0	**0**	**0**
3	Carpet making	0	0	0	0	0	0	**0**	**0**
4	Bamboo utensils	0	0	0	0	0	0	**0**	**0**
5	Weaving	40	47	53	54	44	85	**137**	**58**
6	Paper making	0	0	0	0	0	0	**0**	**0**

River Resources: In Table II. 3.146, data pertaining to the use of various river resources by the inhabitants of the three surveyed village is presented. The data showed that only three river resources viz., drinking water for domestic animals, sand, and stone are used. Out of these three river resources, 78% of all the HHs use river water for domestic animals. In Jangda, all the 99 HHs use sand and stone for self use as well as for selling. All the 236 HHs also use river for performing last rites of the dead. Although aquatic fauna is found in the river, but there is a taboo among the Monpas for using this resource.

It may be mentioned here that the villages are common to at many projects as either affected or influenced villages. Although the river dependency data at household/village levels are correct, the source of collection of these resources i.e. the exact name of the project site could not be ascertained. However, considering the distance from the villages to the proposed project sites, it may be safely concluded that the dependency on the river resources is minimum for Tsa chu-I Lower.

Table II. 3.146: Dependence on river resources among surveyed HHs in three project villages

Sl. No.	Nature of dependence	Rho		Jangda		Thingbu		Total	
		n= 85	%	n= 99	%	n= 52	%	n= 236	%
1	Drinking water	0	0	0	0	0	0	**0**	**0**
2	Water for domestic use	0	0	0	0	0	0	**0**	**0**
3	Water for domestic animal	37	44	94	95	52	100	**261**	**78**
4	Aquatic fauna	0	0	0	0	0	0	**0**	**0**
5	Aquatic flora	0	0	0	0	0	0	**0**	**0**
6	Religious	85	100	99	100	52	100	**236**	**100**
7	Sand	0	0	99	100	0	0	**99**	**42**
8	Stones (boulders)	0	0	99	100	0	0	**99**	**42**

Forest Resources: The villagers of all the three villages are dependent on the forest resources in varying degrees (Table II. 3.147). Salient features in respect of use of forest resources showed that, altogether 12 resources are used in varying degrees in the three surveyed villages (see Table II. 3.147). All the surveyed 236 HHs depend on four forest resources viz., fuel wood, timber, water and stones. More than 50% of HHs use forest resources for food (87%), grazing (78%), spices (78%), sand (72%), religious purposes (58%), and fencing (50%). Only a few HHs use forest resources for making handicrafts and for ornamental purposes.

It is evident from the above that, forest resources contribute significantly to the livelihoods, as well as the quality of life of a majority of the inhabitants of the surveyed villages. It may be mentioned here that the villages are common to many projects as either affected or influenced villages. Although the forest dependency data at household/village levels are correct, the source of collection of these resources i.e. the exact name of the project site could not be ascertained. However, considering the distance from the villages to the proposed project sites, it may be safely concluded that the dependency on the forest resources is minimum for Tsa chu-I Lower.

Table II. 3.147: Dependence on forest resources among surveyed HHs in the three project villages

Sl. No.	Nature of dependence	Rho		Jangda		Thingbu		Total	
		n= 85	%	n= 99	%	n= 52	%	n= 236	%
1	Fuel wood	85	100	99	100	52	100	**236**	**100**
2	Timber	85	100	99	100	52	100	**236**	**100**
3	Medicinal plants	0	0	0	0	36	69	**36**	**15**
4	Honey	0	0	0	0	0	0	**0**	**0**
5	Food	66	78	99	100	41	79	**206**	**87**
6	Edible oil	0	0	0	0	0	0	**0**	**0**
7	Ornamental	2	2	0	0	0	0	**2**	**1**
8	Religious	85	100	0	0	52	100	**137**	**58**
9	Fencing	19	22	99	100	0	0	**118**	**50**
10	Handicrafts	21	25	0	0	0	0	**21**	**9**
11	Thatching	0	0	0	0	0	0	**0**	**0**
12	Spices	0	0	0	0	0	0	**0**	**0**
13	Grazing	37	44	94	95	52	100	**183**	**78**
14	Hunting of wild animals	0	0	0	0	0	0	**0**	**0**
15	Fishes	0	0	0	0	0	0	**0**	**0**
16	Water	85	100	99	100	52	100	**236**	**100**
17	Stones	85	100	99	100	52	100	**236**	**100**
18	Sand	19	22	99	100	52	100	**170**	**72**
19	Dyes	0	0	0	0	0	0	**0**	**0**

Note: In none of the surveyed HHs in the three project villages, the following forest resources were used.

Honey	0
Edible oil	0
Thatching	0
Spices	0
Hunting of wild animals	0
Fishes	0
Dyes	0

Water Resources: In all the villages, the main source of water for various usage are hill stream/springs. Without an exception, all the 236 HHs depend on hill stream/spring water for all their requirements. In Rho and Jangda, the hill stream/spring water is brought to houses by connecting pipes. Water storage tanks have also been installed in these villages and the HHs are connected to the tanks by pipes (Table II. 3.148).

Table II. 3.148: Dependence on river resources among surveyed HHs in three project villages

Sl. No.	Nature of dependence	Rho		Jangda		Thingbu		Total	
		n	%	n	%	n	%	n	%
1	River	85	100	0	0	0	0	**85**	**36**
2	Hill stream/spring	85	100	99	100	52	100	**236**	**100**
3	Wells	0	0	0	0	0	0	**0**	**0**
4	Ponds	0	0	0	0	0	0	**0**	**0**
5	Hand pumps	0	0	0	0	0	0	**0**	**0**
6	Tap water	85	100	99	100	0	0	**184**	**78**

3.3.3 TSA CHU–II

3.3.3.1 PHYSICAL ENVIRONMENT

Geomorphology

The project is located in the sub-alpine zone. The river basin is narrow surrounded by steep to very steep slopes (Figure II. 3.15).

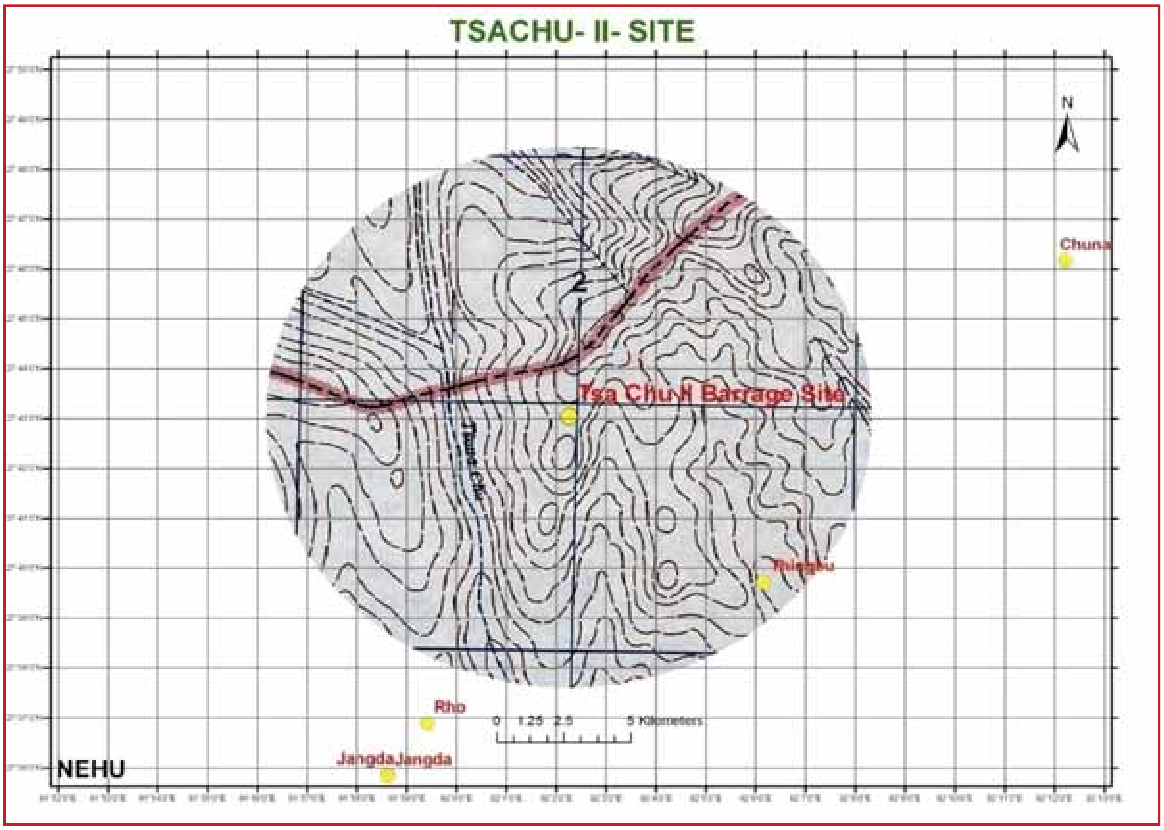


Figure II. 3.15: Contour map of Tsa chu–II HEP

Geology

The rock formations are the same as Tsa Chu-I, except the drainage showing a trellis pattern. Seismic pattern is the same as Tsa Chu-I. The area under various geological classes at Tsa chu–II powerhouse site is presented in Table II. 3.89. The location of Tsa chu–II powerhouse and the impact zone within 10 km radius in Tawang river are depicted in Figures II. 3.16 and 3.17.

Table II. 3.89: Area under various geological classes in Tsa chu–II at powerhouse site

Class	Area	%
Snow covered area	18.15	5.78
Snow covered area	44.85	14.28
Sela group (Structural hill)	151.58	48.25
Glacier	3.28	1.04
Glacier	0.19	0.06
Volcanic sediment (valley)	0.52	0.17
Volcanic sediment (Structural hill)	75.29	23.96
Volcanic sediment (Structural hill)	20.32	6.47
Total	**314.16**	**100.00**

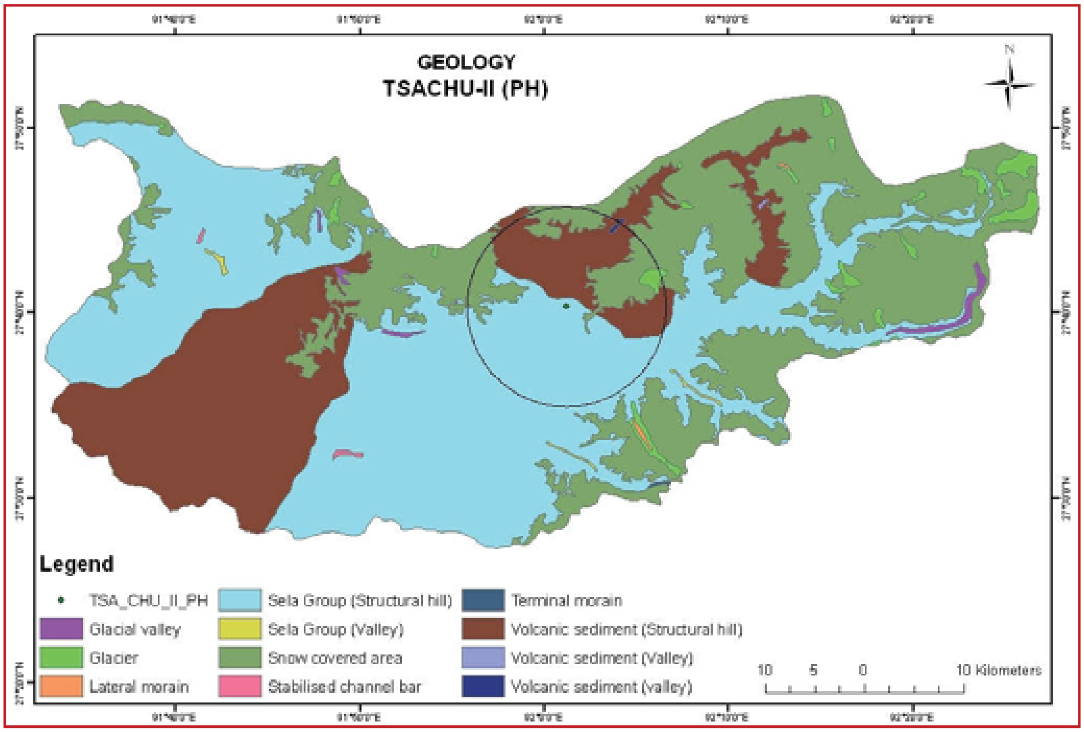


Figure II. 3.16: Geological map of TRB showing location of Tsa chu–II powerhouse site

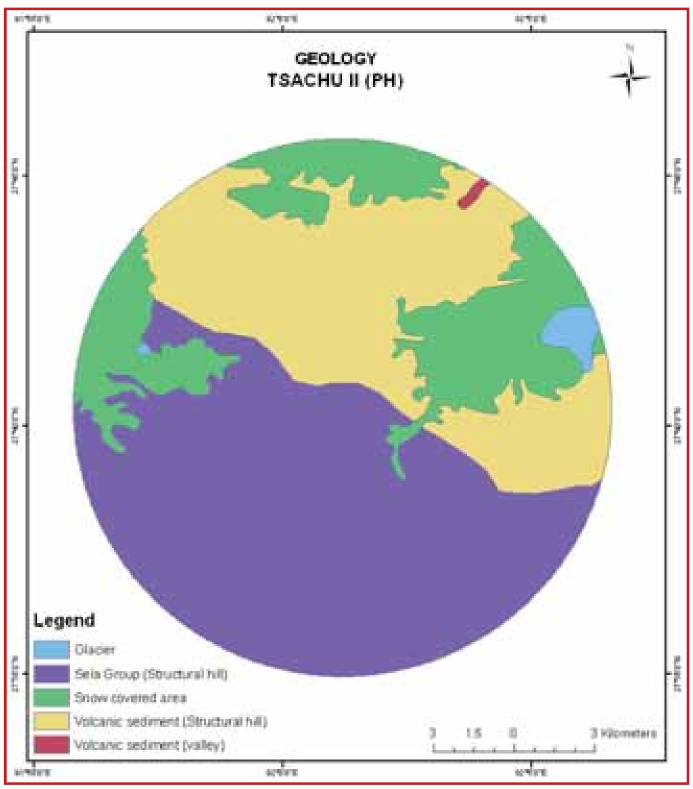


Figure II. 3.17: Geological map of Impact zone (10 km radius) of Tsa chu–II powerhouse site in Tawang river valley

Landuse and Land Cover

The total area within 10 km radius of Tsa chu–II HEP site is 28972.98 ha (Figure II. 3.18). Majority of the area is covered by scrubland (42.18%), followed by forest land which accounts for 38.76% of the total area. Cropland covers the least area (0.03%) followed by grassland (0.04%). Waterbody constitutes 13.80% of the total area (Table II.3.90).

Table II. 3.90: Landuse/land cover area of Tsa chu–II project site

Land category	Area (ha)	%
Forest	11228.5	38.76
Scrubland	12222.1	42.18
Waterbody	3997.76	13.80
Croplands	10.08	0.03
Grasslands	11.97	0.04
Builtuparea	32.6925	0.11
Snow and Ice	1469.88	5.07
Total	**28972.98**	**100**

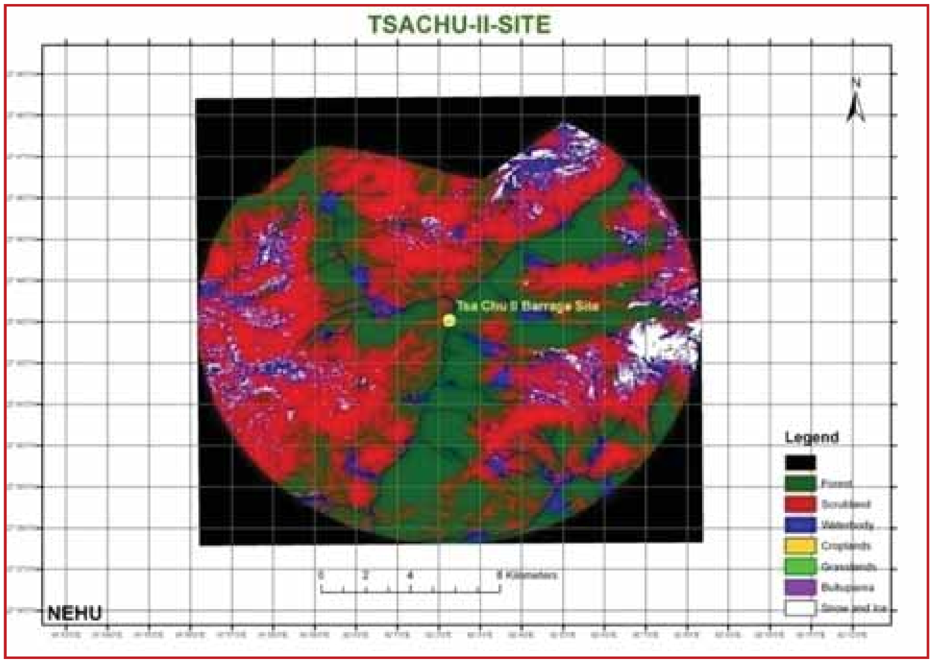


Figure II. 3.18: Landuse/land cover map of Tsa chu–II project site

Soil

Soil is loamy sand with lower water holding capacity, and lower concentration of NH_4^+–N, NO_3^-–N, and Ex. K. Soil microbial biomass-C and microbial biomass-N soil is low in Tsa chu-II project site. Seasonal variation in physical, chemical and biological parameters are shown in Tables II. 3.91 and 3.92.

Table II. 3.91: Soil physical properties at Tsa chu-II project site

Site	Texture	WHC (%)	Bulk density (g/cm³)	Porosity (%)
Barrage	Loamy sand	20.11	1.63	38.49
Powerhouse	Loamy sand	26.76	1.68	36.60

Table II. 3.92: Seasonal variation in soil physico-chemical properties at Tsa chu-II project site

Parameters	Post -monsoon		Monsoon		Winter		Mean	
	B	PH	B	PH	B	PH	B	PH
SMC (%)	30	25	35	31	20	15	28	24
pH	5.4	5.3	5.9	5.6	5.2	4.8	5.5	5.2
Conductivity (µS cm^{-1})	131	70	188	82	109	12	143	55
NH_4^+–N (µg g^{-1})	290	230	300	300	300	200	297	243
NO_3^-–N(µg g^{-1})	19	23	33	34	22	22	24	27
TKN (µg g^{-1}) x10^3	0.500	0.600	0.800	0.900	0.700	0.700	0.670	0.730
Av.P (µg g^{-1})	0.027	0.022	0.120	0.150	0.030	0.020	0.060	0.060
TP (%)	0.130	0.100	0.170	0.120	0.100	0.070	0.130	0.100
SOC (%)	0.003	0.003	0.006	0.005	0.004	0.003	0.000	0.000
Ex. K (µg g^{-1})	163	179	239	202	109	89	171	157
Ex. Mg (%)	0.024	0.025	0.033	0.037	0.015	0.010	0.020	0.020
Ex. Ca (%)	0.136	0.133	0.290	0.285	0.176	0.172	0.200	0.200
Soil microbial biomass–C (µg g^{-1})	21	20	17	14	23	23	20	19
Soil microbial biomass–N (µg g^{-1})	5.7	8.3	3.45	4.67	7.2	6.5	5.5	6.5

(Note: Post–monsoon–October, Monsoon–July, Winter–December); B = Barrage, PH = Powerhouse

Soil Erosion Vulnerability

The area under various soil erosion vulnerable classes under powerhouse site of Tsa chu-II is given in Table II. 3.93. Out of the total area of 314.16 sq. km, only 1.11% area falls under high soil erosion vulnerable zone, and 9.47% falls under moderately high vulnerable zone. 12.31% of the total area is covered under low vulnerable zone, and 36.65% falls under moderately-low vulnerable zone. The soil erosion vulnerable area under moderate category covered about 36.65% of the total area. The spatial distribution map of soil erosion vulnerable areas under powerhouse site of Tsa chu-II is given in Figure II. 3.19.

Table II. 3.93: Areas under various soil erosion vulnerable zones in Tsa chu-II at powerhouse site

Vulnerability	Area (sq. km)	%
High	3.50	1.11
Moderately high	29.75	9.47
Moderate	127.12	40.46
Moderately low	115.13	36.65
Low	38.67	12.31
Total	**314.16**	**100.00**

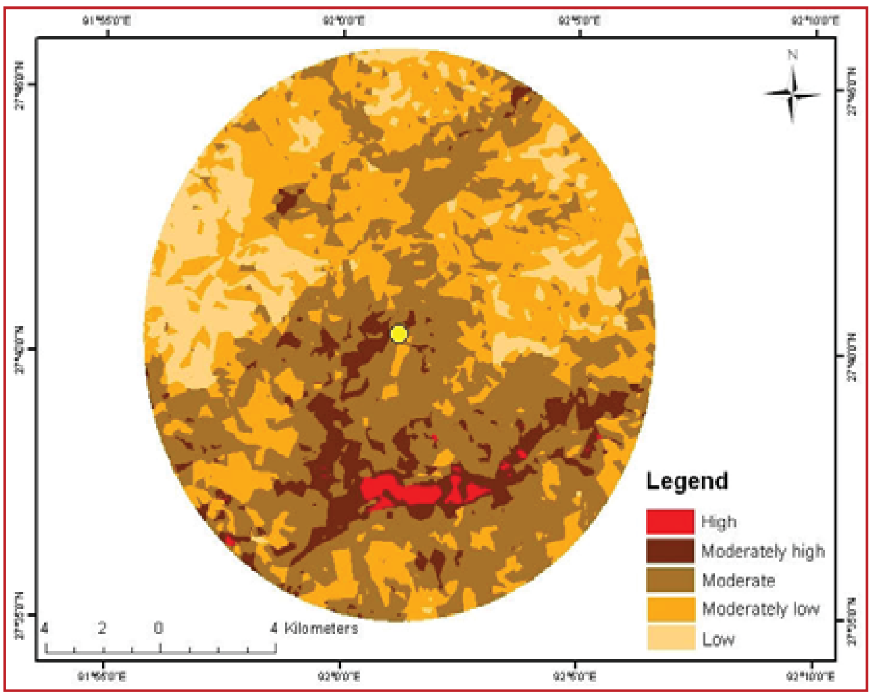


Figure II. 3.19: Spatial distribution of soil erosion vulnerable areas in Tsa chu–II at powerhouse site

Landslide and Erosion Vulnerability

The area under various landslide and erosion vulnerability classes in the powerhouse site of Tsa chu–II is given in Table II. 3.94. Out of the total area of 314.16 sq. km, the lowest proportion of vulnerable area was covered under low (0.39%) and high (0.52%) categories, while higher proportion of vulnerable areas fall under moderately high (11.73%) and moderately low (34.63%) vulnerable classes, respectively. The highest area of landslide and erosion vulnerability was covered under moderate category covering about 51.39% of the total area. The spatial distribution map of landslide and erosion vulnerability areas under powerhouse site of Tsa chu–II is given in Figure II. 3.20.

Table II. 3.94: Area under various landslide and erosion vulnerability classes in Tsa chu–II at powerhouse site

Vulnerability	Area (sq.km)	%
High	1.64	0.52
Moderately high	36.84	11.73
Moderate	165.64	52.73
Moderately low	108.80	34.63
Low	1.24	0.39
Total	**314.16**	**100.00**

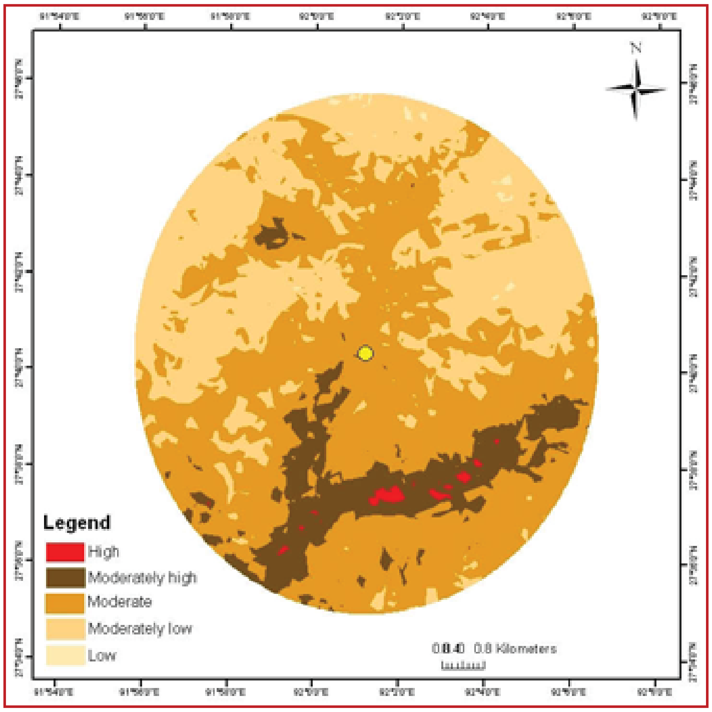


Figure II. 3.20: Area under various erosion and landslide vulnerability classes in Tsa chu–II at powerhouse site

Water

The river water quality at Tsa chu-II also showed seasonal variation like other sites. Mean water temperature was maximum during monsoon season and minimum during winter season. It was interesting to note that, during winter season, turbidity of water was high at this site unlike other sites where it is generally higher during monsoon season. Chloride and sodium concentrations were high during monsoon, so also was the primary productivity and abundance of coliform organisms in the river water. The electrical conductivity (EC), total dissolved solids (TDS), potassium (K^+), total phosphorus and nitrate nitrogen were high during the post-monsoon season, whereas DO, total hardness, and total alkalinity of the river were high during the winter season. Sodium (Na^+), total kjeldhal nitrogen (TKN) and ammonium nitrogen (NH_4^+ N) concentrations were more during the monsoon as compared to the other seasons (Table II. 3.95).

Table II. 3.95: Seasonal variation in physico-chemical and biological properties of water and river primary productivity at Tsa chu-II project site

Parameters	Post-monsoon			Monsoon			Winter		
	B	PH	Mean	B	PH	Mean	B	PH	Mean
Temperature (˚C)	11.10	7.75	9.43	16.30	15.30	15.80	4.70	4.50	4.60
Turbidity (NTU)	0.64	0.54	0.59	0.63	0.78	0.71	0.87	0.89	0.88
pH	7.62	7.59	7.61	8.02	8.14	8.08	7.82	7.88	7.85
Electrical conductivity (µS/cm)	229	220.00	225	179	171.00	175	206	203.00	205
Total dissolved solids (mg/l)	114	110	112	92	88.00	90.00	106	104.00	105.00
Practical salinity (ppt)	0.13	0.12	0.12	0.10	0.10	0.10	0.11	0.11	0.11
Total alkalinity (mg $CaCO_3$/l)	36	34.00	35.00	30	32.00	31.00	48	48.00	48.00
Total hardness (mg/l)	27	26.61	26.60	39	40.93	40.16	43	42.64	42.65
Chloride (mg Cl^-/l)	11.33	11.16	11.25	12.99	14.49	13.74	5.99	5.99	5.99
Ca^{2+} (mg/l)	6.05	6.04	6.04	9.89	10.24	10.06	10.74	10.73	10.73
Mg^{2+}(mg/l)	2.79	2.80	2.80	3.57	3.73	3.65	3.85	3.85	3.85
K^+ ppm	1.10	1.30	1.20	0.70	0.80	0.75	0.70	0.70	0.70
Na^+ ppm	11.30	10.95	11.13	11.90	12.60	12.25	10.80	10.80	10.80
TKN (mg/l)	0.44	0.45	0.45	0.59	0.58	0.59	0.39	0.41	0.40
NH_4^+ N (mg/l)	0.06	0.06	0.06	0.11	0.12	0.12	0.07	0.07	0.07
NO_3–N (mg/l)	0.35	0.35	0.35	0.18	0.16	0.17	0.14	0.15	0.15
Total phosphorus (mg/l)	0.10	0.10	0.10	0.08	0.08	0.08	0.06	0.07	0.07
GPP (mg C/cm^3/h)	0.31	0.39	0.35	0.47	0.47	0.47	0.21	0.21	0.21
NPP (mg C/cm^3/h)	0.10	0.10	0.10	0.31	0.31	0.31	0.10	0.10	0.10
Dissolved oxygen (mg/l)	11.60	11.55	11.58	9.90	10.05	9.98	12.50	12.60	12.55
Total coliforms (CFU/ml)	25	21.00	23.00	26	24.00	25.00	16	11.00	13.50

Ambient Air Quality

Concentration of PM_{10} and $PM_{2.5}$: The concentration of PM_{10} at proposed Tsa chu-II was 7µg/m^3. $PM_{2.5}$ concentration was below detectable limit (Table II. 3.96). The concentration of sulphur-dioxide (SO_2), nitrogen-dioxide (NO_2), ammonia (NH_3) and ground level ozone (O_3) at all the monitored locations were below detectable limits.

Table II. 3.96: Concentration of PM_{10} and $PM_{2.5}$ in air at proposed Tsa chu-II HEP site

Sampling location	Nearest project site covered	PM_{10} (µg/m^3)	$PM_{2.5}$ (µg/m^3)
Tsa chu	Tsa chu–II barrage site Tsa chu–II powerhouse site	10.4	BDL

Meteorological variables for Tsa chu-II HEP could be measured only at Tsa chu location (Table II. 3.97).

Table II. 3.97: Meteorological conditions at proposed Tsa chu-II HEP site

Sampling location	Nearest project site covered	Ambient temperature (°C) Min	Ambient temperature (°C) Max	Relative humidity (%)	Wind Speed (Range in km/hr)	Wind direction
Tsa chu	Tsa chu–II barrage site Tsa chu–II powerhouse site	02	06	42	1.8–2.5	SE

Noise Level: Noise levels at proposed Tsa chu-II HEP were found to be ranging from a minimum of 43.1 dBA at 4.00 PM to a maximum of 44.6 at 8.00 AM (Table II. 3.98).

Table II. 3.98: Noise level at proposed Tsa chu-II HEP site

Sampling location	Nearest project site covered	Noise level (dBA) 8.00 AM	Noise level (dBA) 4.00 PM
Tsachu	Tsa chu–II barrage site Tsa chu–II power house site	44.6	43.1

3.3.3.2 BIOLOGICAL ENVIRONMENT

Vegetation Types

The vegatation types are same as Tsa Chu-I.

Plant Diversity

Plant diversity survey conducted at Tsa chu-II project sites resulted in a total of 84 plant species belonging to different groups. A complete list of plant species found in the study area representing different groups such as tree, shrub, herb, climber, orchid, pteridophyte, bryophyte, lichen and fungi, along with their family name are given in Appendix II.3.27. The number of plant species belonging to different groups is summarized in Table II. 3.99.

Table II. 3.99: Different groups of plant species present at Tsa chu-II HEP site

Sl. No.	Groups	Number of species		
		Barrage site	Power house site	Catchment area
1	Tree	8	9	8
2	Shrub	6	5	7
3	Herb	28	28	31
4	Climber	3		2
5	Orchid	9		1
6	Pteridophyte	1		5
7	Bryophyte	4		3
8	Lichen	5		4
9	Fungi	10	7	12

At the barrage site, 8 trees, 6 shrub, and 28 herbs were recorded, and at the powerhouse site 9 trees, 5 shrub, and 28 herbs were recorded. In the project catchment area, 8 tree species, 7 shrub, and 31 herb species were recorded. A total of 3 climber, 1 orchid, 9 pteridophyte, 4 bryophyte and 5 lichen species were recorded from barrage and powerhouse site, whereas from the catchment area 2 climber, 1 orchid, 5 pteridophyte, 3 bryophyte, 4 lichen and 12 fungus species were recorded (Table II. 3.99) (Appendix II.3.28 and II.3.29).

Threatened and Endemic plants

During the floristic survey, three threatened species were recorded at the project sites. Their name, family, threat status and reference are given in the Table II. 3.100.

Table II. 3.100: Threatened/endemic plants recorded at Tsa chu-II HEP site

Species name	Family	Threat status	References
Aconitum heterophyllum	Ranunculaceae	EN	Walter and Gillet, 1998
Paris polyphylla	Trilliaceae	VU	CAMP and IUCN
Panax bipinnatifidus	Araliaceae	VU	CAMP, 2003

EN=Endangered; VU=Vulnerable

Economically Important Species/Plant Resources

The study area is rich in plant resources. A few important ones are given in Table 3.101.

Table 3.101: Economically important species/plant resources present at Tsa chu-II HEP site

Sl. No.	Uses	Species name
1	Timber	*Abies densa, Alnus nepalensis, Tsuga dumosa*
2	Fuel	*Rhododendron* sp., *Abies densa, Alnus nepalensis*
3	Ornamentals and orchids	*Rhododendron* sp., *Primula* sp., *Aster* sp., *Satyrium* sp., *Salix* sp.
4	Medicine and aromatics	*Panax* sp., *Aconitum* sp.

Vegetation Analysis for Angiosperms and Gymnosperms

The plant community around Tsa chu-II project sites had low species richness. It had 9 tree, 7 shrub, and 28 herbaceous species (Tables II. 3.102 and 3.103).

Table II. 3.102: Tree and shrub species recorded at the barrage and powerhouse site, and in catchment area at Tsa Chu-II project

Trees	Shrub
Abies densa	*Berberis* sp.
Acer sp.	*Daphnae papyracea*
Alnus nepalensis	*Eleagnus parviflora*
Betula utilis	*Pogostemon* sp.
Junipers sp.	*Rosa* sp.
Lyonia ovalifolia	*Rubus ellipticus*
Quercus sp.	*Salix* sp.
Rhododendron sp.	
Tsuga dumosa	

Table II. 3.103: Herbaceous species recorded at the barrage and powerhouse site, and in the catchment area of Tsa chu-II project

Herb		
Aconogonum alpinum	*Impatients* sp.	*Primula denticulata*
Ainsliaea sp.	*Leontopodium Stracheyi*	*Primula* sp.
Arisaema nepenthoides	*Meconopsis* sp.	*Prunella vulgaris*
Elsholtzia strolifera	*Panax bipinnatifidus*	*Rannunculus* sp.
Fragaria sp.	*Persicaria* sp.	*Rumex nepalensis*
Galinsoga parviflora	*Pilea umbrosa*	*Sambacus adnata*
Galium sp.	*Pogostemon* sp.	*Senecio cappa*
Gentiana capitata	*Polygonum hydropiper*	*Stellaria* sp.
Geranium nepalensis	*Potentilla cuneata*	*Swertia* sp.
Hemiphragma heterophyllum	*Pouzolzia* sp.	*Viola sikkimensis*

In general, species richness was high during monsoon season and low during winter season. *Abies densa* was the dominant tree species in all the sites i.e. barrage and power house site, and the catchment area. Among shrubs, *Salix* sp. was dominant both at barrage site and in catchment area, and *Daphnae papyracea* was dominant at power house site (Appendix II.3.39).

Density of trees was highest at power house site, and that of shrubs was highest in the catchment area (Table II. 3.104). Density of herbaceous species varied widely among barrage site, powerhouse site and catchment area. However, at all places it was maximum during rainy season and minimum during winter months. Shannon index of general diversity for tree species in the community was highest at power house site (H'=2.11) followed in decreasing order by catchment area (H'=1.99) and barrage site (H'=1.98). For shrub species highest value was obtained at catchment area (H'=1.79) followed by barrage site (H'=1.67) and power house site (H'=1.51) (Table II. 3.105). Diversity index for herbaceous species ranged between H'=3.19 and 1.98. The highest value was recorded at power house site during monsoon season, and lowest during winter season in other areas. Overall, species diversity was highest at the barrage and catchment area. At all three sites, species richness, density and diversity increased from post monsoon period to attain peak during monsoon and reached to lowest value during winter period (Tables II. 3.104 and 3.105). High diversity and low dominance was the characteristic feature of all three sites. Dominance index value for tree species ranged between 0.13 and 0.15, which was much lower than those obtained for shrubs (0.76-0.81) (Appendix II.3.30- 3.38).

Table II. 3.104: Species richness, diversity and dominance of trees and shrubs, and biomass and carbon stock of trees in the community at Tsa chu-II project site

Parameters	Barrage		Powerhouse		Catchment area	
	Tree	Shrub	Tree	Shrub	Tree	Shrub
Number of species	8	6	9	5	8	7
Density (ha^{-1})	620	928	760	848	640	976
Simpson index of dominance	0.15	0.79	0.13	0.76	0.15	0.81
Shannon index of diversity (H')	1.98	1.67	2.11	1.51	1.99	1.79
Evenness index	0.95	0.88	0.96	0.91	0.96	0.86
Biomass (t/ha)	75.82		67.12			
Carbon (t/ha)	37.91		33.56		103.32	

Table II. 3.105: Species richness, diversity and dominance of herbaceous species in the community at Tsa chu-II project site

Parameter	Barrage			Powerhouse			Catchment area		
	PM	M	W	PM	M	W	PM	M	W
Number of species	17	28	11	14	28	11	18	27	9
Density (ha^{-1})x10^3	92.8	185.6	64.8	89.6	208	70.4	114.4	173.6	55.6
Simpson index of dominance	0.92	0.95	0.85	0.91	0.95	0.85	0.93	0.94	0.82
Shannon index of diversity (H')	2.71	3.16	2.17	2.52	3.19	2.17	2.78	3.12	1.98
Evenness index	0.88	0.84	0.79	0.89	0.87	0.80	0.89	0.83	0.80

PM: Post monsoon; M: Monsoon; W: Winter

Phytoplankton/Periphyton

Eleven species of phytoplankton/periphyton were recorded from Tsa chu-II, of which one species belonged to Cyanobacteria, nine species to Bacillariophyceae, and one species to Chlorophyceae. Maximum species richness (9) was recorded from the catchment area and minimum (6 species) from the project affected areas. Phytoplankton/periphyton density in the catchment area (95 individuals/l) was higher compared to the project affected areas (60 individuals/l) i.e. barrage and powerhouse sites. Similarly, Species diversity index was maximum (H'=1.96) in the catchment area and minimum (H'=1.7) in the project affected areas (barrage and powerhouse sites) (Table II. 3.106).

Table II. 3.106: Density (Individuals/l), species richness and Shannon index of diversity (H') of phytoplankton/periphyton community in river water in project affected areas and catchment area of Tsa chu-II project

List of species	Project affected area	Catchment area
Cyanobacteria		
Oscillatoria sp.		5
Bacillariophyceae		
Achnanthidium rivulare	5	
Amphora sp.		15
Caloneis ventricosa		5
Cymbella tumida	10	15
Encyonema minutum	15	5
Fragillaria sp.	5	
Rhoicosp.haenia sp.		10
Synedra ulna	10	5

Thallassiosira sp.		5
Chlorophyceae		
Spirogyra sp.	15	30
Total density (Individuals/l)	**60**	**95**
Species diversity index	**1.7**	**1.96**
Species richness	**6**	**9**

NB: Blank cells indicate absence of phytoplankton species

Zooplankton

The study was conducted in two seasons in Tsa chu-II area, in which only 1 species viz., *Alona affinis* from Cladocera and 3 species viz., *Keratella serrulata, Lecane closterocerca,* and *Lepadella acuminata* of Rotifera were recorded during monsoon period (Table II. 3.107). *Keratella serrulata*, a rare zooplankton species was recorded from barrage site.

Table II. 3.107: Occurrence of species belonging to Cladocera and Rotifera during monsoon and winter seasons at Tsa chu-II site

Sl. No.	Taxa	Species	Season	
			Monsoon	Winter
1	Cladocera	*Alona affinis* (Leydig, 1860)	+	–
2	Rotifera	*Keratella serrulata* (Ehrenberg, 1838) *	+	–
3	Rotifera	*Lecane closterocerca* (Schmarda, 1859)	+	–
4	Rotifera	*Lepadella acuminata* (Ehrenberg, 1834)	+	–
Total	**2**	**4**	**4**	**0**

*Rare

Fish Fauna

No fish species were recorded from Tsa chu-II project sites.

Soil Fauna

The seasonal variation in soil faunal diversity (Collembola, Acarina and other arthropods) and equitability in litter and soil layer is shown in Table II. 3.108-3.110.

Table II. 3.108: Seasonal variation in soil faunal diversity (Collembola, Acarina and other arthropods) and equitability in litter and soil layer at Tsa chu-II site

Soil fauna	Diversity	Post-monsoon				Monsoon				Winter			
		Barrage		Powerhouse		Barrage		Powerhouse		Barrage		Powerhouse	
		Litter	Soil	Litter	Soil	Litter	Soil	Litter	Soil	Litter	Soil	Litter	Soil
Collembola	Dominance_D	0.15	0.16	0.25	0.50	0.24	0.20	0.13	0.13	0.25	0.50	0.56	0.28
	Shannon_H	1.91	1.89	1.49	0.69	1.49	1.68	2.05	2.06	1.39	0.69	0.64	1.33
	Evenness_e^H/S	0.96	0.94	0.89	1.00	0.89	0.89	0.97	0.98	1.00	1.00	0.94	0.94
Acarina	Dominance_D	0.16	0.25	1.00	0.33	0.15	0.12	0.23	0.21	0.38	0.33	1.00	1.00
	Shannon_H	1.89	1.39	0.00	1.10	1.96	2.15	1.51	1.58	1.04	1.10	0.00	0.00
	Evenness_e^H/S	0.94	1.00	1.00	1.00	0.89	0.95	0.91	0.97	0.94	1.00	1.00	1.00
Other arthropods	Dominance_D	0.13	0.19	1.00	1.00	0.16	0.13	0.17	0.14	1.00	0.33	1.00	0.50
	Shannon_H	2.10	1.79	0.00	0.00	1.88	2.12	1.84	2.12	0.00	1.10	0.00	0.69
	Evenness_e^H/S	0.90	0.86	1.00	1.00	0.93	0.93	0.90	0.84	1.00	1.00	1.00	1.00

Table II. 3.109: Mean annual density (number/m^2) of soil fauna in litter and soil layer (0-5 cm) at Tsa chu-II project site

Soil fauna	Site	Litter layer	Soil layer	Total
Collembola	Barrage	1127	1018	**2145**
	Powerhouse	1418	982	**2400**
Acarina	Barrage	1257	686	**1943**
	Powerhouse	600	371	**971**
Other arthropods	Barrage	1418	2904	**4322**
	Powerhouse	909	2371	**3281**
Total fauna	**Barrage**	**3802**	**4608**	**8410**
	Powerhouse	**2927**	**3724**	**6652**

Table II. 3.110: Seasonal variation in soil faunal density (number/m^2) at barrage and powerhouse site of Tsa chu-II project site

Soil fauna	Site	Post-monsoon	Monsoon	Winter	Mean
Collembola	Barrage	8400	12800	2400	**7867**
	Powerhouse	4000	18800	3600	**8800**
Acarina	Barrage	9200	15200	2800	**9067**
	Powerhouse	2400	10400	800	**4533**
Other arthropods	Barrage	13200	14000	1600	**9600**
	Powerhouse	1200	18800	1200	**7067**

Wildlife

Butterflies: Twenty species of butterflies belonging to 18 genera and four families were recorded in Tsa Chu-II HEP area. Family Pieridae was the dominant family represented by seven species. These 20 species did not include any of the threatened species (Table II. 3.111).

Table II. 3.111: Butterflies recorded in Tsa chu-II HEP area

Sl. No.	Family common name	Scientific name	Project area
I.	**Hesperiidae**		
1	Lucas' Ace	*Sovia lucasii magna*	*
II.	**Papilionidae**		
2	Common Peacock	*Papilio polyctor ganesa*	*
3	Golden Birdwing	*Troides aeacus aeacus*	*
III.	**Pieridae**		
4	Dark Jezebel	*Delias berinda*	*
5	Spotless Grass Yellow	*Eurema laeta*	*
6	Small Grass Yellow	*Eurema brigitta rubella*	*
7	Indian Cabbage White	*Pieris canidia indica*	*
8	Green vein White	*Pieris melete*	*
9	Plain Sulphur	*Dercas lycorias*	*
10	Spotted Sawtooth	*Prioneris thestylis thestylis*	*
IV.	**Lycaenidae**		
11	Peablue	*Lampides boeticus*	*
12	Green Sapphire	*Heliophorus moore*	*
13	Pale Hedgeblue	*Udara dilecta*	*
14	Large Hedgeblue	*Celastrina hugeli oreana*	*
15	Common Flash	*Rapala nissa ratna*	*
16	Common Hedgeblue	*Acytolepis puspa gisca*	*
V.	**Nymphalidae**		
17	Chestnut Tiger	*Parantica sita*	*
18	Large Threering	*Ypthima nareda*	*
19	Glassy Tiger	*Graphium cloanthus*	*
20	Chocolate Pansy	*Junonia iphita iphita*	*

Herpetofauna: Like Tsa Chu-I and Tsa Chu-I Lower project areas, no herpetofauna was reported. The list is based on earlier recorded data (Appendix II.3.167).

Birds: The assessment of birds was carried in and around this project area during monsoon and winter seasons, which revealed the presence of 43 terrestrial birds belonging to 30 genera and 19 families. The Shannon diversity index of 3.1 indicates moderate level of species diversity. Species richness was higher during monsoon season (32 species) than in winter. The low species richness during the winter season might have been due to snowfall and less availability of food resources in the area. The abundance of birds was also high in monsoon (Table II. 3.112).

Migratory status: The migratory and resident status of these bird species showed that most of the birds were residents (28 species), followed by 8 breeding visitors, and 7 winter visitors (Table II. 3.112).

Table II. 3.112: Status of birds recorded in Tsa chu-II HEP area

Details	Post-monsoon	Monsoon	Winter	Overall
Family		14	9	19
Genera		21	12	30
Species		32	15	43
Abundance		205	57	262
Diversity H'		2.8	2.5	3.1
Migratory status				
Breeding visitor		7	1	8
Isolated record		0	0	0
Resident		21	12	28
Winter visitor		4	2	7

Abundance status: The abundance status of birds was derived by classifying the abundance of bird species into five categories i.e. very Low = 1-25 birds, low = 26-50, moderate = 51-75, high = 76-100 and very High = > 100birds). The details of abundance status are given in Table II. 3.113.

Table II. 3.113: No. of species and relative % of birds in different abundance classes

Abundance class	No. of species	Relative %
Very low-1-25 birds	41	95.3
Low-26-50 birds	1	2.3
Moderate-50-75 birds	1	2.3
High-76-100 birds	0	0.0
Very high > 100 birds	0	0.0
Total	**43**	**100.0**

Status of foraging guilds: In Tsa chu-II project area, the recorded bird species belonged to six different foraging guilds, among which insectivore was predominant (33 species) followed by four species of granivores and three omnivores (Table II. 3.114). This shows the low diversity of birds in this project area.

Table II. 3.114: Status of foraging guilds of birds recorded in Tsa chu–II HEP area

Foraging guild	Monsoon	Winter	Overall
Aquatic feeder	0	0	0
Carnivore	0	1	1
Frugivore	0	0	0
Granivore	1	4	4
Insectivore	29	7	33
Nectarivore	1	0	1
Nucivore	0	1	1
Omnivore	1	2	3
Piscivore	0	0	0

Status of threatened species: The assessment of conservation status of birds in this project area showed that there was no threatened bird species in the project site (Appendix II.3.174).

Mammals: Two surveys in and around the Tsa chu-II project site revealed the presence of seven mammalian species, each belonging to separate genus and family. This list consists of 2 rodents, 3 ungulates and 2 carnivore species (Appendix II.3. 175).

Abundance status: Among these seven species, presence of five species was confirmed based on 15 indirect evidences. The Himalayan Stripped Squirrel *(Tamipos macclellandi*) and Hoary-bellied Himalayan Squirrel (*Callosciurus pygerythrus)* were the only two species sighted with one animal each. Presence of Wild pig (*Sus scrofa*) and Himalayan goral (*Naemorhedus goral*) were established on the basis of six and four evidences, respectively (Table II. 3.115). Occurrence of seven species with 15 evidences and two sightings of animal clearly showed the low potential of the project area to support mammalian fauna. Further evaluation of species richness of the project area (7 species) in relation to the total probable species (29 species) of Tawang district (Mishra *et al.* 2006) also revealed the low species richness i.e. 24.13% of the total reported mammalian species in TRB (Table and Appendix II.3.175).

Status of threatened species: Except Himalayan goral (*Naemorhedus goral)* which is Near Threatened (NT) as per IUCN Red List, the remaining five species fall under Least Concern (LC) category of IUCN, and Schedule II and III of WPA (1972) (Table II. 3.115).

Table II. 3.115: Status of mammalian fauna reported in Tsa chu-II HEP area

Sl. No.	Common name	Scientific name	Seasons			Overall	Conservation status	
			PM	M	W		IUCN	WPA
I.	**Cervidae**							
1	Barking deer	*Muntiacus muntjak*		IE2		IE 2	LC	III
II.	**Bovidae**							
2	Himalayan goral	*Naemorhedus goral*		IE3	IE 3	IE 6	NT	III
III.	**Suidae**							
3	Wild pig	*Sus scrofa*		IE 1	IE 3	IE 4	LC	III
IV.	**Felidae**							
4	Jungle cat	*Felis chaus*		IE2		IE 2	LC	II
V.	**Mustelidae**							
5	Yellow Throated Martin	*Martes flavigula*		IE 1		IE 1	LC	II
VI.	**Sciuridae**							
6	Hoary-bellied Himalayan squirrel	*Callosciurus pygerythru.*			A1	A 1	LC	NE
7	Himalayan stripped squirrel	*Tamipos macclellandi*			A1	A1	LC	NE
	No of species			**5**	**4**	**7**		
	Total and types of records			**IE 9**	**IE 6 A2**	**IE 15 A 2**		

IE – Indirect evidences A-animals sighted, W-Winter, PM-Post-monsoon, M-Monsoon, IUCN-Red List, WPA-Wildlife Protection Act, NT-Near threatened, LC-Least concern, NE-Not evaluated

Faunal status within 500 m of project affected area: This section revealed species richness of selected faunal groups such as avifauna and mammal species reported within 500 m up and down streams of the barrage and powerhouse sites of the proposed project area. The species richness reported in these specific sites was evaluated based on subjective rating through estimating percent contribution to the overall species list of the project area. If the species richness of barrage and powerhouse contributes 25% of overall list it was categorized as low, > 25-50% as medium, >50-75% as high and above 75% as very high species richness.

Status of avifauna: At Tsa chu-II project affected site, bird species richness with 18 species was designated as medium species richness area, when compared with the overall list of 43 species reported from the entire project area (41.86%). There was no threatened species in the project site (Appendix II.3.176).

Status of mammals: Site specific evaluation of mammalian fauna within 500 m of up and down streams showed occurrence of only three species in the barrage site. The presence of the three species was ascertained based on six indirect evidences. None of these species fall under high conservation status of IUCN and WPA (1972) (Table II. 3.116). Overall, the barrge site of Tsa chu-II project did not have any mammalian fauna of high conservation significance.

Table II. 3.116: Status of mammalian fauna at barrage site of the proposed Tsa chu-II HEP area

Sl. No.	Common name	Species name	Status	Conservation status	
			BS/PHS	IUCN	WPA
1	Wild pig	*Sus scrofa*	IE 2	LC	III
2	Jungle cat	*Felis chaus*	IE 2	LC	II
3	Yellow Throated Martin	*Martes flavigula*	IE 2	LC	II
	Total no of species		**3**		
	Total no of evidences		**6 IE**		

IE – Indirect evidences, A – No of animals sighted, BS-Barrage Site, PHS – Powerhouse Site, IUCN-Red List, WPA-Wildlife Protection Act, EN-Endangered, NT-Near threatened, LC-Least concern, NE-Not evaluated

3.3.3.3 SOCIO-ECONOMIC PROFILE

The villages within the 10 km influenc zone of Tsa chu-II were the same as Tsa chu-I Lower. Thus, the socio-economic attributes for both the projects remain same.

3.3.4 THINGBU CHU

3.3.4.1 PHYSICAL ENVIRONMENT

Geomorphology

Thingbu chu project site is located at an elevation of 2800 m. The slopes are steep and the river flows in the deep gorges. The geomorphological feature of this site is depicted in Figure II. 3.21

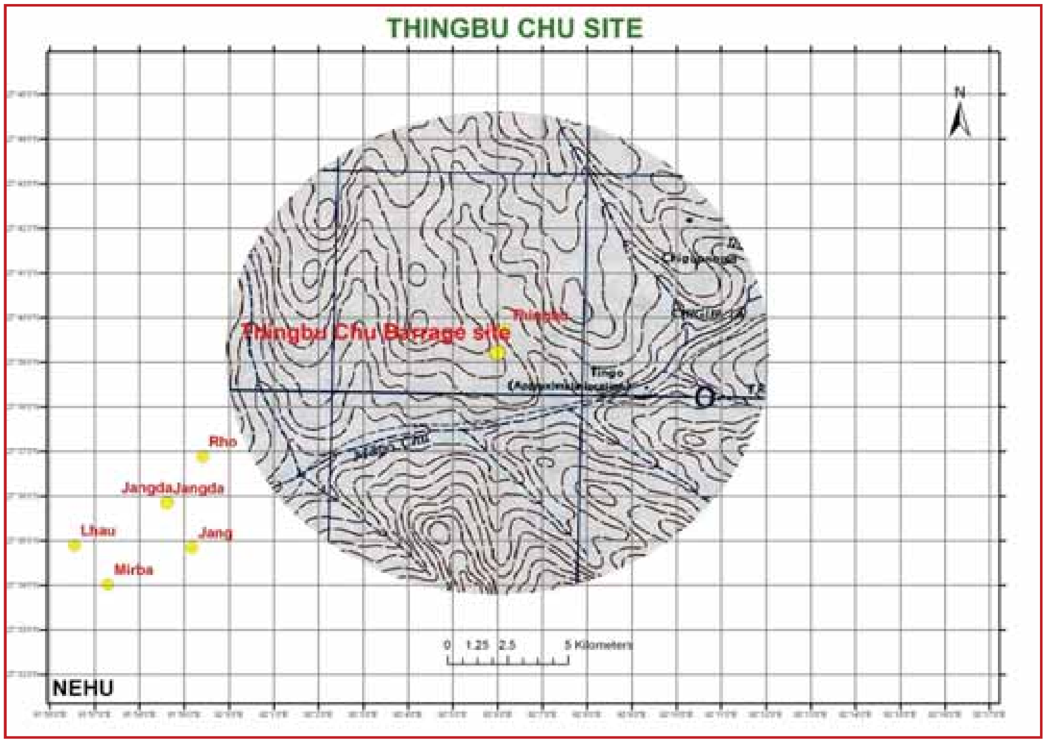


Figure II. 3.21: Contour map of Thingbu chu HEP

Geology

The rock formations are migmatites, tourmaline granites along with the envelope of schists. Structurally the drainage pattern is somewhat simpler as compared to Tsa Chu–I and II.

Landuse and Land Cover

The total area within 10 km radius of Thingbu chu HEP site is 31436.41 ha (Figure II. 3.22). Majority of the area is covered with forest (47.15%) followed by scrubland (34.97%). Cropland covers only 0.03% of the total project area. Waterbody constitutes around 13.12% of the total area, and grassland occupies only 0.6%. The total area occupied by snow and ice and other builtup area altogether is 4.13% (Table II. 3.149).

Table II. 3.149: Landuse/land cover of Thingbu chu project

Land category	Area (ha)	%
Forest	14822.7	47.15
Scrubland	10993.5	34.97
Waterbody	4123.49	13.12
Croplands	8.7075	0.03
Grasslands	189.518	0.60
Builtup area	36.585	0.12
Snow and Ice	1261.91	4.01
Total	**31436.41**	**100.00**

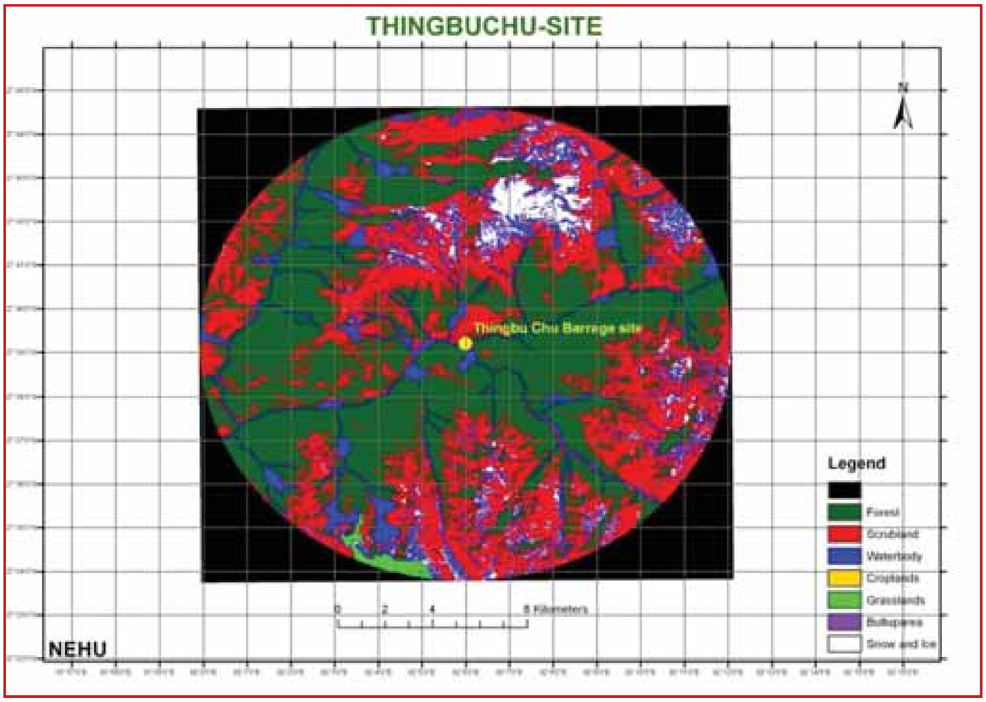


Figure II. 3.22: Landuse/land cover map of Thingbu chu project site

Soil

Soil belongs to loam textural class with high water holding capacity (Table II. 3.150). Soil reaction was strongly acidic (pH 4.5–5.2). NH_4^+–N, NO_3^-–N values were comparable to Tsa chu sites, while Exchangeable K values were very low. Soil pH, conductivity, ammonium and nitrate nitrogen, and TKN and exchangeable calcium values were high during monsoon season compared to other two seasons (Table II. 3.151).

Table II. 3.150: Soil physical properties at Thingbu chu site

Site	Texture	WHC (%)	Bulk density(g/cm³)	Porosity (%)
Barrage	Loam	59.62	1.35	49.05
Powerhouse	Loam	69.80	1.35	47.92

Table II. 3.151: Seasonal variation in soil physico–chemical properties at Thingbu chu site

Parameters	Post-Monsoon		Monsoon		Winter		Mean	
	B	PH	B	PH	B	PH	B	PH
SMC (%)	30	25	35	38	23	20	29	28
pH	4.5	5.2	5.5	5.3	4.2	4.2	4.7	4.9
Conductivity ($\mu S\ cm^{-1}$)	27	28	32	35	26	25	28	29
NH_4^+–N ($\mu g\ g^{-1}$)	240	400	300	400	300	300	280	367
NO_3^-–N($\mu g\ g^{-1}$)	37	37	22	27	15	20	25	28
TKN ($\mu g\ g^{-1}$) x10^3	0.90	0.80	1.12	1.11	0.70	0.50	0.91	0.80
Av.P ($\mu g\ g^{-1}$)	0.022	0.111	0.080	0.040	0.030	0.030	0.040	0.060
TP (%)	0.140	0.130	0.160	0.150	0.130	0.120	0.140	0.130
SOC (%)	0.002	0.008	0.016	0.014	0.012	0.013	0.010	0.010
Ex. K ($\mu g\ g^{-1}$)	73	63	170	166	144	135	129	121
Ex. Mg (%)	0.005	0.005	0.021	0.008	0.011	0.010	0.010	0.010
Ex. Ca (%)	0.054	0.057	0.190	0.185	0.078	0.072	0.110	0.100
Soil microbial biomass–C ($\mu g\ g^{-1}$)	31.7	29.8	25.6	21.6	32.0	28.6	30.0	27.0
Soil microbial biomass–N ($\mu g\ g^{-1}$)	1.00	5.00	0.89	4.13	3.20	6.23	1.70	5.10

(Note: Post-Monsoon–October, Monsoon–July, Winter–December); B = Barrage, PH = Powerhouse

Water

The river water showed little seasonal differences in the turbidity and pH across sites and seasons. However, there was a marked seasonal difference in temperature from 1.1^{0}C in winter to 14.0^{0}C during monsoon. During monsoon season total Kjeldhal nitrogen (TKN) and ammonium nitrogen (NH_4^+ N) concentrations were higher compared to other seasons. Total hardness, total alkalinity, and DO values peaked during the winter. The electrical conductivity

(EC), total dissolved solids (TDS), potassium, sodium, total phosphorus, and nitrate nitrogen concentrations were higher during post-monsoon period. Productivity of the river was high during the monsoon period. The total coliform count was also high during this season (Table II. 3.152).

Table II. 3.152: Seasonal variation in physico–chemical and biological properties of water and its primary productivity at Thingbu chu project site

Parameters	Post-Monsoon			Monsoon			Winter		
	B	PH	Mean	B	PH	Mean	B	PH	Mean
Temperature (°C)	4.70	4.80	4.75	13.90	14.00	13.95	1.10	1.20	1.15
Turbidity (NTU)	0.17	0.20	0.19	0.97	1.41	1.19	1.18	1.20	1.19
pH	7.70	7.65	7.67	7.95	7.79	7.87	7.67	7.64	7.66
Electrical conductivity (µS/cm)	166	169.50	168	132	137.00	135	156	157.00	157
Total dissolved solids (mg/l)	84	85.30	84.80	60	60.30	60.30	81	81.80	81.35
Practical salinity (ppt)	0.10	0.10	0.10	0.06	0.06	0.06	0.08	0.08	0.08
Total alkalinity (mg $CaCO_3$/l)	32	31.20	31.60	36	36.00	36.00	44	44.00	44.00
Total hardness (mg/l)	21	21.20	21.17	26	25.90	25.90	41	40.52	40.59
Chloride (mg Cl^-/l)	10.33	10.17	10.25	9.99	9.99	9.99	7.99	7.99	7.99
Ca^{2+} (mg/l)	4.13	4.15	4.14	5.83	5.83	5.83	9.28	9.24	9.26
Mg^{2+}(mg/l)	2.63	2.63	2.63	2.76	2.76	2.76	4.25	4.24	4.24
K^+ ppm	1.10	1.05	1.08	0.70	0.80	0.75	0.40	0.40	0.40
Na^+ ppm	8.20	7.95	8.08	4.70	5.20	4.95	7.50	7.40	7.45
TKN (mg/l)	0.38	0.42	0.40	0.48	0.50	0.49	0.35	0.35	0.35
NH_4^+ N (mg/l)	0.03	0.03	0.03	0.06	0.06	0.06	0.03	0.03	0.03
NO_3–N (mg/l)	0.33	0.33	0.33	0.12	0.13	0.13	0.28	0.27	0.27
Total phosphorus (mg/l)	0.10	0.10	0.10	0.08	0.08	0.08	0.10	0.10	0.10
GPP (mg C/cm^3/h)	0.26	0.21	0.27	0.47	0.47	0.47	0.23	0.23	0.23
NPP (mg C/cm^3/h)	0.10	0.15	0.13	0.31	0.31	0.31	0.08	0.08	0.08
Dissolved oxygen (mg/l)	12.00	11.85	11.93	10.10	10.20	10.15	12.50	12.50	12.50
Total coliforms (CFU/ml)	23	27.00	25.00	31	36.00	33.50	16	19.00	17.50

Ambient Air Quality

Concentration of PM_{10} and $PM_{2.5}$: Concentration of PM_{10} at proposed Thingbu chu HEP varied between 39.4 µg/m^3 at New Melling and 41.0 µg/m^3 at Thingbu chu. Likewise, $PM_{2.5}$ concentration was minimum (26.9 µg/m3) at Thingbu chu and maximum (38.7 µg/m3) at New Melling (Table II. 3.153). The concentration of sulphur–dioxide (SO_2), nitrogen–dioxide (NO_2), ammonia (NH_3) and ground level ozone (O_3) at all the monitored locations were below detectable limits.

Table II. 3.153: Concentration of PM_{10} and $PM_{2.5}$ in air at proposed Thingbu chu HEP site

Sampling location	Nearest project component covered	PM_{10} (µg/m^3)	$PM_{2.5}$ (µg/m^3)
Thingbu chu	Thingbu chu barrage site New Melling powerhouse	41.0	26.9
New Melling	Thingbu chu barrage site New Melling powerhouse	39.4	38.7

The meterological data of the site are given in Table II. 3.154.

Table II. 3.154: Meteorological conditions at proposed Thingbu chu HEP sites

Sampling location	Nearest project component covered	Ambient temperature (°C) Min	Ambient temperature (°C) Max	Relative humidity (%)	Wind speed (range in km/hr)	Wind direction
Thingbu chu	Thingbu chu barrage site New Melling powerhouse	03	07	34	1.2–2.1	SE
New Melling	Thingbu chu barrage site New Melling powerhouse	04	09	37	1.7–2.5	SE

Noise Level: Noise level near Thingbu chu HEP was measured at Thingbu chu and New Melling. The values ranged between 60.12 dBA at 8.00 AM and 67.1 at 4.00 PM (Table II. 3.155).

Table II. 3.155: Noise level at proposed Thingbu chu HEP site

Sampling location	Nearest project sites covered	Noise level (dBA) 8.00 AM	Noise level (dBA) 4.00 PM
Thingbu chu	Thingbu chu barrage site New Melling powerhouse	60.2	62.0
New Melling	Thingbu chu barrage site New Melling powerhouse	61.3	67.1

3.3.4.2 BIOLOGICAL ENVIRONMENT

Vegetation Types

The project components of Thingbu chu HEP are located in temperate and sub-alpine climatic zones. The vegetation types within 10 km radius area are:

12/C3a East Himalayan mixed coniferous forests (2000-3500 m): These are dense evergreen forests with dominance of oak and rhododendrons. Between 2300-3500 m elevations in the upper ridges, silver fir (*Abies densa*) makes appearance as a dominant tree species. However at lower elevations, other deciduous trees such as *Magnolia* sp., *Acer* sp., *Betula alnoides, Alnus nepalensis*, mixed with oak species, occur at varying extents. Gregarious undergrowth, usually of bamboo, and in its absence *Rhododendron* species and other evergreen shrubs such as *Berberis* sp., *Cotoneaster* sp., *Rhododendron* sp., *Salix* sp., *Thamnocalamus* sp. and *Viburnum* sp. also occur. The trees are mostly covered with many epiphytic mosses and lichens.

12/ISI Alder forest (1800-2200 m): These are typically seen as pure stands of *Alnus nepalensis* and *Populus ciliata*, with heights ranging from 20-30 m. They occur as a strip with varying width along stream sides, spreading out to larger areas, and more or less deciduous in nature. In the lower course of the stream and landslide affected areas, Alder is the dominant formation. There is often an under growth of inedible/thorny shrubs comprising *Berberis, Rubus, Princepia* etc., whilst in the better wooded tracts, progression starts early and other species, notably blue pine and other conifers, are usually present.

12/1S2 Riverine blue-pine forest (1800-3000 m): These forests are characterized by irregular and often dense stands of blue pine with occasional *Picea*, *Tsuga, Populus* and *Alnus*, with little or no undergrowth.

14/C2 East Himalayan sub-alpine birch/fir forest (3500-4000 m): These forests occur between 3500 and 4000m elevation, and comprise of tree species such as *Abies densa, Juniperus* sp., *Larix griffithii, Betula utilis* etc. Small trees (*Rhododendron wightii*) and shrubs (*Rosa* sp., *Berberis* sp., *Spirea* sp.) also occur. The herbaceous layer is comprised of *Polygonum* sp., *Potentilla* sp., *Primula* sp., *Fragaria* sp. etc.

14/2SI Sub-alpine blue-pine forest (3500-4000 m): These types of forest occurs at 3500-4000 m elevation, and are represented by pure stands of *Pinus wallichiana*. Towards higher elevation, Fir forests gradually replaces bluepine.

14/DSI Sub-alpine pastures (3000-4000 m): The sub-alpine pastures are composed of *Gentiana*, *Primula* and members of Asteraceae and Ranunculaceae.

15/CI Birch-rhododendron alpine scrub forest (4000-5500 m): In the Eastern Himalaya, this type forms a low evergreen forest with the species of *Rhododendron* and birch (*Betula utilis*). The dense scrub forest is difficult to penetrate. Moss and fern cover the ground with varying amount of alpine shrubs such as *Sorbus, Viburnum, Gaultheria trichophylla, Rhododendron lepidotum, R. nivale,* and flowering herbs like *Primula, Corydalis, Meconopsis* etc.

15/C3 Alpine pastures (4000-5500 m): The alpine meadows are composed mostly of perennial mesophytic herbs, with little representation of grass species. Conspicuous among the herbs are

Primula, *Anemone, Fritillaria*, *Iris,* and *Gentiana*. Many members of Ranunculaceae, cruciferae, Caryophyllaceae, and Asteraceae are present. This alpine pasture has a short snow free period.
15/E2 Moist alpine dwarf Juniper scrub (4000-4250 m): These types of forests are dominated by *Juniperus communis* and *Juniperus wallichiana* at around 4000-4250 m. Beyond this elevation range, at 4300-4900 m elevation *Juniperus recurva* succeeds Juniperus *wallichiana.*

Plant Diversity

A total of 128 plant species belonging to different groups i.e., tree, shrub, herb, climber, orchid, pteridophyte, bryophyte, lichen and fungi were recorded from the barrage and powerhouse sites, and the catchment area (Appendix II.3.40). The number of plant species belonging to different groups is summarized in Table II. 3.156

Table II. 3.156: Different groups of plant species present at Thingbu chu HEP site

Sl. No.	Groups	Number of species		
		Barrage site	Power house site	Catchment area
1	Tree	10	7	9
2	Shrub	20	18	20
3	Herb	34	33	30
4	Climbers	13		10
5	Orchids	6		6
6	Pteridophytes	9		8
7	Bryophytes	6		4
8	Lichens	11		9
9	Fungi	13	10	14

The trees were laden with a variety of non-vascular epiphytes such as lichens, mosses, and ferns. In the barrage site, 10 tree, 20 shrub, and 34 herb species were recorded while 7 tree, 18 shrub, and 33 herb species were recorded in the powerhouse site. In the project catchment area, 9 tree, 20 shrub, and 30 herb species were recorded. A total of 13 climbers, 6 orchids, 9 pteridophytes, 6 bryophytes, 11 lichens and 13 fungi species were recorded from barrage and powerhouse sites, whereas from the catchment area 10 climber, 6 orchid, 8 pteridophyte, 4 bryophyte, 9 lichen and 14 fungi species were recorded (Appendix II.3.41-3.41).

Threatened and Endemic Species

Six threatened species were recorded from the HEP Site (Table II. 3.157).

Table II. 3.157: Threatened plants recorded at Thingbu chu HEP site

Species name	Family	Threat status	References
Aconitum ferox	Ranunculaceae	EN	Walter and Gillet, 1998
Taxus wallichiana	Taxaceae	EN	CAMP, 2003; Walter and Gillet, 1998
Acer sikkimensis	Aceraceae	EN	Nayar and Sastry, (1987, 1988, 1990)
Swertia chirayita	Gentianaceae	VU	CAMP, 2003
Paris polyphylla	Trilliaceae	VU	CAMP and IUCN
Panax bipinnatifidus	Araliaceae	VU	CAMP, 2003

EN=Endangered; VU=Vulnerable

Economically important species/plant resources

The study area is rich in plant resources. A few of the important ones are listed below under different resource groups (Table II. 3.158).

Table II. 3.158: Economically important species/plant resources present at Thingbu chu HEP site

Sl.No.	Uses	Species name
1	Timber	*Abies densa,Larix griffithii, Pinus wallichiana*
2	Fuel	*Rhododendron* sp., *Abies densa, Pinus wallichiana*
3	Ornamentals and orchids	*Rhododendron* sp., *Primula* sp., *Aster* sp., *Satyrium* sp., *Begonia* sp., *Salix* sp.
4	Medicine and aromatics	*Panax* sp., *Aconitum ferox, Paris polyphylla, Taxus wallichiana*
5	Fodder	*Alnus nepalensis,*
6	Edible	*Elaeagnus* sp.
7	Fibre and paper	*Daphne papyracea*
8	Bamboos	*Arundinaria* sp., *Phyllostachys* sp.

Vegetation Analysis for Angiosperms and Gymnosperms

The plant community at barrage site, power house and catchment had 11 tree species, 21 shrub species and 35 herbaceous species (Tables II. 3.159 and 3.160).

Table II. 3.159: Tree and shrub species present near barrage and powerhouse and in catchment area at Thingbu chu site

Tree species	Shrub species
Abies densa	*Arundinella malling*
Acer sikkimensis	*Arundinella* sp.
Betula alnoides	*Aconogonum molle*
Corylus heterophylla	*Artemesia nilagarica*
Larix griffithii	*Berberis* sp.
Leucosceptrum canum	*Coriaria nepalensis*
Lindera neesiana	*Daphne papyracea*
Picea spinulosa	*Eleagnus parviflora*
Pinus wallichiana	*Girardinia grandiflora*
Taxus wallichiana	*Herachleum*
Tsuga dumosa	*Hypericum choisianum*
	Ilex dipyrena
	Neillia thysiflora
	Philadelphus tomentosus
	Piptanthus nepalensis
	Rosa sp.
	Rubus ellipticus
	Rubus niveus
	Sarcococca sp.
	Seigesbeckia orientalis
	Spirea sp.

Table II. 3.160: Herbaceous species recorded near barrage and powerhouse site and in the catchment area at Thingbu chu project site

Herb species		
Aconitum elswii	*Galium* sp.	*Phlomis* sp.
Aconitum ferox	*Geranium pratense*	*Pilea umbrosa*
Ainsliaea sp.	*Helenia elliptica*	*Pogostemon* sp.
Anaphalis margaritacea	*Herpetospermum pedunculosum*	*Potentilla cuneata*
Aster trinervius	*Lecanthus peduncularis*	*Salvia* sp.
Astilbe rivularis	*Nepata* sp.	*Sambucus adnata*
Cyathula capitata	*Ophiopogon intermedius*	*Swertia chiryita*
Dipsacus aspera	*Opliomenus* sp.	*Thalictrium foliosum*
Dracocephalum sp.	*Panax bipinnatfidus*	*Thladiantha cordifolia*
Elatostemma sessile	*Parochetus communis*	*Urtica dioca*
Elsholtzia stobilifera	*Paris polyphylla*	*Viola sikkimensis*
Fragaria sp.	*Persicaria runcinata*	

In the three sites, number of tree species ranged between 7 and 10, and shrub species between 18 and 20. Herbaceous species richness showed wide variation i.e. from 32 species at power house site during rainy season to 14 species at barrage and catchment area during winter season. It showed distinct seasonal variation in all the three sites with maximum number recorded during monsoon period and minimum during winter season. Dominance index for the trees was calculated on the basis of importance value index as given in Appendix II.3.42- 3.50. Among tree species, *Tsuga dumosa* dominated both in the barrage and power house sites, while *Acer* sp. was dominant in the catchment area. *Daphne papyracea* was dominant among shrub species in all the three sites. Unlike trees and shrubs, in a given season different herbaceous species were dominant at different sites (Appendix II.3.51).

Highest tree density was recorded at barrage site and lowest in catchment area. Shrub density was maximum in catchment area and minimum at barrage site (Table II. 3.161). Highest density of herbaceous species was recorded during monsoon period at barrage site and lowest during post-monsoon period in catchment area. At all the three places, it was maximum during rainy season and minimum during winter months. Shannon index of general diversity for tree species in the community was highest in catchment area (H'=2.11) followed in decreasing order by barrage site (H'=2.06) and power house site (H'=1.87). For shrub species highest value (H'=2.46) was obtained in catchment area, followed by barrage site (H'=2.42) and power house site (H’=2.36) (Table II. 3.162). For herbaceous species the highest value (H’=3.02) was recorded at power house site during monsoon and lowest (H’=2.21) during winter period in catchment area. At all the three sites, diversity of herbaceous species peaked during monsoon and attained lowest value during winter period (Tables II. 3.161and 3.162). Plant community in catchment area and barrage site had higher species diversity of trees, while shrubs and herbs showed greater diversity near power house. In general species dominance was low at all the three sites. Dominance index values for tree species ranged between 0.13and 0.17, which were much lower than those obtained for shrubs (0.86-0.89).

Table II. 3.161: Species richness, diversity and dominance of trees and shrubs, and biomass and carbon stock of trees in the community at Thingbu chu site

Parameters	Barrage		Powerhouse		Catchment area	
	Trees	Shrubs	Trees	Shrubs	Trees	Shrubs
Number of species	10	20	7	18	9	20
Density (ha^{-1})	580	8656	440	8576	370	9104
Simpson index of dominance	0.16	0.86	0.17	0.89	0.13	0.88
Shannon index of diversity (H’)	2.06	2.34	1.87	2.48	2.11	2.43
Evenness index	0.89	0.52	0.96	0.67	0.96	0.57
Biomass (t/ha)	35.17		57.98			
Carbon (t/ha)	17.58		28.99		66.10	

Table II. 3.162: Species richness, diversity and dominance in herbaceous community at Thingbu chu site

Parameters	Barrage			Powerhouse			Catchment area		
	PM	M	W	PM	M	W	PM	M	W
Number of species	22	32	14	23	32	15	25	27	14
Density (ha^{-1})x10^3	274	412	183	324	309	187	394	347	150
Simpson index of dominance	0.92	0.93	0.88	0.90	0.93	0.89	0.92	0.92	0.85
Shannon index of diversity (H’)	2.75	2.96	2.35	2.64	3.02	2.41	2.78	2.85	2.21
Evenness index	0.71	0.60	0.75	0.61	0.64	0.74	0.65	0.64	0.65

PM: Post monsoon; M: Monsoon; W: Winter

Phytoplankton/Periphyton

A total of about 14 species of periphyton was recorded from Thingbu chu. The community was represented by one species of Cyanobacteria and 11 species of Bacillariophyceae. Species richness was maximum at the project affected area with 13 species and minimum with 10 species in the catchment area. Phytoplankton/periphyton density was highest in project affected area (140 individuals/l) and lowest in the catchment area (110 individuals/l). Similarly, species diversity index was maximum (H’=2.43) in the project affected area and minimum (H’=2.16) in the catchment area (Table II. 3.163).

Table II. 3.163: Density (Individuals/l), species richness and Shannon index of diversity (H’) of phytoplankton community in river water at project affected area and catchment area of Thingbu chu HEP site

List of species	Project affected area	Catchment area
Cyanobacteria		
Aphanocapsa sp.	5	
Bacillariophyceae		
Achnanthidium pyrenaicium	10	5
Cocconeis placentula	15	20
Cymbella affinis	5	10
Cymbella tumida	5	
Encyonema minutum	15	5
Encyonema proslatum	5	
Eunotia bilunaris	5	10
Gomphonema olivaceoides	15	
Gomphonema olivaceum	10	5
Hanzchia amphioxys	10	15
Navicula cryptotenella	20	20
Opephora sp.		5
Synedra acus	20	15
Total density (Individuals/l)	140	110
Species diversity index	2.43	2.16
Species richness	13	10

NB: Blank cells indicate absence of periphyton species

Zooplankton

The study was conducted in two seasons in Thingbu chu area. Eight species were recorded during monsoon period out of which one species i.e., *Karualona karua* belongs to Cladocera, and 7 species to Rotifera (Table II. 3.164). *Notholca squamula*, *Lepadella vandenbrandei* and *Lecane signifera* were the rare species of zooplankton recorded from barrage site. These species generally inhabit the littoral and limnetic regions of lentic aquatic ecosystems.

Table II. 3.164: Occurrence of species belonging to Cladocera and Rotifera during monsoon and winter seasons at Thingbu chu site

Sl. No.	Taxa	Species	Season	
			Monsoon	Winter
1	Cladocera	*Karualona karua* (King, 1853)	–	+
2	Rotifera	*Lecane bulla* (Gosse, 1851)	–	+
3	Rotifera	*Lecane luna* (Müller, 1776)	–	+
4	Rotifera	*Notholca squamula* (O.F. Muller, 1786) *	–	+
5	Rotifera	*Lepadella vandenbrandei*(Gillard, 1952) *	–	+
6	Rotifera	*Lecane signifera* (Jennings, 1896) *	–	+
7	Rotifera	*Euchlanis dilatata* (Ehrenberg, 1832)	–	+
8	Rotifera	*Lecane closterocerca* (Schmarda, 1859)	–	+
Total	**2**	**8**	**0**	**8**

*Rare

Fish Fauna

No fish species could be located from Thingbu chu project sites.

Soil Fauna

The seasonal variation in soil fauna (Collembola, Acarina and other arthropods) diversity and equitability in litter and soil layer is shown in Table II. 3.165-3.167.

Table II. 3.165: Seasonal variation in soil fauna (Collembola, Acarina and other arthropods) diversity and equitability in litter and soil layer at Thingbu chu sites

Soil fauna	Diversity	Post-monsoon				Monsoon				Winter			
		Barrage		Powerhouse		Barrage		Powerhouse		Barrage		Powerhouse	
		Litter	Soil	Litter	Soil	Litter	Soil	Litter	Soil	Litter	Soil	Litter	Soil
Collembola	Dominance_D	0.19	0.25	0.24	0.31	0.24	0.20	0.13	0.13	0.33	0.38	0.56	0.56
	Shannon_H	1.73	1.39	1.61	1.28	1.49	1.68	2.05	2.06	1.10	1.04	0.64	0.64
	Evenness_e^H/S	0.94	1.00	0.83	0.90	0.89	0.89	0.97	0.98	1.00	0.94	0.94	0.94
Acarina	Dominance_D	0.22	0.28	0.16	0.22	0.15	0.12	0.23	0.21	0.25	1.00	0.50	0.33
	Shannon_H	1.56	1.33	1.91	1.56	1.96	2.15	1.51	1.58	1.39	0.00	0.69	1.10
	Evenness_e^H/S	0.95	0.95	0.96	0.95	0.89	0.95	0.91	0.97	1.00	1.00	1.00	1.00
Other arthropods	Dominance_D	0.18	0.16	0.13	0.25	0.16	0.13	0.17	0.14	0.33	0.25	0.50	0.20
	Shannon_H	1.75	1.89	2.12	1.39	1.88	2.12	1.84	2.12	1.10	1.39	0.69	1.61
	Evenness_e^H/S	0.96	0.95	0.93	1.00	0.93	0.93	0.90	0.84	1.00	1.00	1.00	1.00

Table II. 3.166: Mean annual density (number/m^2) of soil fauna in litter and soil layer (0-5 cm) at Thingbu chu site

Soil fauna	Site	Litter layer	Soil layer	Total
Collembola	Barrage	945	909	**1855**
	Powerhouse	1491	1055	**2545**
Acarina	Barrage	886	657	**1543**
	Powerhouse	771	571	**1343**
Other arthropods	Barrage	982	1200	**2182**
	Powerhouse	1491	1236	**2727**
Total fauna	**Barrage**	**2813**	**2766**	**5580**
	Powerhouse	**3753**	**2862**	**6615**

Table II. 3.167: Seasonal variation of soil fauna density (number/m^2) at barrage and powerhouse sites of Thingbu chu project

Soil fauna	Site	Post-monsoon	Monsoon	Winter	Mean
Collembola	Barrage	4800	12800	2800	**6800**
	Powerhouse	6800	18800	2400	**9333**
Acarina	Barrage	4400	15200	2000	**7200**
	Powerhouse	6400	10400	2000	**6267**
Other arthropods	Barrage	7200	14000	2800	**8000**
	Powerhouse	8400	18800	2800	**10000**

Wildlife

Butterflies: Nineteen species from 17 genera and 5 families were present in Thingbu chu HEP area. The family Nymphalidae was the dominant with seven species. These 19 species did not include any threatened species (Table II. 3.168).

Table II. 3.168: Butterflies recorded in Thingbu chu HEP area

Sl. No.	Family common name	Scientific name	Project area
I.	**Hesperiidae**		
1	Lucas' Ace	*Sovia lucasii magna*	*
II.	**Papilionidae**		
2	Common Peacock	*Papilio polyctor ganesa*	*
3	Common Bluebottle	*Graphium sarpedon sarpedon*	*
4	Indian Purple Emperor	*Mimathyma ambica*	*
III.	**Pieridae**		
5	Spotless Grass Yellow	*Eurema laeta*	*
6	Small Grass Yellow	*Eurema brigitta rubella*	*
7	Indian Cabbage White	*Pieris canidia indica*	*
8	Plain Sulphur	*Dercas lycorias*	*
IV.	**Lycaenidae**		
9	Green Sapphire	*Heliophorus moore*	*
10	Common Flash	*Rapala nissa ratna*	*
11	Common Hedgeblue	*Acytolepis puspa gisca*	*
12	Punchinello	*Zemeros flegyas indicus*	*
V.	**Nymphalidae**		
13	Chestnut Tiger	*Parantica sita*	*
14	Eastern Comma	*Polygonia egea*	*
15	Large Silverstripe	*Argynnis children*	*
16	Glassy Tiger	*Graphium cloanthus*	*
17	Chocolate Pansy	*Junonia iphita iphita*	*
18	Banded Treebrown	*Lethe confusa*	*
19	Straight-banded Treebrown	*Lethe verma*	*

Herpetofauna: In Thingbu chu project area, since no herpetofauna was sighted during the survey, the probable list of amphibians and reptiles was prepared following Ahmed *et al.* (2009) (Appendix II.3.167).

Birds: The assessment of birds carried out in post-monsoon, monsoon, and winter season, showed the presence of 67 species belonging to 45 genera and 28 families. Species richness was highest during monsoon (36 species) compared to winter (Table II. 3.169).

Migratory status: Most of the birds were residents (47 species), followed by 11 breeding visitors and 9 winter visitors (Table II. 3.169).

Table II. 3.169: Status of birds recorded in Thingbu chu HEP area

Details	Post-monsoon	Monsoon	Winter	Overall
Family	17	17	13	28
Genera	23	26	17	45
Species	29	36	24	67
Abundance	206	316	128	650
Diversity H'	3.1	2.8	2.8	3.6
Migratory status				
Breeding visitor	3	8	2	11
Isolated record	0	0	0	0
Resident	22	23	19	47
Winter visitor	4	5	3	9

Abundance status: The abundance status of birds was derived by classifying the abundance of bird species into five abundance categories (Very Low = 1-25 birds, Low = 26-50, Moderate = 51-75, High = 76-100 and Very high = > 100birds). The details of abundance status are given in the Table II. 3.170.

Table II. 3.170: Number of species and relative % of birds in different abundance classes

Abundance class	No. of species	Relative %
Very low-1-25 birds	62	92.5
Low-26-50 birds	3	4.5
Moderate-50-75 birds	2	3.0
High-76-100 birds	0	0.0
Very high > 100 birds	0	0.0
Total	**67**	**100.0**

Status of foraging guilds: The foraging guild of birds in the Thingbu chu project area was represented by 7 guilds. The most dominant being the insectivores with 52 species, followed by 6 omnivores. The high richness of insectivores revealed the presence of diverse habitat and niches in this project area (Table II. 3.171 and Annexure**)**.

Table II. 3.171: Status of foraging guild of birds recorded in Thingbu chu HEP area

Foraging guild	Post monsoon	Monsoon	Winter	Overall
Aquatic feeder	1	0	0	1
Carnivore	0	0	1	2
Frugivore	0	0	0	0
Granivore	2	2	0	3
Insectivore	18	29	22	52
Nectarivore	2	2	1	3
Nucivore	0	1	0	1
Omnivore	6	2	0	6
Piscivore	0	0	0	0

Status of threatened species: No threatened bird species was recorded within the project area (Appendix II.3.177).

Mammals: Three surveys in and around the Thingbu chu project site revealed the presences of ten mammalian fauna and each belonging to separate genus and in eight families. This list consists of 1 primate, 2 ungulates, 4 rodent and 3carnivore species (Appendix II.3.178).

Abundance status: Ten species were confirmed based on direct sighting during the visit made for survey in three seasons. In the project area, Arunachal Macaque (*Macaca munzala*) was reported based on indirect evidence (Table). Comparison of species richness of the project area (nine species) with the possible species (29 species) of the Tawang district (Mishra *et al.,* 2006) also revealed low species richness (Appendix II.3. 178)

Status of threatened species: Except for the two animals, namely, Arunachal Macaque (*Macaca munzala*) and Himalayan goral (*Naemorhedus goral)* which belong to Endangered(EN) and Near Threatened (NT) categories as per IUCN Red List, the rest of the species of the project area fall under Least Concern (LC) of IUCN and Schedule II and III of WPA (1972) (Table II. 3.172).

Table II. 3.172: Status of mammalian fauna of the proposed Thingbu chu HEP area

Sl. No.	Common name	Scientific name	Seasons			Overall	Conservation status	
			PM	M	W		IUCN	WPA
I.	**Cercopithecidae**							
1	Arunachal Macaque	*Macaca munzala*		A 3		A 3	**EN**	-
II.	**Bovidae**							
2	Himalayan goral	*Naemorhedus goral*	A 1		IE 1	IE 3, A1	NT	III
III.	**Suidae**							
3	Wild pig	*Sus scrofa*		A 2	IE 2	IE 2, A 2	LC	III
IV.	**Felidae**							
4	Jungle cat	*Felis chaus*		A 1	IE 1	IE 1, A 1	LC	II
V.	**Mustelidae**							
5	Yellow Throated Martin	*Martes flavigula*	A 1		IE 1	IE 2, A 1	LC	II
VI.	**Viverridae**							
6	Himalayan Palm Civet	*Paguma larvata*		A 1		A 1	LC	II
VII.	**Sciuridae**							

7	Orange-Bellied Himalayan Squirrel	*Dremomys lokriah*		A-1		A 1	LC	NE
8	Hoary-bellied Himalayan Squirrel	*Callosciurus pygerythrus*	A2			A 2	LC	NE
9	Himalayan stripped Squirrel	*Tamipos macclellandi*	A1	A-2		A 3	LC	NE
VIII.	**Muridae**							
10	Chesnut rat	*Niviventer fluvescens*			A 1	**A1**	LC	NE
	No. of species		**4**	**6**	**5**	**10**		
	Total and types of records		**IE 3 A 5**	**IE 5 A 10**	**IE 5 A1**	**IE 13 A 16**		

IE – Indirect Evidences A-animals sighted, W-Winter, PM-Post-monsoon, M-Monsoon, IUCN-Red List, WPA-Wildlife Protection Act, EN-Endangered, NT-Near threatened, LC-Least concern, NE-Not evaluated

Faunal status within 500 m of project affected area: This section revealed species richness status of selected faunal groups such as avifauna and mammal species reported within 500m up and down streams of the barrage and power house sites. The species richness was evaluated based on subject rating by estimating percent contribution with the overall species list of the project area. If the species richness of barrage and power house list contributes 25% of overall list, categorised as low, > 25-50% as medium, >50-75% as high and above 75% as high species richness.

Status of avifauna: The Thingbu chu powerhouse and barrage sites had high richness of birds (55 species). However, none of them belonged to threatened category (Appendix II.3.179).

Status of mammals: Site specific evaluation of mammalian fauna within 500 m of up and down streams revealed occurrence of 6 species in the powerhouse site. Among these, only one species i.e. Hoary-bellied Himalayan Squirrel, was recorded based on sighting of two animals. Presence of rest of the 4 species was ascertained based on 8 indirect evidences. None of these species belonged to threatened category (Table II. 3.173). Overall, the powerhouse and barrage site of Thingbu chu project did not have any mammalian fauna of high conservation significance.

Table II. 3.173: Status of mammalian fauna at barrage site of the proposed Thingbu chu HEP area

Sl. No.	Common name	Species name	Status	Conservation status	
			BS/PHS	IUCN	WPA
1	Arunachal Macaque	*Macaca munzala*	IE 3,	EN	
2	Himalayan goral	*Naemorhedus goral*	IE 1	NT	III
3	Wild pig	*Sus scrofa*	IE 2	LC	III
4	Jungle cat	*Felis chaus*	IE 1,	LC	II
5	Yellow Throated Martin	*Martes flavigula*	IE 1	LC	II
6	Hoary-bellied Himalayan Squirrel	*Callosciurus pygerythrus*	A, 2,	LC	NE
	Total records		**IE 8, A 2**		

IE – Indirect Evidences, A – No of Animals Sighted, BS–Barrage Site, PHS – Power House Site, IUCN-Red List, WPA-Wildlife Protection Act, EN-Endangered, NT-Near threatened, LC-Least Concern, NE-Not Evaluated

3.3.4.3 SOCIO-ECONOMIC PROFILE

The villages that come under the 10 km affected zone of Thingbu chu are the same as those under Tsa chu-II project site. Therefore, the detail socio-economic data of this project is the same as that of Tsa chu-II project and have been dealt in Section-II. 3.3.3.

3.3.5 NEW MELLING

3.3.5.1 PHYSICAL ENVIRONMENT

Geomorphology

River Mago Chu flows in a general NE–SW direction through a classic V–shaped valley in project area (Figure II. 3.23). The river flows from EL 2710 m at barrage site to EL 2515 m at powerhouse site with a non–uniform gradient. The non–uniform gradient is anticipated due to multiple natural blockage of river by nala alluvial/debris fans. Alluvial fans occur along the tributary streams on both banks right from Thumbin village to Rho village. The river has developed conspicuous terraces upstream of the confluence of the nala alluvial/debris fans. Colluvium deposits are found over the slopes. Some major slide debris deposits have also been found in project area on right bank. Two of them have been found in powerhouse area and a fairly big debris deposit has been found on the right bank at the barrage side. No major lineament, fault and thrust have been found in the project area. However, an antiform has been mapped near the confluence of River Nykcharang Chu and Mago Chu, i.e. far downstream of New Melling powerhouse site.

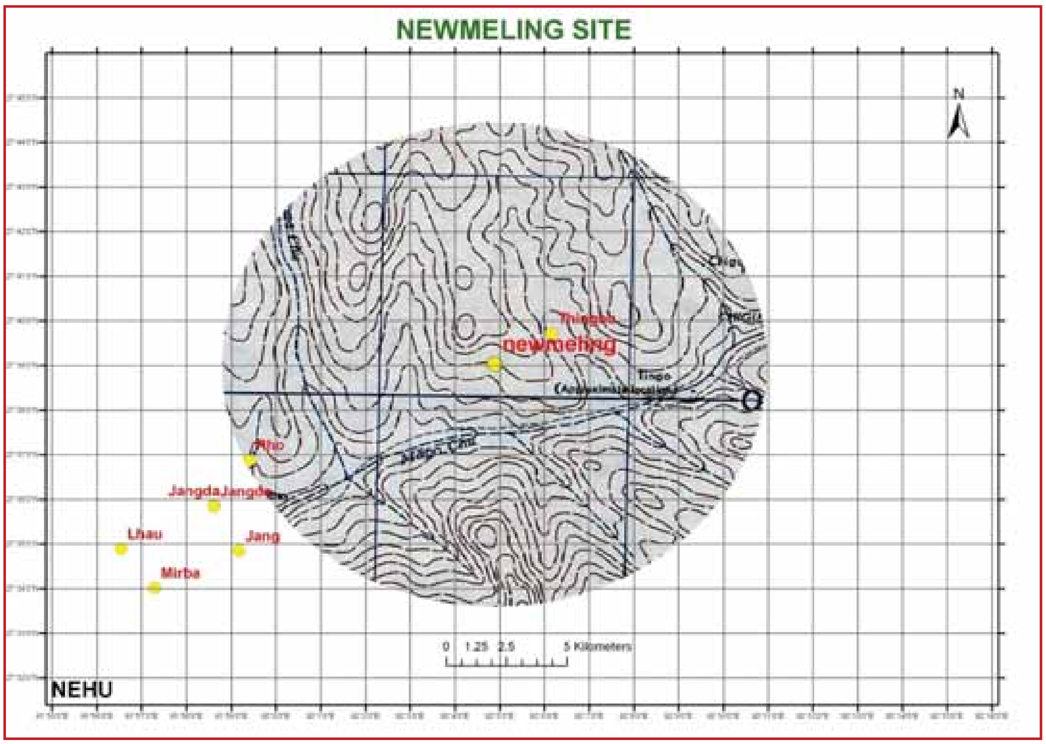


Figure II. 3.23: Contour map of New Melling HEP site

Geology

The project is located in the lower reaches of Thingbu Chu. Geology and seismic considerations will be the same as of Thingbu Chu. The rocks of two different formations have been mapped in the project area, viz., Se La Group (GSI, 2010) towards downstream and Thumbin formation that occupies upstream part of reservoir area. The contact of these two is found concealed under colluvial cover in the reservoir area. However, the contact has been reported as an unconformable contact (GSI, 2010). Se La Group occupies the area from powerhouse to about middle of the reservoir area. It is largely composed of quartz biotite gneiss with subordinate bands of schists, and numerous pegmatite and granite intrusions. The thickness of intrusions is about a few mm to 5–6 m, whereas, the thickness of schist rarely go upto 0.3 m. However, two thick beds of schist have been mapped in project area. The Thumbin formation consists of quartz biotite schist with minor bands of gneisses. The intrusions are rare and only quartz veins have been found. The strata are uniformly dipping in the project area with some occasional tight folding. Therefore, no major geological structure like fold or fault is discernible in the project area. The area under various geological classes in New Melling at barrage site is given in Table

II. 3.174. The location of New Melling barrage site and the impact zone within 10 km radius in Tawang river are depicted in Figures II. 3.24 and 3.25.

Table II. 3.174: Area under various geological classes in New Melling at barrage site

Class	Area	%
Snow covered area	15.30	4.87
Snow covered area	46.64	14.85
Snow covered area	26.15	8.32
Sela group (Structural hill)	168.72	53.70
Glacier	3.67	1.17
Sela group (Valley)	1.06	0.34
Lateral morain	0.70	0.22
Glacier	2.25	0.72
Volcanic sediment (Structural hill)	26.61	8.47
Volcanic sediment (Structural hill)	23.06	7.34
Total	**314.16**	**100.00**

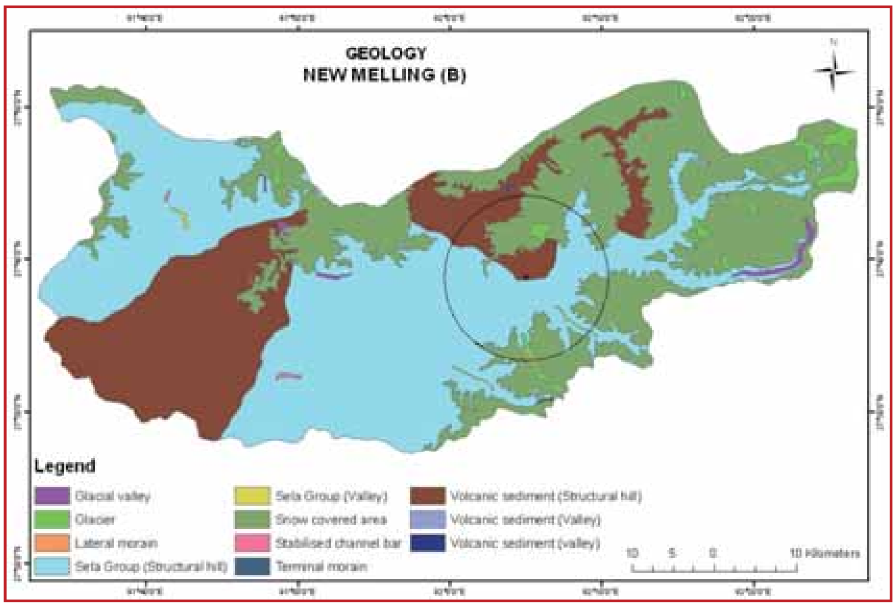


Figure II. 3.24: Geological map of TRB showing location of New Melling barrage site

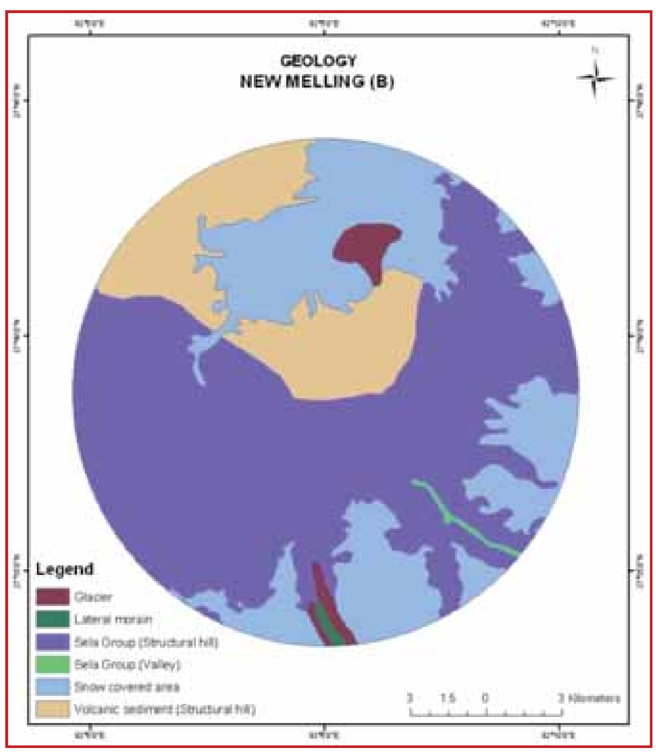


Figure II. 3.25: Geological map of influence zone (10 km radius) of New Melling barrage site

Landuse and Land Cover

The total area within 10 km radius of New Melling HEP site is 31457.63 ha (Figure II. 3.26). Majority of the area is covered with forest (49.97%) followed by scrubland (33.88%). Cropland covers only 0.02% of the total project area. Waterbody constitute around 11.56% of the total area and grassland occupies only 0.98%. Snow and ice and other builtup area altogether is 3.6% of the total area (Table II. 3.175).

Table II. 3.175: Land use/land cover area of New Melling project site

Landuse/land cover category	Area (ha)	%
Forest	15718.2	49.97
Scrubland	10656.4	33.88
Waterbody	3636.77	11.56
Croplands	7.3125	0.02
Grasslands	306.81	0.98
Builtup area	30.375	0.10
Snow and Ice	1101.76	3.50
Total	**31457.63**	**100.00**

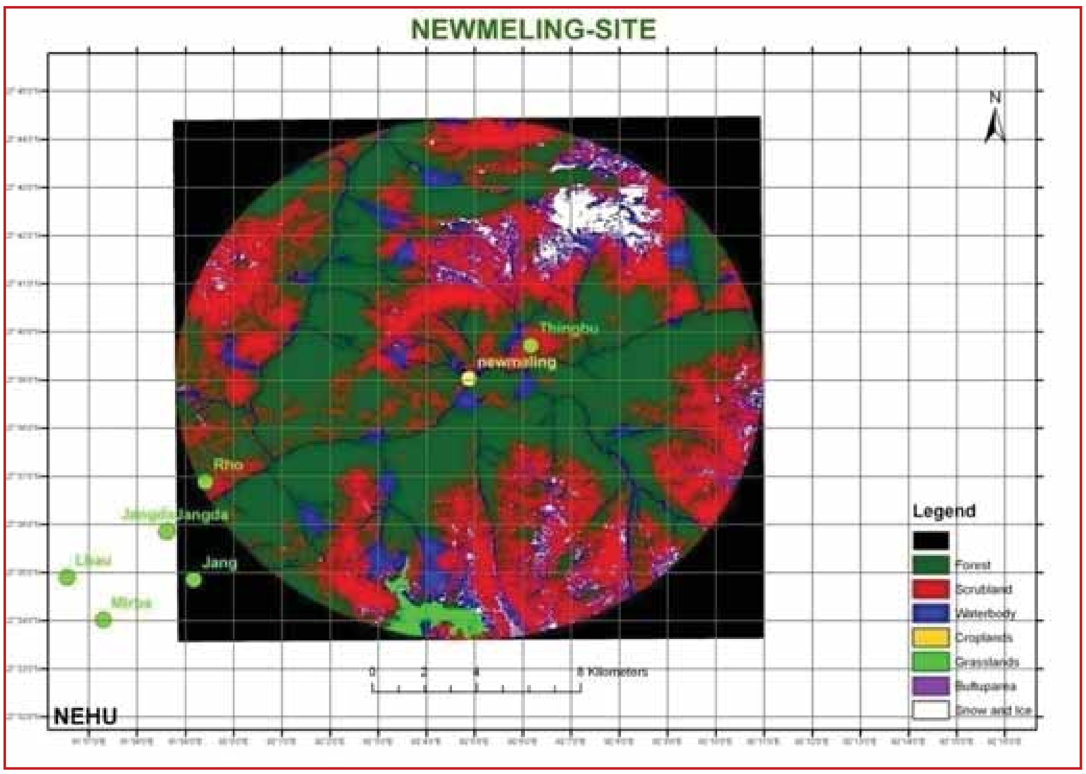


Figure II. 3.26: Land use/land cover area of New Melling project site

Soil

Soil analysis data furnished in Table II. 3.176 indicate that the soil at this site did not differ much from Tawang, Rho, and Mago chu project sites. Seasonal difference was prominent in some parameters while difference between barrage and power house sites did not show any definite trend. Seasonal variation in physical, chemical and biological parameters are presented in Tables II. 3.176-3.177.

Table II. 3.176: Soil physical properties at New Melling project site

Site	Texture	WHC (%)	Bulk density (g/cm³)	Porosity (%)
Barrage	Sandy loam	27.09	1.35	49.05
Powerhouse	Sandy loam	35.06	1.38	47.92

Table II. 3.177: Seasonal variation in soil physico–chemical properties at New Melling project site

Parameters	Post-Monsoon		Monsoon		Winter		Mean	
	B	PH	B	PH	B	PH	B	PH
SMC (%)	30	25	35	38	18	15	28	26
pH	4.5	5.1	5.5	5.2	4.5	4.5	4.8	5.0
Conductivity ($\mu S\ cm^{-1}$)	28	28	32	35	26	25	29	29
NH_4^+–N ($\mu g\ g^{-1}$)	300	200	300	400	300	300	300	300
NO_3^-–N($\mu g\ g^{-1}$)	12	21	22	27	15	20	16	23
TKN ($\mu g\ g^{-1}$) x10^3	0.800	0.600	1.120	1.110	0.700	0.500	0.870	0.740
Av.P ($\mu g\ g^{-1}$)	0.060	0.030	0.080	0.040	0.030	0.030	0.060	0.030
TP (%)	0.140	0.120	0.160	0.150	0.130	0.120	0.140	0.130
SOC (%)	0.014	0.013	0.016	0.014	0.012	0.013	0.010	0.010
Ex. K ($\mu g\ g^{-1}$)	147	148	300	306	144	145	197	199
Ex. Mg (%)	0.032	0.007	0.021	0.008	0.011	0.010	0.020	0.010
Ex. Ca (%)	0.535	0.724	0.009	0.075	0.178	0.142	0.240	0.310
Soil microbial biomass–C ($\mu g\ g^{-1}$)	29	23	21	19	30	26	26	23
Soil microbial biomass–N ($\mu g\ g^{-1}$)	7.0	10.0	5.9	8.9	10.2	14.2	7.7	11.0

(Note: Post-Monsoon–October, Monsoon–July, Winter–December); B = Barrage, PH = Powerhouse

Soil Erosion Vulnerability

Out of the total area of 314.16 sq.km, 1.07% area falls under high soil erosion vulnerable zone, and 8.59% falls under moderately high vulnerable zone. 11.59% of the total area is under low vulnerable zone, and 39.23% falls under moderately–low vulnerable zone (Table II. 3.178). The soil erosion vulnerable area under moderate category covers about 39.52% of the total area. The spatial distribution map of soil erosion vulnerable areas under barrage site of New Melling is given in Figure II. 3.27.

Table II. 3.178: Areas under various soil erosion vulnerable zones in the 10 km radius of the barrage site of New Melling

Vulnerability	Area (sq. km)	%
High	3.35	1.07
Moderately high	27.00	8.59
Moderate	124.15	39.52
Moderately low	123.24	39.23
Low	36.42	11.59
Total	**314.16**	**100.00**

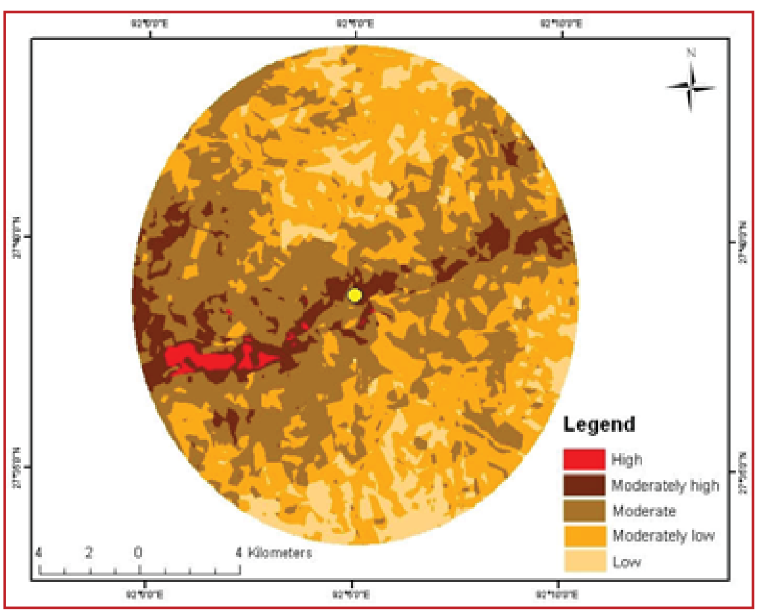


Figure II. 3.27: Spatial distribution of soil erosion vulnerable areas in the 10 km radius of the barrage site of New Melling

Landslide and Erosion Vulnerability

Of the total area of 314.16 sq. km, 0.47% and 0.99% falls under high and low vulnerable zone, respectively. 9.65% and 39.39% of the total area falls under moderately–high and moderately–

low vulnerable category, respectively. The highest area of vulnerability falls under moderate category which is 49.5% of the total area (Table II. 3.179). The spatial distribution map of landslide and erosion vulnerability areas under barrage site of New Melling is given in Figure II. 3.28.

Table II. 3.179: Area under various erosion and landslide vulnerability in the 10 km radius of the barrage site of New Melling

New Melling	Area (sq.km)	%
High	1.48	0.47
Moderately high	30.32	9.65
Moderate	155.50	49.50
Moderately low	123.74	39.39
Low	3.12	0.99
Total	**314.16**	**100.00**

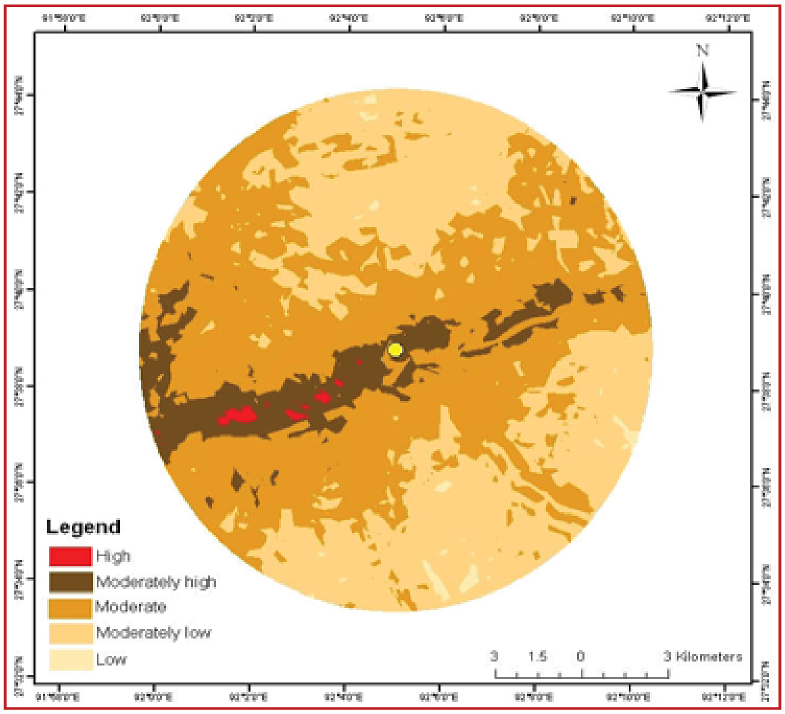


Figure II. 3.28: Area under various erosion and landslide vulnerability areas in the 10 km radius of the barrage site of New Melling

Water

Seasonal change in river water quality was prominent in this project site. The physical parameters viz., temperature and turbidity, were highest during monsoon period. During this period, coliform count was at its peak. GPP and NPP were much higher in the monsoon compared to other seasons. Electrical conductivity (EC), total dissolved solids (TDS), and nutrient concentration was higher during post-monsoon season. Total hardness and total alkalinity of the river were highest during the winter season (Table II. 3.180).

Table II. 3.180: Seasonal variation in physico–chemical and biological properties of water and river primary productivity in New Melling project site

Parameters	Post-Monsoon			Monsoon			Winter		
	B	PH	Mean	B	PH	Mean	B	PH	Mean
Temperature (˚C)	4.90	5.25	5.08	14.20	14.30	14.25	1.20	1.80	1.50
Turbidity (NTU)	0.23	0.26	0.24	1.42	1.62	1.52	1.22	1.33	1.28
pH	7.59	7.62	7.60	7.84	7.89	7.86	7.58	7.62	7.60
Electrical conductivity (µS/cm)	173	172.50	173	139	130.50	135	158	156.00	157
Total dissolved solids (mg/l)	86	86.20	86.25	60	61.65	60.98	83	82.30	82.50
Practical salinity (ppt)	0.10	0.10	0.10	0.07	0.07	0.07	0.09	0.09	0.09
Total alkalinity (mg CaCO3/l)	30	30.40	30.40	36	30.00	33.00	44	48.00	46.00
Total hardness (mg/l)	21	20.84	21.05	26	30.15	28.03	40	40.31	40.36

Chloride (mg Cl–/l)	9.99	9.99	9.99	9.99	9.99	9.99	7.99	5.99	6.99
Ca2+ (mg/l)	4.17	4.17	4.17	5.83	7.16	6.50	9.21	9.20	9.21
Mg2+(mg/l)	2.64	2.53	2.59	2.76	2.98	2.87	4.23	4.21	4.22
K+ ppm	1.00	1.00	1.00	0.80	0.70	0.75	0.40	0.40	0.40
Na+ ppm	7.70	7.95	7.83	5.20	5.80	5.50	7.40	7.50	7.45
TKN (mg/l)	0.42	0.41	0.42	0.52	0.52	0.52	0.35	0.35	0.35
NH4+ N (mg/l)	0.03	0.03	0.03	0.11	0.10	0.11	0.03	0.03	0.03
NO3–N (mg/l)	0.33	0.34	0.33	0.18	0.21	0.20	0.26	0.26	0.26
Total phosphorus (mg/l)	0.10	0.10	0.10	0.08	0.08	0.08	0.10	0.10	0.10
GPP (mg C/cm3/h)	0.31	0.31	0.31	0.47	0.47	0.47	0.26	0.26	0.26
NPP (mg C/cm3/h)	0.20	0.15	0.17	0.23	0.23	0.23	0.10	0.10	0.10
Dissolved oxygen (mg/l)	11.70	11.60	11.65	10.20	10.15	10.18	12.20	12.60	12.40
Total coliforms (CFU/ml)	31	36.00	33.50	28	23.00	25.50	25	27.00	26.00
BOD5 (mg/l)	2.5	2.7	2.6	2.8	3.0	2.9	2.5	2.8	2.6

* Local road construction was in progress

Ambient Air Quality

Concentration of PM_{10} and $PM_{2.5}$: PM_{10} concentration at New Melling HEP was found to be ranging from a minimum of 23.5µg/m^3 at Rho to a maximum of 41.0 µg/m^3 at Thingbu chu. Similarly, concentration of $PM_{2.5}$ ranged from a minimum of 13.4 µg/m^3 at Rho to a maximum of 38.7 µg/m^3 at New Melling (Table II. 3.181). The concentration of sulphur–dioxide (SO_2), nitrogen–dioxide (NO_2), ammonia (NH_3) and ground level ozone (O_3) at all the monitored locations were below detectable limits.

Table II. 3.181: Concentration of PM_{10} and $PM_{2.5}$ in air at the proposed New Melling project site

Sampling location	Nearest project site covered	PM_{10} (µg/m^3)	$PM_{2.5}$ (µg/m^3)
New Melling	New Melling dam site New Melling powerhouse	39.4	38.7
Rho	New Melling dam site New Melling powerhouse	23.5	13.4
Thingbu chu	New Melling dam site New Melling powerhouse	41.0	26.9

Ambient temperature at New Melling HEP was 2°C and 9°C at Rho. Relative humidity varied between 34% at Thingbu chu to 52% at Rho. Wind speed was 1.2 km/hr at Thingbu chu and 3.6 km/hr at Rho. Wind direction varied from NW to SE direction (Table II. 3.182).

Table II. 3.182: Meteorological condition at proposed New Melling HEP site

Sampling location	Nearest project component covered	Ambient temperature (°C) Min	Max	Relative humidity (%)	Wind speed (range in km/hr)	Wind direction
New Melling	New Melling dam site New Melling powerhouse	02	06	37	1.7–2.5	SE
Rho	New Melling dam site New Melling powerhouse	05	09	52	1.8–3.6	NW
Thingbu chu	New Melling dam site New Melling powerhouse	03	07	34	1.2–2.1	SE

Noise Level: Noise level near New Melling HEP ranged between 37.2 dBA at Rho at 8.00 AM and 67.1 dBA at New Melling at 4.00 PM (Table II. 3.183).

Table II. 3.183: Noise level at proposed New Melling HEP site

Sampling location	Nearest project component covered	Noise Level (dBA) 8.00 AM	Noise Level (dBA) 4.00 PM
New Melling	New Melling dam site New Melling powerhouse	61.3	67.1
Rho	New Melling dam site New Melling powerhouse	37.2	39.6
Thingbu chu	New Melling dam site New Melling powerhouse	60.2	62.0

3.3.5.2 BIOLOGICAL ENVIRONMENT

Vegetation Types

The project components of New Melling HEP are located in sub-alpine and temperate climatic zone. The vegetation types within 10 km radius area are:

12/C3a East Himalayan mixed coniferous forests (2000-3500 m): These are dense evergreen forests with dominance of oak and rhododendrons. Between 2300-3500 m elevations in the upper ridges, silver fir (*Abies densa*) makes appearance as a dominant tree species. However at lower elevations, other deciduous trees such as *Magnolia* sp., *Acer* sp., *Betula alnoides, Alnus nepalensis*, mixed with oak species, occur at varying extents. Gregarious undergrowth, usually of bamboo, and in its absence *Rhododendron* species and other evergreen shrubs such as *Berberis* sp., *Cotoneaster* sp., *Rhododendron* sp., *Salix* sp., *Thamnocalamus* sp. and *Viburnum* sp. also occur. The trees are mostly covered with many epiphytic mosses and lichens.

12/ISI Alder forest (1800-2200 m): These are typically seen as pure stands of *Alnus nepalensis* and *Populus ciliata*, with heights ranging from 20-30 m. They occur as a strip with varying width along stream sides, spreading out to larger areas, and more or less deciduous in nature. In the lower course of the stream and landslide affected areas, *Alnus* is the dominant formation. There is often an under growth of inedible/thorny shrubs comprising *Berberis, Rubus, Princepia* etc., whilst in the better wooded tracts, progression starts early and other species, notably blue pine and other conifers, are usually present.

12/1S2 Riverine blue-pine forest (1800-3000 m): These forests are characterized by irregular and often dense stands of blue pine with occasional *Picea*, *Tsuga, Populus* and *Alnus*, with little or no undergrowth.

14/C2 East Himalayan sub-alpine birch/fir forest (3500-4000 m): These forests occur between 3500 and 4000m elevation, and comprise of tree species such as *Abies densa, Juniperus* sp., *Larix griffithii, Betula utilis* etc. Small trees (*Rhododendron wightii*) and shrubs (*Rosa* sp., *Berberis* sp., *Spirea* sp.) also occur. The herbaceous layer is comprised of *Polygonum* sp., *Potentilla* sp., *Primula* sp., *Fragaria* sp. etc.

14/2SI Sub-alpine blue-pine forest (3500-4000 m): These types of forest occurs at 3500-4000 m elevation, and are represented by pure stands of *Pinus wallichiana*. Towards higher elevation, Fir forests gradually replaces bluepine.

Plant Diversity

A total of 152 plant species belonging to different groups were recorded from the barrage and powerhouse site, and the catchment area. A complete list of plant species found in the study area is presented in Appendix II. 3.52. The number of plant species belonging to different groups is summarized in Table II. 3.184.

Table II. 3.184: Different groups of plant species present at New Melling HEP site

Sl. No.	Groups	Number of species		
		Barrage site	Powerhouse site	Catchment area
1	Tree	12	11	10
2	Shrub	17	17	18
3	Herb	37	37	37
4	Climbers	15		10
5	Orchids	7		5
6	Pteridophytes	13		9
7	Bryophytes	7		4
8	Lichens	11		7
9	Fungi	15	12	13

The trees were covered with a variety of non-vascular epiphytes such as lichens, mosses and ferns. 12 tree, 17 shrub, and 37 herb species were recorded from the barrage site, while from the powerhouse site 11 tree, 17 shrub, and 37 herb species were recorded. From the catchment area 10 tree, 18 shrub, and 37 herb species were recorded. 15 climber, 7 orchid, 13 pteridophyte, 7 bryophyte, 11 lichen, and 15 fungus species were recorded from barrage and powerhouse site, whereas from the catchment area 10 climber, 5 orchid, 9 pteridophyte, 4 bryophyte, 7 lichen and 13 fungi species were recorded (Appendix II. 3.53 and 3.54).

Threatened and Endemic Species

Six threatened species were recorded from the project area (Table II. 3.185).

Table II. 3.185: Threatened/endemic plants recorded at New Melling HEP site

Species name	Family	Threat status	References
Panax bipinnatifidus	Araliaceae	VU	CAMP, 2003
Swertia chirayita	Gentianaceae	VU	CAMP, 2003
Taxus wallichiana	Taxaceae	EN	CAMP, 2003; Walter and Gillet, 1998

VU=Vulnerable; EN=Endangered

Economically Important Species/plant Resources

The study area is rich in plant resources. Few important species are listed in Table II. 3.186.

Table II. 3.186: Economically important species/plant resources present at HEP site

Sl. No.	Uses	Species name
1	Timber	*Abies densa, Larix griffithii, Pinus wallichiana*
2	Fuel	*Rhododendron* sp., *Abies densa, Pinus wallichiana*
3	Ornamentals and orchids	*Rhododendron* sp., *Primula* sp., *Aster* sp., *Satyrium* sp., *Salix* sp.
4	Medicine and aromatics	*Panax* sp., *Paris polyphylla, Taxus wallichiana, Drymaria cordata*
5	Fodder	*Alnus nepalensis,*
6	Edible	*Elaeagnus* sp., *Prunus* sp., *Pyrus* sp., *Rubus* sp., *Prasiloa* sp.
7	Fibre and paper	*Daphne papyracea*
8	Bamboos	*Arundinaria* sp., *Phyllostachys* sp.

Vegetation Analysis for angiosperms and gymnosperms

The plant community at barrage and powerhouse sites, and the catchment area were composed of 18 tree, 22 shrub, and 44 herbaceous species (Tables II. 3.187 and 3.188).

Table II. 3.187: Tree and shrub species recorded at barrage and powerhouse sites, and in the catchment area of the proposed New Melling project area

Tree species	Shrub species
Acer sp.	*Artemisia nilagarica*
Alnus nepalensis	*Arundinaria maling*
Betula alnoides	*Aconogonum molle*
Brassiopsis glomerulata	*Berberis* sp.
Corylus heterophylla	*Boenninghausenia albiflora*
Larix griffithii	*Coriaria cylindrica*
Leucosceptrum canum	*Coriaria nepalensis*
Persea sp.	*Daphne papyracea*
Picea spinulosa	*Eleagnus parviflora*
Pinus wallichiana	*Girardinia grandiflora*
Populus ciliata	*Hypericum choisianum*
Populus sp.	*Hypericum* sp.
Quercus semicarpifolia	*Ilex dipyrena*
Rhododendron campanulatum	*Neillia thysiflora*
Rhododendron sp.	*Piptanthus nepalensis*
Sorbus sp.	*Plectranthus* sp.
Taxus wallichiana	*Rosa* sp.
Tsuga dumosa	*Rubus ellipticus*
	Rubus nivies
	Sarcococca sp.
	Seigesbeckia orientalis
	Spirea sp.

Table II. 3.188: Herbaceous species recorded at barrage and powerhouse sites, and in the catchment area of the proposed New Melling project area

Herb species		
Ainsliaea sp.	*Fragaria* sp.	*Phlomis* sp.
Anaphalis margaritacea	*Galium rotundifolium*	*Pilea umbrosa*
Aster sp.	*Galium* sp.	*Pogostemon* sp.
Aster trinervius	*Geranium pratense*	*Potentilla cuneata*
Astilbe rivularis	*Herachleum*	*Rumex acetosella*
Campanula sp.	*Herpetospermum pedunculosum*	*Rumex nepalensis*
Cyathula capitata	*Lecanthus penduncularis*	*Salvia* sp.
Cynoglossum sp.	*Nepata* sp.	*Sambacus adnata*
Dipsacus aspera	*Ophiopogon intermedius*	*Senecio cappa*
Dracocephalum sp.	*Opliomenus* sp.	*Swertia paniculata*
Drymaria cordata	*Panax bipinnatifitus*	*Thalictrium foliosum*
Elatostemma sessile	*Paris polyphylla*	*Thladiantha cordifolia*
Elsholtzia stobilifera	*Parochetus communis*	*Urtica dioca*
Equisetum sp.	*Parasenecio quinquelobus*	*Viola sikkimensis*
Fragaria nubicola	*Persicaria runcinata*	

In the three sites, number of tree species varied from 10 to 12, and the shrub species from 17 to 18. Herbaceous species richness showed wide seasonal variation i.e., from 32 species in the catchment area during rainy season, to 16 species at barrage site during post-monsoon period. Among trees, *Tsuga dumosa* in the barrage site, *Quercus lamellosa* in the powerhouse site, and *Acer* sp., in catchment area were dominant. *Arundinaria maling* was dominant among shrubs in the barrage and powerhouse sites, while *Daphnae papyracea* was dominant in the catchment area. Unlike trees and shrubs, the site-specific dominance of herbaceous species varied between different seasons (Table II. 3.190 and Appendix II. 3.64).

Tree density was highest in the barrage site and lowest in the powerhouse site. Shrub density was highest in catchment area and lowest in the barrage site (Table II. 3.189). Highest density of herbaceous species was recorded during monsoon season in the catchment area, and lowest during post-monsoon season in the barrage site. Shannon diversity index for tree species was highest for the powerhouse (H'=2.29), followed by barrage site (2.03), and catchment area (1.70). For shrub species, Shannon diversity value (H'=2.46) was highest for the catchment area, followed by barrage site (H'=2.42), and powerhouse site (H'=2.36) (Table II. 3.190). For herbaceous species, Shannon diversity value (H'=3.03) was highest area during monsoon for the catchment, and lowest (H'=2.46) for the barrage and powerhouse sites during winter season. In all three sites, diversity of herbaceous species peaked during monsoon, and attained the lowest values during winter season (Table II. 3.190 and Appendix II.3.55- 3.63).

Table II. 3.189: Species richness, diversity, and dominance of trees and shrubs, and biomass and carbon stock of trees in the community at New Melling site

Parameters	Barrage		Powerhouse		Catchment area	
	Trees	Shrubs	Trees	Shrubs	Trees	Shrubs
Number of species	12	17	11	17	10	18
Density (ha^{-1})	700	11600	290	12400	560	11680
Simpson index of dominance	0.20	0.88	0.11	0.87	0.26	0.88
Shannon index of diversity (H')	2.03	2.42	2.29	2.36	1.70	2.46
Evenness index	0.82	0.66	0.95	0.62	0.74	0.65
Biomass (t/ha)	95.93		16.83			
Carbon (t/ha)	47.96		8.41		75.30	

Table II. 3.190: Species richness, diversity and dominance of herbaceous species at New Melling site

Parameters	Barrage			Powerhouse			Catchment area		
	PM	M	W	PM	M	W	PM	M	W
Number of species	23	30	16	23	31	18	22	32	17
Density (ha^{-1})x10^3	314	502	238	318	436	295	342	496	198
Simpson index of dominance	0.92	0.92	0.89	0.92	0.93	0.89	0.92	0.94	0.91
Shannon index of diversity (H')	2.76	2.87	2.46	2.75	2.95	2.46	2.80	3.03	2.62
Evenness index	0.69	0.59	0.73	0.68	0.62	0.65	0.75	0.65	0.81

PM: Post-monsoon; M: Monsoon; W: Winter

Phytoplankton/Periphyton

Eleven species of phytoplankton/periphyton were recorded from New Melling project sites. The phytoplankton/periphyton community was represented by 3 species of Cyanobacteria, and 8 species of Bacillariophyceae. Maximum richness was recorded from the catchment area with 9 species, and minimum with 6 species from the project affected areas. Phytoplankton/periphyton density at the project affected areas (110 individuals/l) was higher than that of catchment area (80 individuals/l). Similarly, species diversity index was higher (H'=2.13) in the catchment area, and lower (H'=1.64) in the project affected areas (Table II. 3.191).

Table II. 3.191: Density (Individuals/l), species richness and Shannon diversity index (H') of phytoplankton community in the project affected and catchment areas of New Melling

List of species	Project affected area	Catchment area
Cyanobacteria		
Lyngbya sp.	35	
Oscillatoria sp.	15	5
Phormidium sp.	30	5
Bacillariophyceae		
Achnanthes brevipes	10	
Achnanthidium rivulare		15
Caloneis ventricosa		10
Calothrix sp.		10
Cymbella delicatula		5
Encyonema minutum	10	10
Synedra acus		10
Synedra ulna	10	10
Total density (Individuals/l)	**110**	**80**
Species diversity index	**1.64**	**2.13**
Species richness	**6**	**9**

NB: Blank cells indicate absence of Periphyton species

Zooplankton

Seventeen species were recorded during winter season, out of which 3 species viz., *Alona affinis*, *Bosmina (Bosmina) longirostris* and *Karualona karua* belonged to Cladocera, and 14 species to Rotifera. *Lecane* of Rotifera was the dominant genus followed by *Lepadella* (Table II. 3.192). Three rare species of zooplankton were recorded from barrage and powerhouse sites, namely, *Notholca squamula, Lecane signifera* and *Lepadella vandenbrandei.*

Table II. 3.192: Occurrence of species belonging to Cladocera and Rotifera during monsoon and winter seasons in New Melling project sites

Sl. No.	Taxa	Species	Season	
			Monsoon	Winter
1	Cladocera	*Alona affinis* (Leydig, 1860)	–	+
2	Cladocera	*Bosmina (Bosmina) longirostris* (O.F. Muller, 1776)	–	+
3	Rotifera	*Cephalaodella gibba* (Ehrenberg, 1830)	–	+
4	Rotifera	*Euchlanis dilatata* (Ehrenberg, 1832)	–	+
5	Cladocera	*Karualona karua* (King, 1853)	–	+
6	Rotifera	*Lecane closterocerca* (Schmarda, 1859)	–	+
7	Rotifera	*Lecane flexilis* (Gosse, 1886)	–	+
8	Rotifera	*Lecane leontina* (Turner, 1892)	–	+
9	Rotifera	*Lecane lunaris* (Ehrenberg, 1832)	–	+
10	Rotifera	*Lecane signifera* (Jennings, 1896) *	–	+
11	Rotifera	*Lepadella acuminata* (Ehrenberg, 1834)	–	+
12	Rotifera	*Lepadella ovalis* (O.F. Muller, 1786)	–	+
13	Rotifera	*Lepadella quadricarinata* (Stenroos, 1898)	–	+
14	Rotifera	*Lepadella vandenbrandei* (Gillard, 1952) *	–	+
15	Rotifera	*Mytilina ventralis* (Ehrenberg, 1830)	–	+
16	Rotifera	*Notholca squamula* (O.F. Muller, 1786) *	–	+
17	Rotifera	*Testudinella patina* (Hermann, 1783)	–	+
Total	**2**	**17**	**0**	**17**

*Rare

Fish Fauna

No fish species were recorded during the project period in New Melling site.

Soil Fauna

The seasonal variation in soil faunal diversity (Collembola, Acarina and other arthropods) and equitability in litter and soil layer are shown in Tables II. 3.193-3.195.

Table II. 3.193: Seasonal variation in soil faunal diversity (Collembola, Acarina and other arthropods) and equitability in litter and soil layer at New Melling project sites

Soil fauna	Diversity	Post-monsoon				Monsoon				Winter			
		Barrage		Powerhouse		Barrage		Powerhouse		Barrage		Powerhouse	
		Litter	Soil	Litter	Soil	Litter	Soil	Litter	Soil	Litter	Soil	Litter	Soil
Collembola	Dominance_D	0.14	0.26	0.13	0.19	0.16	0.16	0.15	0.16	0.18	0.16	0.25	0.18
	Shannon_H	2.07	1.47	2.10	1.74	1.90	1.89	1.97	1.86	1.75	1.96	1.49	1.75
	Evenness_e^H/S	0.88	0.87	0.90	0.94	0.95	0.94	0.89	0.92	0.96	0.88	0.89	0.96
Acarina	Dominance_D	0.17	0.15	0.16	0.28	0.13	0.11	0.20	0.21	0.56	0.50	0.33	0.50
	Shannon_H	1.86	2.06	1.89	1.33	2.16	2.25	1.71	1.67	0.64	0.69	1.10	0.69
	Evenness_e^H/S	0.92	0.87	0.95	0.95	0.87	0.94	0.92	0.89	0.94	1.00	1.00	1.00
Other Arthropods	Dominance_D	0.16	0.16	0.21	0.16	0.11	0.13	0.12	0.13	0.33	0.56	0.56	0.28
	Shannon_H	1.96	1.97	1.65	1.89	2.30	2.19	2.25	2.11	1.10	0.64	0.64	1.33
	Evenness_e^H/S	0.88	0.90	0.87	0.94	0.91	0.89	0.86	0.92	1.00	0.94	0.94	0.94

Table II. 3.194: Mean annual density (number/m^2) of soil fauna in litter and soil layer (0-5 cm) at New Melling site

Soil fauna	Site	Litter layer	Soil layer	Total
Collembola	Barrage	2145	1673	**3818**
	Powerhouse	1927	1127	**3055**
Acarina	Barrage	1229	1000	**2229**
	Powerhouse	771	629	**1400**
Other Arthropods	Barrage	1745	1527	**3273**
	Powerhouse	1600	1345	**2945**
Total fauna	**Barrage**	**5119**	**4200**	**9320**
	Powerhouse	**4298**	**3101**	**7400**

Table II. 3.195: Seasonal variation of soil fauna density (number/m^2) at barrage and powerhouse site of New Melling site

Soil fauna	Site	Post-monsoon	Monsoon	Winter	Mean
Collembola	Barrage	12800	19200	10000	**14000**
	Powerhouse	12000	15600	6000	**11200**
Acarina	Barrage	13200	16000	2000	**10400**
	Powerhouse	6400	10400	2800	**6533**
Other arthropods	Barrage	14000	19600	2400	**12000**
	Powerhouse	9600	19200	3600	**10800**

Wildlife

Butterflies: Nineteen species of butterflies belonging to 17 genera and five families were recorded from the proposed New Melling project area. The family Nymphalidae was the dominant, and was represented by 7 species. No threatened species was recorded from the project area (Table II. 3.196).

Table II. 3.196: Butterflies recorded in New Melling HEP area

Sl. No.	Family/common name	Scientific name	Project area
I.	**Hesperiidae**		
1	Lucas' Ace	*Sovia lucasii magna*	*
II.	**Papilionidae**		
2	Common Peacock	*Papilio polyctor ganesa*	*
3	Paris Peacock	*Papilio paris paris*	*
4	Golden Birdwing	*Troides aeacus aeacus*	*
5	Indian Purple Emperor	*Mimathyma ambica*	*
III.	**Pieridae**		
6	Spotless Grass Yellow	*Eurema laeta*	*
7	Indian Cabbage White	*Pieris canidia indica*	*
8	Plain Sulphur	*Dercas lycorias*	*
9	Spotted Sawtooth	*Prioneris thestylis thestylis*	*
IV.	**Lycaenidae**		
10	Large Hedgeblue	*Celastrina hugeli oreana*	*
11	Common Hedgeblue	*Acytolepis puspa gisca*	*
12	Punchinello	*Zemeros flegyas indicus*	*
V.	**Nymphalidae**		

13	Eastern Comma	*Polygonia egea*	*
14	Large Threering	*Ypthima nareda*	*
15	Large Silverstripe	*Argynnis children*	*
16	Glassy Tiger	*Graphium cloanthus*	*
17	Chocolate Pansy	*Junonia iphita iphita*	*
18	Banded Treebrown	*Lethe confusa*	*
19	Straight-banded Treebrown	*Lethe verma*	*

Herpetofauna: Since no herpetofauna was sighted during the survey, the probable list of amphibians and reptiles was prepared following Ahmed *et al.* (2009) (Appendix II. 3.167**)**.

Birds: Sixty seven species of birds revealed belonging to 46 genera and 26 families were recorded from the project area. Shannon index value of 3.6 portrays a moderate level of diversity. Species richness was higher during monsoon (33 species) compared to winter season (Table II. 3.197).

Table II. 3.197: Status of birds recorded in New Melling HEP area

Details	Post-monsoon	Monsoon	Winter	Overall
Family	16	16	17	26
Genera	24	26	21	46
Species	26	33	30	67
Abundance	368	236	303	907
Diversity H'	3	2.8	2.8	3.6
Migratory status				
Breeding visitor	4	6	3	12
Isolated record	0	0	1	1
Resident	20	21	24	45
Winter visitor	2	6	2	9

Migratory status: Most of the birds were residents (45 species), followed by 12 breeding visitors, and 9 winter visitors (Table II. 3.197).

Abundance status: The abundance status of birds was derived by classifying the abundance of bird species into five abundance category (Very Low = 1-25 birds, Low = 26-50, Moderate = 51-75, High = 76-100 and Very High = > 100birds). The details of abundance status are given in the Table II. 3.198.

Table II. 3.198: Number of species and relative % of birds in different abundance classes

Abundance class	No. of species	Relative %
Very low-1-25 birds	60	89.5
Low-26-50 birds	5	7.5
Moderate-50-75 birds	1	1.5
High-76-100 birds	0	0
Very high > 100 birds	1	1.5
Total	**67**	**100**

*Status of foraging guilds***:** Six foraging guilds of birds in the New Melling project area were identified, among which 48 were insectivores, 8 granivores, and 7 omnivores. The high richness of insectivores showed the presences of diverse habitat and niches in this project site (Table II. 3.199 and Appendix II. 3.180).

Table II. 3.199: Status of foraging guild of birds recorded in New Melling HEP area

Foraging guild	Post monsoon	Monsoon	Winter	Overall
Aquatic feeder	1	0	0	1
Carnivore	0	0	0	0
Frugivore	0	0	0	0
Granivore	1	4	3	8
Insectivore	16	25	24	48
Nectarivore	2	1	1	2
Nucivore	0	1	1	1
Omnivore	6	2	1	7
Piscivore	0	0	0	0

Status of threatened species: No threatened bird species was recorded within the project site (Appendix II. 3.180).

Mammals: Surveys in and around the New Melling project site revealed the presence of 7 mammalian species, each belonging to separate genus and family. They comprised 1 primate, 2 rodents, 3 ungulates and 1 carnivore species (Appendix II. 3.181).

Abundance status: Out of seven species comprising 36 individuals, 32 were Arunachal Macaque (*Macaca munzala)* of a single group, 2 Hoary-bellied Himalayan Squirrel (*Callosciurus pygerythrus),* and 2 Chesnut rat (*Niviventer fluvescens)*. The species richness of the project area (7 species) was low compared to the possible species (29 species) of the Tawang district (Mishra *et al.* 2006) (Appendix II. 3.181)

Status of threatened species: Two mammal species, namely, Arunachal Macaque (*Macaca munzala*), and Himalayan goral (*Naemorhedus goral)* are included under Endangered(EN) and Near Threatened (NT) categories of IUCN Red List, while the rest of the species of the project area fall under Least Concern (LC) category of IUCN and Schedule II and III of WPA (1972) (Table II. 3.200).

Table II. 3.200: Status of mammalian fauna reported in the New Melling HEP area

Sl. No.	Name	Scientific Name	Seasons			Overall	Conservation Status	
			PM	M			IUCN	WPA
I.	**Cercopithecidae**							
1	Arunachal Macaque	*Macaca munzala*		IE-1	A 32	IE 1 A 32	EN	-
II.	**Cervidae**							
2	Barking Deer	*Muntiacus muntjak*	IE-1			IE1	LC	III
III.	**Bovidae**							
3	Himalayan goral	*Naemorhedus goral*			IE 1	IE1	NT	III
IV.	**Suidae**							
4	Wild pig	*Sus scrofa*	IE-1		IE 3	IE4	LC	III
V.	**Viverridae**							
5	Himalayan Palm Civet	*Paguma larvata*		IE-1		IE 1	LC	II
VI.	**Sciuridae**							
6	Hoary-bellied Himalayan Squirrel	*Callosciurus pygerythrus*	A2			A 2	LC	NE
VII.	**Muridae**							
7	Chesnut rat	*Niviventer fluvescens*		A 2		A 2	LC	IV
	No of species		**3**	**3**	**3**	**7**		
	Total and types of records		**IE 2 A 2**	**IE 2 A2**	**IE 4 A 32**	**IE 8 A 36**		

IE–Indirect Evidences A-number of animals sighted, W-Winter, PM-Post-monsoon, M-Monsoon, IUCN-Red List, WPA-Wildlife Protection Act, EN-Endangered, NT-Near threatened, LC-Least Concern, NE–Not Evaluated

Faunal status within 500 m of project affected area (barrage and powerhouse sites): The species richness reported in these sites were evaluated based on subjective rating through estimating percent contribution with the overall species list of the project area. If the species richness of barrage and powerhouse contributes 25% of overall list it was categorized as low, > 25-50% as medium, >50-75% as high and above 75% as high species richness.

Status of avifauna: Powerhouse and barrage sites had high bird richness with 27 (40.29%) species. However, none of them belonged to threatened category (Appendix II. 3.182).

Status of mammals: Site specific evaluation of mammalian fauna within 500 m of up and down streams showed occurrence of only 3 species in the powerhouse site and barrage site. None of these species were categorized under high conservation status of IUCN and WPA (1972) (Table II. 3.201). Overall the powerhouse site of New Melling project did not have any mammalian fauna of high conservation significance.

Table II. 3.201: Status of mammalian fauna at barrage and powerhouse sites of the proposed New Melling HEP area

Species name	Common name	Status	Conservation status	
		BS /PHS	IUCN	WPA
Macaca munzala	Arunachal Macaque	A 32,	EN	-
Naemorhedus goral	Himalayan goral	IE 1,	NT	III
Paguma larvata	Himalayan Palm Civet	IE 2	LC	II
No of species		**3**		
No of evidences		**IE3,A 32 (1G)**		

IE–Indirect Evidences, A–No of Animals Sighted, BS–Barrage site, PHS–Powerhouse site, G–Number of Groups

3.3.5.3 SOCIO–ECONOMIC PROFILE

The results of socio–economic baseline survey for New Melling have been described at both village and HH levels.

Village Level

Profile of the Seven Surveyed Villages: From Table II.3.202, it is evident that Rho and Yuthembu villages are directly affected, while the remaining five are situated within influence zone of the project. These villages are covered under Thingbu, Lhau, Jang, and Mukto circles. The distance of the villages from the river ranges from 2 to 20 km. The circle headquarters of the seven villages are located within 15 km. Except for three villages, i.e., Rho, Jangda, and Thingbu, which are situated at more than 90 km from the district headquarters, all other villages are situated within 55 km.

Table II. 3.202: Profile of the ten surveyed villages

Sl. No.	Village	Circle	Distance of village (in km)			Category of village
			River/ Tributary	Circle HQ	District HQ	
1	Jangda	Lhau	7	15	90	Influenced
2	Kharsa	Jang	2	1	45	Influenced
3	Mirba	Mukto	3	10	55	Influenced
4	Rho	Thingbu	8	5	99.6	Affected
5	Shyro	Lhau	5	7	30	Influenced
6	Thingbu	Thingbu	20	1	151	Influenced
7	Yuthembu	Jang	2.5	1	45	Affected

Private Landuse Pattern: Table II. 3.203 provides details of private land holdings (in hectares) of the six studied villages. The data for Kharsa was not available. The total private land holding in the studied villages is 541.76 ha. Three villages, viz., Rho, Jangda, and Yuthembu, contribute 77% of the total land holdings in the studied villages. In all the villages, the proportion of agricultural land exceeds that of the other land use types. Private forest (35%) is the most important land use type of the surveyed villages.

Table II. 3.203: Private land use pattern and their percentage to total private land

Sl. No.	Village	Total private land	Forest cover (ha)	%	Agricultural land (ha)	%	Horticulture land (ha)	%	Habitation and HG (ha)	%
1	Jangda	120.00	45	38	57	48	0	–	18	15
2	Kharsa	–	–	–	–	–	–	–	–	–
3	Mirba	30.50	12	39	18	59	0	–	0.5	2
4	Rho	160.00	58	36	66	41	0	–	36	23
5	Shyro	34.26	13	38	16.78	49	0	–	4.48	13
6	Thingbu	60.00	10	17	44	73	0	–	6	10
7	Yuthembu	137.00	53	39	62	45	0	–	22	16
	Total*	**541.76**	**191.00**	**207**	**263.78**	**315**	**0**	**–**	**86.98**	**79**

* Excluding Kharsa due to non availability of data

Demography and Literacy Rate: Demographic characteristics are presented in Table II. 3.204. There are a total of 537 HHs in the seven villages. The total population is 2375 (1187 males; 1188 females). In Jangda, Yuthembu, and Kharsa, the number of females are more than that of the males. In the remaining four villages the number of males exceeds the number of females. The literacy rate of Yuthembu is about 64%, in other villages the rate is less than 45 %. Jangda has the least number of literates (30%). Among males the literacy rate varies from 30% in Jangda to 70.8% in Yuthembu and in females it is least with 23% in Rho to 52.5% in Yuthembu. It is noteworthy that in Jangda the literacy rate among females is considerably higher than the males.

Table II. 3.204: Demography and literacy rate

Sl. No.	Village	Demography					Literacy rate*		
		Total	Male	Female	Sex ratio (Per 1000 males)	No. of HH	Male	Female	Total
1	Jangda	525	249	276	1108	99	30.0	41.0	**30.0**
2	Kharsa	468	229	239	1044	107	44.6	37.7	**41.7**
3	Mirba	166	89	77	865	40	43.7	33.3	**39.4**
4	Rho	286	150	136	907	85	58.0	23.0	**45.0**
5	Shyro	305	159	146	918	56	42.6	38.3	**41.4**
6	Thingbu	256	129	127	984	52	46.0	27.0	**39.0**
7	Yuthembu	369	182	187	1027	98	70.8	52.5	**63.6**
	Total	**2375**	**1187**	**1188**	–	**537**	–	–	–

Number of Livestock: The details of livestock holdings in the six villages is given in Table II. 3.205. Altogether, 9 different types of animals are reared in the surveyed villages. Total domestic animals varied from 182 in Mirba to 1021 animals in Jangda. Jangda alone accounts for 28% of all the domestic animals found in the surveyed villages. Three animals, viz., cattle (41%), Yak (29%) and sheep (15%) account for 85% of the total animals.

Table II. 3.205: Number of livestock

Sl. No.	Village	Mithun	Cattle	Goat	Sheep	Poultry	Others	Pig	Pony	Yak	Total
1	Jangda	0	395	37	364	28	1	72	10	114	**1021**
2	Kharsa	0	0	0	0	0	0	0	0	0	**0**
3	Mirba	0	103	5	0	0	0	0	7	67	**182**
4	Rho	0	255	68	85	7	3	14	6	49	**487**
5	Shyro	0	357	0	2	2	0	29	50	69	**509**
6	Thingbu	0	0	0	100	9	0	0	179	529	**817**
7	Yuthembu	10	413	2	10	0	0	0	0	224	**659**
	Total	**10**	**1523**	**112**	**561**	**46**	**4**	**115**	**252**	**1052**	**3675**

Total Estimated Value of Livestock: The monetary value of animals maintained by the inhabitants of the studied villages has been estimated separately for each animal and for each village (Table II. 3.206). The detailed methodology used has been described in the methodology section of the report. As expected, there is considerable intra as well as inter village variation in total estimated value of livestock. The total value of 3675 animals found in the six villages have been estimated at about 774.56 lakhs. The village livestock value varied from 44.36 lakhs in Mirba to 179.47 lakhs in Thingbu. In terms of relative contribution made by different animals to the total value, cattle and Yak together contribute over 643 lakhs (83%).

Table II. 3.206: Total estimated value of livestock

Sl. No.	Village	Total estimated value (in lakhs.)									
		Mithun	Cattle	Goat	Sheep	Poultry	Others	Pig	Pony	Yak	Total
1	Jangda	0.00	98.75	1.85	21.84	0.14	0.15	18.00	2.30	28.50	**171.53**
2	Kharsa	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
3	Mirba	0.00	25.75	0.25	0.00	0.00	0.00	0.00	1.61	16.75	**44.36**
4	Rho	0.00	63.75	3.40	5.10	0.04	0.45	3.50	1.38	12.25	**89.87**
5	Shyro	0.00	89.25	0.00	0.12	0.01	0.00	7.25	11.50	17.25	**125.38**
6	Thingbu	0.00	0.00	0.00	6.00	0.05	0.00	0.00	41.17	132.25	**179.47**
7	Yuthembu	4.00	103.25	0.10	0.60	0.00	0.00	0.00	0.00	56.00	**163.95**
	Total	**4.00**	**380.75**	**5.6**	**33.66**	**0.24**	**0.60**	**28.75**	**57.96**	**263.00**	**774.56**

Average Annual Earnings of the Village: The average annual family income varies from 0.74 in lakhs in Kharsa to 5.53 lakhs in Thingbu (Table II. 3.207). Total earning of the villages per year is estimated to be 1447.55 lakhs. The highest contribution to the total annual earning is made by animal husbandry which amounts to 793.79 lakhs (55%). Traditional skills, especially weaving and daily wage labour together contribute over 28%. It is highly noteworthy that agricultural contributes only 9% of the total annual village earnings.

Table II. 3.207: Average annual earning of the village

Sl. No.	Village	Total earning/year (Lakhs)								Average Family income (Rupees in lakh)
		Agricultural	Animal Husbandry	Horticulture	Traditional Skills	Daily Wages	GS	Others*	Total	
1	Jangda	28.50	220.54	0.00	39.75	40.10	14.94	10.46	**354.28**	3.58
2	Kharsa	0.00	0.00	0.00	12.50	43.34	13.74	9.62	**79.19**	0.74
3	Mirba	9.00	39.31	0.00	15.30	16.20	5.34	3.74	**88.89**	2.22
4	Rho	33.00	105.19	0.00	25.00	34.43	9.00	6.30	**212.92**	2.50
5	Shyro	8.39	109.94	0.00	30.00	22.68	9.54	6.68	**187.23**	3.34
6	Thingbu	22.00	176.47	0.00	55.00	21.06	7.74	5.42	**287.69**	5.53
7	Yuthembu	31.00	142.34	0.00	5.75	39.69	10.92	7.64	**237.35**	2.42
	Total	**131.89**	**793.79**	**0**	**183.30**	**217.50**	**71.22**	**49.86**	**1447.55**	

* Other includes artisans, monks, self–employed contractors etc.

Average Annual Expenditure Pattern of a Family: Average annual family expenditure in the surveyed villages varies from 1.20 lakhs in Gemreteng and Kharsa to 1.58 lakhs in Rho (Table II. 3.208). In the majority of the villages, the maximum expenditure is incurred on health and education followed by transport and clothing. In general, expenditure incurred on food and drinks is least of all expenditures. The total value of average annual expenditure incurred by a family in seven villages is 10.09 lakhs.

Table II. 3.208: Average annual expenditure pattern of a family in village

Sl. No.	Village	Expenditure/year (Rupees in lakh)				
		Food and drinks	Clothing	Transport	Education and health	Total
1	Jangda	0.30	0.35	0.40	0.48	**1.53**
2	Kharsa	0.30	0.30	0.30	0.30	**1.20**
3	Mirba	0.35	0.35	0.27	0.30	**1.27**
4	Rho	0.35	0.35	0.40	0.48	**1.58**
5	Shyro	0.30	0.35	0.40	0.48	**1.53**
6	Thingbu	0.30	0.35	0.40	0.48	**1.53**
7	Yuthembu	0.30	0.30	0.40	0.45	**1.45**
	Total	**2.2**	**2.35**	**2.57**	**2.97**	**10.09**

Water Sources: Table II. 3.209 presents data pertaining to the available water resources and their uses in the surveyed villages. The Table reveals four types of water resources, namely, river, hill stream/springs, pond and tap water available in the studied villages. Except in Shyro, water from hill stream/spring(s) is used for domestic purposes as well as for the domestic animals in studied villages. Only in Shyro, pond water is also used for the domestic animals.

Table II. 3.209: Water sources in the village

		River				Hill stream/spring				Wells				Ponds				Tap Water			
Sl. No.	Village	Drinking water	Domestic use	Livestock use	Agricultural	Drinking water	Domestic use	Livestock use	Agricultural	Drinking water	Domestic use	Livestock use	Agricultural	Drinking water	Domestic use	Livestock use	Agricultural	Drinking water	Domestic use	Livestock use	Agricultural
1	Jangda					1	1	1										1	1		
2	Kharsa					1	1	1										1	1		
3	Mirba	1		1		1	1	1										1	1		
4	Rho					1	1	1										1	1		
5	Shyro													1	1	1		1	1	1	
6	Thingbu					1	1	1										1	1		
7	Yuthembu					1	1	1										1	1		
	Total	**1**	**0**	**1**	**0**	**6**	**6**	**6**	**0**	**0**	**0**	**0**	**0**	**1**	**1**	**1**	**0**	**7**	**7**	**1**	**0**

Amenities in the Villages: Data presented in Table II. 3.210 shows that in Yuthembu and Kharsa villages, except for traditional health healers, all the remaining 11 amenities listed in the Table were present. In Jangda and Shyro only five amenities are present. All the villages have motorable road, electricity, school and TV/radio. Traditional health healers are not found in any one of the studied villages.

Table II. 3.210: Amenities in the villages (NB: Blank indicates absent)

Sl. No.	Village	Road connectivity	Health facility (PHC/sub–centre)	Traditional health healer	Veterinary services	Electricity	Fair price shop	Grocery shop	Post office	Bank	School	Telephone/ Mobile	TV/Radios
1	Jangda	√				√					√	√	√
2	Kharsa	√	√		√	√	√	√	√	√	√	√	√
3	Mirba	√				√	√	√			√	√	√
4	Rho	√	√		√	√					√	√	√
5	Shyro	√				√					√	√	√
6	Thingbu	√	√		√	√					√		√
7	Yuthembu	√	√		√	√	√	√	√	√	√	√	√
	Total	**7**	**4**	**0**	**4**	**7**	**3**	**3**	**2**	**2**	**7**	**6**	**7**

Social Institutions: In none of the seven villages all the social institutions listed in Table II. 3.211 are present. Six villages have community hall, all villages have Gompa and five villages have Anganwadi. SHGs are absent in all the villages.

Table II. 3.211: Social institutions in the village (NB: Blank indicates absent)

Sl. No.	Village	SHGs	Anganwadi	Community hall	Gompa	Any other	Total
1	Jangda		√	√	√		**3**
2	Kharsa		√	√	√	√	**4**
3	Mirba			√	√		**2**
4	Rho			√	√	√	**3**
5	Shyro		√	√	√	√	**4**
6	Thingbu		√	√	√		**3**
7	Yuthembu		√		√	√	**3**
	Total	**0**	**5**	**6**	**7**	**4**	**–**

Occupation Profile: In Table II. 3.212 work force participation in seven villages has been presented. The total working population in the studied villages comprises of 1894 (46%) of total population. Of the total workers main workers are 88% while marginal workers are 12%.

Table II. 3.212: Occupation profile of the village

Sl. No.	Village	Population			Workers			Main Workers			Marginal Workers			Non Workers		
		T	M	F	T	M	F	T	M	F	T	M	F	T	M	F
1	Jangda	682	406	276	458	289	169	320	252	68	138	37	101	224	117	107
2	Kharsa	132	72	60	70	33	37	54	26	28	16	7	9	45	13	32
3	Mirba	269	158	111	149	83	66	148	83	65	1	0	1	120	75	45
4	Rho	652	403	249	21	8	13	10	7	3	11	1	10	16	4	12
5	Shyro	636	448	188	62	35	27	35	20	15	27	15	12	61	25	36
6	Thingbu	363	225	138	235	161	74	234	161	73	1	0	1	128	64	64
7	Yuthembu	1363	828	535	899	629	270	867	605	262	32	24	8	693	310	383
	Total	**4097**	**2540**	**1557**	**1894**	**1238**	**656**	**1668**	**1154**	**514**	**226**	**84**	**142**	**1287**	**608**	**679**

Household Level Survey

Age of the Head of the Household: The age of head of HHs across the seven surveyed villages varied from 20 to 99 years. The age of 37% of HHs heads are over 50 years and 11% of heads are below 30 years (Table II. 3.213). As expected and depending on the demographic structure of the villages, considerable variation has been observed between the seven villages in terms of the age of the Heads of HHs; average age varies from 43 years in Rho to 55 years in Thingbu (Table II. 3.214).

Table II. 3.213: Distribution of head of the HHs by age across seven project villages

Sl. No.	Village	Upto 30		31–40		41–50		>50		Total
		n	%	n	%	n	%	n	%	n
1	Jangda	7	7	19	19	31	31	42	42	**99**
2	Kharsa	18	17	26	24	24	22	39	36	**107**
3	Mirba	4	10	13	33	13	33	10	25	**40**
4	Rho	8	9	36	42	24	28	17	20	**85**
5	Shyro	1	2	17	30	11	20	27	48	**56**
6	Thingbu	2	4	6	12	12	23	32	62	**52**
7	Yuthembu	20	20	27	28	21	21	30	31	**98**
	Total	**60**	**11**	**144**	**27**	**136**	**25**	**197**	**37**	**537**

Table II. 3.214: Minimum, maximum and average age of Head of HHs across seven project villages

Sl. No.	Village	Age range		Average
		From	To	
1	Jangda	25	92	50
2	Kharsa	22	80	46
3	Mirba	24	88	45
4	Rho	24	78	43
5	Shyro	30	98	53
6	Thingbu	20	99	55
7	Yuthembu	22	86	46

Gender of the Head of Households: Data on gender of the HHs in the seven surveyed project villages is given in Table II. 3.215. As expected, in all the seven villages, the number of males exceeds that of females as head of HHs. Across the surveyed villages 75% of heads were males. Interestingly in village Jangda and Yuthembu, the female head of HHs also occur in substantial number being 34 % each.

Table II. 3.215: Distribution of head of HHs by gender in seven project villages

Sl. No.	Village	Male		Female		Total
		n	%	n	%	n
1	Jangda	65	66	34	34	**99**
2	Kharsa	84	79	23	21	**107**
3	Mirba	34	85	6	15	**40**
4	Rho	72	85	13	15	**85**
5	Shyro	45	80	11	20	**56**
6	Thingbu	38	73	14	27	**52**
7	Yuthembu	65	66	33	34	**98**
	Total	**403**	**75**	**134**	**25**	**537**

Ethnicity: All the seven villages are predominantly inhabited by Monpa tribals.

Household Size: The HH size varies from one to thirteen across the seven villages (Table II. 3.216). There is vast variation between the seven villages in terms of distribution of HH size. The average HH size varies from three in Rho to five in Jangda, Shyro and Thingbu and four in rest of the three villages. The average HH size across the surveyed villages is five (Table II. 3.217).

Table II. 3.216: Distribution of HH size in seven project villages

Sl. No.	Village	1		2		3		4		5		6–8		9 and above		Total
		n	%	n	%	n	%	n	%	n	%	n	%	n	%	n
1	Jangda	5	5	11	11	6	6	13	13	14	14	39	39	11	11	**99**
2	Kharsa	12	11	8	7	17	16	21	20	19	18	28	26	2	2	**107**
3	Mirba	2	5	3	8	8	20	10	25	10	25	7	18	0	0	**40**
4	Rho	9	11	8	9	22	26	39	46	4	5	3	4	0	0	**85**
5	Shyro	4	7	2	4	9	16	7	13	8	14	19	34	7	13	**56**
6	Thingbu	5	10	5	10	4	8	8	15	12	23	14	27	4	8	**52**
7	Yuthembu	9	9	14	14	18	18	27	28	16	16	14	14	0	0	**98**
	Total	**46**	**9**	**51**	**9**	**84**	**16**	**125**	**23**	**83**	**15**	**124**	**23**	**24**	**4**	**537**

Table II. 3.217: Minimum, maximum and average HH size across seven project villages

Sl. No.	Village	HH size range		Average HH size
		From	To	
1	Jangda	1	9	5
2	Kharsa	1	9	4
3	Mirba	1	7	4
4	Rho	1	7	3
5	Shyro	1	12	5
6	Thingbu	1	13	5
7	Yuthembu	1	8	4
	Total	**1**	**13**	**4**

Education: Relevant data on the education of the head of the HHs in the seven project villages is presented in Table II. 3.218. It is highly noteworthy that a majority of the heads were illiterate. It varied from 65% in Mirba to 93% in Yuthembu village. Out of 537 Head of HHs, 450 (84%) were illiterate. There were only seven head of HHs who were Graduates.

Table II. 3.218: Distribution of education of head of HH in seven project villages

Sl. No.	Village	Illiterate		Primary		Upper Primary		Secondary		Higher Secondary		Graduate or above		Total
		n	%	n	%	n	%	n	%	n	%	n	%	n
1	Jangda	84	85	3	3	5	5	4	4	2	2	1	1	**99**
2	Kharsa	86	80	1	1	8	7	10	9	1	1	1	1	**107**
3	Mirba	26	65	1	3	6	15	5	13	0	0	2	5	**40**
4	Rho	74	87	0	0	2	2	5	6	3	4	1	1	**85**
5	Shyro	41	73	1	2	8	14	5	9	1	2	0	0	**56**
6	Thingbu	48	92	0	0	1	2	1	2	2	4	0	0	**52**
7	Yuthembu	91	93	0	0	2	2	2	2	1	1	2	2	**98**
	Total	**450**	**84**	**6**	**1**	**32**	**6**	**32**	**6**	**10**	**2**	**7**	**1**	**537**

Main occupation of Household Heads: The main occupations of the head of HHs across the seven villages include Agricultural, labour, pastoralism and government service. Table II. 3.219 reveal the following main features:

Agricultural: It varies from zero in Thingbu to 78% in Rho. 43% of the HHs pursue Agricultural.

Labour: Except in Rho and Thingbu, head of the HHs in other villages reported labour as one of the mode of occupation. Across the surveyed villages 24% of 537 HH heads pursued labour as main occupation. 76% of the head of HHs in Kharsa returned wage labour as their main occupation;

Pastoralist: Some of the heads of HHs in five surveyed villages returned pastoralism as main occupation. It varied from 8% in Jangda to 87% in Thingbu. In all the seven villages the animal associated with this occupation was Yak. Out of 537 heads 82 (15%) were engaged in this activity.

Government service: Government servants were reported from all the seven villages. The largest number is from Rho being 22% followed by Mirba (15%) and other villages. Government service constitutes 11% of the main occupations among studied villages.

Any other occupation: 35 (7%) HHs were engaged in other occupations.

Table II. 3.219: Distribution of head of HHs by main occupation in seven project villages

Sl. No.	Village	Farmer		Labour		Pastoral		Govt Servant		Others		Total
		n	%	n	%	n	%	n	%	n	%	n
1	Jangda	51	52	15	15	8	8	10	10	15	15	**99**
2	Kharsa	14	13	81	76	0	0	8	7	4	4	**107**
3	Mirba	4	10	13	33	11	28	6	15	6	15	**40**
4	Rho	66	78	0	0	0	0	19	22	0	0	**85**
5	Shyro	32	57	7	13	7	13	1	2	9	16	**56**
6	Thingbu	0	0	0	0	45	87	7	13	0	0	**52**
7	Yuthembu	64	65	13	13	11	11	9	9	1	1	**98**
	Total	**231**	**43**	**129**	**24**	**82**	**15**	**60**	**11**	**35**	**7**	**537**

Private Land Holding Pattern: The private land holding pattern in the six villages comprises of Agricultural land, horticultural land, habitation, home garden and forest land. It may be noted here that, a majority of the inhabitants of the concerned villages do not know the actual area either in acres or hectares of all categories of land holdings. Therefore, the area reported here should be considered as very rough estimates. Data pertaining to this aspect have been described below:

Agricultural land: An examination of data given in Table II. 3.220 reveal that except 17 HHs (4%), all the remaining HHs (96%) in surveyed villages owned Agricultural land in varying proportions. A majority of the HHs (44%) owned Agricultural land between 1–2 acres whereas, only 24% of HHs owned land which is greater than 2 acres.

Table II. 3.220: Distribution of Agricultural land holding among surveyed HHs in six project villages

Sl. No.	Village	0.00 acre		< 1 acre		1–2 acre		>2 acre	
		n	%	n	%	n	%	n	%
1	Jangda	6	6	22	22	54	55	17	17
2	Mirba	2	5	23	58	9	23	6	15
3	Rho	2	2	0	0	64	75	19	22
4	Shyro	1	2	27	48	28	50	0	0
5	Thingbu	2	4	10	19	11	21	29	56
6	Yuthembu	4	4	37	38	23	23	34	35
	Total	**17**	**4**	**119**	**28**	**189**	**44**	**105**	**24**

Note: Kharsa village= Land holding data NA

Horticultural land: None of the HHs in the six villages owned horticultural land (Table II. 3.221).

Table II. 3.221: Distribution of horticultural land among surveyed HHs in six project villages

Sl. No.	Village	0.00 acre		< 1 acre		1–2 acre		>2 acre	
		n	%	n	%	n	%	n	%
1	Jangda	99	100	0	0	0	0	0	0
2	Mirba	40	100	0	0	0	0	0	0
3	Rho	85	100	0	0	0	0	0	0
4	Shyro	56	100	0	0	0	0	0	0
5	Thingbu	52	100	0	0	0	0	0	0
6	Yuthembu	98	100	0	0	0	0	0	0
	Total	**430**	**100**	**0**	**0**	**0**	**0**	**0**	**0**

Habitation and home–garden land: Data presented in Table II. 3.222 reveal that only 3% of HHs in the surveyed villages did not own any such land. A majority of HHs (84%) own less than one acre of such land whereas 13% of the HHs owned 1 to 2 acre of such land.

Table II. 3.222: Distribution of habitation and home garden land among surveyed HHs in the six project villages

Sl. No.	Village	0.00 acre		< 1 acre		1–2 acre		>2 acre	
		n	%	n	%	n	%	n	%
1	Jangda	6	6	93	94	0	0	0	0
2	Mirba	0	0	40	100	0	0	0	0
3	Rho	0	0	32	38	53	62	0	0
4	Shyro	2	4	52	93	2	4	0	0
5	Thingbu	6	12	45	87	1	2	0	0
6	Yuthembu	0	0	98	100	0	0	0	0
	Total	**14**	**3**	**360**	**84**	**56**	**13**	**0**	**0**

Note: Kharsa village= Land holding data NA

Forest land: About 81 HHs (19%) in the surveyed villages do not own private forest land. A majority of HHs (54%) owned 1–2 acres of such land. In Rho, it is noteworthy that 20% of HHs have more than 2 acre of forest land (Table II. 3.223).

Table II. 3.223: Distribution of forest land holding among surveyed HHs in the six project villages

Sl. No.	Village	0.00 acre		< 1 acre		1–2 acre		>2 acre	
		n	%	n	%	n	%	n	%
1	Jangda	15.0	15.2	15	15	59	60	10	10
2	Mirba	9	23	23	58	4	10	4	10
3	Rho	14	16	0	0	54	64	17	20
4	Shyro	18	32	12	21	26	46	0	0
5	Thingbu	13	25	25	48	12	23	2	4
6	Yuthembu	12	12	0	0	76	78	10	10
	Total	**81**	**19**	**75**	**17**	**231**	**54**	**43**	**10**

Note: Kharsa village= Land holding data NA

Total land holdings: The key features from data given in Table II. 3.224–3.227 showed that there are only 7 HHs (2%) that do not own any type of private land. Out of total HHs (430), 304 HHs (71%) owned more than 2 acres of total land. There is considerable variation between the HHs in a village as well as between villages in ownership of total land. For example, in Rho inter–HHs holdings vary from 1 acre to 26 acres, whereas in Thingbu it varies from 0.0–4.5

acres. The proportion of agricultural land is greater than other types of land owned in several villages whereas in a few villages Habitation and home garden land is greater than agricultural–land. The 430 HHs in the six villages owned total private land amounting to about 1348 acres. Out of this Rho, Jangda and Yuthembu accounts for 1039 acres (77%). Agricultural land accounts for 49% and forest land 35% of total land holding in the six villages.

Table II. 3.224: Distribution of total land holding among surveyed HHs in the six project villages

Sl. No.	Village	0.00 acre		< 1 acre		1–2 acre		>2 acre	
		n	%	n	%	n	%	n	%
1	Jangda	6	6	7	7	19	19	67	68
2	Mirba	0	0	14	35	18	45	8	20
3	Rho	0	0	0	0	10	12	75	88
4	Shyro	1	2	25	45	4	7	26	46
5	Thingbu	0	0	11	21	1	2	40	77
6	Yuthembu	0	0	5	5	5	5	88	90
	Total	**7**	**2**	**62**	**14**	**57**	**13**	**304**	**71**

Note: Kharsa village= Land holding data NA

Table II. 3.225: Number of HHs having land types in the six project villages

Sl. No.	Village	Total HH	Agricultural land		Horticultural land		Habitation and home garden land		Forest land	
			n	%	n	%	n	%	n	%
1	Jangda	99	93	94	0	0	93	94	84	85
2	Mirba	40	38	95	0	0	40	100	31	78
3	Rho	85	83	98	0	0	85	100	71	84
4	Shyro	56	55	98	0	0	54	96	38	68
5	Thingbu	52	50	96	0	0	46	88	39	75
6	Yuthembu	98	94	96	0	0	98	100	86	88
	Total	**430**	**413**	**96**	**0**	**0**	**416**	**97**	**349**	**81**

Note: Kharsa village= Land holding data NA

Table II. 3.226: Minimum, maximum and average land holdings across the six project villages

Sl. No.	Village	Agricultural land			Horticultural land			Habitation and Homegarden land			Forest land			Total land		
		From	To	Avg.	From	To	Avg.	From	To	Avg.	From	To	Avg.	From	To	Avg.
1	Jangda	0.00	6.00	1.42	0.00	0.00	0.00	0.00	0.74	0.45	0.00	4.00	1.13	**0.00**	**10.74**	**3.00**
2	Mirba	0.00	9.88	1.11	0.00	0.00	0.00	0.02	0.07	0.03	0.00	4.94	0.74	**0.02**	**12.39**	**1.89**
3	Rho	0.00	12.00	1.94	0.00	0.00	0.00	0.46	2.00	1.04	0.00	12.00	1.69	**1.00**	**26.00**	**4.68**
4	Shyro	0.00	2.00	0.74	0.00	0.00	0.00	0.00	1.50	0.20	0.00	1.50	0.56	**0.00**	**4.50**	**1.50**
5	Thingbu	0.00	4.00	2.10	0.00	0.00	0.00	0.00	1.00	0.28	0.00	5.00	0.51	**0.70**	**8.50**	**2.89**
6	Yuthembu	0.00	3.75	1.57	0.00	0.00	0.00	0.20	0.74	0.58	0.00	4.00	1.36	**0.20**	**7.49**	**3.51**
	Total	**0.00**	**12.00**	**1.48**	**0.00**	**0.00**	**0.00**	**0.00**	**2.00**	**0.43**	**0.00**	**12.00**	**1.00**	**0.00**	**26.00**	**2.91**

Note: Kharsa village= Land holding data NA

Table II. 3.227: Distribution of area (in acres) of land holding among HHs in the six project villages

Sl. No.	Village	Agricultural land		Horticultural land		Habitation and Homegarden land		Forest land		Total land
		Area	%	Area	%	Area	%	Area	%	Area
1	Jangda	141	47	0	0	44	15	112	38	**297**
2	Mirba	45	59	0	0	1	2	30	39	**75**
3	Rho	165	41	0	0	89	22	144	36	**398**
4	Shyro	41	49	0	0	11	13	32	38	**84**
5	Thingbu	109	73	0	0	15	10	27	18	**150**
6	Yuthembu	154	45	0	0	57	17	133	39	**344**
	Total	**655**	**49**	**0**	**0**	**217**	**16**	**476**	**35**	**1348**

Note: Kharsa village= Land holding data NA

Livestock Holdings: Data presented in Table II. 3.228–3.230 with respect to distribution of livestock holdings in the six surveyed villages revealed that altogether nine different types of animals are domesticated (Table II. 3.228). In Rho and Jangda, except Mithun, all the other eight animals are maintained in varying proportions. All the HHs in Thingbu rear Yak and Pony in appreciable numbers (only three HHs maintain poultry). The preferred animals in Rho and Jangda are cattle, goat and sheep, whereas in Jangda, in addition to these animals, 64% of HHs also rear pigs in appreciable numbers. In all the surveyed villages, Yaks and Ponies were domesticated, with the exception of Yuthembu where Pony is not reared. Altogether, 3674 animals have been domesticated in the surveyed villages (Table II. 3.229). Considerable inter–

village variation is observed in total number of animals reared. It varied from 181 in Mirba, to 1021 animals in Jangda. Jangda alone accounts for 28% of all the animals found in the surveyed village, followed by Thingbu (22%). Three animals, viz., Yak (29%), cattle (41%), and sheep (15%), account for 85% of the total animals (3674). 40% of the HHs did not own any animals, whereas 33% HHs owned more than 10 animals (Table II. 3.230).

Table II. 3.228: Livestock holding by HHs in the six project villages

Sl. No.	Livestock	Jangda		Mirba		Rho		Shyro		Thingbu		Yuthembu		Total HH of 10 villages	
		n	%	n	%	n	%	n	%	n	%	n	%	n	%
1	Mithun	0	0	0	0	0	0	0	0	0	0	2	2	**2**	**0.5**
2	Cattle	92	93	10	25	30	35	24	43	0	0	21	21	**177**	**41**
3	Yak	25	25	6	15	5	6	10	18	52	100	19	19	**117**	**27**
4	Goat	22	22	1	3	17	20	0	0	0	0	1	1	**41**	**10**
5	Sheep	71	72	0	0	20	24	2	4	52	100	1	1	**146**	**34**
6	Pig	63	64	0	0	6	7	29	52	0	0	0	0	**98**	**23**
7	Pony	2	2	1	3	1	1	16	29	52	100	0	0	**72**	**17**
8	Poultry	13	13	0	0	2	2	1	2	3	6	0	0	**19**	**4**
9	Others	1	1	0	0	1	1	0	0	0	0	0	0	**2**	**0.5**

Note: Kharsa village= Livestock data NA

Table II. 3.229: Number of livestock in surveyed HHs across the six project villages

Sl. No.	Village	Jangda		Mirba		Rho		Shyro		Thingbu		Yuthembu		Total	
		LS	%	LS	%	LS	%	LS	%	LS	%	LS	%	LS	%
1	Mithun	0	0	0	0	0	0	0	0	0	0	10	2	**10**	**0.3**
2	Cattle	395	39	102	56	255	52	357	70	0	0	413	63	**1522**	**41**
3	Yak	114	11	67	37	49	10	69	14	529	65	224	34	**1052**	**29**
4	Goat	37	4	5	3	68	14	0	0	0	0	2	0	**112**	**3**
5	Sheep	364	36	0	0	85	17	2	0	100	12	10	2	**561**	**15**
6	Pig	72	7	0	0	14	3	29	6	0	0	0	0	**115**	**3**
7	Pony	10	1	7	4	6	1	50	10	179	22	0	0	**252**	**7**
8	Poultry	28	3	0	0	7	1	2	0	9	1	0	0	**46**	**1**
9	Others	1	0	0	0	3	1	0	0	0	0	0	0	**4**	**0.1**
	Total livestock	**1021**	**100**	**181**	**100**	**487**	**100**	**509**	**100**	**817**	**100**	**659**	**100**	**3674**	**100**

Note: LS–Livestock; Kharsa village= Livestock data NA

Table II. 3.230: Distribution of total number of livestock in HHs of the six project villages

Sl. No.	Village	0		1–5		6–10		>10		Total
		n	%	n	%	n	%	n	%	n
1	Jangda	5	5	25	25	33	33	36	36	**99**
2	Mirba	27	68	3	8	3	8	7	18	**40**
3	Rho	48	56	9	11	11	13	17	20	**85**
4	Shyro	22	39	18	32	3	5	13	23	**56**
5	Thingbu	0	0	0	0	0	0	52	100	**52**
6	Yuthembu	68	69	7	7	4	4	19	19	**98**
	Total	**170**	**40**	**62**	**14**	**54**	**13**	**144**	**33**	**430**

Note: Kharsa village= Livestock data NA

Traditional Skills: Data pertaining to this aspect is presented in Table II. 3.231. Four types of crafts are being practiced in the surveyed villages. In four villages, a total of 12 HHs are engaged in wood carving. Weaving is practiced in all surveyed villages, and varies from 20% of HHs in Mirba to 85% in Thingbu. Overall, 46% of the HHs practice this craft. The craft is exclusively persued by women, and they are highly skilled in weaving various types of garments which are primarily used at home. Across the studied villages, there are three HHs who are engaged in carpet making, and 15 HHs make utensils from bamboo. Shyro is the only village where all the four traditional crafts are pursued.

Table II. 3.231: Distribution of various skills among surveyed HHs in the six project villages

Sl. No.	Village	Wood carving		Thanka painting		Carpet making		Bamboo utensil		Weaving		Paper making	
		n	%	n	%	n	%	n	%	n	%	n	%
1	Jangda	1	1	0	0	0	0	0	0	53	54	0	0
2	Mirba	2	5	0	0	2	5	0	0	8	20	0	0
3	Rho	0	0	0	0	0	0	2	2	40	47	0	0
4	Shyro	5	9	0	0	1	2	8	14	20	36	0	0
5	Thingbu	0	0	0	0	0	0	0	0	44	85	0	0
6	Yuthembu	4	4	0	0	0	0	5	5	31	32	0	0
	Total	**12**	**3**	**0**	**0**	**3**	**1**	**15**	**3**	**196**	**46**	**0**	**0**

River Resources: In Table II. 3.232, data pertaining to the use of various river resources by the inhabitants of the seven surveyed village is presented. As per information provided by villagers in HH survey, six different river resources, namely, drinking water, water for domestic use, water for livestock, religion, sand and stone are used. In the six villages, the inhabitants use river water for domestic animals. In Jangda, all the 99 HHs collect sand and stone for self use as well as for selling. All the 537 HHs in the surveyed villages use river for performing last rites of the dead. None of the surveyed HHs use aquatic flora and fauna found in the river.

Table II. 3.232: Dependence on river resources among surveyed HHs in the seven project villages

Sl. No.	Village	Jangda		Kharsa		Mirba		Rho		Shyro		Thingbu		Yuthembu		Total	
		n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
1	Drinking water	0	0	107	100	0	0	0	0	0	0	0	0	24	24	**131**	**24**
2	Water for domestic use	0	0	107	100	0	0	0	0	0	0	0	0	18	18	**125**	**23**
3	Water for livestock	94	95	0	0	13	33	37	44	35	63	52	100	30	31	**261**	**49**
4	Aquatic fauna	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**	**0**
5	Aquatic flora	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**	**0**
6	Religious	99	100	107	100	40	100	85	100	56	100	52	100	98	100	**537**	**100**
7	Sand	99	100	0	0	40	100	0	0	56	100	0	0	65	66	**260**	**48**
8	Stone	99	100	0	0	40	100	0	0	56	100	0	0	67	68	**262**	**49**

Forest Resources: The villagers from all the seven villages are dependent on forest resources in varying degrees of use (Table II. 3.233). Altogether, 16 forest resources are used in varying degrees in the seven surveyed villages (Table II. 3.233). All the surveyed villages in varying proportion depend on two forest resources, viz., fuel wood and grazing. More than 50% of HHs also use forest resources such as timber (79%), water (67%), stone (79%) and sand (67%). 46% of the HH in four villages use a variety of forest products as food. A few HHs also use forest for making handicrafts and for ornamental purposes. It is evident from the above that forest resources contribute significantly to the livelihoods as well as the quality of life of a majority of the inhabitants of the surveyed villages.

Table II. 3.233: Dependence on forest resources among surveyed HHs in the seven project villages

Sl. No.	Forest resources	Jangda		Kharsa		Mirba		Rho		Shyro		Thingbu		Yuthembu		Total	
		n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
1	Fuel wood	99	100	107	100	40	100	85	100	56	100	52	100	90	92	**529**	**99**
2	Timber	99	100	0	0	40	100	85	100	56	100	52	100	90	92	**422**	**79**
3	Medicinal plants	0	0	0	0	40	100	0	0	0	0	36	69	0	0	**76**	**14**
4	Honey	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**	**0**
5	Food	99	100	0	0	40	100	66	78	0	0	41	79	0	0	**246**	**46**
6	Edible oil	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**	**0**
7	Ornamental	0	0	0	0	0	0	2	2	0	0	0	0	0	0	**2**	**0**
8	Religious	0	0	0	0	40	100	85	100	0	0	52	100	64	65	**241**	**45**
9	Fencing	99	100	0	0	0	0	19	22	0	0	0	0	84	86	**202**	**38**
10	Handicrafts	0	0	0	0	0	0	21	25	0	0	0	0	4	4	**25**	**5**
11	Thatching	0	0	0	0	0	0	0	0	0	0	0	0	1	1	**1**	**0**
12	Spices	0	0	0	0	40	100	0	0	0	0	0	0	2	2	**42**	**8**
13	Grazing	94	95	0	0	13	33	37	44	35	63	52	100	30	31	**261**	**49**
14	Hunting of wild animals	0	0	0	0	0	0	0	0	0	0	0	0	2	2	**2**	**0**
15	Fishes	0	0	0	0	0	0	0	0	0	0	0	0	1	1	**1**	**0**
16	Water	99	100	0	0	0	0	85	100	56	100	52	100	67	68	**359**	**67**
17	Stones	99	100	0	0	40	100	85	100	56	100	52	100	92	94	**424**	**79**
18	Sand	99	100	0	0	40	100	19	22	56	100	52	100	92	94	**358**	**67**
19	Dyes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**	**0**

Water Resources: The main source of water for various usage in the surveyed villages are hill stream/springs except for Mirba and Shyro. Out of 537 HHs in the study area, about 427 HHs (80%) use hill stream/spring water. In Shyro village, all the 56 HHs use both ponds and tap water for fulfilling their water requirements (Table II. 3.234).

Table II. 3.234: Dependence on water resources among surveyed HHs in seven project villages

Sl. No.	Village	River		Hill stream/spring		Wells		Ponds		Hand pumps		Tap water	
		n	%	n	%	n	%	n	%	n	%	n	%
1	Jangda	0	0	99	100	0	0	0	0	0	0	99	100
2	Kharsa	0	0	100	93	0	0	0	0	0	0	0	0
3	Mirba	0	0	0	0	0	0	0	0	0	0	40	100
4	Rho	85	100	85	100	0	0	0	0	0	0	85	100
5	Shyro	0	0	0	0	0	0	56	100	0	0	56	100
6	Thingbu	0	0	52	100	0	0	0	0	0	0	0	0
7	Yuthembu	26	27	91	93	0	0	0	0	0	0	0	0
	Total	**111**	**21**	**427**	**80**	**0**	**0**	**56**	**10**	**0**	**0**	**280**	**52**

3.3.6 MAGO CHU

3.3.6.1 PHYSICAL ENVIRONMENT

Geomorphology

The geomorphological features at Mago chu barrage site have been depicted in the toposheet (Figure II. 3.29).

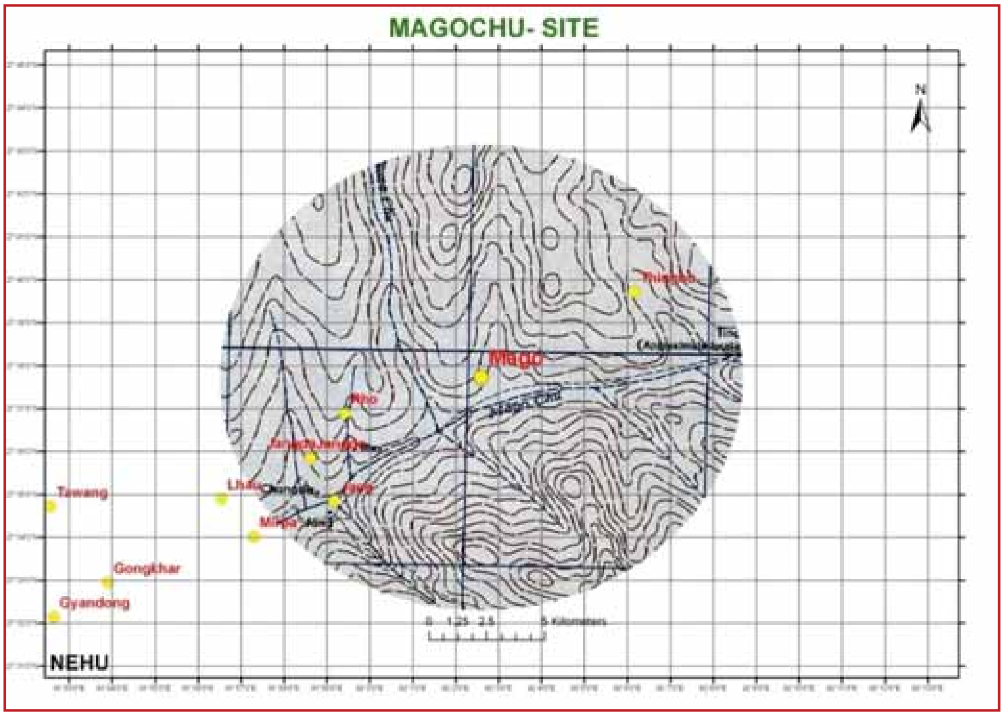


Figure II. 3.29: Contour map of Mago chu HEP

Geology

Geology and rock types are the same as in New Melling and Thingbu chu. Seismically the area is active. The rocks in the project area are represented by granite gneiss with occasional minor bands of schist and migmatites. They have been intruded by pegmatite and quartz veins. The granite gneisses are mostly light to dark grey coloured, fine to medium grained, and moderately jointed. The granites are mostly leucocratic to mesocratic, medium to coarse grained and intrusive into gneisses. The rock foliation (J1) generally strikes in NW–SE direction and dip at 20^0–45^0 towards north and south–westerly directions. Rock foliation is very well developed in the granite gneisses. This indicates an asymmetrical anticlinal fold in the downstream part of the project area. The area under various geological classes at Mago chu barrage and powerhouse sites is presented in Table II. 3.235. The location of Mago chu project site and the impact zone within 10 km radius in Tawang river are depicted in Figures II. 3.30 and 3.31.

Table II. 3.235: Area under various geological classes in Mago chu at barrage and powerhouse sites

Class	Barrage		Powerhouse	
	Area	**%**	**Area**	**%**
Snow covered area	1.40	0.44	6.31	2.01
Snow covered area	21.48	6.84	12.53	3.99
Snow covered area	25.57	8.14	15.26	4.86
Sela group (Structural hill)	216.24	68.83	242.63	77.23
Snow covered area	–	–	0.21	0.07
Glacier	1.17	0.37	–	–
Sela group (Valley)	0.66	0.21	0.75	0.24
Sela group (Valley)	0.38	0.12	–	–
Lateral morain	0.95	0.30	0.36	0.11
Glacier	2.56	0.81	1.61	0.51
Volcanic sediment (Structural hill)	22.15	7.05	20.54	6.54
Volcanic sediment (Structural hill)	21.60	6.88	13.97	4.45
Total	**314.16**	**100.00**	**314.16**	**100.00**

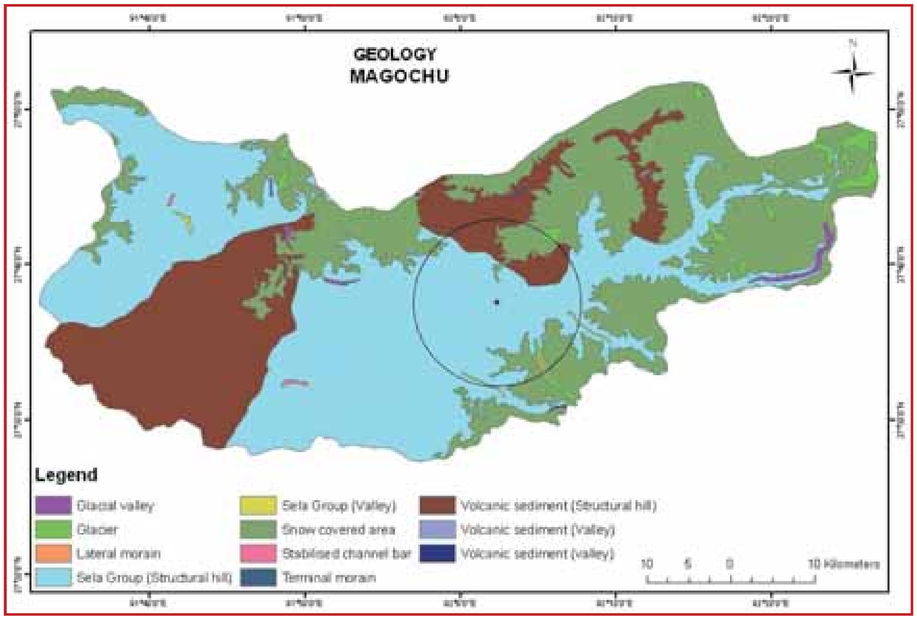


Figure II. 3.30: Geological map of TRB showing location of Mago chu project site

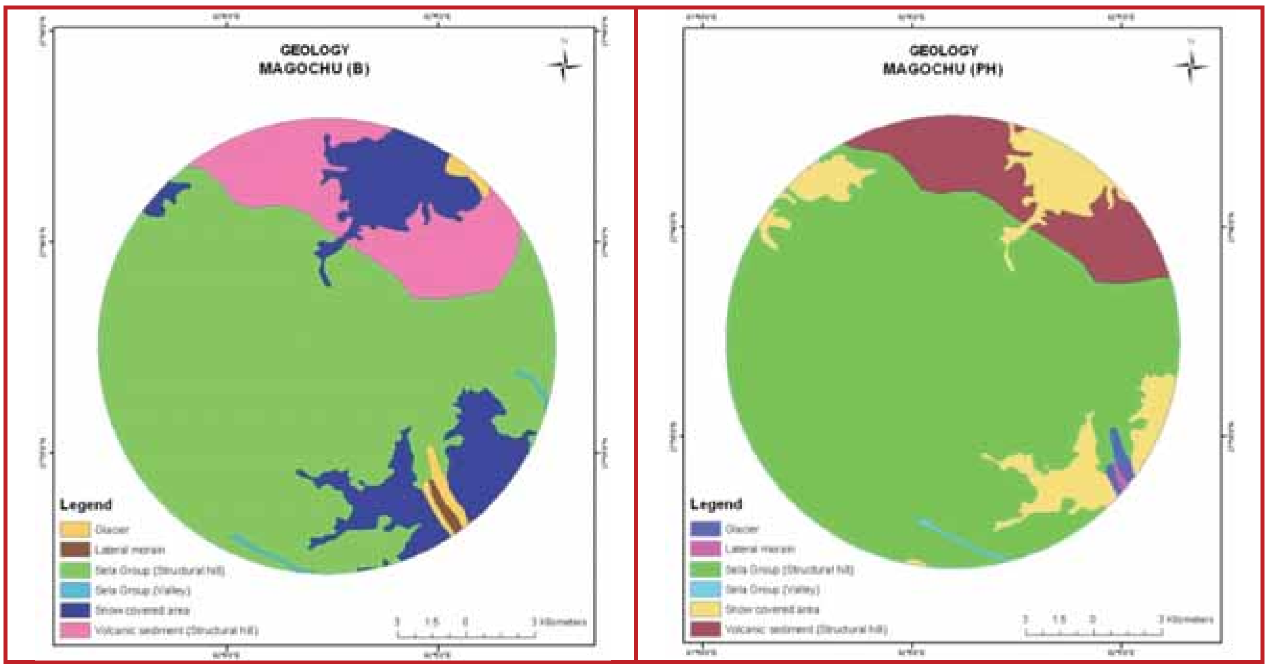


Figure II. 3.31: Geological map of Impact zone (10 km radius) of Mago chu barrage and powerhouse in Tawang river valley

Landuse and Land Cover

The total area within 10 km radius of Mago chu HEP site is 31458.51 ha (Figure II. 3.32). Most of the area is covered with forest (50.93%) followed by scrubland (35.30%). Cropland covers only 0.02% of the total project area. Waterbody constitutes 10.39% of the total area, and grassland occupies only 1.28%. The total area occupied by snow and ice and other builtup area altogether is 2.09% (Table II. 3.236).

Table II. 3.236: Landuse/land cover area of Mago chu project site

Landuse/land cover category	Area (ha)	%
Forest	16021.3	50.93
Scrubland	11104.1	35.30
Waterbody	3268.19	10.39
Croplands	4.77	0.02
Grasslands	401.4	1.28
Builtup area	97.3125	0.31
Snow and Ice	561.42	1.78
Total	**31458.51**	**100.00**

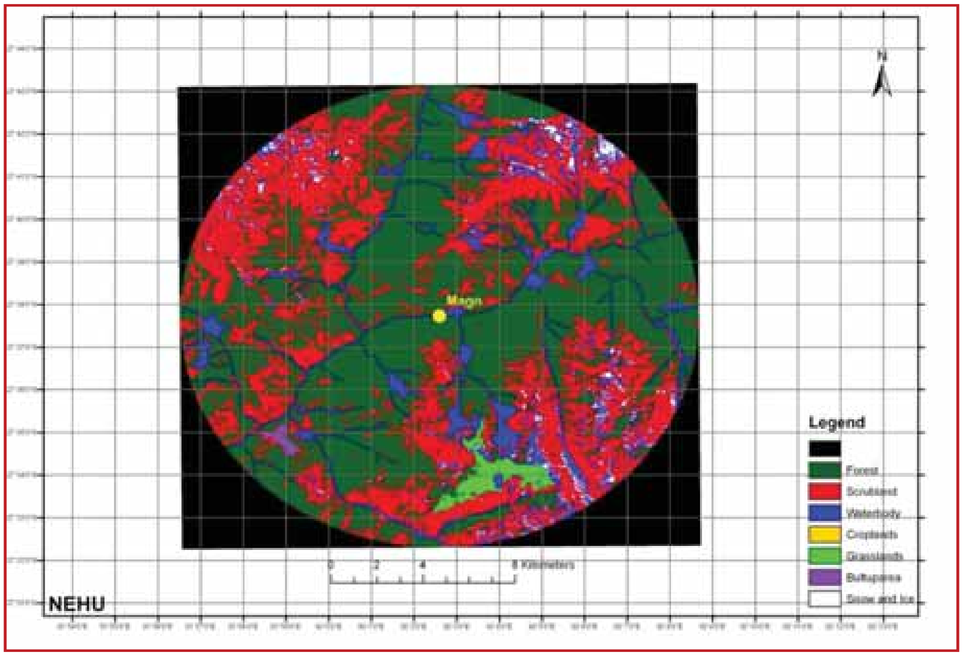


Figure II. 3.32: Landuse/land cover map of Mago chu project site

Soil

The soil properties were similar to Tawang and Rho sites (Table II. 3.237). Soil was coarse textured and acidic in nature, and poor in nutrients. However, the striking feature was low value of exchangeable potassium compared to Tawang and Rho sites. Marked seasonal variation in SMC was noticed. Conductivity, $NH4^{+}$–N, NO_3^{-}–N, and Ex. K had higher values during monsoon season, and lower values during winter season. Seasonal changes in physical, chemical and biological parameters are shown in Table II. 3.238.

Table II. 3.237: Soil physical properties at Mago chu project site

Site	Texture	WHC (%)	Bulk density (g/cm³)	Porosity (%)
Barrage	Sandy loam	21.51	1.37	48.30
Powerhouse	Sandy loam	28.89	1.36	48.67

Table II. 3.238: Seasonal variation in soil physico–chemical properties at Mago chu project site

Parameters	Post-monsoon		Monsoon		Winter		Mean	
	B	PH	B	PH	B	PH	B	PH
SMC (%)	25	30	35	41	15	15	25	29
pH	4.4	5.5	5.4	6.8	4.6	5.6	4.8	5.9
Conductivity ($\mu S\ cm^{-1}$)	29	22	39	36	14	14	27	24
NH_4^{+}–N ($\mu g\ g^{-1}$)	200	300	400	400	200	200	267	300
NO_3^{-}–N($\mu g\ g^{-1}$)	15	20	20	23	11	14	15	19
TKN ($\mu g\ g^{-1}$) x10^3	2.30	2.91	3.80	3.90	1.60	1.20	2.57	2.67
Av.P ($\mu g\ g^{-1}$)	0.040	0.070	0.050	0.110	0.030	0.020	0.040	0.070
TP (%)	0.140	0.180	0.150	0.210	0.130	0.180	0.140	0.190
SOC (%)	0.003	0.017	0.009	0.014	0.002	0.007	0.000	0.010
Ex. K ($\mu g\ g^{-1}$)	58	68	88	178	54	48	66	98
Ex. Mg (%)	0.006	0.024	0.018	0.018	0.002	0.003	0.010	0.020
Ex. Ca (%)	0.104	0.108	0.114	0.239	0.110	0.201	0.110	0.180
Soil microbial biomass–C ($\mu g\ g^{-1}$)	18	16	10	9	21	19	17	15
Soil microbial biomass–N ($\mu g\ g^{-1}$)	1.27	2.00	1.01	0.91	3.01	2.86	1.80	1.90

(Note: Post-monsoon–October, Monsoon–July, Winter–December); B = Barrage, PH = Powerhouse

Soil Erosion Vulnerability

The area under various soil erosion vulnerable classes in the project areas of Mago chu is presented in Table II. 3.239. In the influence zone of barrage site, 1.31% and 11.96% falls under high and moderately high risk zones, respectively. 8.62% and 35.02% of the total area falls under low and moderately low vulnerable zones, respectively. The vulnerable area of soil erosion under moderate category was 43.09%. Similarly, in the influence zone of the powerhouse site, out of the total area of 314.16 sq.km, only 1.43% area falls under high soil erosion vulnerable zone whereas, 13.61% falls under moderately high vulnerable zone. Only 7.87% of the total area is covered under low vulnerable zone, while 32.47% falls under moderately–low vulnerable zone. The soil erosion vulnerable area under moderate category covered about 44.62% of the total area. The spatial distribution map of soil erosion vulnerable areas under barrage and powerhouse sites of Mago chu is given in Figure II. 3.33.

Table II. 3.239: Areas under various soil erosion vulnerable zones in Mago chu at barrage and powerhouse sites

Vulnerability	Barrage		Powerhouse	
	Area (sq. km)	**%**	**Area (sq. km)**	**%**
High	4.13	1.31	4.50	1.43
Moderately high	37.58	11.96	42.75	13.61
Moderate	135.36	43.09	140.16	44.62
Moderately low	110.00	35.02	102.02	32.47
Low	27.08	8.62	24.73	7.87
Total	**314.16**	**100.00**	**314.16**	**100.00**

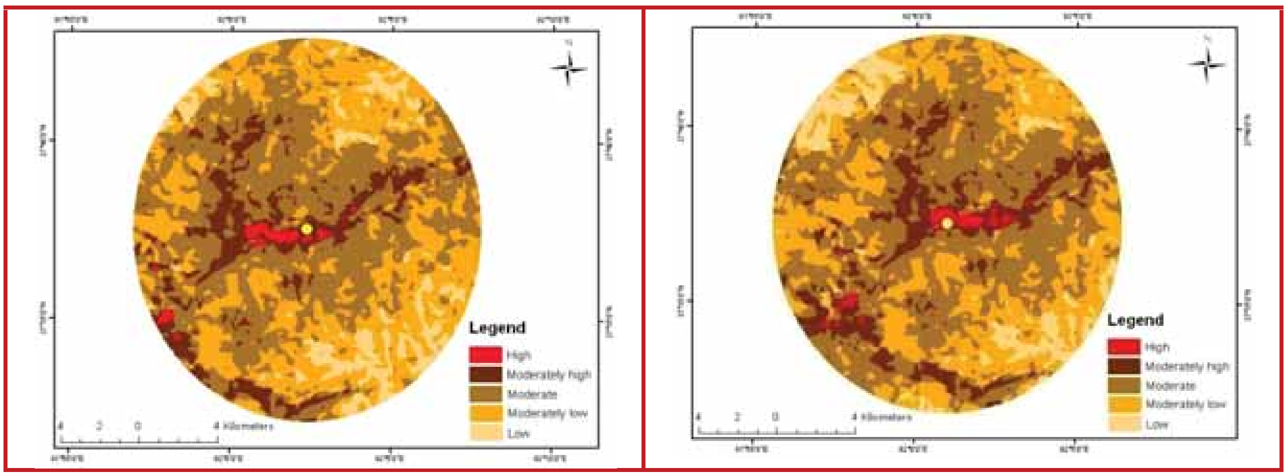


Figure II. 3.33: Spatial distribution of soil erosion vulnerable areas in Mago chu at barrage and powerhouse sites

Landslide and Erosion Vulnerability

The area under various landslide and erosion vulnerability classes within the influence zones of barrage and powerhouse site are presented in Table II. 3.240. In the barrage site, out of a total area of 314.16 sq.km, only 0.72% and 0.46% falls under high and low vulnerable zone respectively, whereas 14.69% and 27.5% of the total area falls under moderately–high and moderately–low vulnerable zones, respectively. The highest area of vulnerability falls under moderate category covering 56.63% of the total area. Similarly, in the influence zone of the powerhouse site, out of a total area of 314.16 sq.km, only 0.80% and 0.17% area falls under high and low vulnerable zone respectively. 17.06% and 23.74% of the total area falls under moderately–high and moderately–low vulnerable zone. The highest area of vulnerability falls under moderate category which covers 58.23% of the total area. The spatial distribution map of landslide and erosion vulnerability areas under barrage and powerhouse site of Mago chu are given in Figure II. 3.34.

Table II. 3.240: Area under various landslide and erosion vulnerability classes in Mago chu at barrage and powerhouse site

Vulnerability	Barrage		Powerhouse	
	Area (sq.km)	**%**	**Area (sq.km)**	**%**
High	2.28	0.72	2.53	0.80
Moderately high	46.15	14.69	53.59	17.06
Moderate	177.91	56.63	182.94	58.23
Moderately low	86.39	27.50	74.58	23.74
Low	1.43	0.46	0.53	0.17
Total	**314.16**	**100.00**	**314.16**	**100.00**

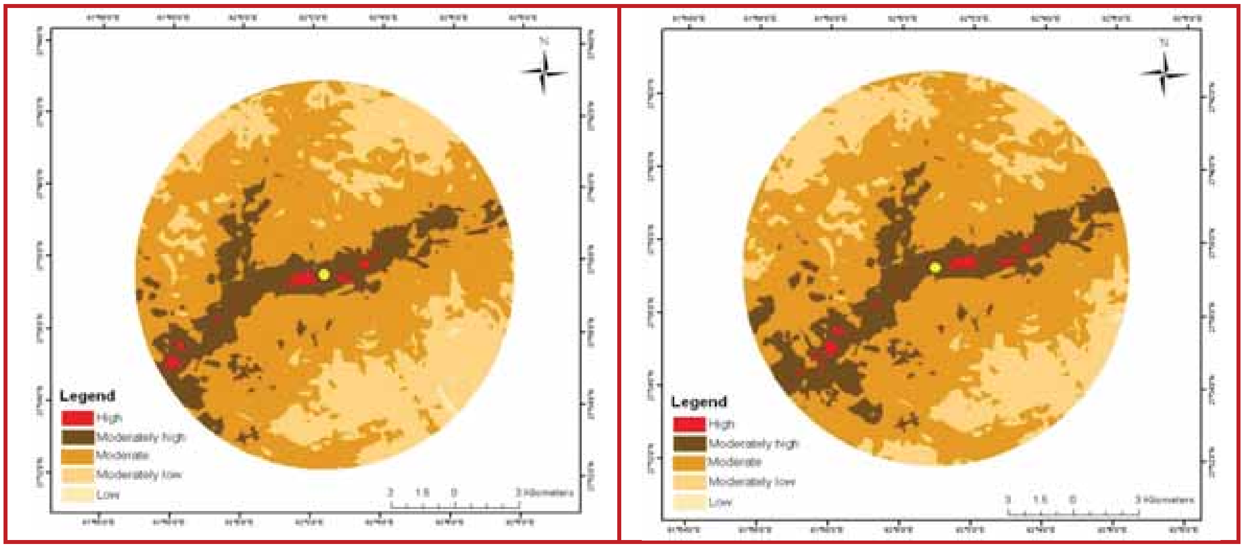


Figure II. 3.34: Area under various erosion and landslide vulnerability classes in Mago chu at barrage and powerhouse sites

Water

Marked seasonal variation in the water chemistry was observed in this site. The most prominent difference was seen in water temperature which varied from a low of 2.4^{0}C during winter season to a high of 14.6^{0}C during the monsoon season. The average (barrage and powerhouse site) conductivity, salinity, TDS, K, Na, NO_3–N, TP, coliform count peaked during post-monsoon season. Highest values of temperature, turbidly, pH, Chloride, TKN, NH_4–N, GPP and NPP were recorded during the monsoon season. During the winter season, total hardness, total alkalinity and DO concentration in water was markedly higher than the other seasons (Table II. 3.241).

Table II. 3.241: Seasonal variation in physico–chemical and biological properties of water and river primary productivity at Mago chu project sites

Parameters	Post-monsoon			Monsoon			Winter		
	B	**PH**	**Mean**	**B**	**PH**	**Mean**	**B**	**PH**	**Mean**
Temperature (˚C)	5.60	6.35	5.98	14.40	14.60	14.50	2.40	2.90	2.65
Turbidity (NTU)	0.28	0.39	0.34	1.68	1.66	1.67	1.36	1.35	1.36
pH	7.64	7.69	7.66	7.93	8.02	7.98	7.66	7.68	7.67
Electrical conductivity (µS/cm)	172	183.00	178	122	133.50	128	154	155.00	155
Total dissolved solids (mg/l)	86	91.55	88.83	63	69.00	66.00	80	81.50	80.95
Practical salinity (ppt)	0.10	0.11	0.10	0.07	0.08	0.07	0.08	0.08	0.08
Total alkalinity (mg $CaCO_3$/l)	30	31.20	30.80	30	28.00	29.00	48	48.00	48.00
Total hardness (mg/l)	20	21.59	20.99	34	35.27	34.84	40	40.28	40.29
Chloride (mg Cl^-/l)	9.99	10.50	10.25	9.99	11.99	10.99	5.99	5.99	5.99
Ca^{2+} (mg/l)	4.16	4.42	4.29	8.50	8.64	8.57	9.21	9.56	9.38
Mg^{2+}(mg/l)	2.43	2.56	2.50	3.20	3.32	3.26	4.20	3.98	4.09
K^+ ppm	1.00	1.10	1.05	0.60	0.65	0.63	0.40	0.50	0.45
Na^+ ppm	8.20	9.60	8.90	5.80	8.90	7.35	7.60	7.50	7.55
TKN (mg/l)	0.42	0.43	0.43	0.54	0.54	0.54	0.36	0.37	0.37
NH_4^+ N (mg/l)	0.03	0.03	0.03	0.13	0.13	0.13	0.03	0.03	0.03
NO_3–N (mg/l)	0.34	0.34	0.34	0.15	0.16	0.16	0.29	0.29	0.29
Total phosphorus (mg/l)	0.11	0.11	0.11	0.08	0.09	0.09	0.11	0.11	0.11
GPP (mg C/cm^3/h)	0.31	0.34	0.32	0.47	0.47	0.47	0.26	0.26	0.26
NPP (mg C/cm^3/h)	0.12	0.11	0.11	0.23	0.27	0.25	0.10	0.10	0.10
Dissolved oxygen (mg/l)	11.50	11.45	11.48	10.10	10.20	10.15	12.70	12.60	12.65
Total coliforms (CFU/ml)	40	44.00	**42.00**	15	12.00	**13.50**	27	25.00	**26.00**
BOD_5 (mg/l)	2	2.2	**2.1**	2.6	2.6	**2.6**	2	2.3	**2.15**

Ambient Air Quality

Concentration of PM_{10} and $PM_{2.5}$: Concentration of PM_{10} at Mago chu HEP was found ranging from a minimum of 11.7 µg/m^3 at Jaswantgarh to a maximum of 49.7 µg/m^3 at Nuranang falls. Similarly, $PM_{2.5}$ concentration ranged from a minimum of 13.4 µg/m^3 at Rho and Jaswantgarh to a maximum of 38.7 µg/m^3 at New Melling (Table II. 3.242). The concentration of sulphur–

dioxide (SO_2), nitrogen–dioxide (NO_2), ammonia (NH_3) and ground level ozone (O_3) at all the monitored locations were below detectable limits.

Table II. 3.242: Concentration of PM_{10} and $PM_{2.5}$ in air at proposed Mago chu HEP sites

Sampling location	Nearest project site covered	PM_{10} (µg/m^3)	$PM_{2.5}$ (µg/m^3)
Rho	Mago chu powerhouse site Mago chu barrage site	23.5	13.4
Jaswantgarh	Mago chu powerhouse site Mago chu barrage site	11.7	13.4
Nuranang falls	Mago chu powerhouse site Mago chu barrage site	49.7	38.0
Jang	Mago chu powerhouse site Mago chu barrage site	41.7	23.9
New Melling	Mago chu powerhouse site Mago chu barrage site	39.4	38.7
Thingbu chu	Mago chu powerhouse site Mago chu barrage site	41.0	26.9

Ambient temperature at proposed Mago chu HEP ranged from a minimum of 3°C at Thingbu chu to a maximum of 10°C at Nuranang Falls. Relative humidity was 27% at Nuranang Falls and 52% at Rho. Wind speed varied between 1.2 km/hr at Thingbu chu and 3.6 km/hr at Rho. Wind direction varied from NW to SE direction (Table II. 3.243).

Table II. 3.243: Meteorological condition at proposed Mago chu HEP sites

Sampling location	Nearest project component covered	Ambient temperature (°C)		Relative humidity (%)	Wind speed (range in km/hr)	Wind direction
		Min	Max			
Rho	Mago chu powerhouse site Mago chu barrage site	05	09	52	1.8–3.6	NW
Jaswantgarh	Mago chu powerhouse site Mago chu barrage site	05	09	32	2.1–2.7	SE
Nuranang falls	Mago chu powerhouse site Mago chu barrage site	06	10	27	2.4–3.2	SE
Jang	Mago chu powerhouse site Mago chu barrage site	04	08	39	1.6–2.3	SE
New Melling	Mago chu powerhouse site Mago chu barrage site	04	09	37	1.7–2.5	SE
Thingbu chu	Mago chu powerhouse site Mago chu barrage site	03	07	34	1.2–2.1	SE

Noise Level: Noise level at Mago chu HEP area ranged from a minimum of 27.1 dBA at Jaswantgarh Stage–I at 8.00 AM to a maximum of 67.1 dBA at New Melling at 4.00 PM (Table II. 3.244).

Table II. 3.244: Noise level at proposed Mago chu HEP sites

Sampling location	Nearest project sites covered	Noise level (dBA) 8.00 AM	Noise level (dBA) 4.00 PM
Rho	Mago chu powerhouse site Mago chu barrage site	37.2	39.6
Jaswantgarh	Mago chu powerhouse site Mago chu barrage site	27.1	25.2
Nuranang falls	Mago chu powerhouse site Mago chu barrage site	64.6	63.2
Jang	Mago chu powerhouse site Mago chu barrage site	38.2	29.7
New Melling	Mago chu powerhouse site Mago chu barrage site	61.3	67.1
Thingbu chu	Mago chu powerhouse site Mago chu barrage site	60.2	62.0

3.3.6.2 BIOLOGICAL ENVIRONMENT

Vegetation Types

The project components of Mago chu HEP are located in temperate and sub-alpine climatic zone. The vegetation types within 10 km radius area are:

11B/CI East Himalayan wet temperate forest (2000-3000 m): These are mixed evergreen forests with moderate size trees, occurring between 1800 and 3000 m elevation. In these forests important tree associates were: *Acer campbellii, Lithocarpus pachyphylla, Prunus cerasoides, Quercus serrata, Rhododendron arboreum, Schima wallichii* and *Tetracentron sinense*. Shrubs were represented by: *Berberis asiatica, Coriaria nepalensis, Elaeagnus parvifolia, Rosa brunonii, Rubus ellipticus* and *Viburnum erubescens*. Climber and epiphytes were not common.

12/C3a East Himalayan mixed coniferous forests (2000-3500 m): These are dense evergreen forests with dominance of oak and rhododendrons. Between 2300-3500 m elevations in the upper ridges, silver fir (*Abies densa*) makes appearance as a dominant tree species. However, at lower elevations, other deciduous trees such as *Magnolia* sp., *Acer* sp., *Betula alnoides, Alnus nepalensis*, mixed with oak species, occur at varying extents. Gregarious undergrowth, usually of bamboo, and in its absence *Rhododendron* species and other evergreen shrubs such as *Berberis* sp., *Cotoneaster* sp., *Rhododendron* sp., *Salix* sp., *Thamnocalamus* sp. and *Viburnum* sp. also occur. The trees are mostly covered with many epiphytic mosses and lichens.

12/ISI Alder forest (1800-2200 m): These are typically seen as pure stands of *Alnus nepalensis* and *Populus ciliata*, with heights ranging from 20-30 m. They occur as a strip with varying width along stream sides, spreading out to larger areas, and more or less deciduous in nature. In the lower course of the stream and landslide affected areas, *Alnus* is the dominant formation. There is often an under growth of inedible/thorny shrubs comprising *Berberis, Rubus, Princepia* etc., whilst in the better wooded tracts, progression starts early and other species, notably blue pine and other conifers, are usually present.

12/1S2 Riverine blue-pine forest (1800-3000 m): These forests are characterized by irregular and often dense stands of blue pine with occasional *Picea*, *Tsuga, Populus* and *Alnus*, with little or no undergrowth.

14/2SI Sub-alpine blue-pine forest (3500-4000 m): These types of forest occurs at 3500-4000 m elevation, and are represented by pure stands of *Pinus wallichiana*. Towards higher elevation, Fir forests gradually replaces bluepine.

Plant Diversity

A total of 157 plant species belonging to different groups were recorded from the barrage and powerhouse sites, and the catchment area. A complete list of plant species representing different groups such as tree, shrub, herb, climber, orchid, pteridophyte, bryophyte, lichen and fungi along with their family name is given in Appendix II. 3.65. The number of plant species belonging to different groups is summarized in Table II. 3.245.

Table II. 3.245: Different groups of plant species present at Mago chu HEP site

Sl. No.	Groups	Number of species		
		Barrage site	**Power house site**	**Catchment area**
1	Tree	12	10	9
2	Shrub	17	18	17
3	Herb	48	48	47
4	Climbers	16		11
5	Orchids	8		5
6	Pteridophytes	10		6
7	Bryophytes	7		5
8	Lichens	8		7
9	Fungi	16	10	19

The trees were covered with a large variety of non-vascular epiphytes such as lichens, mosses, and ferns. In the barrage site 12 tree, 17 shrub, and 48 herb species were recorded, while in the powerhouse site 10 tree, 18 shrub, and 17 herb species were recorded. In the catchment area 9 tree, 17 shrub and 47 herb species were recorded. Sixteen climber, 8 orchid, 10 pteridophyte,7 bryophyte, 8 lichen and 16 fungi species were recorded from barrage and powerhouse site, whereas from the catchment area 11 climber, 5 orchid, 6 pteridophyte, 5 bryophyte, 7 lichen and 19 fungi species were recorded (Appendix II. 3.66 and 3.67).

Threatened and Endemic Plants

Five threatened species were recorded from the project site (Table II. 3.246).

Table II. 3.246: Threatened/endemic plants recorded at Mago chu HEP site

Species name	Family	Threat status	References
Acer hookeri	Aceraceae	EN	Nayar and Sastry, (1987, 1988, 1990)
Acer sikkimensis	Aceraceae	EN	Nayar and Sastry, (1987, 1988, 1990)
Panax bipinnatifidus	Araliaceae	VU	CAMP, 2003
Swertia chirayita	Gentianaceae	VU	CAMP, 2003
Taxus wallichiana	Taxaceae	EN	CAMP, 2003; Walter and Gillet, 1998

EN=Endangered; VU=Vulnerable

Economically Important Species/Plant Resources

The study area is rich in plant resources. Some of the important species are listed below under different resource groups (Table II. 3.247).

Table II. 3.247: Economically important species/plant resources present at HEP site

Sl. No.	Uses	Species name
1	Timber	*Populus ciliata, Betula alnoides, Pinus wallichiana*
2	Fuel	*Quercus griffithii, Q. semicarpifolia, Quercus lamellosa, Rhododendron* sp., *Rhododendron* sp., *Pinus wallichiana*
3	Ornamentals and orchids	*Rhododendron* sp.,
4	Medicine and aromatics	*Panax* sp., *Paris polyphylla, Taxus wallichiana, Swertia chirayita, Drymaria cordata*
5	Fodder	*Alnus nepalensis, Quercus griffithii, Q. semicarpifolia, Quercus lamellosa, Rhododendron* sp.
6	Edible	*Elaeagnus* sp., *Zanthoxylum armatum, Rubus ellipticus*
7	Fibre and paper	*Daphne papyracea*
8	Bamboos	*Arundinaria maling, Phyllostachys* sp.
9	Ornamentals and orchids	*Rhododendron* sp., *Sedum multicaule, Cymbidium* sp., *Hydrangea* sp., *Impatiens* sp.

Vegetation Analysis for Angiosperms and Gymnosperms

The plant community in the barrage and power house sites, and the catchment area comprised of 17 tree, 18 shrub, and 50 herbaceous species (Tables II. 3.248 and 3.249).

Table II. 3.248: Tree and shrub species recorded at barrage and powerhouse sites, and in the catchment area at Mago chu project sites

Tree species	Shrub species
Acer hookerii	*Artemesia nilagirica*
Acer sikkimensis	*Arundinaria manii*
Acer sp.	*Berberis aristrata*
Alangium alpinum.	*Coraria napalensis*
Alnus nepalensis	*Daphnae papyracea*
Brassiopsis glomerulata	*Eleagnus parviflora*
Corylus hetrophylla	*Euphorbia sikkemensis*
Leucosceptrum canum	*Girardinia grandiflora*
Lindera neesiana	*Hypericum choisianum*
Pinus wallichiana	*Ilex dipyrena*
Populus ciliata	*Neillia thysiflora*
Quercus lamellosa	*Philadelphus tomentosus*
Quercus semicarpifolia	*Pipthanthus nepalensis*
Rhododendron sp.	*Plectranthus* sp.
Rhus javanica	*Rosa* sp.
Taxus wallichiana	*Rubus ellipticus*
Tsuga dumosa	*Zanthoxylum armatum*
	Zanthoxylum oxyphyllum

Table II. 3.249: Herbaceous species recorded at the barrage and powerhouse sites, and in the catchment area at Mago chu project sites

Herb species		
Achyranthes aspera	*Fragaria nubicola*	*Panax bipinnatifidus*
Ainsliaea sp.	*Fragaria* sp.	*Pilea umbrosa*
Anaphalis margaritacea	*Galinsoga parviflora*	*Plantago major*
Arisaema erubescens	*Galium* sp.	*Pogostemon* sp.
Arisaema nepenthoides	*Geranium pratense*	*Polygonum capitata*
Aster sp.	*Goldfusia nutans*	*Potentilla cuneata*
Aster trinervius	*Gonatanthus pumilus*	*Roscoea alpina*
Astilbe rivularis	*Hepetospermum pendunculosum*	*Rumex acetosella*
Cirsium falconeri	*Imperata cylindrica*	*Phlomis* sp.
Crawfurdia speciosa	*Iris lactea*	*Sambacus adnata*
Cyathula capitata	*Nepata* sp.	*Senecio cappa*
Didymocarpus sp.	*Ophiopogon intermedius*	*Thaladiantha cordifolia*
Dipsacus aspera	*Opliomenus* sp.	*Thalictrum foliolosum*
Dracocephalum sp.	*Oxalis corniculata*	*Urtica dioca*
Drymaria cordata	*Parasenecio quinquelobus*	*Viola sikkimensis*
Paspallum sp.	*Persicaria runcinata*	*Elatostemma sessile*
Elsholtzia stobilifera	*Paris polyphylla*	

The number of tree species varied from 9 to 12, and the shrub species from 16 to 18 in the three sites. Herbaceous species richness showed wide variation i.e., from 46 species at power house site during rainy season to 16 species at barrage site during post-monsoon period. It showed distinct seasonal variation in all the three sites with maximum number recorded during monsoon season and minimum during post-monsoon season. Among tree species, *Tsuga dumosa* in the barrage site, *Quercus lamellose* in the power house, and *Acer* sp. in catchment area, were dominant. *Arundinaria maling* was dominant among shrubs in the barrage and power house sites, and *Daphnae papyracea* was dominant in the catchment area. Unlike trees and shrubs, in a given season different herbaceous species were dominant at a given site (Appendix II. 3.77).

Tree density was highest in the barrage site, and lowest in the power house site. Shrub density was highest in the catchment area, and lowest in the barrage site (Table II. 3.250). Highest density of herbaceous species was recorded during monsoon season in the catchment area, and lowest during post-monsoon season in the barrage site. Shannon diversity index for tree species was highest in the barrage site (H'=2.31), followed by power house site (2.06), and catchment area (1.87). For shrub species, highest diversity value (H'=2.58) was obtained in the power house site, followed by catchment area (2.56), and barrage site (2.43) (Table II. 3.250). For herbaceous species, the highest value (H'=3.44) was recorded in the power house site during monsoon season, and lowest (H'=2.44) during post-monsoon season in the catchment area. In all the three sites, diversity of herbaceous species peaked during monsoon season and had the lowest value during post-monsoon season (Table II. 3.251) (Appendix II.3.68- 3.76). Highest diversity of tree species was recorded near the barrage site, while diversity of shrubs and herbs was more in the power house and catchment area.

Table II. 3.250: Species richness, diversity and dominance of trees and shrubs, and biomass and carbon stock of trees in the community at Mago chu project sites

Parameters	**Barrage**		**Powerhouse**		**Catchment area**	
	Trees	**Shrubs**	**Trees**	**Shrubs**	**Trees**	**Shrubs**
Number of species	12	16	10	18	9	17
Density (ha^{-1})	580	8736	320	8928	450	8976
Simpson index of dominance	0.12	0.89	0.16	0.90	0.19	0.90
Shannon index of diversity (H')	2.31	2.43	2.06	2.58	1.87	2.56
Evenness index	0.93	0.71	0.89	0.73	0.85	0.76
Biomass (t/ha)	64.10		41.871		69.10	
Carbon (t/ha)	32.05		20.93		34.55	

Table II. 3.251: Species richness, diversity and dominance of herbaceous species at Mago chu project sites

Parameters	Barrage			Powerhouse			Catchment area		
	PM	M	W	PM	M	W	PM	M	W
Number of species	23	44	17	21	46	16	21	45	17
Density (ha^{-1})x10^3	284	607	218	325	598	209	274	747	236
Simpson index of dominance	0.92	0.96	0.90	0.90	0.96	0.90	0.91	0.96	0.89
Shannon index of diversity (H')	2.73	3.40	2.48	2.57	3.44	2.46	2.65	3.40	2.45
Evenness index	0.67	0.68	0.70	0.62	0.68	0.73	0.67	0.66	0.68

PM: Post-monsoon; M: Monsoon; W: Winter

Phytoplankton/Periphyton

Eleven species of phytoplankton/periphyton were recorded from Mago chu project sites. The phytoplankton/periphyton community was represented by one species of Cyanobacteria and ten species of Bacillariophyceae. Maximum species richness was recorded from the catchment area with 11 species and minimum with 5 species from the project affected areas. Phytoplankton/periphyton density at the project affected areas (110 individuals/l) was lower than that of catchment area (480 individuals/l). Similarly, species diversity index was maximum (H'=1.98) at the catchment area and minimum (H'=1.03) at the project affected areas (Table II. 3.252).

Table II. 3.252: Density (Individuals/l), species richness and Shannon index of diversity (H') of phytoplankton community in river water at project affected area and catchment area of Mago chu project sites

List of species	Project affected area	Catchment area
Cyanobacteria		
Oscillatoria sp.		80
Bacillariophyceae		
Achnanthidium rivulare	5	15
Cymbella delicatula	20	30
Encyonema minutum	30	130
Eunotia exuca	275	105
Gomphonema olivaceoides		10
Navicula capitata	150	20
Opephora sp.		10
Synedra ulna		20
Thallassiosira sp.		85
Hydrurus fueditus		5
Total density (Individuals/l)	**480**	**510**
Species diversity index	**1.03**	**1.98**
Species richness	**5**	**11**

NB: Blank cells indicate absence of Periphyton species

Zooplankton

Only 3 species of zooplanktons viz., *Lepadella patella, Testudinella patina* and *Trichocerca bidens* belonging to Rotifera were recorded during monsoon season (Table II. 3.253). *Trichocerca bidens* a rare zooplankton species was recorded from the barrage site.

Table II. 3.253: Occurrence of species belonging to Cladocera and Rotifera during monsoon and winter seasons at Mago chu project sites

Sl. No.	Taxa	Species	Season	
			Monsoon	Post-monsoon
1	Rotifera	*Lepadella patella* (O.F. Muller, 1773)	+	–
2	Rotifera	*Testudinella patina* (Hermann, 1783)	+	–
3	Rotifera	*Trichocerca bidens* (Lucks, 1912) *	+	–
Total	**1**	**3**	**3**	**0**

*Rare

Fish Fauna

No fish species was recorded from Mago chu project site.

Soil Fauna

The seasonal variation in soil faunal diversity (Collembola, Acarina and other arthropods) and equitability in litter and soil layer is presented in Tables II. 3.254-3.256.

Table II. 3.254: Seasonal variation in soil faunal (Collembola, Acarina and other arthropods) diversity and equitability in litter and soil layer at Mago chu project sites

Soil fauna	Diversity	Post-monsoon				Monsoon				Winter			
		Barrage		Powerhouse		Barrage		Powerhouse		Barrage		Powerhouse	
		Litter	Soil	Litter	Soil	Litter	Soil	Litter	Soil	Litter	Soil	Litter	Soil
Collembola	Dominance_D	0.19	0.16	0.14	0.12	0.14	0.15	0.15	0.16	0.20	0.33	0.33	0.28
	Shannon_H	1.74	1.89	2.03	2.18	2.00	1.93	1.97	1.86	1.61	1.10	1.10	1.33
	Evenness_e^H/S	0.94	0.94	0.95	0.98	0.93	0.98	0.89	0.92	1.00	1.00	1.00	0.95
Acarina	Dominance_D	0.16	0.14	0.16	0.23	0.12	0.11	0.20	0.21	0.50	0.28	0.33	0.50
	Shannon_H	1.90	2.02	1.90	1.53	2.17	2.25	1.71	1.67	0.69	1.33	1.10	0.69
	Evenness_e^H/S	0.95	0.94	0.95	0.92	0.97	0.95	0.92	0.89	1.00	0.95	1.00	1.00
Other Arthropods	Dominance_D	0.16	0.17	0.11	0.13	0.16	0.13	0.12	0.13	0.50	0.22	0.12	1.00
	Shannon_H	1.96	1.86	2.22	2.12	1.86	2.11	2.20	2.11	0.69	1.55	2.16	0.00
	Evenness_e^H/S	0.88	0.92	0.92	0.92	0.92	0.92	0.90	0.92	1.00	0.94	0.97	1.00

Table II. 3.255: Mean annual density (number/m^2) of soil fauna in litter and soil layer (0-5 cm) at Mago chu project sites

Soil fauna	Site	Litter layer	Soil layer	Total
Collembola	Barrage	1273	1018	**2291**
	Powerhouse	1818	1491	**3309**
Acarina	Barrage	1200	1143	**2343**
	Powerhouse	1057	800	**1857**
Other Arthropods	Barrage	1600	1418	**3018**
	Powerhouse	2764	1164	**3927**
Total fauna	**Barrage**	**4073**	**3579**	**7652**
	Powerhouse	**5639**	**3455**	**9093**

Table II. 3.256: Seasonal variation of soil fauna density (number/m^2) at barrage and powerhouse site of Mago chu project

Soil fauna	Site	Post-monsoon	Monsoon	Post-monsoon	Mean
Collembola	Barrage	7200	14800	3200	**8400**
	Powerhouse	17600	15600	3200	**12133**
Acarina	Barrage	10800	19200	2800	**10933**
	Powerhouse	13600	10400	2000	**8667**
Other arthropods	Barrage	11600	17200	4400	**11067**
	Powerhouse	17200	21600	4400	**14400**

Wildlife

Butterflies: Nineteen species of butterflies belonging to 17 genera and five families were recorded from the project sites. Nymphalidae was the dominant family, and was represented by six species. No threatened species were recorded (Table II. 3.257).

Table II. 3.257: Butterflies recorded in Mago chu HEP area

Sl. No.	Family common name	Scientific name	Project area
I.	**Hesperiidae**		
1	Lucas' Ace	*Sovia lucasii magna*	*
II.	**Papilionidae**		
2	Common Peacock	*Papilio polyctor ganesa*	*
3	Paris Peacock	*Papilio paris paris*	*
4	Golden Birdwing	*Troides aeacus aeacus*	*
5	Indian Purple Emperor	*Mimathyma ambica*	*
III.	**Pieridae**		
6	Spotless Grass Yellow	*Eurema laeta*	*
7	Small Grass Yellow	*Eurema brigitta rubella*	*
8	Indian Cabbage White	*Pieris canidia indica*	*
9	Plain Sulphur	*Dercas lycorias*	*
10	Spotted Sawtooth	*Prioneris thestylis thestylis*	*
IV.	**Lycaenidae**		
11	Peablue	*Lampides boeticus*	*
12	Large Hedgeblue	*Celastrina hugeli oreana*	*
13	Common Hedgeblue	*Acytolepis puspa gisca*	*

V.	**Nymphalidae**		
14	Large Silverstripe	*Argynnis children*	*
15	Glassy Tiger	*Graphium cloanthus*	*
16	Indian Tortoiseshell	*Aglais caschmirensis*	*
17	Chocolate Pansy	*Junonia iphita iphita*	*
18	Banded Treebrown	*Lethe confusa*	*
19	Straight-banded Treebrown	*Lethe verma*	*

Herpetofauna: Since no herpetofauna was sighted during the survey, the probable list of amphibians and reptiles was prepared following Ahmed *et al.* (2009) (Appendix II. 3.167).

Birds: The assessment of birds in this project area, revealed presence of 95 species belonging to 65 genera, and 34 families. Shannon index of 3.6 shows moderate level of species diversity. Species richness was higher during monsoon (50 species) as compared to other seasons (Table II. 3.258).

Migratory status: Most of the bird species were residents (66 species), followed by 15 breeding visitors and 14 winter visitors (Table II. 3.258).

Table II. 3.258: Status of birds recorded in the Mago chu HEP area

Details	Post-monsoon	Monsoon	Winter	Overall
Family	17	20	25	34
Genera	26	38	34	65
Species	32	50	46	95
Abundance	385	359	361	1105
Diversity H'	3.2	3.2	2.8	3.6
Migratory status				
Breeding visitor	3	9	5	15
Isolated record	0	0	0	0
Resident	26	32	36	66
Winter visitor	3	9	5	14

Abundance status: The abundance status of birds was derived by classifying the abundance of bird species into five abundance category (Very Low = 1-25 birds, Low = 26-50, Moderate = 51-75, High = 76-100 and Very High = >100birds). The details of abundance status are given in the Table II. 3.259.

Table II. 3.259: Number of species and relative % of birds in different abundance classes

Abundance class	No. of species	Relative %
Very low-1-25 birds	85	89.5
Low-26-50 birds	7	7.4
Moderate-50-75 birds	1	1.1
High-76-100 birds	0	0
Very high > 100 birds	2	2.0
Total	**95**	**100**

Status of foraging guilds: The status of foraging guilds was determined based on the types of food consumed. A total of 8 foraging guilds were identified, of which insectivores were predominant with 69 species, followed by 8 species of omnivores, and 7 species of granivores. The high richness of insectivores showed the presence of diverse habitat and niches in this project site (Table II. 3.260 and Appendix II. 3.183).

Table II. 3.260: Status of foraging guild of birds recorded in the Mago chu HEP area

Foraging guild	Post monsoon	Monsoon	Winter	Overall
Aquatic Feeder	1	0	0	1
Carnivore	0	2	1	3
Frugivore	1	0	0	1
Granivore	0	4	4	7
Insectivore	23	39	35	69
Nectarivore	2	2	3	5
Nucivore	0	0	1	1
Omnivore	5	3	2	8
Piscivore	0	0	0	0

Status of threatened species: The only threatened bird species, the Rufous-necked Hornbill (*Aceros nipalensis*), a vulnerable species of IUCN Red List (Rahmani, 2012; IUCN 2013), was recorded from this project area (Appendix II 3.183). Only one individual of this species was reported from the entire Project area.

Mammals: Mammals in Mago chu project area was represented by 10 species that belonged to 8 families and 8 genera. They were dominated by family Sciuridae, with three species.
Abundance status: A total of 10 species were reported from the project area, of which 6 species were reported based on direct sighting of 16 animals, and 4 species were reported based on indirect evidence. Across the season, 5 species were observed. Further evaluation showed that the project area had low species richness (10 species) compared to the total possible species (28 species) of the TRB (Mishra *et al.,* 2006) (Table II. 3. and Appendix II. 3.184)

Status of threatened species: Himalayan goral (*Naemorhedus goral)* was the only species reported from this project study area that has been classified as Near Threatened (NT) under IUCN and schedule III of WPA (1972) (Table II. 3.261). Other nine species of the study area fall under Least Concern (LC) of IUCN and Schedule II and III of WPA.

Table II. 3.261: Status of mammalian fauna of in the Mago chu HEP area

Sl. No.	Common name	Scientific name	Seasons			Overall	Conservation status	
			PM	M	W		IUCN	WPA
I.	**Cervidae**							
1	Barking Deer	*Muntiacus muntjak*		A 4		A 4	LC	**III**
II.	**Bovidae**							
2	Himalayan goral	*Naemorhedus goral*	IE 2			IE 2	NT	III
III.	**Suidae**							
3	Wild pig	*Sus scrofa*	IE 2		IE 3	IE 5	LC	III
IV.	**Felidae**							
4	Jungle cat	*Felis chaus*	IE-1		IE 2	IE 3	LC	II
V.	**Mustelidae**							
5	Yellow Throated Martin	*Martes flavigula*		A2		A 2	LC	II
VI.	**Viverridae**							
6	Himalayan Palm Civet	*Paguma larvata*		IE1		IE 1	LC	II
VII.	**Sciuridae**							
7	Orange-Bellied Himalayan Squirrel	*Dremomys lokriah*	A 1			A 1	LC	NE
8	Hoary-bellied Himalayan Squirrel	*Callosciurus pygerythrus*	A 2	A-1	A 2	A 5	LC	NE
9	*Himalayan Stripped Squirrel*	*Tamipos macclellandi*		A-2	A1	A 3	LC	NE
VIII.	**Muridae**							
10	Chesnut rat	*Niviventer fluvescens*			A 1	**A1**	LC	NE
No of species			**5**	**5**	**5**	**10**		
Total and types of records			**IE 5 A 3**	**IE 1 A-9**	**IE 5 A 4**	**IE 11 A 16**		

IE – Indirect Evidences A-animals sighted, W-Winter, PM-Post-monsoon, M-Monsoon, IUCN-Red List, WPA-Wildlife Protection Act, NT-Near threatened, LC-Least Concern, NE –Not Evaluated

Faunal status within 500 m of project affected area: This section shows the species richness status of selected faunal groups such as avifauna and mammal species reported within 500m up and down streams of the barrage and powerhouse sites of the proposed project area. The species richness in these sites was evaluated based on subjective rating i.e. by estimating percent contribution with the overall species list of the project area. If the species richness of barrage and powerhouse contributes 25% of overall list it was categorised as low, > 25-50% as medium, >50-75% as high and above 75% as high species richness.

Status of avifauna: Twenty seven bird species were reported both from powerhouse and barrage sites. A total of 95 species were reported from the entire project area, which is 28.42% overall species richness. This list also included one threatened hornbill species (Brown-necked Hornbill-

Aceros nipalensis), which is listed as vulnerable in the IUCN Red List (Appendix II. 3.185 and 3.186**)**.

Status of mammals: Site specific evaluation of mammalian fauna within 500 m of up and down streams showed occurrence of one and five species at the powerhouse site and barrage site respectively. Presence of these species was ascertained based on seven indirect evidences and sightings of four Squirrels belonging to two species, namely, Hoary-bellied Himalayan Squirrel and Himalayan Stripped Squirrel. None of these species were categorized under high conservation status of IUCN and WPA (1972) (Table II. 3.262). Overall the powerhouse site of Mago chu project did not have any mammalian fauna of high conservation significance.

Table II. 3.262: Status of mammalian fauna at barrage and powerhouse sites of the proposed Mago chu HEP area

Sl. No.	Common name	Species name	Status		Conservation status	
			BS	PHS	IUCN	WPA
1	Himalayan goral	*Naemorhedus goral*		IE2,	NT	III
2	Wild pig	*Sus scrofa*	IE 2	IE 2,	LC	III
3	Jungle cat	*Felis chaus*		IE	LC	II
4	Hoary-bellied Himalayan Squirrel	*Callosciurus pygerythrus*		A2	LC	NE
5	Himalayan Stripped Squirrel	*Tamipos macclellandi*		A2,	LC	NE
	No of species		**1**	**5**		
	Total records		**IE2**	**IE5, A4**		

IE – Indirect Evidences, A – No of Animals Sighted, BS-Barrage Site, PHS – Powerhouse Site, IUCN-Red List, WPA-Wildlife Protection Act, NT-Near threatened, LC-Least Concern, NE-Not Evaluated

3.3.6.3 SOCIO-ECONOMIC PROFILE

There are two directly affected villages under each of the project, In Mago chu HEP, Rho and Yuthembu are the affected villages while in Nykcharong chu HEP, Rho and Jangda are the affected villages. Further, the villages that come under the 10 km affected zone of Mago chu are the same as those falling under Nykcharong chu project affected zone. Therefore, detail socio-economic data of this project is the same as that of Nykcharong chu project and have been dealt with in Section-II. 3.3.7.

3.3.7 NYKCHARONG CHU

3.3.7.1 PHYSICAL ENVIRONMENT

Geomorphology

The Nykcharong HEP site is located on the river Nykcharong chu in TRB. The terrain is rugged, representing typical mountainous topography. River valley has steep slopes of about 65º-70º at the left bank and 70º-80º at the right side and the drainage system in the area is mostly jointed and controlled to sub-parallel (Figure II. 3.35).

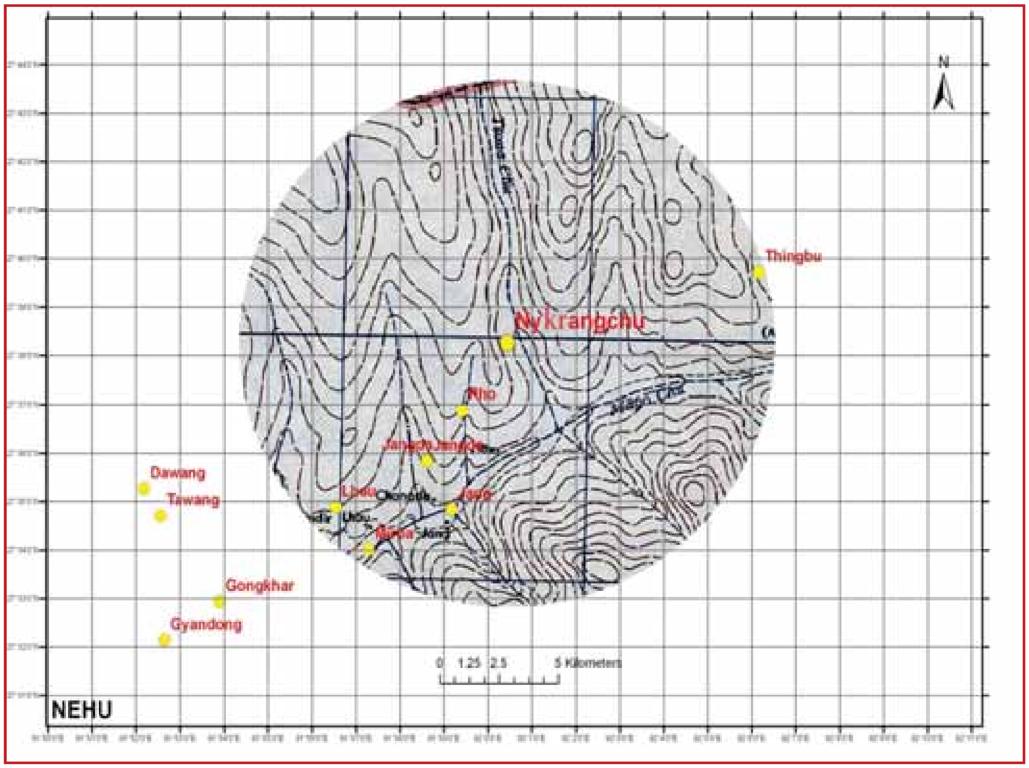


Figure II. 3.35: Contour map of Nykcharong chu HEP site

Geology

The rocks in the project area are represented by gneiss with occasional minor bands of granites. They belong to Lum La Formation. The gneisses are mostly leucocratic to melanocratic, fine to medium grained and moderately jointed. The granites are mostly leucocratic to mesocratic, medium to coarse grained and intrusive into gneisses. The foliation (J1) planes of rock generally strike in NW–SE direction and dip at 20^0–45^0 in south–westerly direction. They are mostly fresh, compact and moderately jointed. The area under various geological classes in Nykcharong chu at barrage site is given in Table II. 3.263. The location of Nykcharong chu barrage site and the impact zone within 10 km radius in Tawang river are depicted in Figures II. 3.36 and 3.37.

Table II. 3.263: Area under various geological classes in Nykcharong chu at barrage site

Class	Area	%
Snow covered area	13.93	4.44
Snow covered area	15.31	4.87
Snow covered area	5.01	1.59
Sela group (Structural hill)	228.10	72.61
Glacier	0.19	0.06
Sela group (Structural hill)	0.04	0.01
Sela group (Valley)	0.17	0.06
Glacier	0.07	0.02
Volcanic sediment (Structural hill)	38.57	12.28
Volcanic sediment (Structural hill)	12.77	4.07
Total	**314.16**	**100.00**

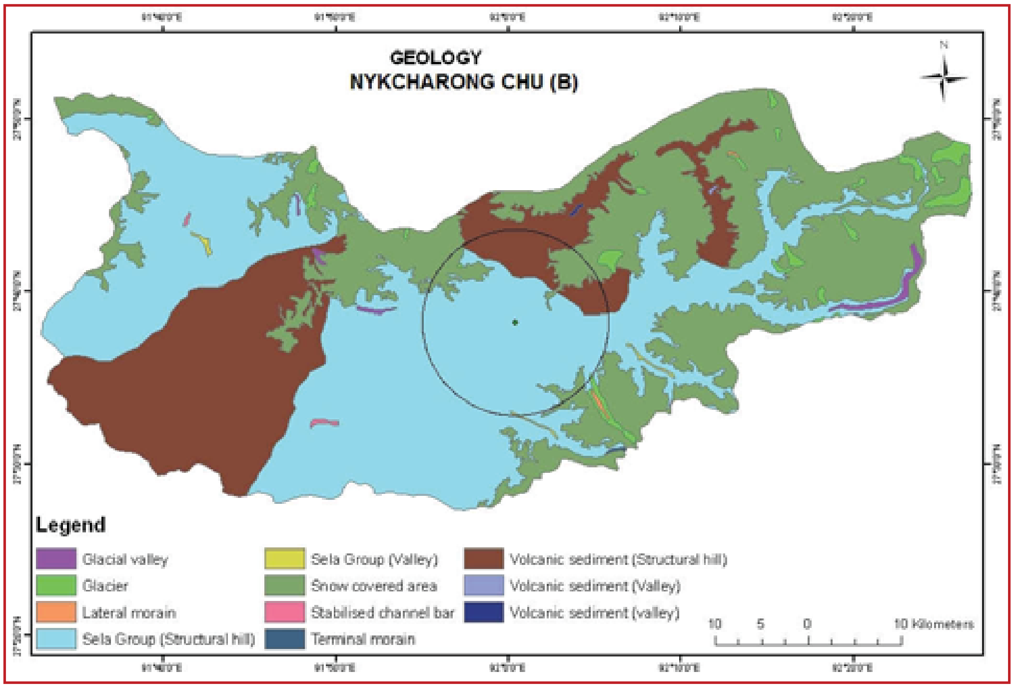


Figure II. 3.36: Geological map of TRB showing location of Nykcharong chu barrage site

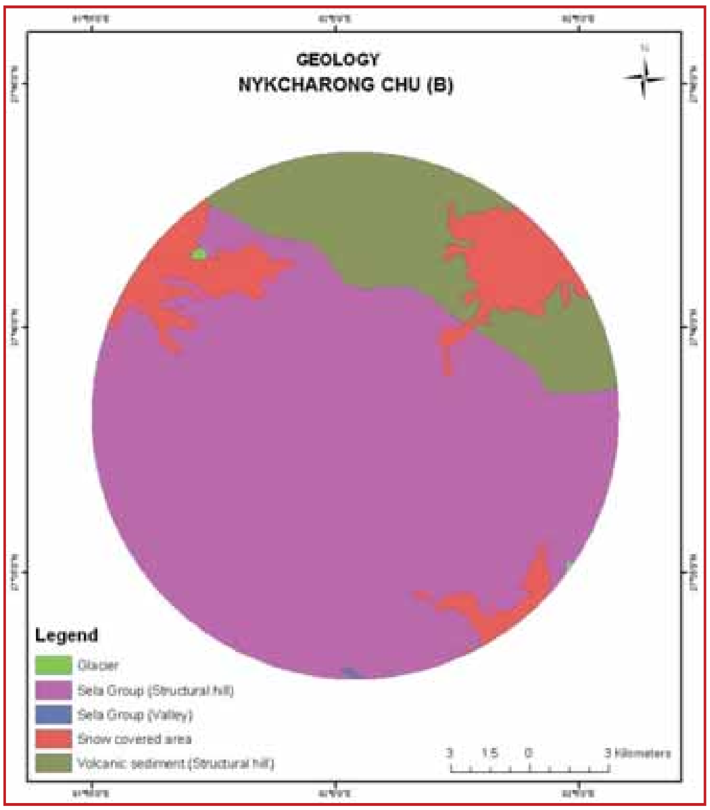


Figure II. 3.37: Geological map of impact zone (10 km radius) of Nykcharong chu barrage site

Landuse and Land Cover

The total area within 10 km radius of Nykcharong chu HEP site is 31459.12 ha (Figure II. 3.38). Majority of the area is covered with forest (50.42%) followed by scrubland (37.07%). Cropland covers only 0.01% of the total project area. Waterbody constitute around 9.65% and grassland occupies only 0.86% of the total area. The total area occupied by snow and ice and other builtup area altogether is 2.99% (Table II. 3.264).

Table II. 3.264: Landuse/land cover area of Nykcharong chu project site

Landuse/land cover category	Area (ha)	%
Forest	15862.5	50.42
Scrubland	11661.3	37.07
Waterbody	3036.2	9.65
Croplands	3.3975	0.01
Grasslands	270.653	0.86
Builtuparea	146.88	0.47
Snow and Ice	478.193	1.52
Total	**31459.12**	**100.00**

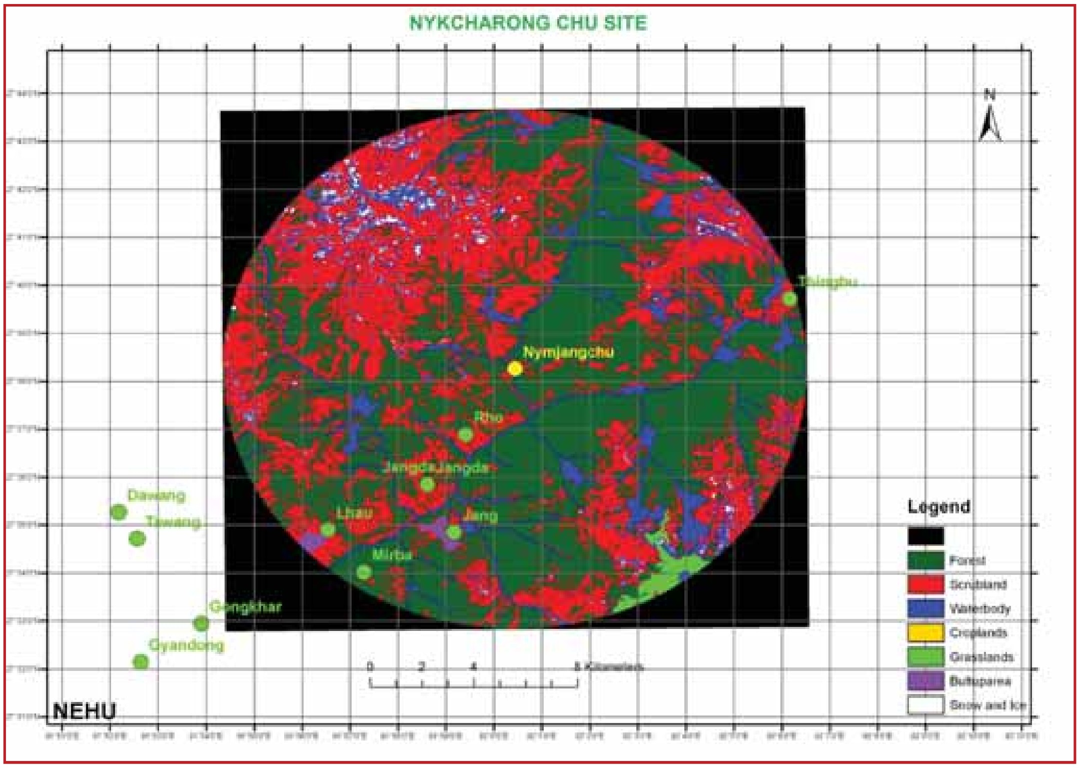


Figure II. 3.38: Landuse/land cover map of Nykcharong chu project site

Soil

The soil in Nykcharong chu was acidic loam with high porosity and high water holding capacity (Table II. 3.265). Despite wide variation in conductivity between barrage and powerhouse site, seasonal difference was clearly observed with high values during rainy season compared to other two seasons. Nitrate nitrogen and exchangeable potassium concentration was higher than other sites. Generally, values of all parameters were lower in winter season compared to monsoon season. Seasonal variation in physical, chemical, and biological parameters are presented in Table II. 3.266.

Table II. 3.265: Soil physical properties at Nykcharong chu project site

Site	Texture	WHC (%)	Bulk density (g/cm³)	Porosity (%)
Barrage	loam	69.51	0.84	68.30
Powerhouse	loam	56.11	0.85	67.92

Table II. 3.266: Seasonal variation in soil physico–chemical properties at Nykcharong chu project site

Parameters	Post-monsoon		Monsoon		Winter		Mean	
	B	PH	B	PH	B	PH	B	PH
SMC (%)	35	30	45	38	25	15	35	28
pH	5.7	5.2	6.7	5.6	6.2	4.8	6.2	5.2
Conductivity ($\mu S\ cm^{-1}$)	69	23	188	82	109	12	122	39
NH_4^+–N ($\mu g\ g^{-1}$)	300	30	200	200	300	200	267	233
NO_3^-–N($\mu g\ g^{-1}$)	21	28	33	34	22	22	25	28
TKN ($\mu g\ g^{-1}$) x10^3	0.890	0.930	1.090	1.110	0.760	0.850	0.910	0.960
Av.P ($\mu g\ g^{-1}$)	0.040	0.070	0.120	0.150	0.030	0.020	0.060	0.080

TP (%)	0.140	0.090	0.170	0.120	0.100	0.070	0.140	0.090
SOC (%)	0.015	0.007	0.015	0.007	0.015	0.004	0.020	0.010
Ex. K ($\mu g\ g^{-1}$)	526	182	739	302	223	89	496	191
Ex. Mg (%)	0.024	0.008	0.033	0.037	0.024	0.004	0.030	0.020
Ex. Ca (%)	0.160	0.060	0.390	0.260	0.360	0.100	0.300	0.140
Soil microbial biomass–C ($\mu g\ g^{-1}$)	22	21	17	16	23	23	21	20
Soil microbial biomass–N ($\mu g\ g^{-1}$)	5.4	6.3	3.5	4.7	7.2	6.5	5.3	5.8

(Note: Post-monsoon– October, Monsoon–July, Winter– December); B = Barrage, PH = Powerhouse

Soil Erosion Vulnerability

The area under various soil erosion vulnerable classes at Nykcharong chu site is given in Table II. 3.267. Out of the total area of 314.16 sq.km, only 1.43% area falls under high soil erosion vulnerable zone, while 12.96% falls under moderately high vulnerable zone. Only 8.44% of the total area is covered under low vulnerable zone, while 33.43% falls under moderately–low vulnerable zone. The soil erosion vulnerable area under moderate category covered about 43.75% of the total area. The spatial distribution map of soil erosion vulnerable areas at Nykcharong chu site is given in Figure II. 3.39.

Table II. 3.267: Areas under various soil erosion vulnerable zones in Nykcharong chu site

Vulnerability	Area (sq. km)	%
High	4.48	1.43
Moderately high	40.70	12.96
Moderate	137.44	43.75
Moderately low	105.02	33.43
Low	26.52	8.44
Total	**314.16**	**100.00**

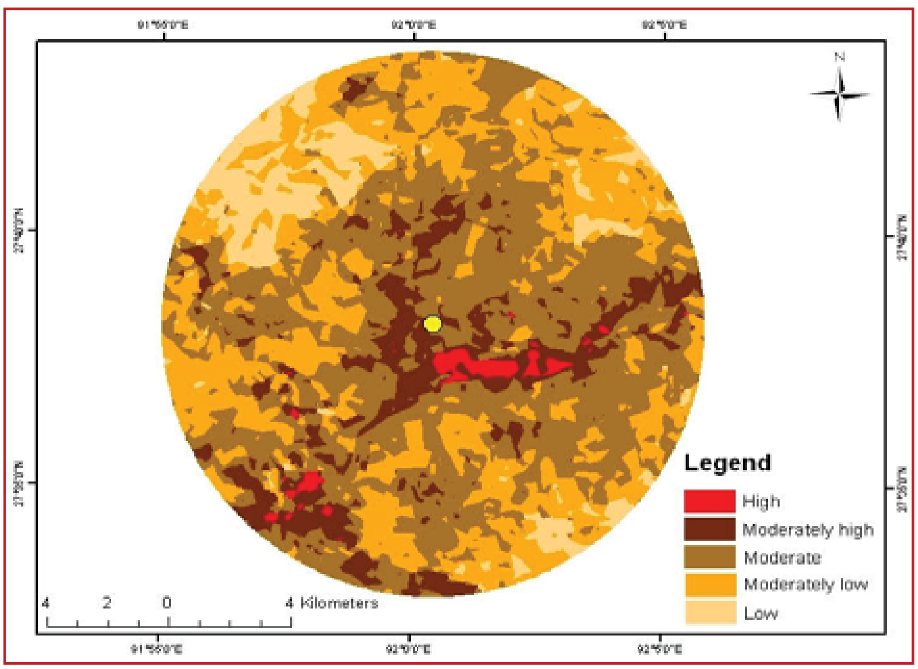


Figure II. 3.39: Spatial distribution of soil erosion vulnerable areas in Nykcharong chu project site

Landslide and Erosion Vulnerability

The area under various landslide and erosion vulnerability classes under barrage site of Nykcharong chu is given in Table II. 3.268. Out of the total area of 314.16 sq.km, the high and low vulnerable categories covered only 0.8% and 0.07% of the total area, respectively, whereas about 17.11% and 23.75% of the total area falls under moderately–high and moderately–low vulnerable zones, respectively. The highest area of vulnerability falls under moderate category which covers about 58.27% of the total area. The spatial distribution map of landslide and erosion vulnerability areas under barrage and powerhouse site of Nykcharong chu is given in Figure II. 3.40.

Table II. 3.268: Area under various landslide and erosion vulnerability classes in Nykcharong chu at barrage site

Nykcharong chu	Area (sq.km)	%
High	2.51	0.80
Moderately high	53.75	17.11
Moderate	183.07	58.27
Moderately low	74.60	23.75
Low	0.23	0.07
Total	**314.16**	**100.00**

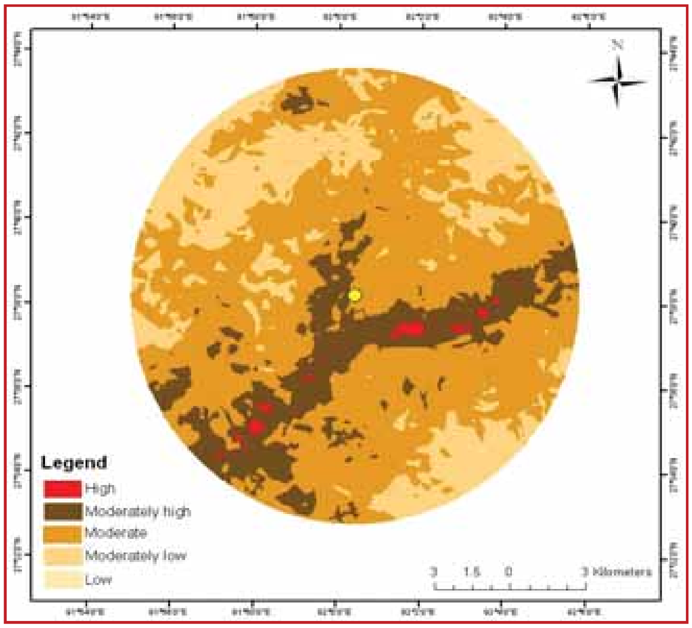


Figure II. 3.40: Area under various erosion and landslide vulnerability classes in Nykcharong chu at barrage site

Water

The river water at Nykcharong chu site showed higher values of pH, temperature, turbidity, sodium (Na^+), total Kjeldahl nitrogen (TKN), ammonium nitrogen (NH_4^+–N) and coliform count during the monsoon season. Peak values of GPP and NPP were also recorded during monsoon period. Highest concentration of DO was recorded during the winter period when water temperature was lowest in the year. The electrical conductivity (EC) and total dissolved solids (TDS) was higher during the post-monsoon period, whereas the total hardness and total alkalinity of the river was higher during the winter season (Table II. 3.269).

Table II. 3.269: Seasonal variation in physico–chemical and biological properties of water and its primary productivity at Nykcharong chu project site**.**

Parameters	Post-monsoon			Monsoon			Winter		
	B	**PH**	**Mean**	**B**	**PH**	**Mean**	**B**	**PH**	**Mean**
Temperature (°C)	4.40	4.55	4.48	14.30	14.60	14.45	4.70	4.70	4.70
Turbidity (NTU)	0.44	0.31	0.38	0.93	1.37	1.15	0.96	0.98	0.97
pH	7.56	7.63	7.60	8.17	8.21	8.19	7.85	7.86	7.86
Electrical conductivity (µS/cm)	211	188.50	200	163	168.00	166	197	200.00	199
Total dissolved solids (mg/l)	106	95.15	100.58	84	86.00	85.00	102	103.00	102.50
Practical salinity (ppt)	0.12	0.11	0.11	0.10	0.10	0.10	0.10	0.11	0.11
Total alkalinity (mg $CaCO_3$/l)	32	32.00	32.00	32	36.00	34.00	44	44.00	44.00
Total hardness (mg/l)	27	23.88	25.26	41	40.21	40.40	43	42.42	42.51
Chloride (mg Cl^-/l)	10.99	10.66	10.83	15.99	15.99	15.99	5.99	5.99	5.99
Ca^{2+} (mg/l)	6.03	5.08	5.56	10.08	9.89	9.98	10.73	10.65	10.69
Mg^{2+}(mg/l)	2.81	2.72	2.76	3.75	3.77	3.76	3.84	3.85	3.84
K^+ ppm	1.50	1.30	1.40	0.80	0.90	0.85	0.60	0.70	0.65
Na^+ ppm	10.60	9.40	10.00	13.40	14.10	13.75	10.80	10.80	10.80
TKN (mg/l)	0.43	0.45	0.44	0.54	0.59	0.57	0.43	0.46	0.45
NH_4^+ N (mg/l)	0.06	0.07	0.07	0.09	0.12	0.11	0.07	0.08	0.08
NO_3–N (mg/l)	0.35	0.34	0.34	0.15	0.16	0.16	0.32	0.31	0.31
Total phosphorus (mg/l)	0.10	0.10	0.10	0.08	0.08	0.08	0.07	0.08	0.08
GPP (mg C/cm^3/h)	0.47	0.36	0.42	0.47	0.47	0.47	0.21	0.21	0.21

NPP (mg C/cm^3/h)	0.10	0.10	0.10	0.31	0.31	0.31	0.10	0.10	0.10
Dissolved oxygen (mg/l)	11.50	11.75	11.63	10.20	10.30	10.25	12.50	12.50	12.50
Total coliforms (CFU/ml)	17	20.00	18.50	21	24.00	22.50	13	15.00	14.00
BOD_5 (mg/l)	2.0	2.2	2.1	2.4	2.4	2.4	2.1	1.8	1.9

(Note: Post-monsoon– October, Monsoon–July, Winter– December); B = Barrage, PH = Powerhouse

Ambient Air Quality

Concentration of PM_{10} and $PM_{2.5}$: PM_{10} concentration at Nykcharong chu HEP ranged from a minimum of 10.4µg/m^3 at Tsa chu to a maximum of 49.7 µg/m^3 at Nuranang falls. Likewise, Concentration of $PM_{2.5}$ varied from a minimum of BDL at Tsa chu to a maximum of 38.7 µg/m^3 at New Melling (Table II. 3.270). The concentration of sulphur–dioxide (SO_2), nitrogen–dioxide (NO_2), ammonia (NH_3) and ground level ozone (O_3) at all the monitored locations were below detectable limits.

Table II. 3.270: Concentration of PM_{10} and $PM_{2.5}$ in air at proposed Nykcharong chu HEP site

Sampling location	Nearest project site covered	PM_{10} (µg/m^3)	$PM_{2.5}$ (µg/m^3)
Rho	Nykcharong chu powerhouse site Nykcharong chu barrage site	23.5	13.4
Nuranang falls	Nykcharong chu powerhouse site Nykcharong chu barrage site	49.7	38.0
New Melling	Nykcharong chu powerhouse site Nykcharong chu barrage site	39.4	38.7
Thingbu chu	Nykcharong chu powerhouse site Nykcharong chu barrage site	41.0	26.9
Tsa chu	Nykcharong chu powerhouse site Nykcharong chu barrage site	10.4	BDL

Ambient temperature at Nykcharong HEP ranged between a low of 2°Cat Tsa chu to a high of 10°C at Nuranang Falls. Relative humidity varied between 27% at Nuranang Falls to 52% at Rho. Wind speed was 1.2 km/hr at Thingbu chu and 3.6 km/hr at Rho while wind direction was NW to SE direction (Table II. 3.271).

Table II. 3.271: Meteorological condition at proposed Nykcharong chu HEP site

Sampling location	Nearest project component covered	Ambient temperature (°C)		Relative humidity (%)	Wind speed (range in km/hr)	Wind direction
		Min	Max			
Rho	Nykcharong chu powerhouse site Nykcharong chu barrage site	05	09	52	1.8–3.6	NW
Nuranang falls	Nykcharong chu powerhouse site Nykcharong chu barrage site	06	10	27	2.4–3.2	SE
New Melling	Nykcharong chu powerhouse site Nykcharong chu barrage site	04	09	37	1.7–2.5	SE
Thingbu chu	Nykcharong chu powerhouse site Nykcharong chu barrage site	03	07	34	1.2–2.1	SE
Tsa chu	Nykcharong chu powerhouse site Nykcharong chu barrage site	02	06	42	1.8–2.5	SE

Noise Level: Noise level near Nykcharong chu HEP was 37.2 dBA at Rho at 8.00 AM and 67.1 dBA at New Melling at 4.00 PM (Table II. 3.).

Table II. 3.272: Noise level at proposed Nykcharong chu HEP site

Sampling location	Nearest project sites covered	Noise level (dBA) 8.00 AM	Noise level (dBA) 4.00 PM
Rho	Nykcharong chu powerhouse site Nykcharong chu barrage site	37.2	39.6
Nuranang falls	Nykcharong chu powerhouse site Nykcharong chu barrage site	64.6	63.2
New Melling	Nykcharong chu powerhouse site Nykcharong chu barrage site	61.3	67.1
Thingbu chu	Nykcharong chu powerhouse site Nykcharong chu barrage site	60.2	62.0
Tsa chu	Nykcharong chu powerhouse site Nykcharong chu barrage site	44.6	43.1

3.3.7.2 BIOLOGICAL ENVIRONMENT

Vegetation Types

The project components of Nykcharong chu HEP are located in temperate forest and sub-alpine forest area.

11B/CI East Himalayan wet temperate forest (2000-3000 m): These are mixed evergreen forests with moderate size trees, occurring between 1800 and 3000 m elevation. In these forests important tree associates were: *Acer campbellii, Lithocarpus pachyphylla, Prunus cerasoides, Quercus serrata, Rhododendron arboreum, Schima wallichii* and *Tetracentron sinense*. Shrubs were represented by: *Berberis asiatica, Coriaria nepalensis, Elaeagnus parvifolia, Rosa brunonii, Rubus ellipticus* and *Viburnum erubescens*. Climber and epiphytes were not common.

12/C3a East Himalayan mixed coniferous forests (2000-3500 m): These are dense evergreen forests with dominance of oak and rhododendrons. Between 2300-3500 m elevations in the upper ridges, silver fir (*Abies densa*) makes appearance as a dominant tree species. However at lower elevations, other deciduous trees such as *Magnolia* sp., *Acer* sp., *Betula alnoides, Alnus nepalensis*, mixed with oak species, occur at varying extents. Gregarious undergrowth, usually of bamboo, and in its absence *Rhododendron* species and other evergreen shrubs such as *Berberis* sp., *Cotoneaster* sp., *Rhododendron* sp., *Salix* sp., *Thamnocalamus* sp. and *Viburnum* sp. also occur. The trees are mostly covered with many epiphytic mosses and lichens.

12/ISI Alder forest (1800-2200 m): These are typically seen as pure stands of *Alnus nepalensis* and *Populus ciliata*, with heights ranging from 20-30 m. They occur as a strip with varying width along stream sides, spreading out to larger areas, and more or less deciduous in nature. In the lower course of the stream and landslide affected areas, *Alnus* is the dominant formation. There is often an under growth of inedible/thorny shrubs comprising *Berberis, Rubus, Princepia* etc., whilst in the better wooded tracts, progression starts early and other species, notably blue pine and other conifers, are usually present.

12/1S2 Riverine blue-pine forest (1800-3000 m): These forests are characterized by irregular and often dense stands of blue pine with occasional *Picea*, *Tsuga, Populus* and *Alnus*, with little or no undergrowth.

14/2SI Sub-alpine blue-pine forest (3500-4000 m): These types of forest occurs at 3500-4000 m elevation, and are represented by pure stands of *Pinus wallichiana*. Towards higher elevation, Fir forests gradually replaces bluepine.

Plant Diversity

One hundred and fifty nine plant species belonging to different groups were recorded from the barrage and powerhouse sites, and the catchment area. A complete list of plant species found in the study area representing different groups such as tree, shrub, herb, climber, orchid, pteridophyte, bryophyte, lichen and fungi is presented in Appendix II 3.78. The number of plant species belonging to different groups is summarized in Table II. 3.273.

Table II. 3.273: Plants belonging to different groups recorded from the HEP sites

Sl. No.	Groups	Number of species		
		Barrage site	Powerhouse site	Catchment area
1	Tree	17	9	11
2	Shrub	14	15	13
3	Herb	38	31	29
4	Climbers	17		12
5	Orchids	10		4
6	Pteridophytes	13		10
7	Bryophytes	7		4
8	Lichens	11		7
9	Fungi	16	10	15

The trees in the project sites were covered with a variety of non-vascular plants such as epiphytes, lichens, mosses, and ferns. Seventeen tree, 14 shrub, and 38 herb species were recorded from the barrage site, while 9 tree, 15 shrub, and 31 herb species were recorded from the powerhouse site. In the catchment area, 11 tree, 13 shrub and 29 herb species were recorded. A total of 17 climber, 10 orchid, 13 pteridophyte,7 bryophyte, 11 lichen, and 16 fungi species were recorded from barrage and powerhouse site, whereas from the catchment area 12 climber, 4 orchid, 10 pteridophyte, 4 bryophyte, 7 lichen and 15 fungi species were recorded (Appendix II. 3.79 and 3.80).

Threatened and Endemic Plants

Two threatened species were recorded from this project site (Table II. 3.274).

Table II. 3.274: Threatened/endemic plants recorded at Nykcharong chu HEP site

Species name	Family	Threat status	References
Acer sikkimensis	Aceraceae	EN	Nayar and Sastry, (1987, 1988, 1990)
Panax bipinnatifidus	Araliaceae	VU	CAMP, 2003

EN = Endangered; VU = Vulnerable

Economically Important Species/Plant Resources

The study area is rich in plant resources. A few important species are listed in Table II. 3.275.

Table II. 3.275: Economically important species/plant resources present at HEP site

Sl. No.	Uses	Species name
1	Timber	*Populus ciliata, Betula alnoides, Pinus wallichiana, Magnolia campbelii*
2	Fuel	*Quercus griffithii, Q. semicarpifolia, Quercus lamellosa, Rhododendron* sp., *Rhododendron* sp., *Pinus wallichiana*
3	Ornamentals & orchids	*Rhododendron* sp.
4	Medicine and aromatics	*Panax* sp., *Paris polyphylla, Taxus wallichiana, Swertia chirayita, Drymaria cordata*
5	Fodder	*Alnus nepalensis, Quercus griffithii, Q. semicarpifolia, Quercus lamellosa, Rhododendron* sp.
6	Edible	*Elaeagnus* sp., *Zanthoxylum armatum, Rubus ellipticus, Prasiola* sp.
7	Fibre and paper	*Daphne papyracea*
8	Bamboos	*Arundinaria maling, Phyllostachys* sp.
9	Ornamentals & orchids	*Rhododendron* sp., *Sedum multicaule, Cymbidium* sp., *Hydrangea* sp., *Impatiens* sp., *Calanthe* sp.

Angiosperm and Gymnosperm Species Diversity

The plant community at barrage site, powerhouse and catchment area comprised of 22 tree, 18 shrub, and 47 herbaceous species (Tables II. 3.276-3.278).

Table II. 3.276: Tree species recorded near barrage and powerhouse sites, and in the catchment area at Nykcharong project

Tree species	
Acer campbellii	*Magnolia campbellii*
Acer sikkimensis	*Morus laevigatum*
Alangium alpinum	*Neolitsea* sp.
Alnus nepalensis	*Persea odoratissima*
Betula alnoides	*Quercus lamellosa*
Brassiopsis glomerulata	*Quercus semecarpifolia*
Eurya acuminata	*Rhododendron arboreum*
Fraxinus floribunda	*Rhododendron campanulatum*
Leucosceptrum canum	*Rhododendron maddeni*
Lindera neesiana	*Rhododendron* sp.
Lyonia ovalifolia	*Rhus acuminata*

Table II. 3.277: Shrub species recorded near barrage and powerhouse sites, and in the catchment area of Nykcharong chu project

Shrub species	
Artemesia nilagirica	*Ilex dipyrena*
Berberis aristrata	*Neillia thysiflora*
Berberis sp.	*Philadelphus tomentosus*
Coraria napalensis	*Pipthanthus nepalensis*
Daphnae papyracea	*Rosa* sp.
Eleagnus parviflora	*Rubus ellipticus*
Elsholtzia sp.	*Sarcococca* sp.

Girardinia grandiflora	*Spirea* sp.
Hypericum choisianum	*Zanthoxylum oxyphyllum*

Table II. 3.278: Herbaceous species recorded near barrage and powerhouse sites, and in catchment area at Nykcharong chu project

Herb species		
Ainsliaea sp.	*Elsholtzia stobilifera*	*Pilea umbrosa*
Anaphalis margaritacea	*Fragaria* sp.	*Plantago major*
Arisaema erubescens	*Galium rotundifolia*	*Pogonotherum* sp.
Arisaema nepenthoides	*Galium* sp.	*Pogostemon* sp.
Aster sp.	*Gentiana capitata*	*Potentilla cuneata*
Aster trinervius	*Geranium pratense*	*Roscoea alpina*
Astilbe rivularis	*Goldfusia nutans*	*Rumex acetosella*
Calanthe tricarinata	*Imperata cylindrica*	*Salvia* sp.
Codonopsis gracilis	*Iris lactea*	*Sambucus adnata*
Crawfurdia speciosa	*Nepata* sp.	*Phlomis* sp.
Cynoglossum sp.	*Ophiopogon intermedius*	*Senecio cappa*
Cyathula capitata	*Opliomenus* sp.	*Thalictrium foliosum*
Dicrosocephala sp.	*Panax bipinnatifidus*	*Trifolium repens*
Dipsacus aspera	*Paris polyphylla*	*Urtica dioca*
Dracocephalum sp.	*Parasenecio quinquelobus*	*Viola sikkimensis*
Elatostemma sessile	*Persicaria runcinata*	

The number of tree species varied from 9 to 17, and the shrub species from 13 to 15 in the three sites. Herbaceous species richness showed wide variation i.e., from 35 species in the barrage site during rainy season to 16 species in the catchment area during winter season. It displayed distinct seasonal variation in all the three sites with maximum species recorded during monsoon season and minimum during winter season. Among tree species, *Alnus nepalensis* in barrage site, *Quercus lamellosa* in powerhouse site and *Alnus nepalensis* in the catchment areas, were dominant. *Daphne papyracea* was dominant among the shrubs in barrage and powerhouse sites, while *Berberis aristrata* was dominant in the catchment area. Unlike trees and shrubs, in a given season different herbaceous species were dominant in different sites (Appendix II. 3.90).

Tree density was highest in the barrage site, and lowest in the powerhouse site. Shrub density was highest in the barrage site, and lowest in catchment area (Table II. 3.279). Highest density of herbaceous species was recorded during monsoon season in the barrage site, and lowest during winter season in the powerhouse site. But in all the three places, it was maximum during rainy season and minimum during winter months. Shannon diversity for tree species was highest for the barrage sites (H'= 2.63), followed by catchment area (2.29) and powerhouse site (1.99). For shrub species, highest value (H'=2.42) was obtained for powerhouse, followed by catchment area (2.26) and barrage site (1.83) (Table II. 3.279). For herbaceous species, the highest diversity value (H'= 3.15) was obtained for the barrage site during monsoon season, and lowest (H'= 2.46) for the catchment areas during winter season. In all the three sites, diversity of herbaceous species peaked during monsoon season and attained lowest value during winter season (Table II. 3.280) (Appendix II.3.81- 3.89). Tree diversity was highest near the barrage site, and shrubs & herbs showed greater diversity in the powerhouse and barrage area respectively.

Table II. 3.279: Species richness, diversity and dominance of trees and shrubs, and biomass and carbon stock of trees in Nykcharong chu project site

Parameters	**Barrage**		**Powerhouse**		**Catchment areas**	
	Trees	**Shrubs**	**Trees**	**Shrubs**	**Trees**	**Shrubs**
Number of species	17	15	9	15	11	13
Density (ha^{-1})	1120	17056	440	8784	690	7008
Simpson index of dominance	0.09	0.72	0.16	0.89	0.11	0.87
Shannon index of diversity (H')	2.63	1.83	1.99	2.42	2.29	2.26
Evenness index	0.93	0.41	0.91	0.75	0.95	0.74
Biomass (t/ha)	86.38		41.87		66.94	
Carbon (t/ha)	43.19		20.93		33.47	

Table II. 3.280: Species richness, diversity and dominance of herbaceous species in Nykcharong chu project site

Parameters	Barrage			Powerhouse			Catchment areas		
	PM	M	W	PM	M	W	PM	M	W
Number of species	25	35	18	24	28	17	23	27	16
Density (ha^{-1})x10^3	293	572	211	300	499	185	314	425	238
Simpson index of dominance	0.91	0.94	0.90	0.92	0.93	0.90	0.91	0.93	0.90
Shannon index of diversity (H')	2.73	3.15	2.56	2.74	2.94	2.55	2.71	2.94	2.46
Evenness index	0.61	0.67	0.72	0.64	0.68	0.75	0.65	0.70	0.73

PM: Post-monsoon; M: Monsoon; W: Winter

Phytoplankton/Periphyton

A total of about 15 species of phytoplankton/periphyton were recorded from Nyukcharong chu project site. The phytoplankton/periphyton community was represented by one species of Cyanobacteria, 13 species of Bacillariophyceae, and one species of Chlorophyceae. Species richness was highest in the project affected area with 11 species, and minimum with 8 species in the catchment area. Phytoplankton/periphyton density was highest in the project affected area (155 individuals/l), and lowest in the catchment area (95 individuals/l). Similarly, species diversity index was maximum (H'= 2.14) in the project affected area and minimum (H'= 2.03) in the catchment area (Table II. 3.281).

Table II. 3.281: Density (Individuals/l), species richness and Shannon index of diversity (H') of phytoplankton community in river water at project affected area and catchment area of Nykcharong chu project sites

List of species	Project affected area	Catchment area
Cyanobacteria		
Oscillatoria sp.	5	
Bacillariophyceae		
Achnanthidium pyrenaicium	10	10
Achnanthidium rivulare	15	15
Amphora sp.	10	10
Caloneis ventricosa	5	
Cymbella tumida	10	5
*Didymo*sp.*henia germinata*		
Encyonema minutum	25	10
Encyonema proslatum		
Fragillaria		
Gomphonema olivaceoides	5	
*Rhoico*sp.*haenia* sp.	15	15
Synedra ulna		
Thallassiosira sp.	10	15
Chlorophyceae		
Spirogyra	45	10
Total density (Individuals/lit)	**155**	**90**
Species diversity index	**2.14**	**2.03**
Species richness	**11**	**8**

NB: Blank cells indicate absence of phytoplankton specie

Zooplankton

Only 1 species of zooplankton i.e. *Karualona karua* belonging to Cladocera and 2 species i.e., *Lecane papuana* and *Lepadella acuminata* of Rotifera were recorded during monsoon season (Table II. 3.282).

Table II. 3.282: Occurrence of species belonging to Cladocera and Rotifera during monsoon and winter seasons in Nykcharong chu project site

Sl. No.	Taxa	Species	Season	
			Monsoon	Winter
1	Cladocera	*Karualona karua* (King, 1853)	+	–
2	Rotifera	*Lecane papuana* (Murray, 1913)	+	–
3	Rotifera	*Lepadella acuminata* (Ehrenberg, 1834)	+	–
Total	**2**	**3**	**3**	**0**

Fish Fauna

No fish species was recorded from Nykcharong chu project sites.

Soil Fauna

The seasonal variation in soil faunal diversity (Collembola, Acarina and other arthropods) and equitability in litter and soil layer is presented in Tables II. 3.293-3.285.

Table II. 3.283: Seasonal variation in soil faunal diversity (Collembola, Acarina and other arthropods) and equitability in litter and soil layer at Nykcharong chu project site

Soil fauna	Diversity	Post monsoon				Monsoon				Winter			
		Barrage		Powerhouse		Barrage		Powerhouse		Barrage		Powerhouse	
		Litter	Soil	Litter	Soil	Litter	Soil	Litter	Soil	Litter	Soil	Litter	Soil
Collembola	Dominance_D	0.30	0.22	0.17	0.33	0.17	0.14	0.17	0.22	0.18	0.16	0.21	0.18
	Shannon_H	1.28	1.55	1.85	1.24	1.91	2.01	1.86	1.65	1.75	1.96	1.68	1.75
	Evenness_e^H/S	0.90	0.94	0.91	0.87	0.84	0.94	0.91	0.87	0.96	0.88	0.89	0.96
Acarina	Dominance_D	0.19	0.22	0.17	0.19	0.18	0.16	0.14	0.12	0.56	0.50	0.33	0.50
	Shannon_H	1.71	1.55	1.84	1.74	1.74	1.90	2.04	2.17	0.64	0.69	1.10	0.69
	Evenness_e^H/S	0.93	0.94	0.90	0.94	0.95	0.95	0.96	0.97	0.94	1.00	1.00	1.00
Other Arthropods	Dominance_D	0.27	0.19	0.19	0.25	0.12	0.13	0.15	0.17	0.33	0.56	0.56	0.22
	Shannon_H	1.48	1.72	1.73	1.39	2.22	2.11	2.00	1.83	1.10	0.64	0.64	1.56
	Evenness_e^H/S	0.87	0.93	0.94	1.00	0.92	0.91	0.92	0.89	1.00	0.94	0.94	0.95

Table II. 3.284: Mean annual density (number/m^2) of soil fauna in litter and soil layer (0-5 cm) in Nykcharong chu project site

Soil fauna	Site	Litter layer	Soil layer	Total
Collembola	Barrage	1673	1491	**3164**
	Powerhouse	1455	945	**2400**
Acarina	Barrage	1000	686	**1686**
	Powerhouse	1029	743	**1771**
Other Arthropods	Barrage	1345	1382	**2727**
	Powerhouse	800	873	**1673**
Total fauna	**Barrage**	**4018**	**3559**	**7577**
	Powerhouse	**3284**	**2561**	**5844**

Table II. 3.285: Seasonal variation of soil fauna density (number/m^2) in barrage and powerhouse site of Nykcharong chu project area

Soil fauna	Site	Post monsoon	Monsoon	Winter	Mean
Collembola	Barrage	6800	18000	10000	**11600**
		6800	15600	8200	**10200**
Acarina	Barrage	8800	12800	2000	**7867**
		9200	12600	2400	**8067**
Other arthropods	Barrage	7200	20400	2400	**10000**
		6000	14800	3400	**8067**

Wildlife

Butterflies: Eighteen species of butterflies belonging to 15 genera and five families were found in the project area. The family Nymphalidae was the dominant, and was represented by 7 species. No threatened species was recorded from the project area (Table II. 3.286).

Table II. 3.286: Butterflies recorded in Nykcharong chu HEP area

Sl. No.	Family common name	Scientific name	Project area
I.	**Papilionidae**		
1	Common Peacock	*Papilio polyctor ganesa*	*
2	Paris Peacock	*Papilio paris paris*	*
3	Golden Birdwing	*Troides aeacus aeacus*	*
4	Common Bluebottle	*Graphium sarpedon sarpedon*	*
5	Indian Purple Emperor	*Mimathyma ambica*	*
II.	**Pieridae**		
6	Dark Jezebel	*Delias berinda*	*
7	Indian Cabbage White	*Pieris canidia indica*	*
8	Green vein White	*Pieris melete*	*
III.	**Lycaenidae**		
9	Peablue	*Lampides boeticus*	*
10	Green Sapphire	*Heliophorus moore*	*
11	Common Flash	*Rapala nissa ratna*	*

IV	**Nymphalidae**		
12	Chestnut Tiger	*Parantica sita*	*
13	Eastern Comma	*Polygonia egea*	*
14	Large Silverstripe	*Argynnis children*	*
15	Glassy Tiger	*Graphium cloanthus*	*
16	Chocolate Pansy	*Junonia iphita iphita*	*
17	Banded Treebrown	*Lethe confusa*	*
18	Straight-banded Treebrown	*Lethe verma*	*

Herpetofauna: Since no herpetofauna was sighted during the survey, the probable list of amphibians and reptiles was prepared following Ahmed *et al.* (2009) (Appendix II. 3.167).

Birds: One hundred and six species of birds belonging to 68 genera and 32 families were recorded from the project area. Shannon diversity of 3.9 signifies moderate species diversity. Species richness was higher during winter (57 species) followed by monsoon and post monsoon, while abundance of birds was high in monsoon (Table II. 3.287).

Migratory status: Most of the birds were residents (73 species) followed by 17 breeding visitors and 15 winter visitors (Table II. 3.287).

Table II. 3.287: Status of birds recorded in the Nykcharong chu HEP area

Details	Post monsoon	Monsoon	Winter	Overall
Family	18	22	27	32
Genera	27	35	41	68
Species	34	53	57	106
Abundance	515	566	311	1392
Diversity H'	3.3	3.1	3.5	3.9
Migratory status				
Breeding visitor	4	9	6	17
Isolated record	0	0	1	1
Resident	26	36	43	73
Winter visitor	4	8	7	15

Abundance status: The abundance status of birds was derived by classifying the abundance of bird species into five abundance category (Very Low = 1-25 birds, Low = 26-50, Moderate = 51-75, High = 76-100 and Very High = > 100birds). The details of abundance status are given in the Table II. 3.288.

Table II. 3.288: Number of species and relative % of birds in different abundance classes

Abundance class	No. of species	Relative %
Very low-1-25 birds	91	85.8
Low-26-50 birds	9	8.5
Moderate-50-75 birds	3	2.8
High-76-100 birds	1	0.9
Very high > 100 birds	2	1.9
Total	**106**	**100.0**

Status of foraging guilds: The foraging guild of birds in the Nykcharong chu was represented by seven guilds, with insectivores being the most dominant with 80 species. Among the other guilds, omnivores were represnted by 11 species, while rest of the guilds were poorly represented. The high richness of insectivores revealed the presence of diverse habitat and niches in this project site (Table II. 3.289 and Appendix II. 3.187).

Table II. 3.289: Status of foraging guild of birds recorded in Nykcharong chu HEP area

Foraging guild	Post monsoon	Monsoon	Winter	Overall
Aquatic feeder	1	0	0	1
Carnivore	0	2	1	3
Frugivore	0	0	1	0
Granivore	1	2	2	4
Insectivore	24	40	46	80
Nectarivore	2	4	4	6
Nucivore	0	0	1	1
Omnivore	6	5	2	11
Piscivore	0	0	0	0

Status of threatened species: No threatened bird species was recorded within the project site (Appendix II. 3.187).

Mammals: Field surveys in and around the Nykcharong chu project site revealed the presence of 13 mammalian faunal species belonging to nine families, and each species fell under separate genus. Amongst all, carnivore group was dominated with five species followed by four species of rodents, three species of ungulates and one primate (Appendix II. 3.188).

Abundance status: Out of 13 species, only six species were reported based on direct sighting of 14 animals, while presence of seven species were confirmed based on the indirect evidences with a total record of 41 evidences. Barking Deer *(Muntiacus muntjak),* Himalayan goral (*Naemorhedus goral),* Yellow Throated Martin (*Martes flavigula)* and 3 species of squirrel (Orange-Bellied Himalayan Squirrel-*Dremomys lokriah,* Hoary-bellied Himalayan Squirrel-*Callosciurus pygerythrus* and *Himalayan Stripped Squirrel-Tamipos macclellandi)* were the six species, which were represented by only few animals. Rest of the five species were found with the range of one to three animals. The sightings of very few animals clearly indicates the low abundance of mammalian fauna (Table II. 3.290) and the status of species richness of the project area could be of moderate level (44.82%), when compared with the possible list of mammalian fauna (29 species) of the Tawang region, reported by Mishra *et al.* 2006 (Appendix II. 3.188).

Status of threatened species: Among the 13 species, Arunachal Macaque (*Macaca munzala)* and Dhole (*Cuon alpines)* are categorized as Endangered by IUCN. Though Himalayan goral (*Naemorhedus goral)* and Common leopard *(Panthera pardus)* fall under Near Threatened (NT) category of IUCN, they have been scheduled under III and I (endangered) as per the WPA, 1972 (Table II. 3.290). However, none of these species have been reported based on the direct sighting.

Table II. 3.290: Status of mammalian fauna recorded in the Nykcharong chu HEP area

Sl. No.	Common name	Scientific name	Seasons			Overall	Conservation status	
			PM	M	W		IUCN	WPA
I.	**Cercopithecidae**							
1	Arunachal Macaque	*Macaca munzala*		IE-1		IE1	EN	-
II	**Cervidae**							
2	Barking Deer	*Muntiacus muntjak*	IE-2	A-4	IE 8	IE 10 A4	LC	III
III.	**Bovidae**							
3	Himalayan goral	*Naemorhedus goral*	IE-4 A-1		IE 2	IE 6 A 1	NT	III
IV.	**Suidae**							
4	Wild pig	*Sus scrofa*	IE-2	IE-2	IE 7	IE 11	LC	III
V.	**Canidae**							
5	Asiatic wild dog or Dhole	*Cuon alpines*	IE-2			IE 2	EN	II
VI.	**Felidae**							
6	Jungle cat	*Felis chaus*	IE-3		IE 3	IE 6	LC	II
7	Leopard Cat	*Prionailurus bengalensis*	IE 1			IE 1	LC	-
8	Common Leopard	*Panthera pardus*	IE-1			IE 1	NT	I
VII.	**Mustelidae**							
9	Yellow Throated Martin	*Martes flavigula*	A 2			A 2	LC	II
VIII.	**Sciuridae**							
10	Orange-Bellied Himalayan Squirrel	*Dremomys lokriah*		A-1		A 1	LC	NE
11	Hoary-bellied Himalayan Squirrel	*Callosciurus pygerythrus*	A1	A-1	A 1	A 3	LC	NE
12	Himalayan Stripped Squirrel	*Tamipos macclellandi*		A-1	A 2	A 3	LC	NE
IX.	**Hystricidae**							
13	Indian Porcupine	*Hystrix indica*		IE1	IE 2	IE 3	LC	IV
	No of species		**9**	**7**	**7**	**13**		
	Total and types of records		**IE 15 A 4**	**IE 4 A 7**	**IE 22 A 3**	**IE 41 A 14**		

IE – Indirect Evidences A-animals sighted, W-Winter, PM-Post monsoon, M-Monsoon, IUCN-Red List, WPA-Wildlife Protection Act, EN-Endangered, NT-Near threatened, LC-Least Concern, NE – Not Evaluated

Faunal status within 500 m of project affected area: This section revealed the species richness status of selected faunal groups such as avifauna and mammal species reported within 500 m up and down streams of the barrage and powerhouse sites of the proposed project area. The species richness reported in these specific sites was evaluated based on subjective rating through estimating percent contribution with the overall species list of the project area. If the species richness of barrage and powerhouse contributes 25% of overall list it was categorised as low, > 25-50% as medium, >50-75% as high and above 75% as high species richness.

Status of avifauna: In the barrage site, 31 species of birds were recorded that belonged to 22 genera and 16 families., which is about 28.30% of the total 106 species recorded in the overall project area. The species richness of the barrage site was slightly towards lower side of medium category and none of them were under threatened category (Appendix II. 3.189 and 3.190).

Status of mammals: From the barrage site six species were reported based on 15 indirect evidences, while from the powerhouse site five species were reported. Conservation status of these species showed that Common Leopard (*Panthera pardus*) is classified under Near threatened in the IUCN Red List and under Schedule I category in Wildlife Protection Act (1972). Dhole (*Cuon alpines*) belongs to Endangered category of IUCN and Schedule II of Wildlife Protection Act (1972) (Table II. 3.291). Evidences of both were present within 0.5 km from the barrage site and not in the powerhouse site. Overall the barrage and powerhouse sites of Nykcharong chu project did not have any mammalian fauna of high conservation significance.

Table II. 3.291: Status of mammalian fauna in the barrage and powerhouse sites of the proposed Nykcharong chu HEP area

Sl. No.	Species	Common name	Status		Conservation status	
			BS	PHS	IUCN	WPA
1	Wild pig	*Sus scrofa*	IE 4	IE2	LC	III
2	Jungle cat	*Felis chaus*	IE 1	IE 1	LC	II
3	Himalayan goral	*Naemorhedus goral*	IE 6	IE 2	NT	III
4	Barking Deer	*Muntiacus muntjak*	IE 2		LC	III
5	Common Leopard	*Panthera pardus*	IE 1		NT	I
6	Asiatic wild dog or Dhole	*Cuon alpines*	IE 2		EN	II
7	Hoary-bellied Himalayan Squirrel	*Callosciurus pygerythrus*		A 2	LC	NE
8	*Himalayan Stripped Squirrel*	*Tamipos macclellandi*		A 2	LC	NE
	Total records		**IE 15**	**IE 5, A 4**		

IE – Indirect Evidences, A – No of Animals Sighted, BS-Barrage Site, PHS – Powerhouse Site

3.3.7.3 SOCIO–ECONOMIC PROFILE

The results of socio–economic baseline survey for Nykcharong chu have been described separately for data gathered at the village and the HH level.

Village Level Survey

Profile of the Ten Surveyed Villages: From Table II. 3.292, it is seen that Rho and Jangda are affected villages and the remaining eight villages fall within influence zone of the Project. The ten villages fall under four administrative circles of Thingbu, Lhau, Jang, and Mukto. The distance of the ten villages from the river varies from 2–20 km. Seven villages are situated within a distance of 10 km from the river. The circle headquarters of the ten villages are within 15 km. Except for three villages Rho, Jangda and Thingbu which are situated more than 90 km from the district headquarters, the remaining seven are situated within 45 km.

Table II. 3.292: Profile of the ten surveyed villages

Sl. No.	Village	Circle	Distance of village (in km)			Category of village
			River/ Tributary	Circle HQ	District HQ	
1	Rho	Thingbu	8	5	99.6	Affected
2	Jangda	Lhau	7	15	90	Affected
3	Thingbu	Thingbu	20	1	151	Influenced
4	Yuthembu	Jang	2.5	1	45	Influenced
5	Kharsa	Jang	2	1	45	Influenced
6	Shyaro	Lhau	5	7	30	Influenced

7	Gemreteng	Lhau	2	4	24	Influenced
8	Regyang	Lhau	2	3	23	Influenced
9	Kregyang	Lhau	2	2	22	Influenced
10	Mirba	Mukto	3	10	55	Influenced

Private Landuse Pattern: The details of private land holdings (in hectares) of the nine villages (data for Kharsa not available) is given in Table II. 3.293. The total private land holdings in the studied villages are about 572.11 ha. Four villages, namely, Rho, Jangda, Thingbu, and Yuthembu contribute 84% to the total land holdings in studied villages. In all the villages, the proportion of agricultural land exceeds that of the other land use types. Private forest land also contributes significantly (34%) to the total land holdings of the villages.

Table II. 3.293: Private land use pattern and their percentage to total private land

Sl. No.	Name of village	Total private land (ha)	Forest cover (ha)	%	Agriculture (ha)	%	Horticulture (ha)	%	Habitation and HG (ha)	%
1	Rho	160.00	58	36	66	41	0	–	36	23
2	Jangda	120.00	45	38	57	48	0	–	18	15
3	Thingbu	60.00	10	17	44	73	0	–	6	10
4	Yuthembu	137.00	53	39	62	45	0	–	22	16
5	Kharsa	–	–	–	–	–	–	–	–	–
6	Shyaro	34.26	13	38	16.78	49	0	–	4.48	13
7	Gemreteng	1.70	0	0	1.7	100	0	–	0	0
8	Regyang	16.85	2.75	16	8.9	53	0	–	5.2	31
9	Kregyang	11.80	2.2	19	6	51	0	–	3.6	31
10	Mirba	30.50	12	39	18	59	0	–	0.5	2
	Total*	**572.11**	**195.95**	**34**	**280.38**	**49**	**0**	**–**	**95.78**	**17**

* Excluding Kharsa due to non availability of data

Demography and Literacy Rate: From Table II. 3.294, the following main features emerges. The total number of HHs in the ten villages is 590. The total population is 2614 (1311 males; 1300 females). In Jangda, Yuthembu and Kharsa the number of females are more than that of the males and in six villages the reverse is true. The literacy rate in seven studied villages is less than 50%. In three villages the rate is more than 50 %. Jangda has the least number of literates (30%). Among males it varies from 30% in Jangda to 70.8% in Yuthembu and in females it varies from 23% in Rho to 80% in Gemreteng. It is highly noteworthy that in Jangda and Gemreteng the literacy rate among females is considerably higher compare to the males.

Table II. 3.294: Demography and literacy rate

Sl. No.	Village	Demography					Literacy rate*		
		Total	Male	Female	Sex ratio (Per 1000 males)	No. of HH	Male	Female	Total
1	Rho	286	150	136	907	85	58.0	23.0	**45.0**
2	Jangda	525	249	276	1108	99	30.0	41.0	**30.0**
3	Thingbu	256	129	127	984	52	46.0	27.0	**39.0**
4	Yuthembu	369	182	187	1027	98	70.8	52.5	**63.6**
5	Kharsa	468	229	239	1044	107	44.6	37.7	**41.7**
6	Shyaro	305	159	146	918	56	42.6	38.3	**41.4**
7	Gemreteng	39	23	16	696	9	42.9	80.0	**58.3**
8	Regyang	116	58	58	1000	26	57.6	47.9	**55.0**
9	Kregyang	84	43	38	884	18	40.0	26.5	**31.1**
10	Mirba	166	89	77	865	40	43.7	33.3	**39.4**
	Total	**2614**	**1311**	**1300**	–	**590**	–	–	–

Number of Livestock: The details of livestock holding in the nine villages are given in Table II. 3.295. Altogether, 9 different types of animals are domesticated in nine surveyed villages. None of the villages owned all the nine animal types. In total, 3808 animals are reared in the nine villages. Considerable inter–village variation is observed in total number of animals reared. It varied from 20 in Gemreteng to 1021 animals in Jangda. Jangda alone accounts for 27% of all the animals found in the surveyed village. Three animals, viz., cattle (42%), Yak (28%) and sheep (16%) account for 86% of the total animals. 44% of the HHs did not own any animals, whereas 30% HHs owned more than 10 animals.

Table II. 3.295: Number of livestock

Sl. No.	Village	Mithun	Cattle	Yak	Goat	Sheep	Pig	Pony	Poultry	Others	Total
1	Rho	0	255	49	68	85	14	6	7	3	**487**
2	Jangda	0	395	114	37	364	72	10	28	1	**1021**
3	Thingbu	0	0	529	0	100	0	179	9	0	**817**
4	Yuthembu	10	413	224	2	10	0	0	0	0	**659**
5	Kharsa	0	0	0	0	0	0	0	0	0	**0**
6	Shyaro	0	357	69	0	2	29	50	2	0	**509**
7	Gemreteng	0	20	0	0	0	0	0	0	0	**20**
8	Regyang	0	26	0	0	0	0	0	0	0	**26**
9	Kregyang	0	27	0	0	60	0	0	0	0	**87**
10	Mirba	0	103	67	5	0	0	7	0	0	**182**
	Total	**10**	**1596**	**1052**	**112**	**621**	**115**	**252**	**46**	**4**	**3808**

* Excluding Kharsa due to non availability of data

Total Estimated Value of Livestock: The monetary value of animals maintained by the inhabitants of the studied villages has been estimated separately for each animal and for each village (Table II. 3.296). The selling price of different animals was obtained from the knowledgeable person in the respective village. The detailed methodology used has been described in the methodology section of the report. As expected, there is considerable intra and inter village variation in this respect. The value of total animals numbering 3808 found in the ten villages is estimated to be 796.41 lakhs. The value varied from 5.0 lakhs in Gemreteng to 179.47 lakhs in Thingbu. In terms of relative contribution made by different animals to the total value, cattle and Yak together contribute over 662 lakhs (83%).

Table II. 3.296: Total estimated value of livestock

Sl. No.	Village	Total estimated value (Lakhs.)									
		Mithun	Cattle	Yak	Goat	Sheep	Pig	Pony	Poultry	Others	Total
1	Rho	0.00	63.75	12.25	3.40	5.10	3.50	1.38	0.04	0.45	**89.87**
2	Jangda	0.00	98.75	28.50	1.85	21.84	18.00	2.30	0.14	0.15	**171.53**
3	Thingbu	0.00	0.00	132.25	0.00	6.00	0.00	41.17	0.05	0.00	**179.47**
4	Yuthembu	4.00	103.25	56.00	0.10	0.60	0.00	0.00	0.00	0.00	**163.95**
5	Kharsa	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
6	Shyaro	0.00	89.25	17.25	0.00	0.12	7.25	11.50	0.01	0.00	**125.38**
7	Gemreteng	0.00	5.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**5.00**
8	Regyang	0.00	6.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**6.50**
9	Kregyang	0.00	6.75	0.00	0.00	3.60	0.00	0.00	0.00	0.00	**10.35**
10	Mirba	0.00	25.75	16.75	0.25	0.00	0.00	1.61	0.00	0.00	**44.36**
	Total	**4.00**	**399.00**	**263.00**	**5.6**	**37.26**	**28.75**	**57.96**	**0.24**	**0.60**	**796.41**

Average Annual Earnings of the Village: The average annual family income varies from 0.74 in lakhs in Kharsa to 5.53 lakhs in Thingbu (Table II. 3.297). The value of total earnings per year in the villages is estimated 1521.19 lakhs. The contribution made by animal husbandry compared to the other resources, to the total earnings, is maximum in all the villages. Of the total annual earnings, animal husbandry contributes 939.16 lakhs (62%). Traditional skills, in particular weaving and daily wage labour together contribute over 28%. It is highly noteworthy that agriculture contributes only 9% of the total annual village earnings.

Table II. 3.297: Average annual earning of the village

Sl. No.	Village	Total earning/year (Lakhs)								Average Family income (Rs.in lakh)
		Agriculture	Animal Husbandry	Horticulture	Traditional Skills	Daily Wages	GS	Others*	Total	
1	Rho	33.00	105.19	0.00	25.00	34.43	9.00	6.30	**212.92**	2.50
2	Jangda	28.50	220.54	0.00	39.75	40.10	14.94	10.46	**354.28**	3.58
3	Thingbu	22.00	176.47	0.00	55.00	21.06	7.74	5.42	**287.69**	5.53
4	Yuthembu	31.00	142.34	0.00	5.75	39.69	10.92	7.64	**237.35**	2.42
5	Kharsa	0.00	0.00	0.00	12.50	43.34	13.74	9.62	**79.19**	0.74
6	Shyaro	8.39	109.94	0.00	30.00	22.68	9.54	6.68	**187.23**	3.34
7	Gemreteng	0.85	4.32	0.00	1.25	3.65	1.38	0.97	**12.41**	1.38
8	Regyang	4.45	5.62	0.00	-	10.53	3.48	2.44	**26.51**	1.02
9	Kregyang	3.00	18.79	0.00	1.25	7.29	2.58	1.81	**34.72**	1.93
10	Mirba	9.00	39.31	0.00	15.30	16.20	5.34	3.74	**88.89**	2.22
	Total	**140.19**	**939.16**	**0**	**185.80**	**238.97**	**78.66**	**55.08**	**1521.19**	**24.66**

* Other includes artisans, monks, self–employed contractors etc.

Average Annual Expenditure Pattern of a Family: The average annual family expenditure in the surveyed villages varies from 1.10 lakhs in Gemreteng to 1.58 lakhs in Rho. In all the villages, the maximum expenditure is incurred on health and education followed by transport and clothing. In general, expenditure incurred on food and drinks is less than any other expenditures (Table II. 3.298).

Table II. 3.298: Average annual expenditure pattern of a family in village

Sl. No.	Village	Expenditure/year (Rupees in lakh)				
		Food and drinks	**Clothing**	**Transport**	**Education and health**	**Total**
1	Rho	0.35	0.35	0.40	0.48	**1.58**
2	Jangda	0.30	0.35	0.40	0.48	**1.53**
3	Thingbu	0.30	0.35	0.40	0.48	**1.53**
4	Yuthembu	0.30	0.30	0.40	0.45	**1.45**
5	Kharsa	0.30	0.30	0.30	0.30	**1.20**
6	Shyro	0.30	0.35	0.40	0.48	**1.53**
7	Gemreteng	0.20	0.30	0.25	0.35	**1.10**
8	Regyang	0.30	0.30	0.36	0.36	**1.32**
9	Kregyang	0.30	0.30	0.36	0.36	**1.32**
10	Mirba	0.35	0.35	0.27	0.30	**1.27**
	Total	**3.00**	**3.25**	**3.54**	**4.04**	**13.83**

Water Sources: The data pertaining to water resources available and their pattern of use in the surveyed villages is presented in Table II. 3.299. The Table II. 3.299 reveals that there are four types of water resources, namely, river, hill stream/springs, pond and tap water available in the studied villages. Except in Shyro, water from hill stream/spring(s) in studied villages is used for domestic purposes as well as for the domestic animals. Tap water is used for domestic purposes and for domestic animals in all surveyed villages. In Shyro and Gemreteng pond water is also used and in Mirba river water is also used.

Table II. 3.299: Water sources in the village

Sl.. No.	Village	River				Hill streams/hill stream/spring				Wells				Ponds				Tap Water			
		Drinking water	**Domestic use**	**Livestock use**	**Agriculture**	**Drinking water**	**Domestic use**	**Livestock use**	**Agriculture**	**Drinking water**	**Domestic use**	**Livestock use**	**Agriculture**	**Drinking water**	**Domestic use**	**Livestock use**	**Agriculture**	**Drinking water**	**Domestic use**	**Livestock use**	**Agriculture**
1	Rho					1	1	1										1	1		
2	Jangda					1	1	1										1	1		
3	Thingbu					1	1	1										1	1		
4	Yuthembu					1	1	1										1	1		
5	Kharsa					1	1	1										1	1		
6	Shyro													1	1	1		1	1	1	
7	Gemreteng					1	1	1						1	1	1		1	1	1	
8	Regyang					1	1	1										1	1	1	
9	Kregyang					1	1	1										1	1	1	
10	Mirba	1		1		1	1	1										1	1		
	Total	**1**	**0**	**1**	**0**	**9**	**9**	**9**	**0**	**0**	**0**	**0**	**0**	**2**	**2**	**2**	**0**	**10**	**10**	**4**	**0**

Amenities in the Villages: Data presented in Table II. 3.300 revealed that in Yuthembu and Kharsa villages, except for traditional health healer, all the remaining 11 amenities as listed in the Table II. 3.300 were present. In Gemreteng, Regyang and Kregyang the least number of amenities (4 of 12) are observed. All the villages have motorable road, electricity and TV/radio. Traditional health healers are not found in any one of the studied villages.

Table II. 3.300: Amenities in the villages

Sl. No.	Village	Road connectivity	Health facility (PHC/sub-centre)	Traditional health healer	Veterinary services	Electricity	Fair price shop	Grocery shop	Post office	Bank	School	Telephone/Mobile	TV/Radios
1	Rho	√	√		√	√					√	√	√
2	Jangda	√				√					√	√	√
3	Thingbu	√	√		√	√					√		√
4	Yuthembu	√	√		√	√	√	√	√	√	√	√	√
5	Kharsa	√	√		√	√	√	√	√	√	√	√	√
6	Shyaro	√				√					√	√	√
7	Gemreteng	√				√						√	√
8	Regyang	√				√						√	√
9	Kregyang	√				√						√	√
10	Mirba	√				√	√	√			√	√	√
	Total	**10**	**4**	**0**	**4**	**10**	**3**	**3**	**2**	**2**	**7**	**9**	**10**

NB: Blank indicates absent

Social Institutions: In none of the ten villages all the four social institution listed in Table II. 3.301 are present. Eight villages have community hall, seven villages have Anganwadi and Gompa. SHGs are absent in all the villages.

Table II. 3.301: Social institutions in the village

Sl. No.	Village	SHGs	Anganwadi	Community hall	Gompa	Any other	Total
1	Rho			√	√	√	3
2	Jangda		√	√	√		3
3	Thingbu		√	√	√		3
4	Yuthembu		√		√	√	3
5	Kharsa		√	√	√	√	4
6	Shyaro		√	√	√	√	4
7	Gemreteng						0
8	Regyang		√	√			2
9	Kregyang		√	√			2
10	Mirba			√	√		2
	Total	**0**	**7**	**8**	**7**	**4**	**–**

NB: Blank indicates absent

Occupation Profile: In Table II. 3.302, work force participation in ten villages has been presented. The total working population in the studied villages comprises of 1901 (46%) of total population. Of the total workers main workers are 88% while marginal workers are 12%.

Table II. 3.302: Occupation profile of the village

Sl. No.	Village	Population			Workers			Main Workers			Marginal Workers			Non Workers		
		T	M	F	T	M	F	T	M	F	T	M	F	T	M	F
1	Rho	652	403	249	21	8	13	10	7	3	11	1	10	16	4	12
2	Jangda	682	406	276	458	289	169	320	252	68	138	37	101	224	117	107
3	Thingbu	363	225	138	235	161	74	234	161	73	1	0	1	128	64	64
4	Yuthembu	1363	828	535	899	629	270	867	605	262	32	24	8	693	310	383
5	Kharsa	132	72	60	70	33	37	54	26	28	16	7	9	45	13	32
6	Shyaro	636	448	188	62	35	27	35	20	15	27	15	12	61	25	36
7	Gemreteng	24	14	10	129	62	67	128	62	66	1	0	1	133	75	58
8	Regyang	180	132	48	21	10	11	21	10	11	0	0	0	19	10	9
9	Kregyang	74	25	49	6	3	3	4	2	2	2	1	1	6	2	4
	Total	**4106**	**2553**	**1553**	**1901**	**1230**	**671**	**1673**	**1145**	**528**	**228**	**85**	**143**	**1325**	**620**	**705**

* Data for Mirba was not available.

Household Level Survey

Age of the Head of the Household: Data presented in Tables II. 3.303 and 3.304 in respect of age of head of the HHs in ten surveyed villages revealed that the age of head of HHs across the three surveyed villages varied from 16 in Kregyang to 99 years in Thingbu. The age of 36% of heads is over 50 years and 12% of heads age was below 30 years. Considerable variation is observed average age of heads of HH between villages. It varied from 43 to 55 (Table II. 3.304).

Table II. 3.303: Distribution of head of the HHs by age across the ten project villages

Sl. No.	Village	Up to 30		31–40		41–50		> 50		Total	
		n	%	n	%	n	%	n	%	n	%
1	Gemreteng	0	0	2	22	4	44	3	33	9	**100**
2	Jangda	7	7	19	19	31	31	42	42	99	**100**
3	Kharsa	18	17	26	24	24	22	39	36	107	**100**
4	Kregyang	3	17	4	22	5	28	6	33	18	**100**
5	Mirba	4	10	13	33	13	33	10	25	40	**100**
6	Rengyang	5	19	3	12	10	38	8	31	26	**100**
7	Rho	8	9	36	42	24	28	17	20	85	**100**
8	Shyro	1	2	17	30	11	20	27	48	56	**100**
9	Thingbu	2	4	6	12	12	23	32	62	52	**100**
10	Yuthembu	20	20	27	28	21	21	30	31	98	**100**
	Total	**68**	**12**	**153**	**26**	**155**	**26**	**214**	**36**	**590**	**100**

Table II. 3.304: Minimum, maximum and average age of head of HHs across the ten project villages

Sl. No.	Village	Age range		Average
		From	To	
1	Gemreteng	37	70	52
2	Jangda	25	92	50
3	Kharsa	22	80	46
4	Kregyang	16	75	45
5	Mirba	24	88	45
6	Rengyang	24	80	48
7	Rho	24	78	43
8	Shyro	30	98	53
9	Thingbu	20	99	55
10	Yuthembu	22	86	46

Gender of the Head of Households: Data on gender of the head of HHs in the ten surveyed project villages is given in Table II. 3.305 As expected in all the ten villages, the number of males exceeds that of females as head of HHs. Across the surveyed villages, 75% of heads were males. Interestingly, in village Kregyang, the female head of HHs also occur in substantial number being 39%.

Table II. 3.305: Distribution of head of HHs by gender in the ten project villages

Sl. No.	Village	Male		Female		Total	
		n	%	n	%	n	%
1	Gemreteng	7	78	2	22	9	100
2	Jangda	65	66	34	34	99	100
3	Kharsa	84	79	23	21	107	100
4	Kregyang	11	61	7	39	18	100
5	Mirba	34	85	6	15	40	100
6	Rengyang	23	88	3	12	26	100
7	Rho	72	85	13	15	85	100
8	Shyro	45	80	11	20	56	100
9	Thingbu	38	73	14	27	52	100
10	Yuthembu	65	66	33	34	98	100
	Total	**444**	**75**	**146**	**25**	**590**	**100**

Ethnicity: All the ten villages are predominantly inhabited by Monpa tribals.

Household Size: From Tables II. 3.306 and 3.307, the distribution of HH size in ten project villages varies from one to thirteen across the ten villages. There is vast variation between the ten villages in terms of distribution of HH size. The average HH size varies from three in Rho to five in several villages, and the average HH size across the surveyed villages is four.

Table II. 3.306: Distribution of HH size in the ten project villages

Sl. No.	Village	1		2		3		4		5		6–8		9 and above		Total
		n	%	n	%	n	%	n	%	n	%	n	%	n	%	n
1	Gemreteng	0	0	1	11	1	11	3	33	3	33	1	11	0	0	**9**
2	Jangda	5	5	11	11	6	6	13	13	14	14	39	39	11	11	**99**
3	Kharsa	12	11	8	7	17	16	21	20	19	18	28	26	2	2	**107**
4	Kregyang	1	6	4	22	1	6	2	11	5	28	4.5	25	0	6	**18**
5	Mirba	2	5	3	8	8	20	10	25	10	25	7	18	0	0	**40**
6	Rengyang	2	8	3	12	3	12	5	19	6	23	7	27	0	0	**26**
7	Rho	9	11	8	9	22	26	39	46	4	5	3	4	0	0	**85**
8	Shyro	4	7	2	4	9	16	7	13	8	14	19	34	7	13	**56**
9	Thingbu	5	10	5	10	4	8	8	15	12	23	14	27	4	8	**52**
10	Yuthembu	9	9	14	14	18	18	27	28	16	16	14	14	0	0	**98**
	Total	**49**	**8**	**59**	**10**	**89**	**15**	**135**	**23**	**97**	**16**	**136.5**	**23**	**24**	**4**	**590**

Table II. 3.307: Minimum, maximum and average HH size across the ten project villages

Sl. No.	Village	HH size range		Average HH size
		From	To	
1	Gemreteng	2	7	4
2	Jangda	1	9	5
3	Kharsa	1	9	4
4	Kregyang	1	9	5
5	Mirba	1	7	4
6	Rengyang	1	8	4
7	Rho	1	7	3
8	Shyro	1	12	5
9	Thingbu	1	13	5
10	Yuthembu	1	8	4
	Total	**1**	**13**	**4**

Education: Relevant data on the education of the head of the HHs in the ten project villages is given in Table II. 3.308. It is highly noteworthy that a majority of the heads are illiterate. It varied from 65% in Mirba to 93% in Yuthembu. Out of 590 head of HHs, 489 (83%) were illiterate. There are only nine HHs head (2%), in seven villages who were Graduates.

Table II. 3.308: Distribution of education of head of HH in the ten project villages

Sl. No.	Village	Illiterate		Primary		Upper Primary		Secondary		Higher Secondary		Graduate or above		Total
		n	%	n	%	n	%	n	%	n	%	n	%	n
1	Gemreteng	8	89	0	0	1	11	0	0	0	0	0	0	**9**
2	Jangda	84	85	3	3	5	5	4	4	2	2	1	1	**99**
3	Kharsa	86	80	1	1	8	7	10	9	1	1	1	1	**107**
4	Kregyang	12	67	1	6	2	11	0	0	2	11	1	6	**18**
5	Mirba	26	65	1	3	6	15	5	13	0	0	2	5	**40**
6	Rengyang	19	73	1	4	2	8	1	4	2	8	1	4	**26**
7	Rho	74	87	0	0	2	2	5	6	3	4	1	1	**85**
8	Shyro	41	73	1	2	8	14	5	9	1	2	0	0	**56**
9	Thingbu	48	92	0	0	1	2	1	2	2	4	0	0	**52**
10	Yuthembu	91	93	0	0	2	2	2	2	1	1	2	2	**98**
	Total	**489**	**83**	**8**	**1**	**37**	**6**	**33**	**6**	**14**	**2**	**9**	**2**	**590**

Main Occupation of Household Heads: The main occupations of the head of HHs across the ten villages are agriculture, labour, pastoralist and government service. Table II. 3.309 reveal the following:

Agriculture: It varies from nil in Thingbu to 89% in Gemreteng. 45% of the surveyed head of HHs pursue agriculture.

Labour: In several villages head of the HHs reported labour as main occupation. It varied from nil in two villages to 76% in Kharsa. Across the surveyed villages 24% of 590 heads pursued labour as main occupation.

Pastoralist: Some of the heads of HHs in five out of ten surveyed villages returned pastoralism as main occupation. It varies from 8% in Jangda to 87% in Thingbu. In all the five villages the animal associated with this occupation was Yak. Out of 590 heads 82(14%) were engaged in this activity.

Government service: Government servants were reported from all the ten villages except in Gemreteng. The largest number is from Rho being 22% followed by Mirba (15%) and other villages. Government service constitutes 11% of the main occupations.

Any other occupation: Six (6%) out of ten villages were engaged in other occupation.

Table II. 3.309: Distribution of head of HHs by main occupation in the ten project villages

Sl. No.	Village	Farmer		Labour		Pastoral		Govt. Servant		Others		Total
		n	%	n	%	n	%	n	%	n	%	n
1	Gemreteng	8	89	1	11	0	0	0	0	0	0	**9**
2	Jangda	51	52	15	15	8	8	10	10	15	15	**99**
3	Kharsa	14	13	81	76	0	0	8	7	4	4	**107**
4	Kregyang	10	56	6	33	0	0	1	6	1	6	**18**
5	Mirba	4	10	13	33	11	28	6	15	6	15	**40**
6	Rengyang	19	73	5	19	0	0	2	8	0	0	**26**
7	Rho	66	78	0	0	0	0	19	22	0	0	**85**
8	Shyro	32	57	7	13	7	13	1	2	9	16	**56**
9	Thingbu	0	0	0	0	45	87	7	13	0	0	**52**
10	Yuthembu	64	65	13	13	11	11	9	9	1	1	**98**
	Total	**268**	**45**	**141**	**24**	**82**	**14**	**63**	**11**	**36**	**6**	**590**

Private Land Holding Pattern: The private land holding pattern in the nine villages comprises of agricultural land, horticulture land, habitation and home garden land and forest land. It may be noted here that a majority of the inhabitants of the concerned villages did not know actual area either in acres or hectares of all categories of land holdings. Therefore the area reported here should be considered as "*very rough estimates*". Data pertaining to this aspect have been described below:

Agricultural land: An examination of data given in Table II. 3.310 reveals that except 31 HHs (6.4%), all the HHs (93.6%) in nine surveyed villages owned agricultural land in varying proportions. A majority of the HHs (43%) owned agri–land between 1–2 acres. Only 22% of HHs owned land which is greater than 2 acres. There exists a striking variation between the villages in terms of agri–land holdings. For example, 97% of the HHs in Rho own more than one acre of land while 89% of HHs in Gemreteng own less than one acre of land.

Table II. 3.310: Distribution of agricultural land holding among surveyed HHs in the nine project villages

Sl. No.	Village	Number of HHs	0.00 acre		< 1 acre		1–2 acre		> 2 acre	
			n	%	n	%	n	%	n	%
1	Gemreteng	9	1	11	8	89	0	0	0	0
2	Jangda	99	6	6	22	22	54	55	17	17
3	Kregyang	18	7	39	3	17	8	44	0	0
4	Mirba	40	2	5	23	58	9	23	6	15
5	Rengyang	26	6	23	8	31	11	42	1	4
6	Rho	85	2	2	0	0	64	75	19	22
7	Shyro	56	1	2	27	48	28	50	0	0
8	Thingbu	52	2	4	10	19	11	21	29	56
9	Yuthembu	98	4	4	37	38	23	23	34	35
	Total	**483**	**31**	**6**	**138**	**29**	**208**	**43**	**106**	**22**

* Excluding Kharsa due to non availability of data

***Horticultural land*:** None of the HHs in the nine villages owned horticultural land.

***Habitation and home–garden land*:** Data presented in Table II. 3.311 showed that only 5% of HHs in surveyed villages did not owned any such land. A majority of HHs (84%) owned less than one acre of such land and only 12% of the HHs owned land between 1–2 acre. It is highly noteworthy that in Gemreteng village all the nine HHs do not own such land.

Table II. 3.311: Distribution of habitation and home garden land among surveyed HHs in the nine project villages

Sl. No.	Village	Number of HHs	0.00 acre		< 1 acre		1–2 acre		> 2 acre	
			n	%	n	%	n	%	n	%
1	Gemreteng	9	9	100	0	0	0	0	0	0
2	Jangda	99	6	6	93	94	0	0	0	0
3	Kregyang	18	0	0	18	100	0	0	0	0
4	Mirba	40	0	0	40	100	0	0	0	0
5	Rengyang	26	0	0	26	100	0	0	0	0
6	Rho	85	0	0	32	38	53	62	0	0
7	Shyro	56	2	4	52	93	2	4	0	0
8	Thingbu	52	6	12	45	87	1	2	0	0
9	Yuthembu	98	0	0	98	100	0	0	0	0
	Total	**483**	**23**	**5**	**404**	**84**	**56**	**12**	**0**	**0**

* Excluding Kharsa due to non availability of data

Forest land: About 115 HHs (24%) in surveyed villages do not owned private forest land whereas 49% of HHs owned such land between 1–2 acres. In Rho, it is noteworthy that 20% of HHs owned more than 2 acre of forest land (Table II. 3.312).

Table II. 3.312: Distribution of forest land holding among surveyed HHs in the nine project villages

Sl. No.	Village	0.00 acre		< 1 acre		1–2 acre		> 2 acre	
		n	%	n	%	n	%	n	%
1	Gemreteng	9	100	0	0	0	0	0	0
2	Jangda	15.0	15.2	15	15	59	60	10	10
3	Kregyang	10	56	5	28	3	17	0	0
4	Mirba	9	23	23	58	4	10	4	10
5	Rengyang	15	58	8	31	3	12	0	0
6	Rho	14	16	0	0	54	64	17	20
7	Shyro	18	32	12	21	26	46	0	0
8	Thingbu	13	25	25	48	12	23	2	4
9	Yuthembu	12	12	0	0	76	78	10	10
	Total	**115**	**24**	**88**	**18**	**237**	**49**	**43**	**9**

* Excluding Kharsa due to non availability of data

Total land holdings: The data given in Table II. 3.313-3.316 showed that there are only 8 HHs (2%) that do not own any type of private land. About 66% of the HHs owned more than 2 acres of total land. There is striking variation between the HH within a village as well as between villages in ownership of total land. For example, in Rho inter HHs holdings vary from 1 acre to 26 acres, whereas in Gemreteng it varies from 0.0–0.5 acre. The proportion of agri–land is greater than other types of land owned in several villages whereas in a few villages Habitation and home garden land is greater than agri–land. The 483 HHs in the nine villages owned total private land totalling 1423 acres. Out of this Jangda, Rho and Yuthembu accounts for 73% of the total land. Agri–land accounts for 49% and forest land 34% of total land holding in the nine villages.

Table II. 3.313: Number of HHs having land types in nine project villages

Sl. No.	Village	Total HH	Agricultural land		Horticultural land		Habitation and home garden land		Forest land	
			n	%	n	%	n	%	n	%
1	Gemreteng	9	8	89	0	0	0	0	0	0
2	Jangda	99	93	94	0	0	93	94	84	85
3	Kregyang	18	11	61	0	0	18	100	8	44
4	Mirba	40	38	95	0	0	40	100	31	78
5	Rengyang	26	20	77	0	0	26	100	11	42
6	Rho	85	83	98	0	0	85	100	71	84
7	Shyro	56	55	98	0	0	54	96	38	68
8	Thingbu	52	50	96	0	0	46	88	39	75
9	Yuthembu	98	94	96	0	0	98	100	86	88
	Total	**483**	**452**	**94**	**0**	**0**	**460**	**95**	**368**	**76**

* Excluding Kharsa due to non availability of data

Table II. 3.314: Distribution of total land holding among surveyed HHs in nine project villages

Sl. No.	Village	0.00 acre		< 1 acre		1–2 acre		> 2 acre	
		n	%	n	%	n	%	n	%
1	Gemreteng	1	11	8	89	0	0	0	0
2	Jangda	6	6	7	7	19	19	67	68
3	Kregyang	0	0	7	39	4	22	7	39
4	Mirba	0	0	14	35	18	45	8	20
5	Rengyang	0	0	6	23	13	50	7	27
6	Rho	0	0	0	0	10	12	75	88
7	Shyro	1	2	25	45	4	7	26	46
8	Thingbu	0	0	11	21	1	2	40	77
9	Yuthembu	0	0	5	5	5	5	88	90
	Total	**8**	**2**	**83**	**17**	**74**	**15**	**318**	**66**

* Excluding Kharsa due to non availability of data

Table II. 3.315: Minimum, maximum and average land holdings across nine project villages

Sl. No.	Village	Agricultural land			Horticultural land			Habitation and Home garden land			Forest land			Total land		
		From	To	Avg.	From	To	Avg.	From	To	Avg.	From	To	Avg.	From	To	Avg.
1	Gemreteng	0.00	0.50	0.43	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**	**0.50**	**0.43**
2	Jangda	0.00	6.00	1.42	0.00	0.00	0.00	0.00	0.74	0.45	0.00	4.00	1.13	**0.00**	**10.74**	**3.00**
3	Kregyang	0.00	2.00	0.83	0.00	0.00	0.00	0.50	0.50	0.50	0.00	1.00	0.31	**0.50**	**3.50**	**1.64**
4	Mirba	0.00	9.88	1.11	0.00	0.00	0.00	0.02	0.07	0.03	0.00	4.94	0.74	**0.02**	**12.39**	**1.89**
5	Rengyang	0.00	2.50	0.85	0.00	0.00	0.00	0.50	0.50	0.50	0.00	1.00	0.26	**0.50**	**4.00**	**1.61**
6	Rho	0.00	12.00	1.94	0.00	0.00	0.00	0.46	2.00	1.04	0.00	12.00	1.69	**1.00**	**26.00**	**4.68**
7	Shyro	0.00	2.00	0.74	0.00	0.00	0.00	0.00	1.50	0.20	0.00	1.50	0.56	**0.00**	**4.50**	**1.50**
8	Thingbu	0.00	4.00	2.10	0.00	0.00	0.00	0.00	1.00	0.28	0.00	5.00	0.51	**0.70**	**8.50**	**2.89**
9	Yuthembu	0.00	3.75	1.57	0.00	0.00	0.00	0.20	0.74	0.58	0.00	4.00	1.36	**0.20**	**7.49**	**3.51**
	Total	**0.00**	**12.00**	**1.22**	**0.00**	**0.00**	**0.00**	**0.00**	**2.00**	**0.40**	**0.00**	**12.00**	**0.73**	**0.00**	**26.00**	**2.35**

Table II. 3.316: Distribution of area (in acres) of land holding among HHs in nine project villages

Sl. No.	Village	Agricultural land		Horticultural land		Habitation and Home garden land		Forest land		Total land
		Area	%	Area	%	Area	%	Area	%	Area
1	Gemreteng	4	100	0	0	0	0	0	0	4
2	Jangda	141	47	0	0	44	15	112	38	297
3	Kregyang	15	51	0	0	9	31	6	19	30
4	Mirba	45	59	0	0	1	2	30	39	75
5	Rengyang	22	53	0	0	13	31	7	16	42
6	Rho	165	41	0	0	89	22	144	36	398
7	Shyro	41	49	0	0	11	13	32	38	84
8	Thingbu	109	73	0	0	15	10	27	18	150
9	Yuthembu	154	45	0	0	57	17	133	39	344
	Total	**696**	**49**	**0**	**0**	**239**	**17**	**489**	**34**	**1423**

Livestock Holding: The data presented in Tables II. 3.317–3.319 in respect of distribution of livestock holding in the nine surveyed villages revealed that altogether 9 different types of animals are domesticated in nine surveyed villages (Table II. 3.317). None of the villages owned all the nine animals. Altogether 3807 animals have been domesticated in the nine villages (Table II. 3.318). Considerable inter–village variation is observed in total number of animals reared. It varied from 20 in Gemreteng to 1021 animals in Jangda. Jangda alone accounts for 27% of all the animals found in all the surveyed village. Three animals, viz, cattle (42%), Yak (28%) and sheep (16%) account for 86% of the total animals (3807). 44% of the HHs did not own any animals, whereas 30% HHs owned more than 10 animals (Table II. 3.319).

Table II. 3.317: Livestock holding by HHs in nine project villages

Sl. No.	Livestock		Gemreteng	Jangda	Kregyang	Mirba	Rengyang	Rho	Shyro	Thingbu	Yuthembu	Total HH
1	Mithun	n	0	0	0	0	0	0	0	0	2	**2**
		%	0	0	0	0	0	0	0	0	2	**0**
2	Cattle	n	3	92	3	10	4	30	24	0	21	**187**
		%	33	93	17	25	15	35	43	0	21	**39**
3	Yak	n	0	25	0	6	0	5	10	52	19	**117**
		%	0	25	0	15	0	6	18	100	19	**24**
4	Goat	n	0	22	0	1	0	17	0	0	1	**41**

		%	0	22	0	3	0	20	0	0	1	**8**
5	Sheep	n	0	71	1	0	0	20	2	52	1	**147**
		%	0	72	6	0	0	24	4	100	1	**30**
6	Pig	n	0	63	0	0	0	6	29	0	0	**98**
		%	0	64	0	0	0	7	52	0	0	**20**
7	Pony	n	0	2	0	1	0	1	16	52	0	**72**
		%	0	2	0	3	0	1	29	100	0	**15**
8	Poultry	n	0	13	0	0	0	2	1	3	0	**19**
		%	0	13	0	0	0	2	2	6	0	**4**
9	Others	n	0	1	0	0	0	1	0	0	0	**2**
		%	0	1	0	0	0	1	0	0	0	**0**

Table II. 3.318: Number of livestock in surveyed HHs across nine project villages

Sl. No.	Livestock		Gemreteng	Jangda	Kregyang	Mirba	Rengyang	Rho	Shyro	Thingbu	Yuthembu	Total animals
1	Mithun	LS	0	0	0	0	0	0	0	0	10	**10**
		%	0	0	0	0	0	0	0	0	2	**0.3**
2	Cattle	LS	20	395	27	102	26	255	357	0	413	**1595**
		%	100	39	31	56	100	52	70	0	63	**42**
3	Yak	LS	0	114	0	67	0	49	69	529	224	**1052**
		%	0	11	0	37	0	10	14	65	34	**28**
4	Goat	LS	0	37	0	5	0	68	0	0	2	**112**
		%	0	4	0	3	0	14	0	0	0	**3**
5	Sheep	LS	0	364	60	0	0	85	2	100	10	**621**
		%	0	36	69	0	0	17	0	12	2	**16**
6	Pig	LS	0	72	0	0	0	14	29	0	0	**115**
		%	0	7	0	0	0	3	6	0	0	**3**
7	Pony	LS	0	10	0	7	0	6	50	179	0	**252**
		%	0	1	0	4	0	1	10	22	0	**7**
8	Poultry	LS	0	28	0	0	0	7	2	9	0	**46**
		%	0	3	0	0	0	1	0	1	0	**1**
9	Others	LS	0	1	0	0	0	3	0	0	0	**4**
		%	0	0	0	0	0	1	0	0	0	**0.1**
	Total livestock	**LS**	**20**	**1021**	**87**	**181**	**26**	**487**	**509**	**817**	**659**	**3807**
		%	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**

Note: LS– Livestock

Table II. 3.319: Distribution of total number of livestock in HHs of nine project villages

Sl. No.	Village	0		1–5		6–10		> 10		Total
		n	%	n	%	n	%	n	%	n
1	Gemreteng	6	67	1	11	2	22	0	0	**9**
2	Jangda	5	5	25	25	33	33	36	36	**99**
3	Kregyang	14	78	0	0	2	11	2	11	**18**
4	Mirba	27	68	3	8	3	8	7	18	**40**
5	Rengyang	22	85	2	8	2	8	0	0	**26**
6	Rho	48	56	9	11	11	13	17	20	**85**
7	Shyro	22	39	18	32	3	5	13	23	**56**
8	Thingbu	0	0	0	0	0	0	52	100	**52**
9	Yuthembu	68	69	7	7	4	4	19	19	**98**
	Total	**212**	**44**	**65**	**13**	**60**	**12**	**146**	**30**	**483**

Traditional Skills: Data pertaining to this aspect is presented in Table II. 3.320. It is highly noteworthy that, while in Tawang district at least 6 types of craft are practiced (Table II. 3.320), in the surveyed village four types of crafts, namely, Wood Carving, Carpet Making, Bamboo Utensil and Weaving are being practiced. 12 HH in surveyed villages are engage in wood carving, four HH make carpets, 15 HH make Bamboo utensils and weaving is practiced by 196 HH (41%).

Table II. 3.320: Distribution of various skills among surveyed HHs in nine project villages

Sl. No.	Village	Wood carving		Thanka painting		Carpet making		Bamboo utensil		Weaving		Paper making	
		n	%	n	%	n	%	n	%	n	%	n	%
1	Gemreteng	0	0	0	0	1	11	0	0	0	0	0	0
2	Jangda	1	1	0	0	0	0	0	0	53	54	0	0
3	Kregyang	0	0	0	0	0	0	0	0	0	0	0	0
4	Mirba	2	5	0	0	2	5	0	0	8	20	0	0
5	Rengyang	0	0	0	0	0	0	0	0	0	0	0	0
6	Rho	0	0	0	0	0	0	2	2	40	47	0	0
7	Shyro	5	9	0	0	1	2	8	14	20	36	0	0
8	Thingbu	0	0	0	0	0	0	0	0	44	85	0	0
9	Yuthembu	4	4	0	0	0	0	5	5	31	32	0	0
	Total	**12**	**2**	**0**	**0**	**4**	**1**	**15**	**3**	**196**	**41**	**0**	**0**

River Resources: In Table II. 3.321, data gathered pertaining to the use of various river resources by the inhabitants of the ten surveyed village is presented. The data revealed that seven different river resources, namely, drinking water, water for domestic use, water for livestock, aquatic flora, religious, sand and stone are used. Atleast one river resource is used by all the 10 villages. There is vast inter–village variation in terms of number of river resources used. It varies from two in Gemreteng, Kregyang, Rengyang, Rho and Thingbu to six resources used in Yuthembu. It is highly noteworthy that all the 590 HHs in the surveyed villages use river for performing last rites of the dead. Although aquatic fauna is found in the river but there is a taboo among the Monpas for using this resource. However in Rengyang two HHs used aquatic flora.

It may be mentioned here that the villages are common to other projects as either affected or influenced villages. Although the river dependency data of households/village are correct, the source of collection of these resources i.e. the exact name of the project site could not be ascertained. However, considering the distance from the villages to the proposed project sites, it may be safely concluded that the dependency on the river resources is minimum for Nyikcharong chu, often limited to water use for livestock.

Table II. 3.321: Dependence on river resources among surveyed HHs in the ten project villages

Sl. No.	River resources		Gemreteng	Jangda	Kharsa	Kregyang	Mirba	Rengyang	Rho	Shyro	Thingbu	Yuthembu	Total H
1	Drinking water	n	0	0	107	0	0	0	0	0	0	24	**131**
		%	0	0	100	0	0	0	0	0	0	24	**22**
2	Water for domestic use	n	0	0	107	0	0	0	0	0	0	18	**125**
		%	0	0	100	0	0	0	0	0	0	18	**21**
3	Water for livestock	n	3	94	0	4	13	4	37	35	52	30	**272**
		%	33	95	0	22	33	15	44	63	100	31	**46**
4	Fishes	n	0	0	0	0	0	0	0	0	0	0	**0**
		%	0	0	0	0	0	0	0	0	0	0	**0**
5	Aquatic flora	n	0	0	0	0	0	2	0	0	0	0	**2**
		%	0	0	0	0	0	8	0	0	0	0	**0.34**
6	Religious	n	9	99	107	18	40	26	85	56	52	98	**590**
		%	100	100	100	100	100	100	100	100	100	100	**100**
7	Sand	n	0	99	0	0	40	0	0	56	0	65	**260**
		%	0	100	0	0	100	0	0	100	0	66	**44**
8	Stone	n	0	99	0	0	40	0	0	56	0	67	**262**
		%	0	100	0	0	100	0	0	100	0	68	**44**

Forest Resources: The villagers of all the ten villages are dependent in varying degrees of forest resources (Table II. 3.322). Out of listed resources in Table II. 3.322, two resources, viz., fuel wood and grazing are used by atleast some HHs of all the surveyed villages. Over 50% of HH surveyed also use six forest resources, namely, timber, food, religious purposes, sand, stones and water. A few HHs also use several other forest resources. It is evident from above that forest resources contribute significantly to the livelihoods as well as the quality of life of a majority of the inhabitants of the surveyed villages.

Table II. 3.322: Dependence on forest resources among surveyed HHs in the ten project villages

Sl. No.	Forest resources		Gemreteng	Jangda	Kharsa	Kregyang	Mirba	Rengyang	Rho	Shyro	Thingbu	Yuthembu	Total
1	Fuel wood	n	9	99	107	18	40	26	85	56	52	90	**582**
		%	100	100	100	100	100	100	100	100	100	92	**99**
2	Timber	n	9	99	0	18	40	0	85	56	52	90	**449**
		%	100	100	0	100	100	0	100	100	100	92	**76**
3	Medicinal plants	n	3	0	0	18	40	0	0	0	36	0	**97**
		%	33	0	0	100	100	0	0	0	69	0	**16**
4	Honey	n	2	0	0	0	0	2	0	0	0	0	**4**
		%	22	0	0	0	0	8	0	0	0	0	**1**
5	Food	n	9	99	0	18	40	26	66	0	41	0	**299**
		%	100	100	0	100	100	100	78	0	79	0	**51**
6	Edible oil	n	0	0	0	0	0	0	0	0	0	0	**0**
		%	0	0	0	0	0	0	0	0	0	0	**0**
7	Ornamental	n	0	0	0	0	0	0	2	0	0	0	**2**
		%	0	0	0	0	0	0	2	0	0	0	**0**
8	Religious	n	9	0	0	18	40	26	85	0	52	64	**294**
		%	100	0	0	100	100	100	100	0	100	65	**50**
9	Fencing	n	0	99	0	0	0	0	19	0	0	84	**202**
		%	0	100	0	0	0	0	22	0	0	86	**34**
10	Handicrafts	n	0	0	0	0	0	0	21	0	0	4	**25**
		%	0	0	0	0	0	0	25	0	0	4	**4**
11	Thatching	n	0	0	0	0	0	0	0	0	0	1	**1**
		%	0	0	0	0	0	0	0	0	0	1	**0**
12	Spices	n	1	0	0	0	40	3	0	0	0	2	**46**
		%	11	0	0	0	100	12	0	0	0	2	**8**
13	Grazing	n	3	94	0	4	13	4	37	35	52	30	**272**
		%	33	95	0	22	33	15	44	63	100	31	**46**
14	Hunting	n	0	0	0	0	0	0	0	0	0	2	**2**
		%	0	0	0	0	0	0	0	0	0	2	**0**
15	Fishes	n	0	0	0	0	0	0	0	0	0	1	**1**
		%	0	0	0	0	0	0	0	0	0	1	**0**
16	Water	n	0	99	0	0	0	5	85	56	52	67	**364**
		%	0	100	0	0	0	19	100	100	100	68	**62**
17	Stones	n	9	99	0	18	40	26	85	56	52	92	**477**
		%	100	100	0	100	100	100	100	100	100	94	**81**
18	Sand	n	9	99	0	18	40	26	19	56	52	92	**411**
		%	100	100	0	100	100	100	22	100	100	94	**70**
19	Dyes	n	0	0	0	0	0	0	0	0	0	0	**0**
		%	0	0	0	0	0	0	0	0	0	0	**0**

Water Resources: From Table II. 3.323, the main points in respect of the water sources found in the surveyed villages shows that except for Mirba and Shyro, the main source of water for various usage is hill stream/springs in all of the villages. Out of 590 HHs in the study area, 480 HHs use hill stream/spring water whereas in four villages all the 109 HHs use ponds for water requirements.

Table II. 3.323: Dependence on water resources among surveyed HHs in the ten project villages

Sl. No.	Village	River		Hill stream/spring		Wells		Ponds		Hand pumps		Tap water	
		n	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**
1	Gemreteng	0	0	9	100	0	0	9	100	0	0	9	100
2	Jangda	0	0	99	100	0	0	0	0	0	0	99	100
3	Kharsa	0	0	100	93	0	0	0	0	0	0	0	0
4	Kregyang	0	0	18	100	0	0	18	100	0	0	18	100
5	Mirba	0	0	0	0	0	0	0	0	0	0	40	100
6	Rengyang	0	0	26	100	0	0	26	100	0	0	26	100
7	Rho	85	100	85	100	0	0	0	0	0	0	85	100
8	Shyro	0	0	0	0	0	0	56	100	0	0	56	100
9	Thingbu	0	0	52	100	0	0	0	0	0	0	0	0
10	Yuthembu	26	27	91	93	0	0	0	0	0	0	0	0
	Total	**111**	**19**	**480**	**81**	**0**	**0**	**109**	**18**	**0**	**0**	**333**	**56**

3.3.8 RHO

3.3.8.1 PHYSICAL ENVIRONMENT

Geomorphology

The project is located in temperate zone of Himalayas. The river basin is narrow surrounded by steep to very steep slopes (Figure II. 3.41).

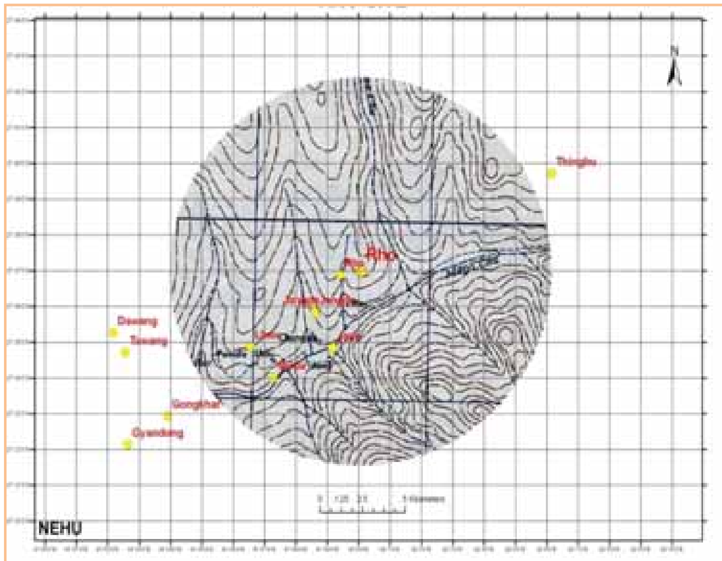


Figure II. 3.41: Contour map of Rho HEP

Geology

The Rho HEP site is located in the higher Himalayan region of Arunachal Pradesh. It is located 26 km northwest from the surface trace of MCT. Geologically, the project area is represented mainly by the gneiss rocks. The bedrock exposed above riverbed on the steep abutment slope comprises of schistose quartzite along with thin schist bands, basic bodies and pegmatite bodies. The right abutment rises along a moderate slope up to 30 m above riverbed, and is covered by slope wash deposits. The left abutment is moderately sloping, and is covered by slope wash deposits along the dam axis. Bedrock on the left abutment is exposed about 30-40 m downstream of the dam axis. The bedrock at the site is foliated and traversed by four sets of joints in addition to those oriented parallel to foliation. It appears that bedrock may be available at around 25-30 m depth in the riverbed and at shallow depth on the right abutment.

The rock types are similar to Thingbu chu area. The drainage pattern is trellis type. As the area is near main central thrust, so seismically it will have a bearing on this area also. The area under various geological classes in Rho at barrage and powerhouse sites is given in Table II. 3.324. The location of Rho project site and the impact zone within 10 km radius in Tawang river are depicted in Figures II. 3.42 and 3.43.

Table II. 3.324: Area under various geological formation/classes in the influence zone (10 km radius) of Rho at barrage and powerhouse sites

Class	Barrage		Powerhouse	
	Area	**%**	**Area**	**%**
Snow covered area	7.59	2.42	5.17	1.65
Snow covered area	4.93	1.57	1.16	0.37
Snow covered area	9.93	3.16	8.93	2.84
Sela group (Structural hill)	267.85	85.26	291.19	92.69
Snow covered area	1.16	0.37	3.08	0.98
Sela group (Valley)	0.82	0.26	0.90	0.29
Lateral morain	0.06	0.02		
Glacier	0.84	0.27	0.01	0.00
Volcanic sediment (Structural hill)	14.18	4.51	3.33	1.06
Volcanic sediment (Structural hill)	6.79	2.16	0.40	0.13
Total	**314.16**	**100.00**	**314.16**	**100.00**

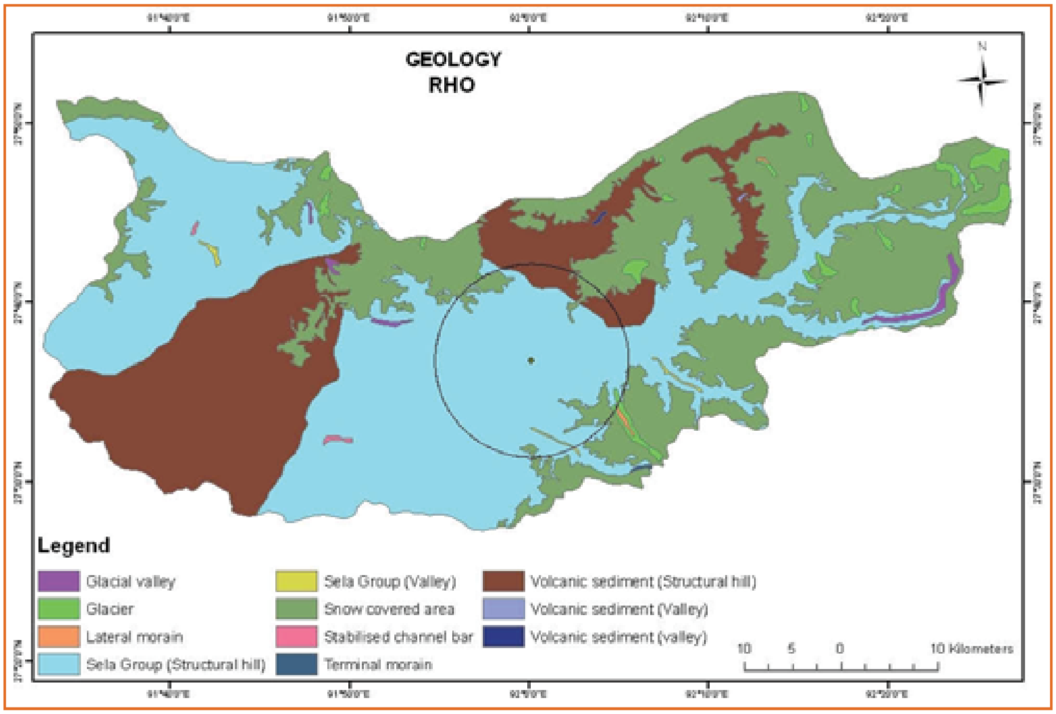


Figure II. 3.42: Geological map of TRB showing location of Rho project site

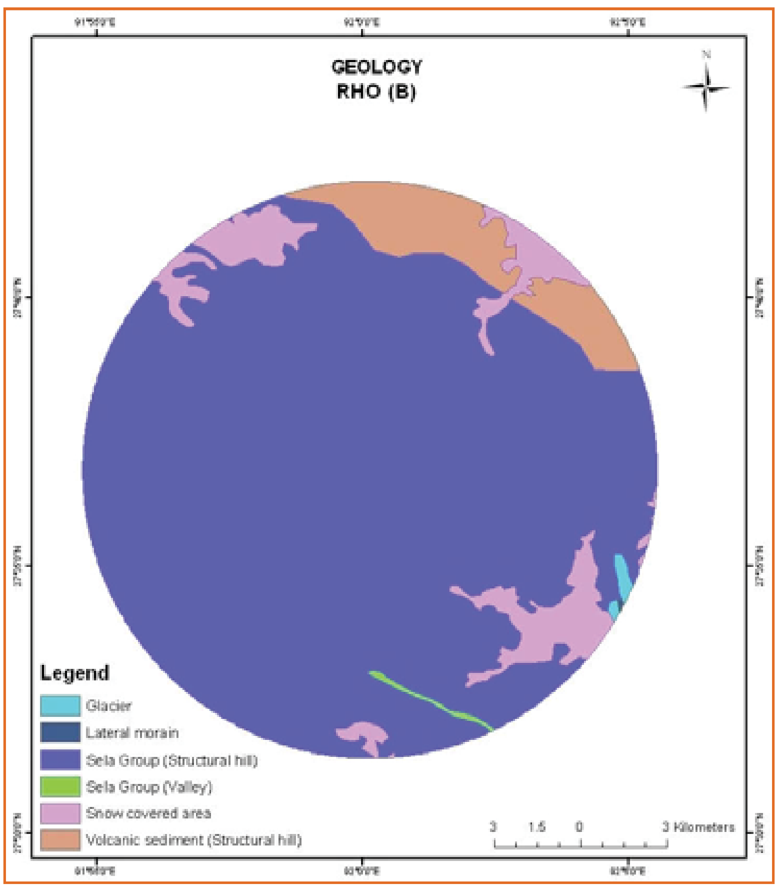


Figure II. 3.43: Geological map of Impact zone (10 km radius) of Rho barrage site in Tawang river valley

Landuse and Land Cover

The total area within 10 km radius of Rho HEP area is 31,456.94 ha (Figure II. 3.44). Large proportion of the area is covered with forest which occupies about 52% of the total area of Rho HEP, followed by scrubland which accounts for 36.4%. Grasslands cover only 1.2% of the total project area. Waterbody constitute around 8.4% of total area. Cropland occupies only 0.01% of the total project area. The total area occupied by snow and ice and other builtup area altogether is 1.9% (Table II. 3.325).

Table II. 3.325: Landuse/land cover area of Rho project site

Land category	Area (ha)	%
Forest	16384.4	52.1
Scrubland	11461	36.4
Waterbody	2643.57	8.4
Croplands	3.0375	0.0
Grasslands	382.86	1.2
Builtup area	182.273	0.6
Snow and Ice	399.803	1.3
Total	**31456.94**	**100.0**

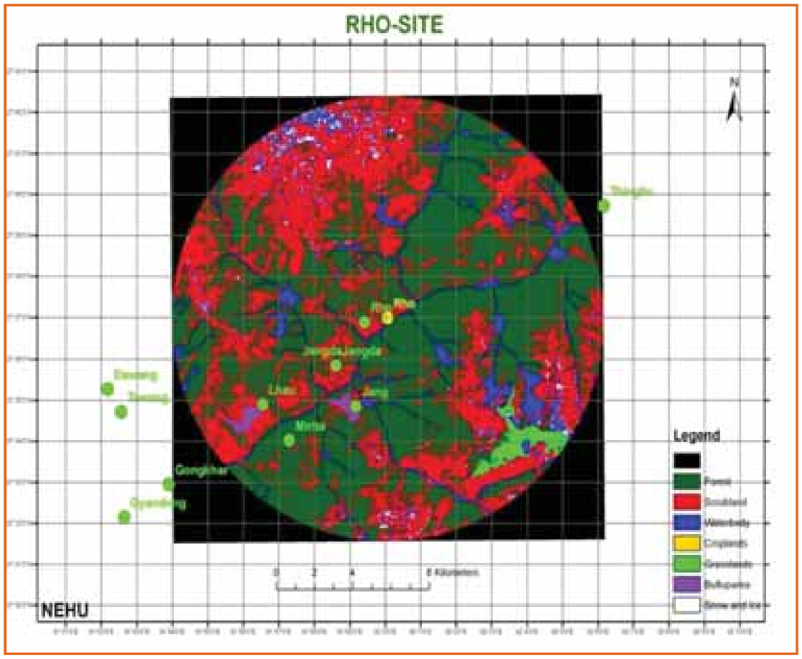


Figure II. 3.44: Landuse/land cover map of Rho project site

Soil

The soil at this site was sandy loam, acidic with low water holding capacity but poor in available phosphorus and organic carbon content particularly during post-monsoon season. Except NH_4^+–N and Ex. K all other nutrients like NO_3^-–N, , Ex. Ca, were present in very small quantities. Soil also had very low concentration of organic carbon and microbial biomass carbon. Seasonal fluctuation in physical, chemical and biological parameters are shown in (Table II. 3.326).

Table II. 3.326: Soil physical properties at Rho project sites

Site	Texture		WHC (%)		Bulk density (g/cm³)		Porosity (%)	
Barrage	Sandy loam		27.58		1.43		46.04	
Powerhouse	Sandy loam		33.44		1.41		46.79	
Seasonal variation in soil physico–chemical properties at Rho village								
Parameters	**Post-monsoon**		**Monsoon**		**Winter**		**Mean**	
	B	**PH**	**B**	**PH**	**B**	**PH**	**B**	**PH**
SMC (%)	25	25	38	33	18	18	27	25
pH	5.3	5.3	5.9	5.8	4.9	4.9	5.4	5.3
Conductivity (µS cm^{-1})	29	22	36	31	16	12	27	22
NH_4^+–N (µg g^{-1})	300	400	400	300	200	200	300	300
NO_3^-–N(µg g^{-1})	24	23	25	30	20	22	23	25
TKN (µg g^{-1}) x10^3	0.700	0.600	0.800	0.600	0.500	0.500	0.670	0.570
Av. P (µg g^{-1})	0.030	0.020	0.020	0.020	0.030	0.040	0.030	0.030
TP (%)	0.090	0.080	0.100	0.120	0.090	0.100	0.090	0.100
SOC (%)	0.006	0.007	0.007	0.007	0.003	0.002	0.010	0.010
Ex. K (µg g^{-1})	300	160	159	75	63	60	174	98
Ex. Mg (%)	0.009	0.013	0.005	0.003	0.010	0.008	0.010	0.010
Ex. Ca (%)	0.087	0.446	0.023	0.064	0.650	0.624	0.250	0.380
Soil microbial biomass–C (µg g^{-1})	29	23	25	20	36	30	30	25
Soil microbial biomass–N (µg g^{-1})	1.73	4.00	2.41	2.01	3.80	3.21	2.60	3.10

(Note: Post-monsoon–October, Monsoon–July, Winter–December); B =Barrage, PH =Powerhouse

Soil Erosion Vulnerability

In the influence zone i.e. 10 km radius of the barrage site, out of the total area of 314.16 sq. km, 1.53% of soil erosion vulnerable areas fall under moderately high risk class, 7.43% and 30.57% of the total area fall under low and moderately low vulnerable class, respectively. The vulnerable area of soil erosion under moderate category was 46.22% (Table II. 3.327).

In the influence zone of powerhouse site, out of the total area of 314.16 sq.km, only 1.77% area falls under high soil erosion vulnerable zone, and 15.19% falls under moderately high vulnerable zone. Only 6.17% of the total area is covered under low vulnerable zone, and 29.26% falls under moderately-low vulnerable zone. The soil erosion vulnerable area under moderate category covered about 47.62% of the total area. The spatial distribution map of soil erosion vulnerable areas under barrage and powerhouse site of Rho is given in Figure II. 3.45.

Table II. 3.327: Areas under various vulnerable zones in Rho at barrage and powerhouse sites

Vulnerability	Barrage		Powerhouse	
	Area (sq. km)	**%**	**Area (sq. km)**	**%**
High	4.80	1.53	5.55	1.77
Moderately high	44.78	14.25	47.73	15.19
Moderate	145.20	46.22	149.60	47.62
Moderately low	96.04	30.57	91.91	29.26
Low	23.33	7.43	19.38	6.17
Total	**314.16**	**100.00**	**314.16**	**100.00**

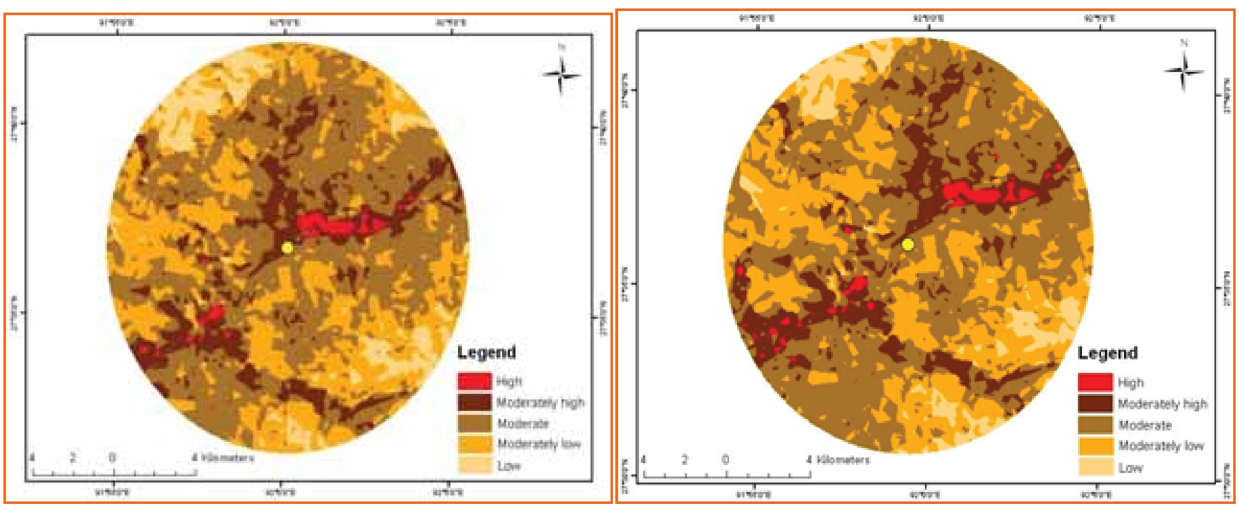


Figure II. 3.45: Spatial distribution of soil erosion vulnerable areas in Rho at barrage and powerhouse sites

Landslide and Erosion Vulnerability

The area vulnerable to both landslide and erosion were worked out. The area under different landslide and erosion vulnerability classes in the barrage and powerhouse site of Rho project is given in Table II. 3.328. In the barrage site, out of the total area of 314.16 sq.km, the low and moderately high vulnerable categories covered only 0.11% and 0.93% of the total area, respectively, and 59.11% of the total area falls under moderate zone of vulnerability. Similarly, at powerhouse site, out of the total area of 314.16 sq.km, only 0.14% and 19.27% of the total area were covered under low and moderately high vulnerable categories, respectively, and about 60.16% of the total area falls under moderate zone of vulnerability. The spatial distribution map of landslide and erosion vulnerability areas under barrage and powerhouse site of Rho is given in Figure II. 3.46.

Table II. 3.328: Area under various landslide and erosion vulnerability classes in Rho at barrage and powerhouse site

Vulnerability	Barrage		Powerhouse	
	Area (sq.km)	**%**	**Area (sq.km)**	**%**
High	2.92	0.93	3.21	1.02
Moderately high	56.31	17.92	60.53	19.27
Moderate	185.70	59.11	189.00	60.16
Moderately low	68.90	21.93	60.98	19.41
Low	0.33	0.11	0.43	0.14
Total	**314.16**	**100.00**	**314.16**	**100.00**

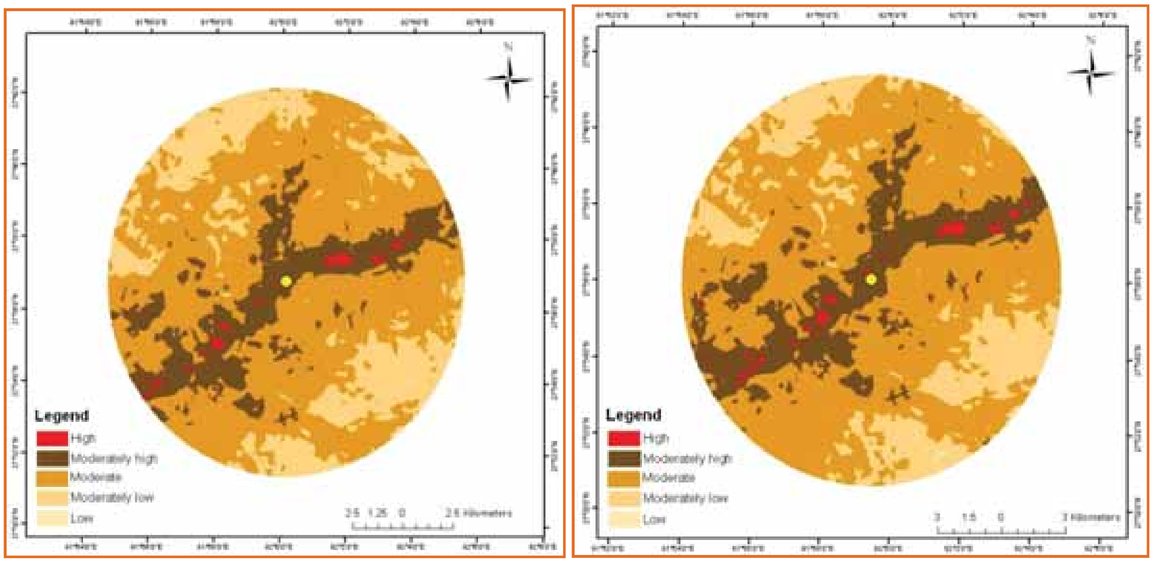


Figure II. 3.46: Area under various erosion and landslide vulnerability classes in Rho at barrage site

Water

Distinct seasonal variation was observed in the river water quality due to changes in the physico-chemical parameters. Nine out of 20 parameters, viz., temperature, turbidity, pH, Chloride, Na, NH_4, TKN, GPP, and NPP, peaked during the monsoon season. During post-monsoon season, conductivity, TDS, K, NO_3, total P concentration and coliform bacterial count in the river were highest as compared to the other seasons.. Highest value for total alkalinity, total hardness, Ca, Mg, and DO, were recorded during the winter season (Table II. 3.329).

Table II. 3.329: Seasonal variation in physico–chemical and biological properties of water and its primary productivity

Parameters	Post-monsoon			Monsoon			Winter		
	B	**PH**	**Mean**	**B**	**PH**	**Mean**	**B**	**PH**	**Mean**
Temperature (˚C)	7.10	7.15	7.13	14.80	14.75	14.78	3.90	4.60	4.25
Turbidity (NTU)	0.50	0.43	0.46	1.64	1.45	1.55	1.35	1.04	1.20
pH	7.73	7.72	7.72	8.11	7.98	8.05	7.41	7.53	7.47
Electrical conductivity (µS/cm)	194	190.00	192	145	138.50	142	180	164.00	172
Total dissolved solids (mg/l)	97	95.15	96.08	75	66.90	70.95	92	84.00	87.90
Practical salinity (ppt)	0.11	0.11	0.11	0.09	0.08	0.08	0.94	0.09	0.51
Total alkalinity (mg $CaCO_3$/l)	32	32.00	32.00	30	33.00	31.50	52	48.00	50.00
Total hardness (mg/l)	23	22.17	22.47	36	36.05	36.08	41	41.17	41.30
Chloride (mg Cl^-/l)	10.99	10.83	10.91	13.99	13.49	13.74	5.99	5.99	5.99
Ca^{2+} (mg/l)	4.67	4.65	4.66	8.78	8.77	8.77	9.34	9.33	9.33
Mg^{2+}(mg/l)	2.70	2.57	2.63	3.45	3.44	3.44	4.40	4.34	4.37
K^+ ppm	1.20	1.22	1.21	0.70	0.60	0.65	0.60	0.50	0.55
Na^+ ppm	11.00	10.90	10.95	12.00	11.50	11.75	9.80	9.10	9.45
TKN (mg/l)	0.44	0.46	0.45	0.56	0.57	0.57	0.40	0.41	0.41
NH_4^+ N (mg/l)	0.05	0.05	0.05	0.12	0.13	0.13	0.05	0.05	0.05
NO_3–N (mg/l)	0.34	0.34	0.34	0.16	0.17	0.17	0.31	0.31	0.31
Total phosphorus (mg/l)	0.16	0.12	0.14	0.09	0.09	0.09	0.10	0.10	0.10
GPP (mg C/cm^3/h)	0.36	0.36	0.36	0.47	0.47	0.47	0.21	0.31	0.26
NPP (mg C/cm^3/h)	0.10	0.13	0.12	0.31	0.31	0.31	0.10	0.10	0.10
Dissolved oxygen (mg/l)	11.40	11.35	11.38	10.00	10.10	10.05	12.60	12.40	12.50
Total coliforms (CFU/ml)	35	53.00	44.00	32	35.00	33.50	17	21.00	19.00
BOD_5 (mg/l)	19	x		2	x		1.7	x	

Ambient Ambient Air Quality

Concentration of PM_{10} and $PM_{2.5}$: PM_{10} concentrations at proposed Rho HEP area ranged from a minimum of 11.7 µg/m^3 at Jaswantgarh to a maximum of 49.7 µg/m^3 at Nuranang falls. Likewise, $PM_{2.5}$ concentration ranged from a minimum of 13.4 µg/m^3 at Jaswantgarh to a maximum of 38.7 µg/m^3 at New Melling (Table II. 3.330). The concentration of sulphur-dioxide (SO_2), nitrogen-dioxide (NO_2), ammonia (NH_3) and ground level ozone (O_3) at all the monitored locations were below detectable limits.

Table II. 3.330: Concentration of PM_{10} and $PM_{2.5}$ in air at proposed Rho HEP area

Sampling location	Nearest project site covered	PM_{10} (µg/m^3)	$PM_{2.5}$ (µg/m^3)
Rho	Rho barrage site Rho powerhouse site	23.5	13.4
Jaswantgarh	Rho barrage site Rho powerhouse site	11.7	13.4
Nuranang falls	Rho barrage site Rho powerhouse site	49.7	38.0
Jang	Rho barrage site Rho powerhouse site	41.7	23.9
New Melling	Rho barrage site Rho powerhouse site	39.4	38.7

Ambient temperature at Rho HEP area varied between 4°C at Jang and New Melling and (10°C) at Khet bridge. Relative humidity ranged between 27% at Nuranang Falls to 52% at Rho. Wind speed was varied from a minimum of 1.6 km/hr at Jang to a maximum of 3.6 km/hr at Rho. Wind was blowing in NW to SE direction (Table II. 3.331).

Table II. 3.331: Meteorological condition at proposed Rho HEP area

Sampling location	Nearest project component covered	Ambient temperature (°C) Min Max	Relative humidity (%)	Wind speed (range in km/hr)	Wind direction
Rho	Rho barrage site Rho powerhouse site	05 09	52	1.8–3.6	NW
Jaswantgarh	Rho barrage site Rho powerhouse site	05 09	32	2.1–2.7	SE
Nuranang falls	Rho barrage site Rho powerhouse site	06 10	27	2.4–3.2	SE
Jang	Rho barrage site Rho powerhouse site	04 08	39	1.6–2.3	SE
New Melling	Rho barrage site Rho powerhouse site	04 09	37	1.7–2.5	SE

Noise Level: Noise levels at Jaswantgarh was 27.1 dBA at 8.00 AM and 67.1 dBA at 4.00 PM in New Melling area (Table II. 3.332).

Table II. 3. 332: Noise level at proposed Rho HEP area

Sampling location	Nearest project sites covered	Noise level (dBA) 8.00 AM	Noise level (dBA) 4.00 PM
Rho	Rho barrage site Rho powerhouse site	37.2	39.6
Jaswantgarh	Rho barrage site Rho powerhouse site	27.1	25.2
Nuranang falls	Rho barrage site Rho powerhouse site	64.6	63.2
Jang	Rho barrage site Rho powerhouse site	38.2	29.7
New Melling	Rho barrage site Rho powerhouse site	61.3	67.1

3.3.8.2 BIOLOGICAL ENVIRONMENT

Vegetation Types

The project components of Rho HEP are located in montane sub-tropical forest and temperate forest area.

11B/CI East Himalayan wet temperate forest (2000-3000 m): These are mixed evergreen forests with moderate size trees, occurring between 1800 and 3000 m elevation. In these forests important tree associates were: *Acer campbellii, Lithocarpus pachyphylla, Prunus cerasoides, Quercus serrata, Rhododendron arboreum, Schima wallichii* and *Tetracentron sinense*. Shrubs were represented by *Berberis asiatica, Coriaria nepalensis, Elaeagnus parvifolia, Rosa brunonii, Rubus ellipticus* and *Viburnum erubescens*. Climber and epiphytes were not common.

12/C3a East Himalayan mixed coniferous forests (2000-3500 m): These are dense evergreen forests with dominance of oak and rhododendrons. Between 2300-3500 m elevations in the upper ridges, silver fir (*Abies densa*) makes appearance as a dominant tree species. However at lower elevations, other deciduous trees such as *Magnolia* sp., *Acer* sp., *Betula alnoides, Alnus nepalensis*, mixed with oak species, occur at varying extents. Gregarious undergrowth, usually of bamboo, and in its absence *Rhododendron* species and other evergreen shrubs such as *Berberis* sp., *Cotoneaster* sp., *Rhododendron* sp., *Salix* sp., *Thamnocalamus* sp. and *Viburnum* sp. also occur. The trees are mostly covered with many epiphytic mosses and lichens.

Eastern Himalayan sub-tropical pine forest (1200-1800 m): These forests do not appear in the Champion and Seth classification. However, they occur in and around 1200 m and extend up to 1800 m elevations mostly repalcing the broad-leaved forests following disturbances. The canopy is comprised of *Pinus wallichiana*. However, remnants of broad-leaved forest elements with *Mallotus philippensis, Pyrus pashia, Albizzia arunachalensis, Prunus cerasoides, Purus* sp., are quite conspicuous. Shrubs were represented by *Artimisia nilagirica, Coriaria nepalensis, Elaeagnus parvifolia, Rosa* sp., *Rubus ellipticus, Butea buteiformis* and *Viburnum erubescens*. The herbaceous layer constitutes of Climber and epiphytes are not common.

12/ISI Alder forest (1800-2200 m): These are typically seen as pure stands of *Alnus nepalensis* and *Populus ciliata*, with heights ranging from 20-30 m. They occur as a strip with varying width along stream sides, spreading out to larger areas, and more or less deciduous in nature. In the lower course of the stream and landslide affected areas, *Alnus* is the dominant formation. There is often an under growth of inedible/thorny shrubs comprising *Berberis, Rubus, Princepia* etc., whilst in the better wooded tracts, progression starts early and other species, notably blue pine and other conifers, are usually present.

12/1S2 Riverine blue-pine forest (1800-3000 m): These forests are characterized by irregular and often dense stands of blue pine with occasional *Picea*, *Tsuga, Populus* and *Alnus*, with little or no undergrowth.

Plant Diversity

The survey at Rho HEP sites resulted in the documentation of 155 plant species belonging to different groups at barrage and powerhouse sites, and the catchment area. A complete list of plant species found in the study area representing different groups such as tree, shrub, herb, climber, orchid, pteridophyte, bryophyte, lichen and fungi along with the family names is given in Appendix II. 3.91. The number of plant species belonging to different groups is summarized in Table II. 3.333.

Table II. 3.333: Plants belonging to different groups recorded from Rho HEP site

Sl. No.	Groups	Number of species		
		Barrage site	Powerhouse site	Catchment area
1	Tree	12	9	11
2	Shrub	14	14	14
3	Herb	48	43	42
4	Climber	16		13
5	Orchid	10		8
6	Pteridophyte	13		10
7	Bryophyte	7		5
8	Lichen	10		8
9	Fungi	17	14	15

At the barrage site, 12 tree, 14 shrub, and 48 herb species were recorded, and at the powerhouse site 9 tree, 14 shrub, and 43 herb species were recorded. From the project catchment area, 11 tree, 14 shrub, and 42 herb species were recorded. A total of 16 climber, 10 orchid, 13 pteridophyte,7 bryophyte, 10 lichen and 17 fungus species were recorded from barrage and powerhouse site. From the catchment area 13 climber, 10 orchid, 10 pteridophyte, 5 bryophyte, 8 lichen and 15 fungus species was recorded (Appendix II. 3.92 and 3.93).

Threatened and Endemic Plants

One threatened species was recorded in the project site (Table II. 3.334).

Table II. 3.334: Threatened/endemic plants recorded at Rho HEP site

Species name	Family	Threat status	References
Acer sikkimensis	Aceraceae	EN	Nayar and Sastry, (1987, 1988, 1990)

EN = Endangered; VU = Vulnerable

Economically Important Species/Plant Resources

The study area is rich in plant resources. A few of the important ones are listed in Table II. 3.335 under different groups.

Table II. 3.335: Economically important species/plant resources present at Rho project site

Sl. No.	Uses	Species name
1	Timber	*Pinus wallchiana, Magnolia campbelii*
2	Fuel	*Quercus griffithii, Q. Semicarpifolia, Q. Lanuginosa, Alnus nepalensis, Rhododendron* sp.
3	Ornamentals and orchids	*Rhododendron* sp., *Primula* sp., *Luculia pinceana, Sedum multicaule, Pedicularis* sp., *Cymbidium* sp., *Hydrangea* sp., *Inula* sp., *Aster* sp., *Senecio* sp., *Satyrium* sp., *Begonia* sp., *Impatiens* sp.
4	Medicine and aromatics	*Berberis* sp., *Acorus* sp., *Bergenia ligulata*
5	Fodder	*Saurauia nepalensis, Ficus* sp., *Quercus griffithii, Villebrunea* sp.
6	Edible	*Pyrus pasha, Prunus* sp., *Rubus ellipticus, Benthamidia capitata, Elaeagnus* sp.
7	Fibre and paper	*Daphne papyracea*
8	Bamboo	*Arundinaria* sp., *Phyllostachys* sp.
9	Resins and gums	*Pinus wallichiana*

Vegetation Analysis for Angiosperms and Gymnosperms

The plant communities at barrage and powerhouse sites, and catchment area were studied. At the study sites, the species richness was high. It had 18 tree species, 16 shrub species, and 50 herbaceous species (Tables II. 3.336 and 3.337).

Table II. 3.336: Tree and shrub species recorded near barrage and powerhouse sites and in the catchment area at Rho project

Tree species	Shrub species
Acer campbellii	*Artemesia nilagirica*
Acer sikkimensis	*Arundinaria manii*
Alangium alpinum	*Berberis aristrata*
Alnus nepalensis	*Boenninghausenia albiflora*
Brassiopsis glomerulata	*Coraria napalensis*
Euvodia fraxinifolia	*Daphnae papyracea*
Lindera neesiana	*Eleagnus parviflora*
Magnolia campbellii	*Euphorbia sikkemensis*
Photinia integrifolia	*Girardinia grandiflora*
Pinus wallichiana	*Hypericum choisianum*
Populus ciliata	*Neillia thysiflora*
Quercus griffithi	*Pipthanthus nepalensis*
Quercus lamellosa	*Rosa* sp.
Quercus serrata	*Rubus ellipticus*
Rhododendron arboreum	*Sarcococca* sp.
Rhus chinensis	*Viburnum foetidum*
Schima wallichi	
Toricellia tiliifolia	

Table II. 3.337: Herbaceous species recorded near barrage and powerhouse and in the catchment area at Rho village

Herb species		
Achyranthes aspera	*Eupatorium adenophorum*	*Oxalis corniculata*
Ainsliaea sp.	*Euphorbia sikkemensis*	*Paspallum* sp.
Anaphalis margaritacea	*Fragaria nubicola*	*Persicaria runcinata*
Arisaema erubescens	*Fragaria* sp.	*Phlomis* sp.
Arisaema nepenthoides	*Galeola lindleyana*	*Pilea umbrosa*
Aster sp.	*Galinsoga parviflora*	*Plantago major*
Aster trinervius	*Galium asparine*	*Pleione precox*
Astilbe rivularis	*Galium* sp.	*Pogostemon* sp.
Berginia ciliata	*Geranium pratense*	*Polygonum capitata*
Cirsium falconeri	*Gonatanthus pumilus*	*Potentilla cuneata*
Cyanoglossum sp.	*Herpetospermum pendulosum*	*Rumex acetosella*
Cynoglossum sp.	*Hypoetes roxburghii*	*Sambacus adnata*
Cyathula capitata	*Imperata cylindrica*	*Senecio cappa*
Didymocarpus sp.	*Iris lactea*	*Urtica dioca*
Dracocephalum sp.	*Nepata* sp.	*Valeriana hardwickii*
Drymaria cordata	*Ophiopogon intermedius*	*Viola sikkimensis*
Elsholtzia stobilifera	*Opliomenus* sp.	

In general, species richness was high during monsoon season and low during winter season. *Alnus nepalensis* was dominant at the barrage and powerhouse sites, and in the catchment area. Among shrubs, *Artemesia nilagarica* was dominant at all the three sites.. The herbaceous community being mostly annual in nature, at a given site, different species were dominant in three different seasons (Appendix II. 3.103).

The highest tree density was recorded in the catchment area, while that for shrubs was at barrage site (Table II. 3.338). Density of herbaceous species varied widely among barrage site, powerhouse site, and catchment area. It was maximum during monsoon season and minimum during winter season at all the sites (Appendix II. 3.94-3.102).

Shannon diversity index for tree species in the community was highest in the barrage site (H'=2.16) followed by catchment area (2.15) and powerhouse site (1.99). For shrub species, highest diversity value (H'=2.38) was obtained at barrage site followed by powerhouse site (2.28) and catchment area (2.27) (Table II. 3.338).

Shannon diversity index for herbs ranged from 2.69-3.45. The highest and lowest value was recorded from the catchment area during monsoon season and winter season respectively. Overall, species diversity was highest in the catchment area.

Table II. 3.338: Species richness, diversity and dominance of trees and shrubs, and biomass and carbon stock of trees in the community in Rho project sites

Parameters	Barrage		Powerhouse		Catchment area	
	Trees	Shrubs	Trees	Shrubs	Trees	Shrubs
Number of species	12	14	9	14	11	14
Density (ha^{-1})	610	8512	570	8240	700	8448
Simpson index of dominance	0.15	0.89	0.17	0.86	0.14	0.86
Shannon index of diversity (H')	2.16	2.38	1.99	2.28	2.15	2.27
Evenness index	0.87	0.77	0.90	0.70	0.90	0.69
Biomass (t/ha)	81.24		47.38			
Carbon (t/ha)	40.62		23.69		33.64	

Table II. 3.339: Species richness, diversity and dominance of in herbaceous community in Rho project sites

Parameters	Barrage			Powerhouse			Catchment area		
	PM	M	W	PM	M	W	PM	M	W
Number of species	29	44	20	29	35	21	30	42	19
Density (ha^{-1})x10^3	291	532	227	286	462	220	343	554	230
Simpson index of dominance	0.94	0.96	0.92	0.94	0.96	0.92	0.94	0.96	0.92
Shannon index of diversity (H')	2.97	3.44	2.76	3.01	3.33	2.74	3.02	3.45	2.69
Evenness index	0.67	0.71	0.79	0.70	0.80	0.74	0.68	0.75	0.78

PM: Post monsoon; M: Monsoon; W: Winter

Phytoplankton/Periphyton

Thirty two species of phytoplankton/periphyton were recorded from Rho project sites. The phytoplankton/periphyton community was represented by three species of Cyanobacteria and 29 species of Bacillariophyceae. Species richness was highest in the project affected area with 29 species and minimum with 16 species in the catchment area. Phytoplankton/periphyton density was highest in the project affected area (655 individuals/l) and lowest in the catchment area (180 individuals/l). Similarly, species diversity index was maximum (H'= 3.23) in the project affected area and minimum (H'= 2.61) in the catchment area (Table II. 3.340).

Table II. 3.340: Density (Individuals/l), species richness and Shannon index of diversity (H') of phytoplankton/periphyton community in the project affected area and catchment area of Rho HEP site

List of species	Project affected area	Catchment area
Cyanobacteria		
Lyngbya sp.	20	
Oscillatoria sp.	45	
Phormidium sp.	25	
Bacillariophyceae		
Achnanthes biporoma		10
Achnanthes brevipes	15	
Achnanthidium pyrenaicium	15	
Achnanthidium rivulare	35	20
Caloneis ventricosa	30	
Cocconeis placentula	25	10
Cymbella affinis	20	10
Cymbella delicatula	15	
Cymbella excisa	25	
Diatoma sp.	20	10
Encyonema minutum	20	10
Encyonema proslatum	25	10
Eunotia bilunaris	40	5
Fragillaria	10	
Fragillaria vauchaeriae	5	20
Gomphonema olivaceoides	20	5
Gomphonema olivaceum	5	15
Hydrosera sp.	15	
Meridion circulare	35	
Navicula capitata		10
Navicula cryptocephala	30	
Navicula cryptotenella	35	
Nitzchia palea		20
Opephora sp.	10	
Planothidium frequentissimum	40	10
Pseudostaurosina sp.	5	
Rhoicosphaenia sp.	5	5

Synedra acus	30	
Synedra ulna	35	10
Total density (Individuals/lit)	**655**	**180**
Species diversity index	**3.23**	**2.61**
Species richness	**29**	**16**

NB: Blank cells indicate absence of phytoplankton species

Zooplankton

The study was conducted during monsoon and winter seasons in Rho area,in which only one species belonging to Cladocera (*Alona cheni*) and one Rotifera (*Lecane lunaris*) were recorded during the monsoon period (Table II. 3.341).

Table II. 3.341: Occurrence of species belonging to Cladocera and Rotifera during monsoon and winter seasons at Rho site

Sl. No.	Taxa	Species	Season	
			Monsoon	Winter
1	Cladocera	*Alona cheni* (Sinev, 1999)	+	–
2	Rotifera	*Lecane lunaris* (Ehrenberg, 1832)	+	–
Total	**2**	**2**	**2**	**0**

Fish Fauna

Three fish species were recorded from Rho project site (Table II. 3.342).

Table II. 3.342: Fish fauna present in Rho HEP area

Family	Species name	Max Length (cm)	Water Depth required (m)	Width of water flow required (m)	Altitude	Substrate
Cyprinidae	*Schizothorax richardsonii*	60.0	2-6	4-5 m	High and mid	Rocky
	Schizothorax progastus	50.0	1-3	3-4 m	High and mid	rocky
Salmonidae	*Pseudechnesis sulcatus*	20.0	2-7	2-4 m	High, mid and low	gravel, cobble substrate

Soil Fauna

The seasonal variation in soil faunal diversity (Collembola, Acarina and other arthropods) and eveness in litter and soil layer is shown in Tables II. 3.343-3.345.

Table II. 3.343: Seasonal variation in soil faunal diversity (Collembola, Acarina and other arthropods) and equitability in litter and soil layer at Rho site

Soil fauna	Diversity	Post monsoon				Monsoon				Winter			
		Barrage		Powerhouse		Barrage		Powerhouse		Barrage		Powerhouse	
		Litter	Soil	Litter	Soil	Litter	Soil	Litter	Soil	Litter	Soil	Litter	Soil
Collembola	Dominance_D	0.16	0.15	0.12	0.16	0.16	0.15	0.16	0.14	0.19	0.20	0.14	0.14
	Shannon_H	1.91	1.91	2.18	1.90	1.90	1.97	1.90	2.00	1.73	1.61	2.02	2.02
	Evenness_e^H/S	0.96	0.96	0.98	0.95	0.95	0.89	0.95	0.93	0.94	1.00	0.94	0.94
Acarina	Dominance_D	0.22	0.19	0.12	0.18	0.13	0.20	0.13	0.12	0.16	0.28	0.16	0.16
	Shannon_H	1.56	1.73	2.17	1.75	2.16	1.71	2.16	2.17	1.89	1.33	1.91	1.91
	Evenness_e^H/S	0.96	0.94	0.97	0.96	0.87	0.92	0.87	0.97	0.94	0.95	0.96	0.96
Other Arthropods	Dominance_D	0.20	0.13	0.12	0.10	0.11	0.12	0.11	0.16	0.15	0.15	0.16	0.16
	Shannon_H	1.78	2.12	2.13	2.35	2.30	2.25	2.30	1.86	1.91	1.91	1.89	1.89
	Evenness_e^H/S	0.85	0.93	0.94	0.95	0.91	0.86	0.91	0.92	0.96	0.96	0.95	0.95

Table II. 3.344: Mean annual density (number/m^2) of soil fauna in litter and soil layer (0-5 cm) at Rho site

Soil fauna	Site	Litter layer	Soil layer	Total
Collembola	Barrage	1891	1491	3382
	Powerhouse	2182	1709	3891
Acarina	Barrage	1343	743	2086
	Powerhouse	1314	1229	2543
Other Arthropods	Barrage	1818	2255	4073
	Powerhouse	2691	2691	5382
Total fauna	**Barrage**	**5052**	**4489**	**9541**
	Powerhouse	**6187**	**5629**	**11816**

Table II. 3.345: Seasonal variation of soil fauna density (number/m^2) at barrage and powerhouse site of Rho HEP area

Soil fauna	Site	Post-monsoon	Monsoon	Winter	Mean
Collembola	Barrage	11200	20800	5200	**12400**
	Powerhouse	14400	19600	8800	**14267**
Acarina	Barrage	9200	14000	6000	**9733**
	Powerhouse	10400	18800	6400	**11867**
Other arthropods	Barrage	13600	20800	10400	**14933**
	Powerhouse	20800	29600	8800	**19733**

Wildlife

Butterflies: There were 20 species of butterfly belonging to 16 genera and four families. The family Nymphalidae dominatedthe site with 7 species. None of these species belonged to threatened category (Table II. 3.346).

Table II. 3.346: Butterflies recorded in Rho HEP area

Sl. No.	Family common name	Scientific name	Project area
1	**Papilionidae**		
1	Common Peacock	*Papilio polyctor ganesa*	*
2	Paris Peacock	*Papilio paris paris*	*
3	Golden Birdwing	*Troides aeacus aeacus*	*
4	Common Bluebottle	*Graphium sarpedon sarpedon*	*
5	Indian Purple Emperor	*Mimathyma ambica*	*
2	**Pieridae**		
6	Dark Jezebel	*Delias berinda*	*
7	Spotless Grass Yellow	*Eurema laeta*	*
8	Small Grass Yellow	*Eurema brigitta rubella*	*
9	Indian Cabbage White	*Pieris canidia indica*	*
10	Green-veined White	*Pieris napi montana*	*
3	**Lycaenidae**		
11	Green Sapphire	*Heliophorus moore*	*
12	Common Flash	*Rapala nissa ratna*	*
13	Common Hedgeblue	*Acytolepis puspa gisca*	*
4	**Nymphalidae**		
14	Chestnut Tiger	*Parantica sita*	*
15	Eastern Comma	*Polygonia egea*	*
16	Large Silverstripe	*Argynnis children*	*
17	Glassy Tiger	*Graphium cloanthus*	*
18	Chocolate Pansy	*Junonia iphita iphita*	*
19	Banded Treebrown	*Lethe confusa*	*
20	Straight-banded Treebrown	*Lethe verma*	*

Herpetofauna: No herpetofauna was encountered in Rho project area during field survey. The probable list of amphibians and reptiles was prepared for this site following Ahmed *et al.* (2009 (Appendix II. 3.167).

Birds: The assessment of bird diversity carried out during monsoon and winter seasons in and around this project area revealed the presence of 110 terrestrial bird species that belonged to 77 genera and 34 families, and with a Shannon diversity (H') value of 4.1. This indicates a moderate level of species diversity. When seasonal status was compared, richness was higher during winter (35 species) than in monsoon (51 species). The abundance of birds was high in post monsoon season (Table II. 3.347).

Migratory status: The migratory and resident status of these bird species showed that most of the birds were residents (80 species) followed by 17 breeding visitors and 13 winter visitors (Table II. 3.347).

Table II. 3.347: Status of birds recorded in the Rho HEP area

Details	Post monsoon	Monsoon	Winter	Overall
Family	21	22	25	34
Genera	31	41	40	77
Species	37	51	53	110
Abundance	494	451	270	1215
Diversity H'	3.7	3.3	3.5	4.1
Migratory status				
Breeding visitor	5	9	6	17
Isolated record	0	0	0	0
Resident	30	35	42	80
Winter visitor	2	7	5	13

Abundance status: The abundance status of birds was derived by classifying the abundance of bird species into five abundance category (Very Low = 1-25 birds, Low = 26-50, Moderate = 51-75, High = 76-100, and Very High = > 100 birds). The details of abundance status are given in the Table II. 3.348.

Table II. 3.348: Number of species and relative % of birds in different abundance classes

Abundance class	No. of species	Relative %
Very low -1 -25 Birds	100	90.9
Low -26 -50 birds	7	6.4
Moderate -50 -75 birds	1	0.9
High -76-100 birds	1	0.9
Very high > 100 birds	1	0.9
Total	**110**	**100**

Status of foraging guilds: In Rho HEP site, nine guilds were present, among which insectivore was dominant with 77 species, followed by omnivore and granivore with 11 and 10 species respectively, and other guilds were represented by less number of species. (Table II. 3.349 and Appendix II 3.191). This analysis also indicated low diversity of birds in the area.

Table II. 3.349: Status of foraging guild of birds recorded in the Rho HEP area

Foraging guild	Post monsoon	Monsoon	Winter	Overall
Aquatic Feeder	1	0	0	1
Carnivore	0	2	1	3
Frugivore	1	0	0	1
Granivore	2	3	6	10
Insectivore	22	40	38	77
Nectarivore	3	2	4	5
Nucivore	0	0	1	1
Omnivore	7	4	3	11
Piscivore	1	0	0	1

Status of threatened species: The assessment of conservation status of birds in this project area showed that there was no threatened bird species (Appendix II. 3.191).

Mammals: Surveys in and around Rho project site revealed the presence of eight mammalian fauna and each belonging to separate genus and family. This list consists of 1 primate, 3 ungulates, 2 carnivore and 2 rodent species (Appendix II. 3.192).

Abundance status: Among the eight species, presence of five species was confirmed based on the direct sighting of 26 animals, and three species based on 7 indirect evidences. Further evaluation of species richness of the project area (8 species) with the possible number of species (29 species) of the Tawang basin (Mishra *et al.* 2006) revealed a low richness in the project area formed only 27.58% (Appendix II. 3.192).

Status of threatened species: According to IUCN Red List, only Arunachal Macaque (*M. munzala*) and Himalayan goral (*Naemorhedus goral)* which were categorized as Endangered (EN) and Near Threatened (NT) category, rest of the species of the project area fall under Least Concern (LC) of IUCN and Schedule II and III of WPA (1972) (Table II. 3.350).

Table II. 3.350: Status of mammalian fauna recorded in the Rho HEP area

Sl. No.	Common name	Scientific name	Seasons			Overall	Conservation status	
			PM	M	W		IUCN	WPA
I.	**Cercopithecidae**							
1	Arunachal Macaque	*Macaca munzala*	A 11*		A 15	A 15	**EN**	-
II.	**Cervidae**							
2	Barking Deer	*Muntiacus muntjak*		A 4		A 4	LC	**III**
III.	**Bovidae**							
3	Himalayan goral	*Naemorhedus goral*	IE 2			IE 2	NT	III
IV.	**Suidae**							
4	Wild pig	*Sus scrofa*	IE 3			IE 3	LC	III
V.	**Felidae**							
5	Jungle cat	*Felis chaus*			IE 1	IE 1	LC	II
VI.	**Mustelidae**							
6	Yellow Throated Martin	*Martes flavigula*		IE 1 A 2		IE 1 A 2	LC	II
VII.	**Sciuridae**							
7	Hoary-bellied Himalayan Squirrel	*Callosciurus pygerythrus*	A 1	A 1		A 2	LC	NE
8	*Himalayan Stripped Squirrel*	*Tamipos macclellandi*		A-2	A 1	A 3	LC	NE
	No of species		**4**	**4**	**3**	**8**		
	Total and types of records		**IE 5 A 1**	**IE 1 A 9**	**IE 1 A 16**	**IE 7 A 26**		

IE – Indirect Evidences A-animals sighted, W-Winter, PM-Post monsoon, M-Monsoon, IUCN-Red List, WPA-Wildlife Protection Act, EN-Endangered, NT-Near threatened, LC-Least Concern, * Same group encountered in Post monsoon. NE-Not Evaluated

Faunal status within 500 m of project affected area: This section revealed species richness status of selected faunal groups such as avifauna and mammal species reported within 500 m up and down streams of the barrage and powerhouse sites of the proposed project area. The species richness reported in these specific sites was evaluated based on subjective rating through estimating percent contribution with the overall species list of the project area. If the species richness of barrage and powerhouse contributes 25% of overall list it was categorized as low, > 25-50% as medium, >50-75% as high and above 75% as high species richness.

Status of avifauna: At Rho barrage site, bird species richness with 39 species is designated as medium species richness area, when compared with the overall list of 110 species reported for the entire project area (35.45%).There were no threatened species in the barrage site. The powerhouse site may be designated as a low species richness area (26 species) when compared with the overall list of 110 species reported for the entire project area (23.63%). No threatened species was found in the powerhouse site (Appendix II. 3.193 and 3.194).

Status of mammals: Site specific evaluation of mammalian fauna within 500 m of up and down streams showed occurrence of five mammals in the barrage site and four mammals in the powerhouse site. Among the species, Arunachal Macaque (*Macaca munzala*) was the only endangered species reported with 15 animals in one group in the vicinity of the barrage site while rest of the six species belong to least concern category of IUCN (Table II. 3.351 and Appendix II. 3.192).

Table II. 3.351: Status of mammalian fauna at barrage and powerhouse sites of the proposed Rho HEP area

Common name	Species name	Status		Conservation status	
		BS	PHS	IUCN	WPA
Arunachal Macaque	*Macaca munzala*	A15		EN	-
Barking Deer	*Muntiacus muntjak*	A1		LC	**III**
Wild pig	*Sus scrofa*	IE 2	IE1	LC	III
Jungle cat	*Felis chaus*		IE1	LC	II
Yellow Throated Martin	*Martes flavigula*	A2,	IE 1	LC	II
Hoary-bellied Himalayan Squirrel	*Callosciurus pygerythrus*	A1		LC	-
Himalayan Stripped Squirrel	*Tamipos macclellandi*	A1	A1	LC	-
Total no. of species		**5**	**4**		
Total no. of record		**A20, IE 2**	**IE 3, A1**		

IE – Indirect Evidences, A – No of Animals Sighted, BS –Barrage Site, PHS – Powerhouse Site, IUCN-Red List, WPA-Wildlife Protection Act, NT-Near threatened, LC-Least Concern, EN – Endangered, G – No of groups

3.3.8.3 SOCIO-ECONOMIC PROFILE

The results of socio–economic baseline survey for Rho HEP have been described separately for data gathered at the village level and at the HH level.

Village Level Survey

Profile of the Ten Surveyed Villages: Out of the 10 villages**,** only Rho and Jangda fall under affected villages, while the remaining eight villages fall under influence category (Table II. 3.352). The ten villages fall under four administrative circles, viz., Thingbu, Lhau, Jang and Mukto. All the 10 villages are situated within 8km distance from the Tawang river. The circle headquarters of the ten villages are within 15 km. All the 10 villages are located at a very long distance from the district headquarters.

Table II. 3.352: Profile of the ten surveyed villages

Sl. No.	Village	Circle	Distance of village (in km)			Category of village
			River/ Tributary	Circle HQ	District HQ	
1	Dungse	Jang	2	1	45	Influenced
2	Jangda	Lhau	7	15	90	Affected
3	Kharsa	Jang	2	1	45	Influenced
4	Kregyang	Lhau	2	2	22	Influenced
5	Mirba	Mukto	3	10	55	Influenced
6	Regyang	Lhau	2	3	23	Influenced
7	Rho	Thingbu	8	5	99.6	Affected
8	Shyro	Lhau	5	7	30	Influenced
9	Gomkelleng	Mukto	4	12.8	100	Influenced
10	Yuthembu	Jang	2.5	1	45	Influenced

Private Land Use Pattern: The details of private land holdings (in hectares) of the eight villages (data for Kharsa and Gomkelleng are not available) are given in the Table II. 3.353. The total private land holdings in the 10 villages is about 513.15 ha. Three villages, viz., Rho, Jangda, and Yuthembu contribute 81% to the total land holdings. In all the villages, the proportion of agricultural land exceeds that of the other land use types. Private forest land also contributes significantly (36%) to the total land holdings of the villages.

Table II. 3.353: Private landuse pattern and their percentage to total private land

Sl. No.	Village	Total private land	Forest cover (ha)	%	Agriculture (ha)	%	Horticulture (ha)	%	Habitation and HG (ha)	%
1	Dungse	2.74	0.00	–	2.43	89	0	–	0.31	11
2	Jangda	120.00	45.00	38	57.00	48	0	–	18.00	15
3	Kharsa	–	–	–	–	–	–	–	–	–
4	Kregyang	11.80	2.20	19	6.00	51	0	–	3.60	31
5	Mirba	30.50	12.00	39	18.00	59	0	–	0.50	2
6	Regyang	16.85	2.75	16	8.90	53	0	–	5.20	31
7	Rho	160.00	58.00	36	66.00	41	0	–	36.00	23
8	Shyro	34.26	13.00	38	16.78	49	0	–	4.48	13
9	Gomkelleng	–	–	–	–	–	–	–	–	–
10	Yuthembu	137.00	53.00	39	62.00	45	0	–	22.00	16
	Total*	**513.15**	**185.95**		**237.11**		**0**	–	**90.09**	

* Excluding Kharsa and Gomkelleng due to non availability of data

Demography and Literacy Rate: From Table II. 3.354, the following main features emerge. The total number of HHs in the ten villages is 601 (number varies from 18 in Kregyang to 107 in Kharsa). The total population is 2602 (1303 males; 1299 females). In Jangda, Kharsa, Gomkelleng and Yuthembu the number of females is higher than that of the males. In Regyang the sex ratio is equal. The literacy rate ranged from 30% in Jangda to 63.6% in Yuthembu. In Regyang and Dungse, the literacy rate is more than 50%, and it is less than 50% in the remaing villages.. Among males the rate varies from 30% in Jangda to 70.8% in Yuthembu, and in females it varies from 23% in Rho to 54.3% in Dungse.

Table II. 3.354: Demography and literacy rate

Sl. No.	Village	Demography					Literacy rate*		
		Total	Male	Female	Sex ratio (per 1000 males)	No. of HH	Male	Female	Total
1	Dungse	127	68	59	868	36	67.6	54.3	**61.9**
2	Jangda	525	249	276	1108	99	30.0	41.0	**30.0**
3	Kharsa	468	229	239	1044	107	44.6	37.7	**41.7**
4	Kregyang	81	43	38	884	18	40.0	26.5	**31.1**
5	Mirba	166	89	77	865	40	43.7	33.3	**39.4**
6	Regyang	116	58	58	1000	26	57.6	47.9	**55.0**
7	Rho	286	150	136	907	85	58.0	23.0	**45.0**
8	Shyro	305	159	146	918	56	42.6	38.3	**41.4**
9	Gomkelleng	159	76	83	1092	36	51.1	36.5	**45.2**
10	Yuthembu	369	182	187	1027	98	70.8	52.5	**63.6**
	Total	**2602**	**1303**	**1299**		**601**			

*After Census 2011

Number of Livestock: In Table II. 3.355, the details of livestock holding are given for all the nine villages. Altogether, nine different types of animals are domesticated in ten surveyed villages. In none of the villages all the nine types of animals were domesticated. In total, 3061 animals are found in the ten villages. Considerable inter–village variation is observed in total number of animals reared. It varied from 10 in Dungse to 1021 animals in Jangda.

Table II. 3.355: Number of livestock

Sl. No.	Village	Mithun	Cattle	Yak	Goat	Sheep	Pig	Pony	Poultry	Others	Total
1	Dungse	0	1	0	0	0	0	0	0	9	**10**
2	Jangda	0	395	114	37	364	72	10	28	1	**1021**
3	Kharsa	–	–	–	–	–	–	–	–	–	**–**
4	Kregyang	0	27	0	0	60	0	0	0	0	**87**
5	Mirba	0	103	67	5	0	0	7	0	0	**182**
6	Regyang	0	26	0	0	0	0	0	0	0	**26**
7	Rho	0	255	49	68	85	14	6	7	3	**487**
8	Shyro	0	357	69	0	2	29	50	2	0	**509**
9	Gomkelleng	2	60	1	5	10	0	0	0	5	**83**
10	Yuthembu	10	413	224	2	10	0	0	0	0	**659**
	Total*	**12**	**1637**	**524**	**117**	**531**	**115**	**73**	**37**	**18**	**3064**

* Excluding Kharsa due to non availability of data

Total Estimated Value of Livestock: The monetary value of domesticated animals maintained by the inhabitants of the studied villages has been estimated separately for each animal and for each village (Table II. 3.356). The selling price of different animals was obtained from the knowledgeable persons in the villages. The detailed methodology used in estimating the monetary value of animals has been described in the methodology section of this document. As expected, there is considerable intra–inter village variation in this respect. The total value of animals numbering 3064 found in the nine villages has been estimated as 631.19 lakhs. The value varied from 1.60 lakhs in Mirba to 171.53 lakhs in Jangda. In terms of relative contribution made by different animals to the total value, cattle and Yak together contribute over 540.25 lakhs (86%).

Table II. 3.356: Total estimated value of livestock

Sl. No.	Village	Total estimated value (Rupees in lakh)									
		Mithun	Cattle	Yak	Goat	Sheep	Pig	Pony	Poultry	Others	Total
1	Dungse	0.00	0.25	0.00	0.00	0.00	0.00	0.00	0.00	1.35	**1.60**
2	Jangda	0.00	98.75	28.50	1.85	21.84	18.00	2.30	0.14	0.15	**171.53**
3	Kharsa	–	–	–	–	–	–	–	–	–	**–**
4	Kregyang	0.00	6.75	0.00	0.00	3.60	0.00	0.00	0.00	0.00	**10.35**
5	Mirba	0.00	25.75	16.75	0.25	0.00	0.00	1.61	0.00	0.00	**44.36**
6	Regyang	0.00	6.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**6.50**
7	Rho	0.00	63.75	12.25	3.40	5.10	3.50	1.38	0.04	0.45	**89.87**
8	Shyro	0.00	89.25	17.25	0.00	0.12	7.25	11.50	0.01	0.00	**125.38**
9	Gomkelleng	0.80	15.00	0.25	0.25	0.60	0.00	0.00	0.00	0.75	**17.65**
10	Yuthembu	4.00	103.25	56.00	0.10	0.60	0.00	0.00	0.00	0.00	**163.95**
	Total*	**4.80**	**409.25**	**131.00**	**5.85**	**31.86**	**28.75**	**16.79**	**0.19**	**2.70**	**631.19**

* Excluding Kharsa and due to non availability of data

Average Annual Earnings of the Village: The average annual family income varies from 0.74 in lakhs in Kharsa to 3.58 lakhs in Jangda. The value of total earnings per year in the villages is estimated at 1382.53 lakhs. The contribution made by animal husbandry compared to the other resources, to the total earnings is maximum in a majority of the villages. Of the total annual earnings, animal husbandry contributes 661.82 lakhs (48%). Traditional skills, in particular weaving and daily wage labour together contribute over 34%. It is highly noteworthy that agriculture contributes only 9% of the total annual village earnings (Table II. 3.357).

Table II. 3.357: Average annual earning of the village

Sl. No.	Village	Total earning/year(Rupees in lakh)								Average Family income (Rupees in lakh)
		Agriculture	Animal Husbandry	Horticulture	Traditional Skills	Daily Wages	GS	Others*	Total	
1	Dungse	4.50	2.16	0.00	3.00	14.58	4.08	2.86	**31.18**	0.87
2	Jangda	28.50	220.54	0.00	39.75	40.10	14.94	10.46	**354.28**	3.58
3	Kharsa	NA	NA	NA	12.50	43.34	13.74	9.62	**79.19**	0.74
4	Kregyang	3.00	18.79	0.00	1.25	7.29	2.58	1.81	**34.72**	1.93
5	Mirba	9.00	39.31	0.00	15.30	16.20	5.34	3.74	**88.89**	2.22
6	Regyang	4.45	5.62	0.00		10.53	3.48	2.44	**26.51**	1.02
7	Rho	33.00	105.19	0.00	25.00	34.43	9.00	6.30	**212.92**	2.50
8	Shyro	8.39	109.94	0.00	30.00	22.68	9.54	6.68	**187.23**	3.34
9	Gomkelleng	2.25	17.93	0.00	87.75	14.58	4.56	3.19	**130.26**	3.62
10	Yuthembu	31.00	142.34	0.00	5.75	39.69	10.92	7.64	**237.35**	2.42
	Total	**124.09**	**661.82**	**0**	**220.30**	**243.42**	**78.18**	**54.74**	**1382.53**	**22.24**

* Other includes artisans, monks, self–employed contractors etc; NA=data not available.

Average Annual Expenditure Pattern of a Family: The average annual family expenditure in the surveyed villages varies from 1.20 lakhs in Kharsa to 1.58 lakhs in Rho. In all the villages the maximum expenditure is incurred on health and education followed by transport and clothing. In general, expenditure incurred on food and drinks is less than any other expenditures. The total value of average annual expenditure incurred by a family in ten villages is 13.77 lakhs (Table II. 3.358).

Table II. 3.358: Average annual expenditure pattern of a family in the villages

Sl. No.	Village	Expenditure/year (Rupees in lakh)				
		Food and drinks	Clothing	Transport	Education and health	Total
1	Dungse	0.30	0.30	0.30	0.30	**1.20**
2	Jangda	0.30	0.35	0.40	0.48	**1.53**
3	Kharsa	0.30	0.30	0.30	0.30	**1.20**
4	Kregyang	0.30	0.30	0.36	0.36	**1.32**
5	Mirba	0.35	0.35	0.27	0.30	**1.27**
6	Regyang	0.30	0.30	0.36	0.36	**1.32**
7	Rho	0.35	0.35	0.40	0.48	**1.58**
8	Shyro	0.30	0.35	0.40	0.48	**1.53**
9	Gomkelleng	0.30	0.25	0.37	0.45	**1.37**
10	Yuthembu	0.30	0.30	0.40	0.45	**1.45**
	Total	**3.10**	**3.15**	**3.56**	**3.96**	**13.77**

Water Sources: In Table II. 3.359, data pertaining to the water resources available and their pattern of use in the ten villages are presented. The Table II. 3.359 reveals that four types of water resources, viz., river, hill stream/springs, pond and tap water are available in the studied villages. Except in Shyro and Dungse, water from hill stream/spring(s) is used for domestic purposes as well as for the domestic animals in studied villages. Tap water is used for domestic purposes in all surveyed villages. In Shyro, pond water is also used for various purposes and in Mirba and Dungse, river water is also used.

Table II. 3.359: Water sources in the villages

		River				Hill stream/spring				Wells				Ponds				Tap Water			
Sl. No.	Village	Drinking water	Domestic use	Livestock use	Agriculture	Drinking water	Domestic use	Livestock use	Agriculture	Drinking water	Domestic use	Livestock use	Agriculture	Drinking water	Domestic use	Livestock use	Agriculture	Drinking water	Domestic use	Livestock use	Agriculture
1	Dungse	1		1														1	1	1	
2	Jangda					1	1	1										1	1		
3	Kharsa					1	1	1										1	1		
4	Kregyang					1	1	1										1	1	1	
5	Mirba	1		1		1	1	1										1	1		
6	Regyang					1	1	1										1	1	1	
7	Rho					1	1	1										1	1		
8	Shyro													1	1	1		1	1	1	
9	Gomkelleng					1	1	1										1	1		
10	Yuthembu					1	1	1										1	1		
	Total	**2**	**0**	**2**	**0**	**8**	**8**	**8**	**0**	**0**	**0**	**0**	**0**	**1**	**1**	**1**	**0**	**10**	**10**	**4**	**0**

Amenities in the Villages: From Table II. 3.360, it is observed that in Kharsa and Yuthembu, 11 amenities listed in the Table II. 3.360 were present. In Kregyang and Regyang the least number of amenities (4/12) are observed. All the villages have motorable road, electricity, telephone and TV/radio. Traditional health healers are not found in any one of the studied villages.

Table II. 3.360: Amenities in the villages

Sl. No.	Village	Road connectivity	Health facility (PHC/sub-centre)	Traditional health healer	Veterinary services	Electricity	Fair price shop	Grocery shop	Post office	Bank	School	Telephone/Mobile	TV/Radios
1	Dungse	√	√			√	√	√	√	√		√	√
2	Jangda	√				√					√	√	√
3	Kharsa	√	√		√	√	√	√	√	√	√	√	√
4	Kregyang	√				√						√	√
5	Mirba	√				√	√	√			√	√	√
6	Regyang	√				√						√	√
7	Rho	√	√		√	√					√	√	√
8	Shyro	√				√					√	√	√
9	Gomkelleng	√	√			√					√	√	√
10	Yuthembu	√	√		√	√	√	√	√	√	√	√	√
	Total	**10**	**5**	**0**	**3**	**10**	**4**	**4**	**3**	**3**	**7**	**10**	**10**

NB: Blank indicates absent

Social Institutions: In none of the ten villages all the four social institutions listed in Table II. 3.361 are present. Kharsa (4/10) and Shyro (4/10) have the maximum number of social institutions. Except Kregyang and Regyang all the other villages have Gompa. SHGs are absent in all the villages.

Table II. 3.361: Social institutions in the village

Sl. No.	Village	SHGs	Anganwadis	Community Hall	Gompa	Any Other	Total
1	Dungse		√	√	√		**3**
2	Jangda		√	√	√		**3**
3	Kharsa		√	√	√	√	**4**
4	Kregyang		√	√			**2**
5	Mirba			√	√		**2**
6	Regyang		√	√			**2**

7	Rho			√	√	√	**3**
8	Shyro		√	√	√	√	**4**
9	Gomkelleng		√	√	√		**3**
10	Yuthembu		√		√	√	**3**
	Total	**0**	**8**	**9**	**8**	**4**	**–**

NB: Blank indicates absent

Occupation Profile: Work force participation is detailed in Table II. 3.362. The total working population in the studied villages comprises of 2562 (43%) of total population. Of the total workers main workers are 90% while marginal workers are 10%.

Table II. 3.362: Occupation profile of the village

Sl. No.	Village	Population			Workers			Main Workers			Marginal Workers			Non Workers		
		T	M	F	T	M	F	T	M	F	T	M	F	T	M	F
1	Dungse	1770	1006	764	859	640	219	828	626	202	31	14	17	911	366	545
2	Jangda	682	406	276	458	289	169	320	252	68	138	37	101	224	117	107
3	Kharsa	132	72	60	70	33	37	54	26	28	16	7	9	45	13	32
4	Kregyang	74	25	49	6	3	3	4	2	2	2	1	1	6	2	4
5	Mirba	269	158	111	116	53	63	113	52	61	3	1	2	102	42	60
6	Regyang	180	132	48	21	10	11	21	10	11	0	0	0	19	10	9
7	Rho	652	403	249	21	8	13	10	7	3	11	1	10	16	4	12
8	Shyro	636	448	188	62	35	27	35	20	15	27	15	12	61	25	36
9	Gomkelleng	155	92	63	50	25	25	44	19	25	6	6	0	50	23	27
10	Yuthembu	1363	828	535	899	629	270	867	605	262	32	24	8	693	310	383
	Total	**5913**	**3570**	**2343**	**2562**	**1725**	**837**	**2296**	**1619**	**677**	**266**	**106**	**160**	**2127**	**912**	**1215**

Household Level Survey

Age of the Head of the Household: The age of head of HHs across the ten surveyed villages varied from 16 in Kregyang to 98 years in Shyro. The age of 35% of heads is over 50 years and 12% of heads age was below 30 years (Table II. 3.363). As expected and depending on the demographic structure of the villages, considerable variation has been observed between the villages in terms of the age of the Heads of HHs.. It varied from 43 to 53 (Table II. 3.364).

Table II. 3.363: Distribution of head of the HHs by age across the ten project villages

Sl. No.	Village	Up to 30		31–40		41–50		> 50		Total
		n	%	n	%	n	%	n	%	n
1	Dungse	3	8	5	14	14	39	14	39	**36**
2	Jangda	7	7	19	19	31	31	42	42	**99**
3	Kharsa	18	17	26	24	24	22	39	36	**107**
4	Kregyang	3	17	4	22	5	28	6	33	**18**
5	Mirba	4	10	13	33	13	33	10	25	**40**
6	Rengyang	5	19	3	12	10	38	8	31	**26**
7	Rho	8	9	36	42	24	28	17	20	**85**
8	Shyro	1	2	17	30	11	20	27	48	**56**
9	Gomkelleng	1	3	7	19	12	33	16	44	**36**
10	Yuthembu	20	20	27	28	21	21	30	31	**98**
	Total	**70**	**12**	**157**	**26**	**165**	**27**	**209**	**35**	**601**

Table II. 3.364: Minimum, maximum and average age of head of HHs across the ten project villages

Sl. No.	Village	Age range		Average
		From	To	
1	Dungse	22	74	49
2	Jangda	25	92	50
3	Kharsa	22	80	46
4	Kregyang	16	75	45
5	Mirba	24	88	45
6	Rengyang	24	80	48
7	Rho	24	78	43
8	Shyro	30	98	53
9	Gomkelleng	30	89	53
10	Yuthembu	22	86	46

Gender of the Head of Households: Data on gender of the head of HHs in the ten surveyed villages is given in Table II. 3.365. As expected, in all the ten villages, the number of males exceeds that of females as head of HHs. Across the surveyed villages 75% of heads were males. Interestingly in Jangda and Yuthembu, the female head of HHs also occur in substantial number being 34% each.

Table II. 3.365: Distribution of head of HHs by gender in the ten project villages

Sl. No.	Village	Male		Female		Total
		n	%	n	%	n
1	Dungse	26	72	10	28	**36**
2	Jangda	65	66	34	34	**99**
3	Kharsa	84	79	23	21	**107**
4	Kregyang	11	61	7	39	**18**
5	Mirba	34	85	6	15	**40**
6	Rengyang	23	88	3	12	**26**
7	Rho	72	85	13	15	**85**
8	Shyro	45	80	11	20	**56**
9	Gomkelleng	23	64	13	36	**36**
10	Yuthembu	65	66	33	34	**98**
	Total	**448**	**75**	**153**	**25**	**601**

Ethnicity: All the ten villages are predominantly inhabited by Monpa tribals.

Household Size: The HH size varies from one to 12 across the ten villages. There is vast variation between the ten villages in terms of distribution of HH size. The average HH size varies from three in Rho to five in Jangda, Mirba and Shyro, the remaining villages have average HH size of four. Across the studied villages the average HH size is four (Tables II. 3.366 and 3.367).

Table II. 3.366: Distribution of HH size in the ten project villages

Sl. No.	Village	1		2		3		4		5		6–8		9 and above		Total
		n	%	n	%	n	%	n	%	n	%	n	%	n	%	n
1	Dungse	6	17	4	11	5	14	10	28	8	22	3	8	0	0	**36**
2	Jangda	5	5	11	11	6	6	13	13	14	14	39	39	11	11	**99**
3	Kharsa	12	11	8	7	17	16	21	20	19	18	28	26	2	2	**107**
4	Kregyang	1	6	4	22	1	6	2	11	5	28	5	28	0	0	**18**
5	Mirba	2	5	3	8	8	20	10	25	10	25	7	18	0	0	**40**
6	Rengyang	2	8	3	12	3	12	5	19	6	23	7	27	0	0	**26**
7	Rho	9	11	8	9	22	26	39	46	4	5	3	4	0	0	**85**
8	Shyro	4	7	2	4	9	16	7	13	8	14	19	34	7	13	**56**
9	Gomkelleng	0	0	5	14	8	22	8	22	3	8	11	31	1	3	**36**
10	Yuthembu	9	9	14	14	18	18	27	28	16	16	14	14	0	0	**98**
	Total	**50**	**8**	**62**	**10**	**97**	**16**	**142**	**24**	**93**	**15**	**136**	**23**	**21**	**3**	**601**

Table II. 3.367: Minimum, maximum and average HH size across the ten project villages

Sl. No.	Village	HH size range		Average HH size
		From	To	
1	Dungse	1	6	4
2	Jangda	1	9	5
3	Kharsa	1	9	4
4	Kregyang	1	9	5
5	Mirba	1	7	4
6	Rengyang	1	8	4
7	Rho	1	7	3
8	Shyro	1	12	5
9	Gomkelleng	2	9	4
10	Yuthembu	1	8	4
	Total	**1**	**12**	**4**

Education: Relevant data on the education of the head of the HHs in the ten project villages is given in Table II. 3.368. It is highly noteworthy that a majority of the heads in studied villages were illiterate (83%). It varied from 65% in Mirba to 100% in Dungse. There were 11 head of HHs (2%) in studied villages who were Graduates.

Table II. 3.368: Distribution of education of head of HH in the ten project villages

Sl. No.	Village	Illiterate		Primary		Upper Primary		Secondary		Higher Secondary		Graduate or above		Total
		n	%	n	%	n	%	n	%	n	%	n	%	n
1	Dungse	36	100	0	0	0	0	0	0	0	0	0	0	**36**
2	Jangda	84	85	3	3	5	5	4	4	2	2	1	1	**99**
3	Kharsa	86	80	1	1	8	7	10	9	1	1	1	1	**107**
4	Kregyang	12	67	1	6	2	11	0	0	2	11	1	6	**18**
5	Mirba	26	65	1	3	6	15	5	13	0	0	2	5	**40**
6	Rengyang	19	73	1	4	2	8	1	4	2	8	1	4	**26**
7	Rho	74	87	0	0	2	2	5	6	3	4	1	1	**85**
8	Shyro	41	73	1	2	8	14	5	9	1	2	0	0	**56**
9	Gomkelleng	31	86	0	0	1	3	0	0	2	6	2	6	**36**
10	Yuthembu	91	93	0	0	2	2	2	2	1	1	2	2	**98**
	Total	**500**	**83**	**8**	**1**	**36**	**6**	**32**	**5**	**14**	**2**	**11**	**2**	**601**

Main occupation of Household Heads: The main occupations of the head of HHs across the ten villages are agriculture, labour, pastoralist and government service. Table II. 3.369 revealed the following:

Agriculture: It varies from 10% in Mirba to 78% in Rho. 51% of the surveyed head of HHs pursue agriculture.

***Labour*:** Except in Rho, head of the HHs in several villages reported labour as one of the mode of occupation. Across the surveyed villages 23% of 601 heads reported labour as main occupation.

Pastoralist:About 8% in Jangda to 28% in Mirba were engaged in livestock rearing. In all the ten villages the animal associated with this occupation was Yak. Out of 601 heads 37 (6%) were engaged in this activity.

Government service: Government servants were reported from all the ten villages. The largest number is from Rho and Gomkelleng being 22% followed by Mirba (15%) and other villages. Government service constitutes 11% of the main occupations.

Any other occupation: 45 (7%) HHs was engaged in other occupations.

Table II. 3.369: Distribution of head of HHs by main occupation in the ten project villages

Sl. No.	Village	Farmer		Labour		Pastoral		Govt Servant		Others		No. of HHs
		n	%	n	%	n	%	n	%	n	%	
1	Dungse	23	64	0	0	0	0	5	14	8	22	**36**
2	Jangda	51	52	15	15	8	8	10	10	15	15	**99**
3	Kharsa	14	13	81	76	0	0	8	7	4	4	**107**
4	Kregyang	10	56	6	33	0	0	1	6	1	6	**18**
5	Mirba	4	10	13	33	11	28	6	15	6	15	**40**
6	Rengyang	19	73	5	19	0	0	2	8	0	0	**26**
7	Rho	66	78	0	0	0	0	19	22	0	0	**85**
8	Shyro	32	57	7	13	7	13	1	2	9	16	**56**
9	Gomkelleng	26	72	1	3	0	0	8	22	1	3	**36**
10	Yuthembu	64	65	13	13	11	11	9	9	1	1	**98**
	Total	**309**	**51**	**141**	**23**	**37**	**6**	**69**	**11**	**45**	**7**	**601**

Private Land Holding Pattern: The private land holding pattern in the ten villages comprises of agricultural land, horticulture land, habitation and home garden land and forest land. It may be noted here that, a majority of the inhabitants of the surveyed villages did not know actual area either in acres or hectares for all the categories of land holdings. Therefore, the area reported here should be considered as very rough estimates. Data pertaining to this aspect have been described below.

***Agricultural land*:** Table II. 3.370 revealed that except 44 HHs (10%), all the remaining HHs (90%) in eight surveyed villages owned agricultural land in varying proportions A majority of the HHs (43%) owned agricultural land between 1-2 acres. Only 17% of HHs owned land which is greater than 2 acres. There exists a striking variation between the villages in terms of agricultural land holdings. For example, 97% of the HHs in Rho own more than one acre of land while 3% of HHs in Dungse own less than one acre of land.

Table II. 3.370: Distribution of agricultural cultural land holding among surveyed HHs in the eight project villages

Sl. No.	Village	0.00 acre		< 1 acre		1–2 acre		> 2 acre	
		n	%	n	%	n	%	n	%
1	Dungse	16	44	19	53	1	3	0	0
2	Jangda	6	6	22	22	54	55	17	17
3	Kregyang	7	39	3	17	8	44	0	0
4	Mirba	2	5	23	58	9	23	6	15
5	Rengyang	6	23	8	31	11	42	1	4
6	Rho	2	2	0	0	64	75	19	22
7	Shyro	1	2	27	48	28	50	0	0
8	Yuthembu	4	4	37	38	23	23	34	35
	Total	**44**	**10**	**139**	**30**	**198**	**43**	**77**	**17**

* Excluding Kharsa and Gomkelleng due to non availability of data

***Horticultural land*:** None of the HHs in the ten villages owned horticultural land (Table II. 3.371).

Table II. 3.371: Distribution of horticultural land among surveyed HHs in the eight project villages

Sl. No.	Village	0.00 acre		< 1 acre		1–2 acre		> 2 acre	
		n	%	n	%	n	%	n	%
1	Dungse	36	100	0	0	0	0	0	0
2	Jangda	99	100	0	0	0	0	0	0
3	Kregyang	18	100	0	0	0	0	0	0
4	Mirba	40	100	0	0	0	0	0	0
5	Rengyang	26	100	0	0	0	0	0	0
6	Rho	85	100	0	0	0	0	0	0
7	Shyro	56	100	0	0	0	0	0	0
8	Yuthembu	98	100	0	0	0	0	0	0
	Total	**458**	**100**	**0**	**0**	**0**	**0**	**0**	**0**

* Excluding Kharsa and Gomkelleng due to non availability of data

***Habitation and homegarden land*:** Data presented in Table II. 3.372 reveals that only 5% of HHs (24) in surveyed villages did not own any such land. A majority of HHs (83%) owned less than one acre. 12% of the HHs owned 1-2 acre of such land.

Table II. 3.372: Distribution of habitation and home garden land among surveyed HHs in the eight project villages

Sl. No.	Village	0.00 acre		< 1 acre		1–2 acre		> 2 acre	
		n	%	n	%	n	%	n	%
1	Dungse	16	44	20	56	0	0	0	0
2	Jangda	6	6	93	94	0	0	0	0
3	Kregyang	0	0	18	100	0	0	0	0
4	Mirba	0	0	40	100	0	0	0	0
5	Rengyang	0	0	26	100	0	0	0	0
6	Rho	0	0	32	38	53	62	0	0
7	Shyro	2	4	52	93	2	4	0	0
8	Yuthembu	0	0	98	100	0	0	0	0
	Total	**24**	**5**	**379**	**83**	**55**	**12**	**0**	**0**

* Excluding Kharsa and Gomkelleng due to non availability of data

Forest land: 129 HHs (28%) in surveyed villages do not own private forest land. A majority of HHs (49%) owned such land between 1-2 acres. It is noteworthy that 41 (9%) HHs owned more than 2 acre of forest land (Table II. 3.373).

Table II. 3.373: Distribution of forest land holding among surveyed HHs in the eight project villages

Sl. No.	Village	0.00 acre		< 1 acre		1–2 acre		> 2 acre	
		n	%	n	%	n	%	n	%
1	Dungse	36	100	0	0	0	0	0	0
2	Jangda	15.0	15	15	15	59	60	10	10
3	Kregyang	10	56	5	28	3	17	0	0
4	Mirba	9	23	23	58	4	10	4	10
5	Rengyang	15	58	8	31	3	12	0	0

6	Rho	14	16	0	0	54	64	17	20
7	Shyro	18	32	12	21	26	46	0	0
8	Yuthembu	12	12	0	0	76	78	10	10
	Total	**129**	**28**	**63**	**14**	**225**	**49**	**41**	**9**

* Excluding Kharsa and Gomkelleng due to non availability of data

Total land holdings: Data given in Tables II. 3.374-3.377 shows that there are only 23 HHs (5%) - majority in Dungse - that do not own any type of private land. 61% of the HHs owned more than 2 acres of total land. There is striking variation between the HHs within a village as well as between villages in ownership of total land. For example, in Rho inter-HH holdings vary from 1 acre to 26 acres, whereas in Kregyang it varies from 0.50-3.5 acres. The proportion of agricultural land compared to other types of land to the total land holdings is greater in all villages. The 458 HHs in the eight villages owned total private land totalling 1276 acres. Out of this Jangda, Rho and Yuthembu accounts for 81% of the total land. Agricultural-land accounts for 41% and forest land 32% of total land holdings in the eight villages.

Table II. 3.374: Distribution of total land holding among surveyed HHs in the eight project villages

Sl. No.	Village	0.00 acre		< 1 acre		1–2 acre		> 2 acre	
		n	%	n	%	n	%	n	%
1	Dungse	16	44	19	53	1	3	0	0
2	Jangda	6	6	7	7	19	19	67	68
3	Kregyang	0	0	7	39	4	22	7	39
4	Mirba	0	0	14	35	18	45	8	20
5	Rengyang	0	0	6	23	13	50	7	27
6	Rho	0	0	0	0	10	12	75	88
7	Shyro	1	2	25	45	4	7	26	46
8	Yuthembu	0	0	5	5	5	5	88	90
	Total	**23**	**5**	**83**	**18**	**74**	**16**	**278**	**61**

* Excluding Kharsa and Gomkelleng due to non availability of data

Table II. 3.375: Minimum, maximum and average land holdings across the eight project villages

Sl. No.	Village	Agricultural cultural land			Horticultural land			Habitation and Homegarden land			Forest land			Total land		
		From	To	Avg.	From	To	Avg.	From	To	Avg.	From	To	Avg.	From	To	Avg.
1	Dungse	0.00	1.00	0.16	0.00	0.00	0.00	0.00	0.08	0.02	0.00	0.00	0.00	**0.00**	**1.08**	**0.19**
2	Jangda	0.00	6.00	1.42	0.00	0.00	0.00	0.00	0.74	0.45	0.00	4.00	1.13	**0.00**	**10.74**	**3.00**
3	Kregyang	0.00	2.00	0.83	0.00	0.00	0.00	0.50	0.50	0.50	0.00	1.00	0.31	**0.50**	**3.50**	**1.64**
4	Mirba	0.00	9.88	1.11	0.00	0.00	0.00	0.02	0.07	0.03	0.00	4.94	0.74	**0.02**	**12.39**	**1.89**
5	Rengyang	0.00	2.50	0.85	0.00	0.00	0.00	0.50	0.50	0.50	0.00	1.00	0.26	**0.50**	**4.00**	**1.61**
6	Rho	0.00	12.00	1.94	0.00	0.00	0.00	0.46	2.00	1.04	0.00	12.00	1.69	**1.00**	**26.00**	**4.68**
7	Shyro	0.00	2.00	0.74	0.00	0.00	0.00	0.00	1.50	0.20	0.00	1.50	0.56	**0.00**	**4.50**	**1.50**
8	Yuthembu	0.00	3.75	1.57	0.00	0.00	0.00	0.20	0.74	0.58	0.00	4.00	1.36	**0.20**	**7.49**	**3.51**
	Total	**0.00**	**12.00**	**1.08**	**0.00**	**0.00**	**0.00**	**0.00**	**2.00**	**0.42**	**0.00**	**12.00**	**0.76**	**0.00**	**26.00**	**2.25**

* Excluding Kharsa and Gomkelleng due to non availability of data

Table II. 3.376: Number of HHs having land types in the eight project villages

Sl. No.	Village	Total HH	Agricultural cultural land		Horticultural land		Habitation and home garden land		Forest land	
			n	%	n	%	n	%	n	%
1	Dungse	36	20	56	0	0	20	56	0	0
2	Jangda	99	93	94	0	0	93	94	84	85
3	Kregyang	18	11	61	0	0	18	100	8	44
4	Mirba	40	38	95	0	0	40	100	31	78
5	Rengyang	26	20	77	0	0	26	100	11	42
6	Rho	85	83	98	0	0	85	100	71	84
7	Shyro	56	55	98	0	0	54	96	38	68
8	Yuthembu	98	94	96	0	0	98	100	86	88
	Total	**458**	**414**	**90**	**0**	**0**	**434**	**95**	**329**	**72**

* Excluding Kharsa and Gomkelleng due to non availability of data

Table II. 3.377: Distribution of area (in acres) of land holding among HHs in the eight project villages

Sl. No.	Village	Agricultural cultural land		Horticultural land		Habitation and Home garden land		Forest land		Total land
		Area	%	Area	%	Area	%	Area	%	Area
1	Dungse	6	89	0	0	1	11	0	0	**7**
2	Jangda	141	47	0	0	44	15	112	38	**297**
3	Kregyang	15	51	0	0	9	31	6	19	**30**
4	Mirba	45	59	0	0	1	2	30	39	**75**
5	Rengyang	22	53	0	0	13	31	7	16	**42**
6	Rho	165	41	0	0	89	22	144	36	**398**
7	Shyro	41	49	0	0	11	13	32	38	**84**
8	Yuthembu	154	45	0	0	57	17	133	39	**344**
	Total	**589**	**41**	**0**	**0**	**225**	**16**	**462**	**32**	**1276**

* Excluding Kharsa and Gomkelleng due to non availability of data

Livestock Holding: Data presented in Tables II. 3.378-3.380 in respect of distribution of livestock holding in nine villages reveals that altogether nine different types of animals are domesticated. However none of the villages owned all the nine types of animals. Altogether 3063 animals have been domesticated in the nine villages. Considerable inter–village variation is observed in total number of animals reared. It varied from 10 in Dungse to 1021 in Jangda. Jangda alone accounts for 33% of all the animals found in the surveyed villages. Three animals, viz., cattle (53%), Yak (17%) and sheep (17%) account for 88% of the total animals (3063). 55% (270) of the HHs did not own any animals, whereas 20% HHs owned more than 10 animals.

Table II. 3.378: Livestock holding by HHs in the nine project villages

Sl. No.	Livestock		Dungse	Jangda	Kregyang	Mirba	Rengyang	Rho	Shyro	Gomkelleng	Yuthembu	Total
1	Mithun	n	0	0	0	0	0	0	0	1	2	**3**
		%	0	0	0	0	0	0	0	3	2	**1**
2	Cattle	n	1	92	3	10	4	30	24	4	21	**189**
		%	3	93	17	25	15	35	43	11	21	**38**
3	Yak	n	0	25	0	6	0	5	10	1	19	**66**
		%	0	25	0	15	0	6	18	3	19	**13**
4	Goat	n	0	22	0	1	0	17	0	1	1	**42**
		%	0	22	0	3	0	20	0	3	1	**9**
5	Sheep	n	0	71	1	0	0	20	2	1	1	**96**
		%	0	72	6	0	0	24	4	3	1	**19**
6	Pig	n	0	63	0	0	0	6	29	0	0	**98**
		%	0	64	0	0	0	7	52	0	0	**20**
7	Pony	n	0	2	0	1	0	1	16	0	0	**20**
		%	0	2	0	3	0	1	29	0	0	**4**
8	Poultry	n	0	13	0	0	0	2	1	0	0	**16**
		%	0	13	0	0	0	2	2	0	0	**3**
9	Others	n	3	1	0	0	0	1	0	1	0	**6**
		%	8	1	0	0	0	1	0	3	0	**1**

Table II. 3.379: Number of livestock in surveyed HHs across the nine project villages

Sl. No.	Village		Mithun	Cattle	Yak	Goat	Sheep	Pig	Pony	Poultry	Others	Total
1	Dungse	LS	0	1	0	0	0	0	0	0	9	**10**
		%	0	10	0	0	0	0	0	0	90	**100**
2	Jangda	LS	0	395	114	37	364	72	10	28	1	**1021**
		%	0	39	11	4	36	7	1	3	0	**100**
3	Kregyang	LS	0	27	0	0	60	0	0	0	0	**87**
		%	0	31	0	0	69	0	0	0	0	**100**
4	Mirba	LS	0	102	67	5	0	0	7	0	0	**181**
		%	0	56	37	3	0	0	4	0	0	**100**
5	Rengyang	LS	0	26	0	0	0	0	0	0	0	**26**
		%	0	100	0	0	0	0	0	0	0	**100**
6	Rho	LS	0	255	49	68	85	14	6	7	3	**487**
		%	0	52	10	14	17	3	1	1	1	**100**
7	Shyro	LS	0	357	69	0	2	29	50	2	0	**509**
		%	0	70	14	0	0	6	10	0	0	**100**
8	Gomkelleng	LS	2	60	1	5	10	0	0	0	5	**83**
		%	2	72	1	6	12	0	0	0	6	**100**

9	Yuthembu	LS	10	413	224	2	10	0	0	0	0	659
		%	2	63	34	0	2	0	0	0	0	100
	Total	**LS**	**12**	**1636**	**524**	**117**	**531**	**115**	**73**	**37**	**18**	**3063**
		%	**0.4**	**53**	**17**	**4**	**17**	**4**	**2**	**1**	**1**	**100**

Note: LS–Livestock

Table II. 3.380: Distribution of total number of livestock in HHs of the nine project villages

Sl. No.	Village	0		1–5		6–10		> 10		Total
		n	%	n	%	n	%	n	%	n
1	Dungse	33	92	3	8	0	0	0	0	**36**
2	Jangda	5	5	25	25	33	33	36	36	**99**
3	Kregyang	14	78	0	0	2	11	2	11	**18**
4	Mirba	27	68	3	8	3	8	7	18	**40**
5	Rengyang	22	85	2	8	2	8	0	0	**26**
6	Rho	48	56	9	11	11	13	17	20	**85**
7	Shyro	22	39	18	32	3	5	13	23	**56**
8	Gomkelleng	31	86	1	3	0	0	4	11	**36**
9	Yuthembu	68	69	7	7	4	4	19	19	**98**
	Total	**270**	**55**	**68**	**14**	**58**	**12**	**98**	**20**	**494**

Traditional Skills: Data pertaining to this aspect is presented in Table II. 3.381. In the surveyed village six types of crafts are pursued. In village Gomkelleng the inhabitants were engaged in all the six crafts. It is highly noteworthy that in Rengyang none of the crafts are pursued. Weaving is practiced in seven villages and the total numbers of HHs engaged are 185 (37%). 97% of HHs are engaged in paper making in Gomkelleng (Table II. 3.381).

Table II. 3.381: Distribution of various skills among surveyed HHs in the nine project villages

Sl. No.	Village	Wood carving		Thanka painting		Carpet making		Bamboo utensil		Weaving		Paper making	
		n	%	n	%	n	%	n	%	n	%	n	%
1	Dungse	0	0	0	0	0	0	0	0	4	11	0	0
2	Jangda	1	1	0	0	0	0	0	0	53	54	0	0
3	Kregyang	0	0	0	0	0	0	0	0	0	0	0	0
4	Mirba	2	5	0	0	2	5	0	0	8	20	0	0
5	Rengyang	0	0	0	0	0	0	0	0	0	0	0	0
6	Rho	0	0	0	0	0	0	2	2	40	47	0	0
7	Shyro	5	9	0	0	1	2	8	14	20	36	0	0
8	Gomkelleng	12	33	3	8	8	22	30	83	29	81	35	97
9	Yuthembu	4	4	0	0	0	0	5	5	31	32	0	0
	Total	**24**	**5**	**3**	**1**	**11**	**2**	**45**	**9**	**185**	**37**	**35**	**7**

River Resources: In Table II. 3.382, data gathered pertaining to the use of various river resources by the inhabitants of the ten surveyed village is presented. The data revealed that all the 12 river resources listed in Table II. 3.382 are being used across the studied ten villages. Six river resources, viz., drinking water, water for domestic use, water for livestock, religion, sand and stone are used by a significant number of HHs in the surveyed villages. There is vast inter–village variation in terms of number of river resources used. It is highly noteworthy that all the 601 HHs in the surveyed villages use river for performing last rites of the dead. All the aquatic flora and fauna listed in Table II. 3.382 are used by a small number of HH in Gomkelleng.

Table II. 3.382: Dependence on river resources among surveyed HHs in the ten project villages

Sl. No.	River resources		Dungse	Jangda	Kharsa	Kregyang	Mirba	Rengyang	Rho	Shyro	Gomkelleng	Yuthembu	Total
1	Drinking water	n	0	0	107	0	0	0	0	0	32	24	**163**
		%	0	0	100	0	0	0	0	0	89	24	**27**
2	Water for domestic use	n	0	0	107	0	0	0	0	0	32	18	**157**
		%	0	0	100	0	0	0	0	0	89	18	**26**
3	Water for livestock	n	3	94	0	4	13	4	37	35	5	30	**225**
		%	8	95	0	22	33	15	44	63	14	31	**37**
4	Fishes	n	0	0	0	0	0	0	0	0	35	0	**35**

		%	0	0	0	0	0	0	0	0	97	0	**6**
5	Aquatic flora	n	0	0	0	0	0	2	0	0	35	0	**37**
		%	0	0	0	0	0	8	0	0	97	0	**6**
6	Religious	n	36	99	107	18	40	26	85	56	36	98	**601**
		%	100	100	100	100	100	100	100	100	100	100	**100**
7	Sand	n	34	99	0	0	40	0	0	56	36	65	**330**
		%	94	100	0	0	100	0	0	100	100	66	**55**
8	Stone	n	34	99	0	0	40	0	0	56	36	67	**332**
		%	94	100	0	0	100	0	0	100	100	68	**55**

Forest Resources: The villagers of all the nine villages are dependent and use varying degrees of forest resources (Table II. 3.383). Except for ornamental use, the inhabitant of Gomkelleng use all the remaining forest resources. Rho uses the least number of forest resources being six. It may be highlighted that 97% of HH in Gomkelleng use forest resources as natural dyes. More than 50% of the HHs in general across the studied villages uses six forest resources–fuel wood, timber, religion, water, stones and sand. It is thus evident from above description that for a majority of the inhabitants of the surveyed villages forest resources play a very significant role to the livelihoods as well as the quality of life of the people.

Table II. 3.383: Dependence on forest resources among surveyed HHs in the nine project villages

Sl. No.	Forest Resources		Dungse	Jangda	Kregyang	Mirba	Rengyang	Rho	Shyro	Gomkelleng	Yuthembu	Total
1	Fuel wood	n	36	99	18	40	26	85	56	36	90	**486**
		%	100	100	100	100	100	100	100	100	92	**99**
2	Timber	n	36	99	18	40	0	85	56	36	90	**460**
		%	100	100	100	100	0	100	100	100	92	**77**
3	Medicinal plants	n	36	0	18	40	0	0	0	36	0	**130**
		%	100	0	100	100	0	0	0	100	0	**22**
4	Honey	n	0	0	0	0	2	0	0	36	0	**38**
		%	0	0	0	0	8	0	0	100	0	**6**
5	Food	n	0	99	18	40	26	66	0	36	0	**285**
		%	0	100	100	100	100	78	0	100	0	**47**
6	Edible oil	n	0	0	0	0	0	0	0	36	0	**36**
		%	0	0	0	0	0	0	0	100	0	**6**
7	Ornamental	n	0	0	0	0	0	2	0	0	0	**2**
		%	0	0	0	0	0	2	0	0	0	**0**
8	Religious	n	36	0	18	40	26	85	0	36	64	**305**
		%	100	0	100	100	100	100	0	100	65	**51**
9	Fencing	n	36	99	0	0	0	19	0	36	84	**274**
		%	100	100	0	0	0	22	0	100	86	**46**
10	Handicrafts	n	0	0	0	0	0	21	0	36	4	**61**
		%	0	0	0	0	0	25	0	100	4	**10**
11	Thatching	n	0	0	0	0	0	0	0	36	1	**37**
		%	0	0	0	0	0	0	0	100	1	**6**
12	Spices	n	0	0	0	40	3	0	0	33	2	**78**
		%	0	0	0	100	12	0	0	92	2	**13**
13	Grazing	n	3	94	4	13	4	37	35	5	30	**225**
		%	8	95	22	33	15	44	63	14	31	**37**
14	Hunting of wild animals	n	0	0	0	0	0	0	0	1	2	**3**
		%	0	0	0	0	0	0	0	3	2	**0**
15	Fishes	n	0	0	0	0	0	0	0	33	1	**34**
		%	0	0	0	0	0	0	0	92	1	**6**
16	Water	n	36	99	0	0	5	85	56	33	67	**381**
		%	100	100	0	0	19	100	100	92	68	**63**
17	Stones	n	36	99	18	40	26	85	56	35	92	**487**
		%	100	100	100	100	100	100	100	97	94	**81**
18	Sand	n	36	99	18	40	26	19	56	35	92	**421**
		%	100	100	100	100	100	22	100	97	94	**70**
19	Dyes	n	0	0	0	0	0	0	0	35	0	**35**
		%	0	0	0	0	0	0	0	97	0	**6**

* Excluding Kharsa due to non availability of data

Water Resources: Data pertaining to availability of water resource is given in Table II. 3.384 reveal that except in Dungse, Mirba, Shyro and Gomkelleng, all the remaining villages use hill stream/springs as the main source of water for various usages. Out of 601 HHs in the study area, 419 HHs (70%) use hill stream/spring water. However, in Shyro village all the HHs (56) uses both ponds and tap water (Table II. 3.384).

Table II. 3.384: Dependence on water resources among surveyed HHs in the ten project villages

Sl. No.	Village	River		Hill stream/spring		Wells		Ponds		Hand pumps		Tap water	
		n	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**
1	Dungse	36	100	0	0	0	0	0	0	0	0	36	100
2	Jangda	0	0	99	100	0	0	0	0	0	0	99	100
3	Kharsa	0	0	100	93	0	0	0	0	0	0	0	0
4	Kregyang	0	0	18	100	0	0	18	100	0	0	18	100
5	Mirba	0	0	0	0	0	0	0	0	0	0	40	100
6	Rengyang	0	0	26	100	0	0	26	100	0	0	26	100
7	Rho	85	100	85	100	0	0	0	0	0	0	85	100
8	Shyro	0	0	0	0	0	0	56	100	0	0	56	100
9	Gomkelleng	36	100	0	0	0	0	0	0	0	0	0	0
10	Yuthembu	26	27	91	93	0	0	0	0	0	0	0	0
	Total	**183**	**30**	**419**	**70**	**0**	**0**	**100**	**17**	**0**	**0**	**360**	**60**

3.3.9 TAWANG–I

3.3.9.1 PHYSICAL ENVIRONMENT

Geomorphology

The geomorphological features at Tawang-I HEP have been depicted in the toposheet (Figure II. 3.47). The project is located at an elevation of 2092 m on the Tawang river.

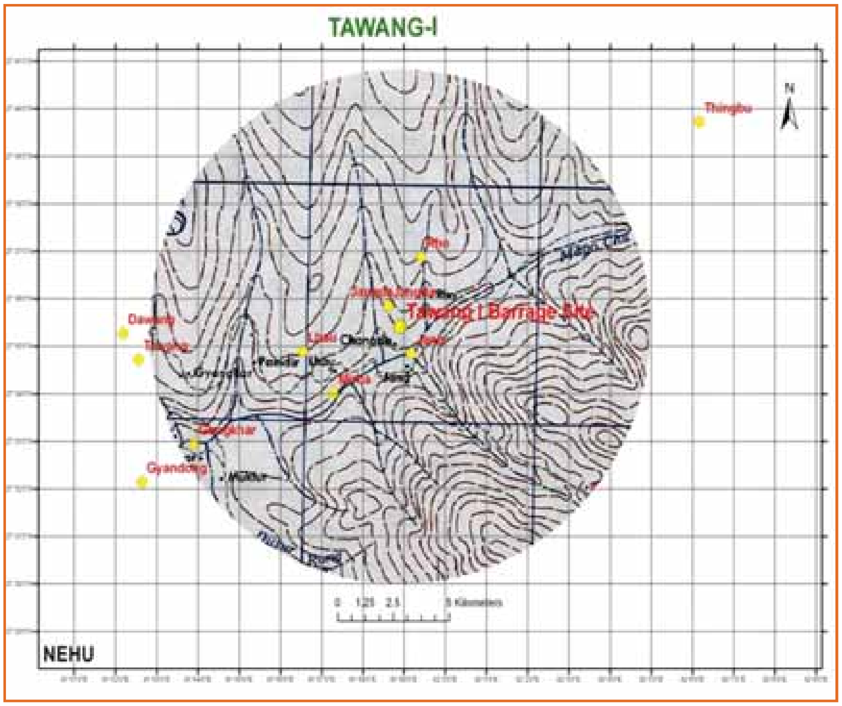


Figure II. 3.47: Contour map of Tawang–I

Geology

The Tawang-I project components (Barrage, HRT and Powerhouse) are proposed to be constructed within rock types of Sela Group. Gneisses with intrusive of leucogranite, pegmatite and amphibolites constituting Sela group of rocks are disposed around the project area. The primary stratification in rock formations is defined by colour and compositional laminations in schistose quartzite of Lumla Formation and in the calc-silicate rocks of the Sela Group. Regional foliation observed in the schist and the gneiss show a swinging trend. South of Jang the schist trend E-W with northerly dips while near the bridge on Tawang chu, the foliation trend swings to N-S. The structural elements indicate a regional F2 fold with an easterly plunging antiformal axis passing through Jabrang, Shyaro and north of Jang. Apart from this regional fold, mesoscopic folds of broad open and tight plunging geometry have also been reported from the area.

Barrage Site: A 26 m high barrage from river bed has been proposed as diversion structure about 1km upstream of fore bridge. At the proposed axis, the river valley is comparatively wider. The river channel is occupied by riverine deposits comprising boulders, cobbles and pebbles in fine to medium sandy matrix. Right bank slope rises gradually from the river bed. A river terrace about 360 m long is present along the river. River borne deposits are observed up to EL 2080 M in most parts of this bank. Slopes above the river terrace are partly occupied by slope wash material up to about EL 2130 M beyond which bedrock is occasionally under thin veneer of slope wash material. The left bank river edge is also occupied by river borne deposits up to EL 2080 M with intermittent stretches of nalla deposits. In the remaining part of slope on left bank mostly slope wash is present. The barrage area has been well investigated with a back up of geophysical surveys and drilling. Overburden in the river channel varies from 53-89 m along the axis and 63-81m along the glacis portion. Permeability of overburden is of the order of 10^{-2} to 10^{-3} cm/sec. The rock formations consist of quartzo-feldspathic gneisses with quartz veins, leucogranite and bands of mica schist. A raft type foundation for barrage is proposed to be constructed on permeable foundation comprising boulders, cobbles and pebbles in medium to fine sandy matrix. *In situ* tests viz., bearing capacity, modulus of sub-grade reaction and SPT tests have been conducted to ascertain the foundation properties. Proposed barrage is a relatively small structure and excavation is limited to overburden only. Since excavation in bedrock is not required, as such no adverse impact is foreseen.

Powerhouse Site: An underground powerhouse has been proposed near village Yusum. Powerhouse ridge trending N-S descends from road level (EL ±2250 M) through Yusum village towards river Tawang Chu. The hill slopes which are generally covered by slope wash material are intermittently cut across by nalla depressions which are aligned in N-S direction. Rock formations are exposed around the proposed surge shaft location. These rock formations consist of quartzo–feldspathic gneiss with bands of schist and augen gneiss. Weathered outcrops of leucogranite are present above the proposed pressure shaft and powerhouse cavern area. Bands of gneiss are also associated with leucogranite. Powerhouse area has been investigated with a backup of geological mapping, drilling and drifting. Powerhouse is suitably located to have sufficient vertical and lateral cover. Moreover orientation of powerhouse has also been optimized so as to make sufficient angle with average orientation of major discontinuity sets. The underground caverns have been planned taking into account the geological conditions revealed during explorations, design support and therefore construction of these caverns is not anticipated to cause adverse environmental impact.

Head Race Tunnel: In order to harness the head in this stretch of river, 13.98 km long head race tunnel had to be planned in the right bank keeping in view the topography, geological conditions and accessibility of the terrain. Along the proposed tunnel route Paleoproterozoic rocks of Sela Group having younger intrusive are exposed. The tunnel route has been investigated with a backup of geological mapping, drilling, drifting and study of imageries. The rock formations in general have undergone several phases of deformation resulting into folding/ warping at several places. Some degree of shearing and fracturation has also resulted from this deformation. Swing in attitude of foliation is a result of these warps. Entire stretch of HRT from Intake to powerhouse shall be housed within rock formations of Sela Group. The rock types of Sela group consist of gneisses which are intruded by leucogranites, pegmatites and amphibolites. These occur as lenses and bands of various shapes and sizes. The gneisses along with intrusives are generally, moderately strong to strong and moderately jointed. They are expected to provide fair to good tunneling media barring few stretches of poor rock mass where shearing is expected within the rock mass. Now a 13.98 km long tunnel is planned with six intermediate adits. The tunnel layout has been planned within rock formations. Construction of this tunnel will not have any adverse impact on the geomorphology of the area as the head race tunnel is housed within the hills and shall be supported as per design plan.

Reservoir: The reservoir of Tawang Hydroelectric Project, Stage–I (FRL EL 2,090 m) will be a very small water body. It will submerge an area of about 12.46 ha only and will extend for a length of about 1.15 km along the river in a moderately wide valley. From about 500 m upstream of barrage axis, the river flows NE-SW. Approach to reservoir area is only through treacherous foot tracks. River Tawang Chu being the master drainage system and bound by hill slopes in this area, possibility of water escaping from the reservoir of this valley to the adjoining valley does not exist. No mineral deposits of economic importance are reported to be present in the reservoir. The area under various geological classes in Tawang-I at barrage site is provided in Table II. 3.385. The location of Tawang-I barrage site and the impact zone within 10 km radius in Tawang river are depicted in Figures II. 3.48 and 3.49.

Table II. 3.385: Area under various geological classes in the influence zone i.e. 10 km radius from the barrage site of Tawang–I project

Class	Area	%
Snow covered area	1.19	0.38
Snow covered area	0.40	0.13
Snow covered area	8.43	2.68
Sela group (Structural hill)	297.38	94.66
Snow covered area	5.77	1.84
Sela group (Valley)	0.99	0.31
Total	**314.16**	**100.00**

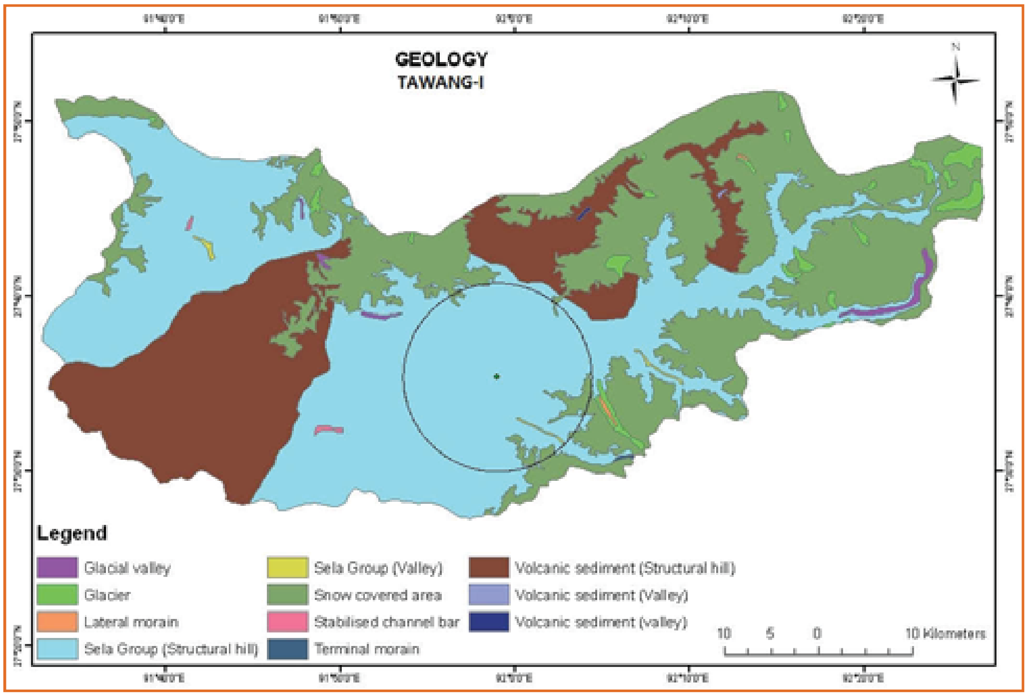


Figure II. 3.48: Geological map of TRB showing location of Tawang–I barrage site

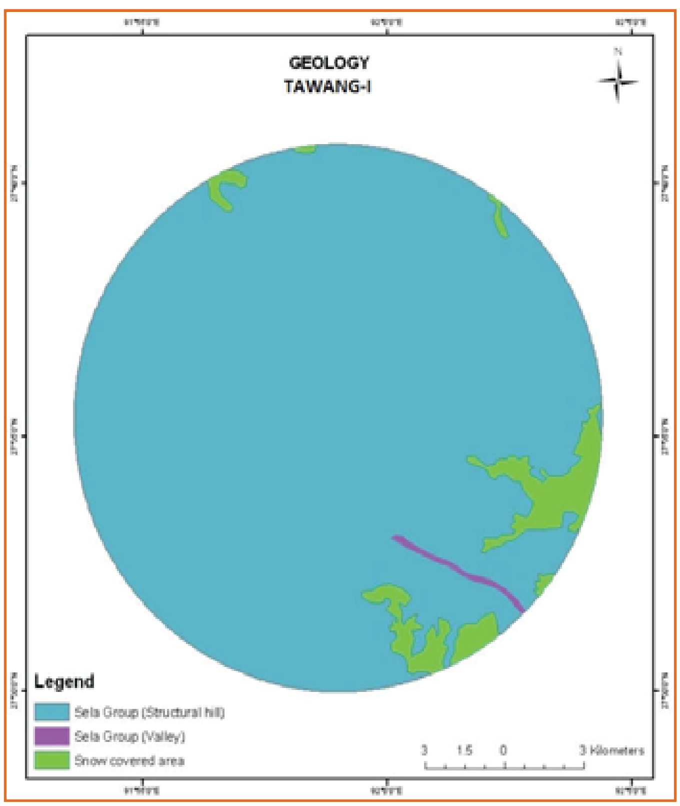


Figure II. 3.49: Geological map of Impact zone (10 km radius) of Tawang–I barrage and powerhouse site in Tawang river valley

Landuse and Land Cover

The total area within 10 km radius of Tawang-I HEP site is 31439.59 ha (Figure II. 3.50). Majority of the area is covered with forest which occupies about 53.98% of the total area followed by scrubland (34.96%). Cropland covers only 0.02% of the total project area. Waterbody constitute around 8.28% of the total area, and grassland occupies only 1.10%. The total area occupied by snow and ice and other builtup area altogether is 1.66% (Table II. 3.386).

Table II. 3.386: Landuse/land cover area of Tawang–I project site

Landuse/land cover category	Area (ha)	%
Forest	16972.6	53.98
Scrubland	10990.8	34.96
Waterbody	2603.14	8.28
Croplands	5.6475	0.02
Grasslands	345.285	1.10
Builtup area	186.458	0.59
Snow and Ice	335.655	1.07
Total	**31439.59**	**100.00**

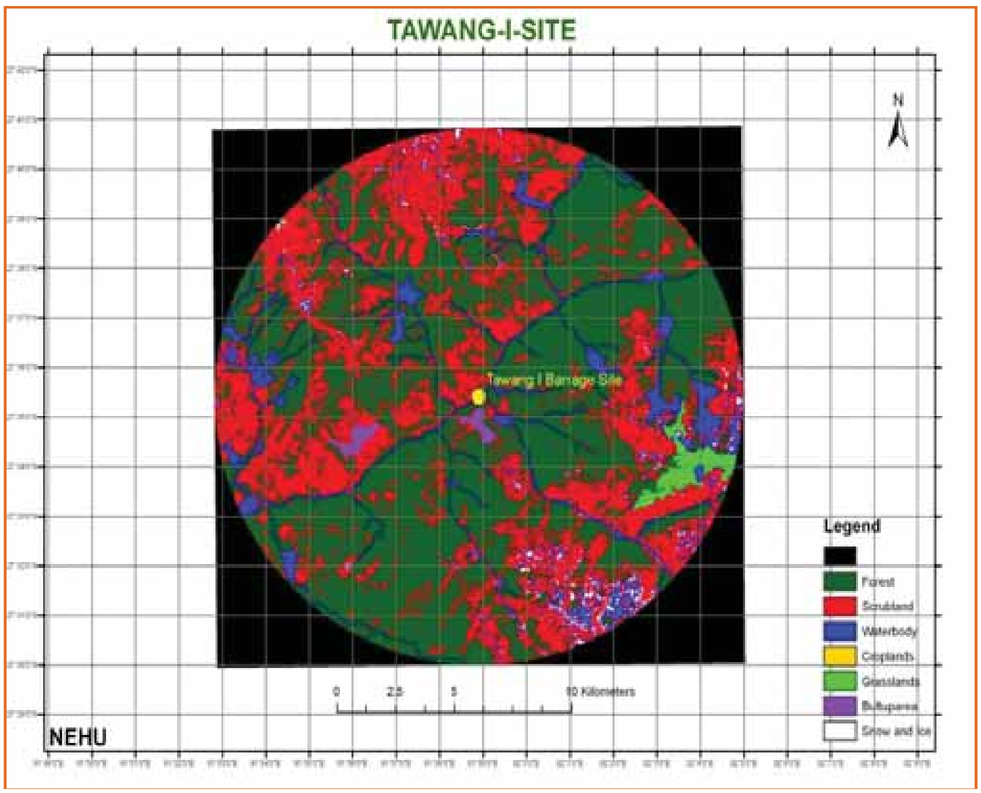


Figure II. 3.50: Landuse/land cover map of Tawang–I project site

Soil

The soil was sandy loam with water holding capacity ranging between 37–49 % and moisture content ranging from 15-47 % (Table II. 3.387). Soil pH play crucial role in availability of nutrients to plants and influence several biological and chemical processes including decay of litter by altering the soil microbial population. Soils with slightly acidic to slightly alkaline pH provide a favourable substratum for plant growth. At Tawang-I, soil was moderately to highly acidic. The values ranged from a low of 4.54 at Powerhouse site to a high of 6.89 at the same site during winter period. Such soils are characteristic feature of subtropical and temperate regions with high annual rainfall. High rainfall removes soluble mineral cations from the soil leaving behind a soil which is poor in nutrient content. Organic matter content in soil though a small component, plays an important role in influencing physical and chemical properties as well as and biological activities in soil. Soil density, porosity, structure, and soil aeration and water retaining capacity and nutrient availability are vastly improved by organic matter.

At Tawang-I site soil was poor in organic matter content. Except for ammonium and exchangeable potassium, concentration of nitrate nitrogen, phosphorus, exchangeable calcium and magnesium were very low suggesting that fertility of soil at this site was low. Since nitrate is easily leached out in acid soils, nitrogen was mostly present in ammonium form which is not easily available to plants.

Microbes present in soil serve both as a source and sink of available nutrient to plants. They accumulate nutrients in their cells during unfavourable period such as winter in temperate climate and during hot summer in the tropics and release the same during warm and humid rainy season due to fast turnover rate. Besides, they are the chief agent of decomposition of litter and therefore play crucial role in nutrient cycling in the ecosystem. The values of microbial biomass-C and biomass-N obtained in soil at Tawang-I are very low compared to the values reported in literature for the subtropical and temperate forest ecosystems. This suggests slower rate of litter decomposition and low nutrient availability in soil at this site. Seasonal variation in physical, chemical and biological parameters are shown in Table II. 3.388.

Table II. 3.387: Soil physical properties at Tawang–I site

Site	Texture	WHC (%)	Bulk density (g/cm³)	Porosity (%)
Barrage	Sandy loam	49.59	1.3	50.94
Powerhouse	Sandy loam	37.34	1.2	54.72

Table II. 3.388: Seasonal variation in soil physico–chemical properties in Tawang–I project site

Parameters	Post-monsoon		Monsoon		Winter		Mean	
	B	PH	B	PH	B	PH	B	PH
SMC (%)	25	25	48	33	15	15	29	24
pH	6.0	4.5	6.0	4.7	6.8	6.9	6.3	5.4
Conductivity ($\mu S\ cm^{-1}$)	70	69	76	74	41	57	62	67
NH_4^+–N ($\mu g\ g^{-1}$)	300	300	300	500	300	300	300	367
NO_3^-–N($\mu g\ g^{-1}$)	38	23	24	26	33	35	32	28
TKN ($\mu g\ g^{-1}$) x10^3	0.800	0.900	0.700	1.200	0.900	1.100	0.800	1.070
Av.P ($\mu g\ g^{-1}$)	0.030	0.020	0.020	0.070	0.030	0.040	0.030	0.040
TP (%)	0.110	10.000	0.140	0.120	0.110	0.120	0.120	3.410
SOC (%)	0.002	0.007	0.007	0.008	0.002	0.004	0.000	0.010
Ex. K ($\mu g\ g^{-1}$)	300	160	243	370	63	60	202	197
Ex. Mg (%)	0.009	0.013	0.005	0.003	0.010	0.008	0.010	0.010
Ex. Ca (%)	0.087	0.446	0.023	0.064	0.650	0.624	0.250	0.380
Soil microbial biomass–C ($\mu g\ g^{-1}$)	29	23	28	20	36	30	31	25
Soil microbial biomass–N ($\mu g\ g^{-1}$)	2.70	5.00	1.86	2.30	8.52	6.21	4.40	4.50

(Note: Post-monsoon–October, Monsoon–July, Winter–December); B =Barrage, PH =Powerhouse

Soil Erosion Vulnerability

The area under various soil erosion vulnerability classes of Tawang-I is presented in Table II. 3.389. Out of the total area of 314.16 sq.km, about 1.95% and 15.65% of the area falls under high and moderately high vulnerable class, respectively. However, about 5.76% and 29.68% of the total area falls under low and moderately low vulnerable class, respectively. The vulnerable soil erosion area under moderate category covered about 46.96% of the total area. The spatial distribution map of soil erosion vulnerable areas under barrage site of Tawang-I is given in Figure II. 3.51.

Table II. 3. 389: Areas under various soil erosion vulnerable zones in Tawang–I at barrage site

Vulnerability	Area (sq. km)	%
High	6.13	1.95
Moderately high	49.15	15.65
Moderate	147.54	46.96
Moderately low	93.25	29.68
Low	18.09	5.76
Total	**314.16**	**100.00**

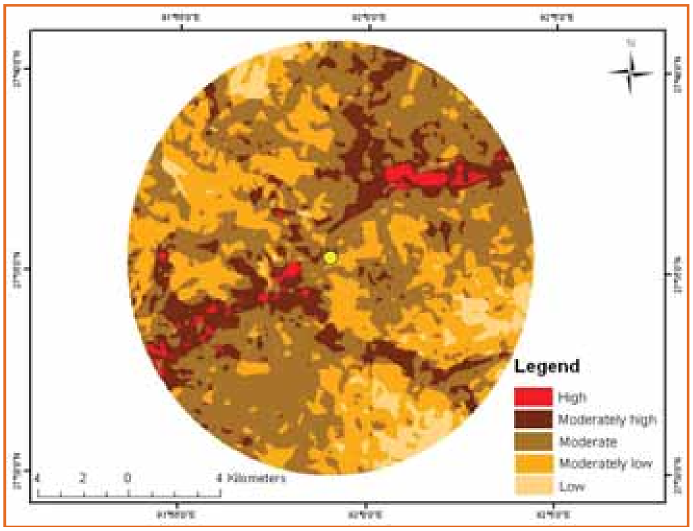


Figure II. 3.51: Spatial distribution of soil erosion vulnerable areas in Tawang–I at barrage site

Landslide and Erosion Vulnerability

The area under various landslide and erosion vulnerability classes at barrage site of Tawang–I is given in Table II. 3.390. Out of the total area of 314.16 sq. km, only 1.05% and 0.27% area falls under high and low vulnerable class, respectively. On the other hand, 20.11% and 19.14% of the total area falls under moderately-high and moderately-low vulnerable class, respectively. The vulnerable area under moderate category covered about 59.43% of the total area. The spatial distribution map of landslide and erosion vulnerability areas under barrage site of Tawang-I is given in Figure II. 3.52.

Table II. 3.390: Area under various landslide and erosion vulnerability classes in Tawang-I at barrage site

Tawang–I	Area (sq.km)	%
High	3.30	1.05
Moderately high	63.18	20.11
Moderate	186.70	59.43
Moderately low	60.14	19.14
Low	0.84	0.27
Total	**314.16**	**100.00**

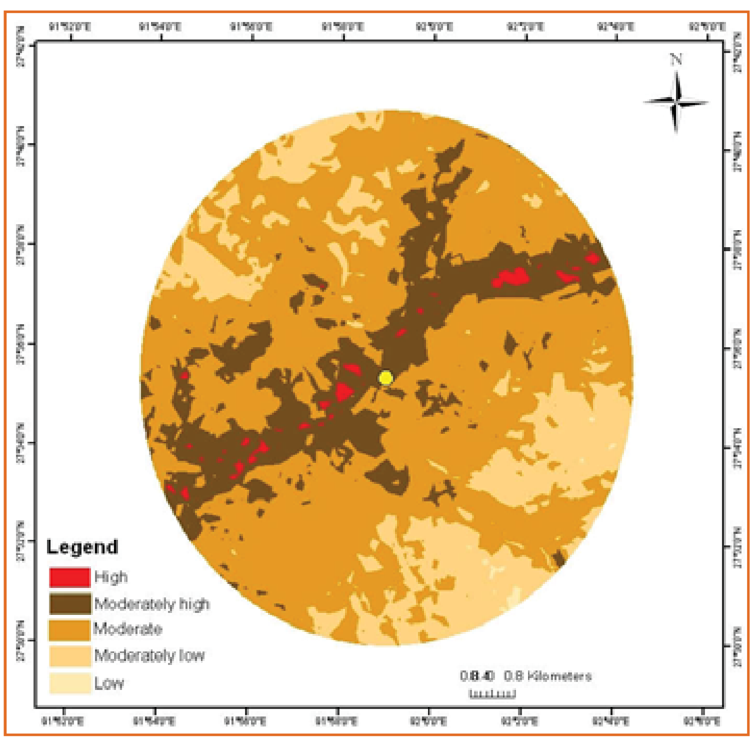


Figure II. 3.52: Area under various erosion and landslide vulnerability classes in Tawang–I at barrage site

Water

Physico-chemical and biological parameters of the river water at Tawang-I site showed distinct seasonal variation. Temperature and turbidity were much higher in monsoon season than the winter period. Highest value of dissolved oxygen (DO), total hardness and total alkalinity was recorded during the winter period whereas electrical conductivity (EC) and total dissolved solids (TDS), total phosphorus, nitrate nitrogen and coliform count peaked during the Post-monsoon period. Potassium (K^+), total Kjeldahl nitrogen (TKN) and ammonium nitrogen (NH_4^+–N) concentration in river water was high in the rainy season. Primary productivity values were much higher during the monsoon period than other two seasons (Table II. 3.391).

Table II. 3.391: Seasonal variation in physico-chemical and biological properties of water and its primary productivity at Tawang-I project site

Parameters	Post-monsoon			Monsoon			Winter		
	B	PH	Mean	B	PH	Mean	B	PH	Mean
Temperature (˚C)	7.20	7.20	7.20	14.70	15.20	14.95	5.90	9.00	7.45
Turbidity (NTU)	0.35	0.40	0.38	1.26	1.15	1.21	0.63	0.81	0.72
pH	7.70	7.74	7.72	7.85	7.76	7.81	7.68	7.52	7.60
Electrical conductivity (µS/cm)	186	172.00	179	132	142.00	137	147	163.00	155
Total dissolved solids (mg/l)	93	85.80	89.55	59	71.00	64.90	75	78.90	77.10
Practical salinity (ppt)	0.11	0.10	0.10	0.06	0.08	0.07	0.08	0.08	0.08
Total alkalinity (mg $CaCO_3$/l)	32	30.00	31.00	36	36.00	36.00	48	48.00	48.00
Total hardness (mg/l)	22	21.44	21.50	36	36.79	36.47	41	40.97	41.04
Chloride (mg Cl^-/l)	10.66	9.99	10.33	12.99	8.99	10.99	5.99	5.99	5.99
Ca^{2+} (mg/l)	4.62	4.58	4.60	8.79	8.94	8.87	9.32	9.27	9.30
Mg^{2+}(mg/l)	2.43	2.43	2.43	3.45	3.52	3.48	4.33	4.33	4.33
K^+ ppm	1.23	1.23	1.23	0.50	2.20	1.35	0.40	0.40	0.40
Na^+ ppm	10.80	10.90	10.85	11.00	4.60	7.80	7.80	8.50	8.15
TKN (mg/l)	0.48	0.48	0.48	0.58	0.58	0.58	0.42	0.44	0.43
NH_4^+ N (mg/l)	0.04	0.04	0.04	0.10	0.12	0.11	0.05	0.05	0.05
NO_3–N (mg/l)	0.35	0.35	0.35	0.21	0.25	0.23	0.31	0.32	0.31
Total phosphorus (mg/l)	0.11	0.10	0.11	0.09	0.09	0.09	0.09	0.09	0.09
GPP (mg C/cm^3/h)	0.36	0.36	0.36	0.47	0.55	0.51	0.31	0.31	0.31
NPP (mg C/cm^3/h)	0.16	0.16	0.16	0.31	0.31	0.31	0.10	0.10	0.10
Dissolved oxygen (mg/l)	11.30	11.60	11.45	10.20	10.00	10.10	12.30	12.60	12.45
Total coliforms (CFU/ml)	71	73.00	72.00	36	44.00	40.00	38	48.00	43.00

Ambient Air Quality

Concentration of PM_{10} and $PM_{2.5}$: Concentration of PM_{10} s at proposed Tawang–I HEP site ranged from a minimum of 11.7µg/m^3 at Jaswantgarh to a maximum of 49.7 µg/m^3 at Nuranang Falls. Likewise, $PM_{2.5}$ concentration ranged from a minimum of 13.4 µg/m^3 at Jaswantgarh and Rho to a maximum of 38.0 µg/m^3 at Nuranang Falls (Table II. 3.392). The concentration of sulphur-dioxide (SO_2), nitrogen-dioxide (NO_2), ammonia (NH_3) and ground level ozone (O_3) at all the monitored locations were below detectable limits.

Table II. 3. 392: Concentration of PM_{10} and $PM_{2.5}$ in air at proposed Tawang–I HEP area

Sampling location	Nearest project site covered	PM_{10} (µg/m^3)	$PM_{2.5}$ (µg/m^3)
Nuranang falls	Tawang–I barrage site	49.7	38.0
Jang	Tawang–I barrage site	41.7	23.9
Jaswantgarh	Tawang–I barrage site	11.7	13.4
Rho	Tawang–I barrage site	23.5	13.4
Khet bridge	Tawang–I powerhouse site	33.8	25.9
Tawang	Tawang–I powerhouse site	32.9	32.2

Ambient air temperature at Tawang-I ranged from a minimum of 3°C at Tawang-I powerhouse to a maximum of 12°C at Khet bridge. The lowest relative humidity was recorded (27%) at Nuranang falls and highest (52%) at Rho. Wind speed was ranges from a minimum of 1.6 km/hr at Jang to a maximum of 4.2 km/hr at Khet bridge. The wind direction was NW to SE (Table II. 3.393).

Table II. 3. 393: Meteorological condition at proposed Tawang–I HEP area

Sampling location	Nearest project sites covered	Ambient temperature (°C) Min Max	Relative humidity (%)	Wind speed (range in km/hr)	Wind direction
Nuranang falls	Tawang–I barrage site	06 10	27	2.4–3.2	SE
Jang	Tawang–I barrage site	04 08	39	1.6–2.3	SE
Jaswantgarh	Tawang–I barrage site	05 09	32	2.1–2.7	SE
Rho	Tawang–I barrage site	05 09	52	1.8–3.6	NW
Khet bridge	Tawang–I powerhouse site	07 12	41	3.6–4.2	NW
Tawang	Tawang–I powerhouse site	03 07	31	2.8–3.4	NW

Noise Level: Noise level near proposed Tawang-I HE ranged from a minimum of 25.2 dBA at Jaswantgarh at 4.00 PM to a maximum of 64.6 dBA at Nuranang falls at 8.00 AM (Table II. 3.394).

Table II. 3. 394: Noise level at proposed Tawang–I HEP area

Sampling location	Nearest project component covered	Noise level (dBA) 8.00 AM	Noise level (dBA) 4.00 PM
Nuranang falls	Tawang–I barrage site	64.6	63.2
Jang	Tawang–I barrage site	38.2	29.7
Jaswantgarh	Tawang–I barrage site	27.1	25.2
Rho	Tawang–I barrage site	37.2	39.6
Khet bridge	Tawang–I powerhouse site	58.4	61.2
Tawang	Tawang–I powerhouse site	39.1	41.2

3.3.9.2 BIOLOGICAL ENVIRONMENT

Vegetation Types

The project components of Tawang-I HEP are located in montane sub-tropical forest and temperate forest area.

8/B/CI East Himalayan sub-tropical wet hill forest (1000-1800 m): These forests occur in and around 1000 m and extend up to 1800 m elevations. The canopy is comprised of: *Alnus nepalensis, Macaranga denticulata, Castanea sativa, Engelhardtia spicata, Erythrina arborescens, Quercus glauca, Rhus succedanea, Schima wallichii*, *Ficus auriculata, Myrica esculenta*, etc. Medium sized evergreen tree species such as by: *Ficus semicordata, Lophopetalum wightianum, Lyonia ovalifolia, Rhus chinensis, Saurauia punduana, Tetracentron sinense, Phyllanthus emblica*, *Rhus javanica, Torricellia tiliifolia* etc., constituted sub-canopy layer. Understory consisted of shrubs such as: *Artimisia nilagarica, Coriaria nepalensis, Elaeagnus parvifolia, Rubus ellipticus, Maesa indica* etc. and climbers. Epiphytes were abundant in the forest.

9/CI Himalayan sub-tropical pine forest (1200-1800 m): These forests do not appear in the Champion and Seth classification. However, they occur in and around 1200 m and extend up to 1800 m elevations mostly repalcing the broad-leaved forests following disturbances. The canopy is comprised of *Pinus wallichiana*. However, remnants of broad-leaved forest elements with: *Mallotus philippensis, Pyrus pashia, Albizzia arunachalensis, Prunus cerasoides, Purus* sp., are quite conspicuous. Shrubs were represented by: *Artimisia nilagirica, Coriaria nepalensis, Elaeagnus parvifolia, Rosa* sp., *Rubus ellipticus, Butea buteiformis* and *Viburnum erubescens*. The herbaceous layer constitutes of Climber and epiphytes are not common.

11B/CI East Himalayan wet temperate forest (2000-3000 m): These are mixed evergreen forests with moderate size trees occurring between 1800 and 3000 m altitude. In these forests important tree associates are: *Acer campbellii, Lithocarpus pachyphylla, Prunus cerasoides, Quercus serrata, Rhododendron arboreum, Schima wallichii* and *Tetracentron sinense*. Shrubs are represented by: *Berberis asiatica, Coriaria nepalensis, Elaeagnus parvifolia, Rosa brunonii, Rubus ellipticus* and *Viburnum erubescens*. Climber and epiphytes are not common.

12/C3a East Himalayan mixed coniferous forests (2000-3500 m): These are dense evergreen forests with dominance of oak and rhododendrons. In the upper ridges between 2300-3500 m elevations, silver fir (*Abies densa*) makes appearance as a dominant tree species. With the oak are mixed deciduous trees such as *Magnolia* sp., *Acer* sp., *Betula alnoides, Alnus nepalensis*, and others to a varying extent. There is usually gregarius undergrowth, usually of bamboo, and in its absence Rhododendron species and other evergreen shrubs such as *Berberis* sp., *Cotoneaster* sp., *Rhododendron* sp., *Salix* sp., *Thamnocalamus* sp. and *Viburnum* sp. These are laden with many epiphytic mosses and lichens.

12/ISI Alder forest (1800-2200 m): Typically seen as pure stand of *Alnus nepalensis, Populus ciliata*, 20-30 m high, as a strip of varying width along stream sides, spreading out to larger areas, more or less deciduous. In the lower course of the stream where the fringe of *Alnus* is the only remaining tree growth owing to cultivation, there is often an under growth of inedible or thorny shrubs comprising *Berberis, Rubus, Princepia* etc, whilst in the better wooded tracts progression starts early and other species, notably blue pine and other conifers, are usually present.

12/1S2 Riverine blue-pine forest (1800-3000 m): Irregular, often dense stands of *Pinus wallichiana* with occasional *Picea*, *Tsuga, Populus* and *Alnus* with little or no undergrowth at first, but often becoming more open with inedible or thorny shrubs, if grazed.

Plant Diversity

The survey at Rho HEP sites resulted in the documentation of of 198 plant species belonging to different groups barrage site, powerhouse site and catchment area. A complete list of plant species found in the study area representing different groups such as tree, shrub, herb, climber, orchid, pteridophyte, bryophyte, lichen and fungi along with names is given Appendix II. 3.104. The number of plant species belonging to different groups is summarized in Table II. 3.395.

Table II. 3.395: Plants belonging to different groups recorded from the HEP site

Sl. No.	Plant groups	Number of species		
		Barrage site	Powerhouse site	Catchment area
1	Tree	14	18	11
2	Shrub	19	22	19
3	Herb	52	40	49
4	Climber	14		9
5	Orchid	4		3
6	Pteridophyte	18		13
7	Bryophyte	5		4
8	Lichen	15		10
9	Fungi	17	9	16

At the barrage site, 14 tree, 19 shrub, and 52 herb species were recorded, and at the powerhouse site 18 tree, 22 shrub, and 40 herb species were recorded.From the project catchment area 11 tree, 19 shrub and 49 herb species were recorded. A total of 14 climber, 4 orchid, 18 pteridophyte, 5 bryophyte, 15 lichen and 17 fungus species were recorded from barrage and powerhouse site whereas from the catchment area 9 climber, 3 orchid, 13 pteridophyte, 4 bryophyte, 10 lichen and 16 fungus species was recorded (Appendix II. 3.105 and 3.106).

Threatened and Endemic Species

Two threatened species was recorded from the project site (Table II. 3.396).

Table II. 3.396: Threatened/endemic plants recorded at Tawang-I HEP site

Species name	Family	Threat status	Endemicity
Albizia arunachalensis	Mimosaceae	Endm	Endemic to india
Torricellia tiliifolia	Torricelliaceae	Endm	Endemic to South East Asia

Endm=Endemic

Economically Important Species/Plant Resources

The study area is rich in plant resources. A few of the important ones are listed in Table II. 3.397 under different groups.

Table II. 3.397: Economically important species/plant resources present in the project sites

Sl. No.	Uses	Species name
1	Timber	*Pinus wallichiana*
2	Fuel	*Quercus griffithii, Q. semicarpifolia, Alnus nepalensis, Rhododendron* sp.
3	Ornamentals and orchids	*Rhododendron* sp., *Luculia pinceana, Buddleja asiatica*
4	Medicine and aromatics	*Rubia cordifolia*
5	Fodder	*Alnus nepalensis, Saurauia nepalensis, Ficus* sp., *Quercus griffithii*
6	Edible	*Prunus* sp., *Rubus ellipticus, Juglans regia, Benthamidia capitata, Elaeagnus* sp., *Prasiola* sp.
7	Fibre and paper	*Daphne papyracea, Sterculia* sp.
8	Bamboos:	*Arundinaria* sp., *Phyllostachys* sp.
9	Resins and gums	*Pinus wallichiana*

Vegetation Analysis for Angiosperms and Gymnosperms

The plant communities around Tawang-I site including barrage, powerhouse site, and catchment area were studied. At the site species richness was high. It had 27 tree species, 35 shrub species and 63 herbaceous species (Tables II. 3.398 and 3.399).

Table II. 3.398: Tree and shrub species recorded in the barrage, powerhouse and catchment area of Tawang-I site

Tree species	Shrub species
Alangium chinensis	*Aconogonum molle*
Albizzia arunachalensis	*Ardesia crenata*
Alnus nepalensis	*Artemesia nilagarica*
Brassiopsis glomerulata	*Arundinella manni*
Brassiopsis miltis	*Boehmeria macrophylla*
Erythrina arborescence	*Buddleja asiatica*
Eurya acuminata	*Butea buetiformis*
Ficus auriculata	*Coriaria nepalensis*
Ilex sp.	*Cyathula tomentosa*
Leucoceptrum cannum	*Debregessia longifolia*
Litsea citrata	*Dicranopteris* sp.
Macaranga denticulata	*Dobinea vulgaris*
Merrilliopanax alpinus	*Elaeagnus parvifolia*
Myrica sp.	*Flemingia macrophylla*
Photinia integrifolia	*Girardiana diversifolia*
Pinus wallichiana	*Hydrangea* sp.
Prunus cerasoides	*Hypericum* sp.
Quercus griffithii	*Indigofera* sp.
Quercus serrata	*Maesa indica*
Quercus semicarpifolia	*Morus rubra*
Rhododendron arboretum	*Mussandra* sp.
Rhus javanica	*Neillia thyrsiflora*
Salix wallichiana	*Rubus ellipticus*
Saurauia punduana	*Rubus rugosus*
Schima wallichii	*Scenecio* sp.
Toricellia tiliifolia	*Solanum khasianum*
	Spirea sp.
	Strobilanthes sp.
	Triumfetta rhomboidea
	Urena lobata
	Viburnum foetidum
	Woodfurdia fructicosa
	Yushania hirsuta

Table II. 3.399: Herbaceous species recorded near barrage, powerhouse and in catchment area of Tawang-I project

Herb species		
Ageratum conizoides	*Eupatorium adenophorum*	*Oxalis corniculata*
Agrimonia pilosa	*Euphorbia hirta*	*Oxalis* sp.
Anaphalis margrateata	*Fagopyrum esculenta*	*Pepromia tetraphylla*
Anemone rivularis	*Fragaria nubicola*	*Persicaria capitata*
Ariesaema sp.	*Galinsuga parviflora*	*Persicaria chinensis*
Bidens pilosa	*Galium aparine*	*Piper pedicellata*
Campanula pallida	*Galium rotundifolium*	*Plantago major*

Canabis sativus	*Galium* sp.	*Pogostemon* sp.
Centella asiatica	*Geranium nepalensis*	*Pteridium aquilinum*
Cirsium	*Geranium* sp.	*Ranunculus diffusus*
Cissampelos prairie	*Houttuynia cordata*	*Roscoea* sp.
Crassocephalum crepidioides	*Hydrocotyle nepalensis*	*Rumex nepalensis*
Cyanoglossum sp.	*Hypoetes* sp.	*Seigesbeckia orientalis*
Cyathula tomentosus	*Impatiens bicolour*	*Selenium* sp.
Cybopogon citratus	*Impatiens* sp.	*Strobilanthes*
Cymbopogon citratus	*Ipomea* sp.	*Urtica dioca*
Cyperus sp.	*Juncus* sp.	*Verbasacum thapsus*
Delphenium sp.	*Lecanthus peduncularis*	*Veronia* sp.
Drymaria cordata	*Lindenbergia* sp.	*Viola sikkimensis*
Elusine sp.	*Lysionanthus* sp.	*Xanthium sumatranum*
Equisetum diffusum	*Melastoma* sp.	*Musa* sp.

In general, species richness was high during monsoon season and low during winter season. *Alnus nepalensis* was the dominant tree at the barrage site and in catchment area, at powerhouse site *Macaranga denticulata* was dominant. In case of shrubs, *Aconogonum molle* was dominant at barrage site, and *Artemisia nilagarica* was dominant at powerhouse site and in catchment areas. The herbaceous community being mostly annual in nature, at a given site, different species were dominant in three different seasons (Appendix II. 3.116).

The density of trees and shrubs was highest at the barrage site (Table II. 3.400). Density of herbaceous species varied widely between barrage site, powerhouse site and catchment areas. It was maximum during monsoon season and low during winter season at all the sites (Appendix II 3.107- 3.116).

Shannon diversity index for tree species in the community was highest at the powerhouse site (H'= 2.51) followed in decreasing order by barrage site (2.11) and catchment area (2.05). For shrub species, highest value was obtained for catchment area (2.59), followed by barrage site (2.51) and powerhouse site (2.27) (Table II. 3.400).

Shannon diversity index for herbs ranged between 3.67 to 2.97. The highest and lowest value was recorded from and catchment area barrage site during monsoon season and winter season respectively. Overall, species diversity was highest at barrage site.

Table II. 3.400: Species richness, diversity and dominance of tree and shrub community, and biomass and carbon stock of trees in Tawang-I project site

Parameters	Barrage		Powerhouse		Catchment areas	
	Tree	Shrub	Tree	Shrub	Tree	Shrub
Number of species	14	19	18	13	11	21
Density (ha $^{-1}$)	1840	14800	1624	11968	1456	14432
Simpson index of dominance	0.17	0.89	0.10	0.87	0.18	0.89
Shannon index of diversity (H')	2.11	2.51	2.51	2.27	2.05	2.59
Evenness index	0.80	0.65	0.87	0.75	0.85	0.64
Biomass (t/ha)			160.67			
Carbon (t/ha)			80.33		64.80	

Table II. 3.401: Species richness, diversity and dominance in herbaceous community in Tawang-I project site

Parameters	Barrage			Powerhouse			Catchment areas		
	PM	M	W	PM	M	W	PM	M	W
Number of species	40	50	29	29	38	20	38	47	24
Density (ha $^{-1}$)x10^3	298	729	266	333	541	149	388	757	179
Simpson index of dominance	0.96	0.97	0.95	0.95	0.97	0.94	0.96	0.97	0.94
Shannon index of diversity (H')	3.40	3.67	3.14	3.22	3.53	2.86	3.39	3.68	2.97
Evenness index	0.75	0.78	0.79	0.86	0.89	0.87	0.78	0.84	0.81

PM: Post monsoon; M: Monsoon; W: Winter

Phytoplankton/Periphyton

Thirteen species of phytoplankton/periphyton were recorded from Tawang-I project site. The phytoplankton/periphyton community was represented by 2 species of Cyanobacteria, 10 species of Bacillariophyceae, and one species of Chlorophyceae. Maximum species richness in the community was recorded in the catchment area (9 species) and minimum (8 species) in the project affected areas. Phytoplankton/periphyton density at the project affected areas (55 individuals/l) was higher than that of catchment area (50 individuals/l). Similarly, Species diversity index was maximum (2.14) in the catchment area and minimum (H'= 2.02) in the project affected areas (Table II. 3.402).

Table II. 3.402: Density (Individuals/l), species richness and Shannon index of diversity (H') of phytoplankton community in river water at project affected area and catchment area of Tawang-I project

List of species	Project affected area	Catchment area
Cyanobacteria		
Oscillatoria sp.	10	
Phormidium sp.	5	5
Bacillariophyceae		
Achnanthidium rivulare	5	5
Cocconeis placentula	10	5
Didymosp.henia germinata		5
Encyonema minutum	5	10
Fragillaria vauchaeriae		10
Gomphonema olivaceoides		5
Gomphonema olivaceum		5
Navicula cryptocephala	5	
Navicula cryptotenella		5
Synedra ulna	5	
Chlorophyceae		
Spirogyra sp.	5	
Total density (individuals/lit)	50	55
Species diversity index	2.02	2.14
Species richness	8	9

NB: Blank cells indicate absence of periphyton species

Zooplankton

Study on zooplankton diversity was conducted during monsoon and winter seasons in Tawang-I area. One species belonging to Cladocera (*Bosmina (Bosmina) longirostris)*, and 12 species belonging to Rotifera were recorded during the monsoon and winter seasons. *Lecane* of Rotifera was the dominant genus followed by *Lepadella*. Out of the total 13 species, 4 were recorded during monsoon season and 9 species were recorded during post-monsoon season (Table II. 3.403). From the project sites, 3 rare species of zooplanktons were recorded, viz., *Lepadella cf. nartiangensis, Trichocerca pusilla* were located from catchment area and *Colurella sulcata* was located from the project site.

Table II. 3.403: Occurrence of species belonging to Cladocera and Rotifera during monsoon and winter seasons in Tawang-I project site

Sl. No.	Taxa	Species	Season	
			Monsoon	Winter
1	Cladocera	*Bosmina (Bosmina) longirostris* (O.F. Muller, 1776)	–	+
2	Rotifera	*Colurella obtusa* (Gosse, 1886)	–	+
3	Rotifera	*Colurella sulcata* (Stenroos, 1898) *	–	+
4	Rotifera	*Lecane curvicornis* (Murray, 1913)	+	–
5	Rotifera	*Lecane flexilis* (Gosse, 1886)	+	–
6	Rotifera	*Lecane lunaris* (Ehrenberg, 1832)	+	–
7	Rotifera	*Lecane bulla* (Gosse, 1851)	+	–
8	Rotifera	*Lecane curvicornis* (Murray, 1913)	–	+
9	Rotifera	*Lecane luna* (Müller, 1776)	–	+
10	Rotifera	*Lepadella acuminata* (Ehrenberg, 1834)	–	+
11	Rotifera	*Lepadella cf. nartiangensis* (Sharma & Sharma, 1987) *	–	+
12	Rotifera	*Lepadella patella* (O.F. Muller, 1773)	–	+
13	Rotifera	*Trichocerca pusilla* (Jennings, 1903) *	–	+
Total	2	13	4	9

*Rare

Fish Fauna

Ten fish species were recorded from Tawang-I project sites Table II. 3.404.

Table II. 3.404: Fish fauna present in Tawang-I HEP area

Family	Species name	Max Length (cm)	Water Depth required (m)	Width of water flow required (m)	Altitude	Substrate
Cyprinidae	*Schizothorax richardsonii*	60.0	2-6	4-5	High and mid	Rocky
	Schizothorax progastus	50.0 cm	1-3	3-4 m	High and mid	rocky
Cobitidae	*Syncrossus berdmorei*	11.0	0.5-3	1-2	Mid and low	sandy and gravel
	Botia rostrata	20.0	0.5-4	2-3	Mid	Rocky
Bagridae	*Mystus vittatus*	21.0	0.5-4	2-3	Mid and low	Sandy, rocky
Sisoridae	*Erethistoides montana*	4.8	0.5-3	1-2	Mid and low	Gravel
	Euchiloglanis hodgarti	6.5	1-4	1-2	Mid and low	Sandy, rocky
	Exostoma berdmorei	10	2-5	2-3	Mid and low	large rocks
	Gagata cenia	15.0	2-4	2-4	Mid and low	sandy/muddy bottom
	Pseudechneis sulcatus	20.0	2-7	2-4	High, mid and low	gravel, cobble substrate

Soil Fauna

The seasonal variation in soil faunal diversity (Collembola, Acarina and other arthropods) and eveness in litter and soil layer is shown in Table II. 3.405-3.407.

Table II. 3.405: Seasonal variation of soil faunal diversity (Collembola, Acarina and other arthropods) and equitability in litter and soil layer in Tawang-I project sites

Soil fauna	Diversity	Post monsoon				Monsoon				Winter			
		Barrage		Powerhouse		Barrage		Powerhouse		Barrage		Powerhouse	
		Litter	Soil	Litter	Soil	Litter	Soil	Litter	Soil	Litter	Soil	Litter	Soil
Collembola	Dominance_D	0.12	0.16	0.15	0.14	0.22	0.22	0.19	0.16	0.14	0.15	0.13	0.28
	Shannon_H	2.20	1.96	1.99	1.95	1.57	1.56	1.73	1.89	2.08	1.91	2.12	1.33
	Evenness_e^H/S	0.90	0.89	0.91	1.00	0.96	0.95	0.94	0.95	0.89	0.96	0.92	0.95
Acarina	Dominance_D	0.10	0.11	0.11	0.12	0.18	0.18	0.16	0.21	0.14	0.21	0.28	0.36
	Shannon_H	2.33	2.23	2.28	2.18	1.76	1.75	1.89	1.58	2.02	1.68	1.33	1.06
	Evenness_e^H/S	0.93	0.93	0.89	0.88	0.97	0.96	0.94	0.97	0.94	0.89	0.94	0.96
Other Arthropods	Dominance_D	0.11	0.12	0.12	0.13	0.12	0.10	0.19	0.15	0.21	0.18	0.22	0.18
	Shannon_H	2.25	2.20	2.15	2.11	2.16	2.33	1.74	1.93	1.68	1.75	1.56	1.82
	Evenness_e^H/S	0.95	0.90	0.95	0.92	0.96	0.93	0.94	0.99	0.89	0.96	0.95	0.88

Table II. 3.406: Mean annual density (number/m^2) of soil fauna in litter and soil layer (0-5 cm) in Tawang-I project sites

Soil fauna	Site	Litter layer	Soil layer	Total
Collembola	Barrage	1673	1455	**3127**
	Powerhouse	1455	1091	**2545**
Acarina	Barrage	1657	1229	**2886**
	Powerhouse	1314	943	**2257**
Other arthropods	Barrage	2364	1964	**4327**
	Powerhouse	2764	2182	**4945**
Total soil fauna	**Barrage**	**5694**	**4648**	**10340**
	Powerhouse	**5533**	**4216**	**9747**

Table II. 3.407: Seasonal variation of soil fauna density (number/m^2) in barrage and powerhouse sites of Tawang-I

Soil fauna	Site	Post monsoon	Monsoon	Winter	Mean
Collembola	Barrage	13600	10000	10800	**11467**
	Powerhouse	12400	7600	8000	**9333**
Acarina	Barrage	19600	11600	9200	**13467**
	Powerhouse	19600	7600	4400	**10533**
Other arthropods	Barrage	21200	18800	7600	**15867**
	Powerhouse	18400	27200	8800	**18133**

Wildlife

Butterflies: There were 28 species of butterflies belonging to 23 genera and five families. The family Nymphalidae dominatedthe site with 9 species. None of these species belonged to threatened category (Table II. 3.408).

Table II. 3.408: Butterflies recorded in Tawang-I HEP area

Sl. No.	Family common name	Scientific name	Project area
1	**Hesperiidae**		
1	Lucas' Ace	*Sovia lucasii magna*	*
2	**Papilionidae**		
2	Common Peacock	*Papilio polyctor ganesa*	*
3	Paris Peacock	*Papilio paris paris*	*
4	Golden Birdwing	*Troides aeacus aeacus*	*
3	**Pieridae**		
5	Dark Jezebel	*Delias berinda*	*
6	Spotless Grass Yellow	*Eurema laeta*	*
7	Small Grass Yellow	*Eurema brigitta rubella*	*
8	Indian Cabbage White	*Pieris canidia indica*	*
9	Green-veined White	*Pieris napi montana*	*
10	Green vein White	*Pieris melete*	*
11	Plain Sulphur	*Dercas lycorias*	*
12	Spotted Sawtooth	*Prioneris thestylis thestylis*	*
4	**Lycaenidae**		
13	Peablue	*Lampides boeticus*	*
14	Green Sapphire	*Heliophorus moore*	*
15	Pale Hedgeblue	*Udara dilecta*	*
16	Large Hedgeblue	*Celastrina hugeli oreana*	*
17	Common Flash	*Rapala nissa ratna*	*
18	Common Hedgeblue	*Acytolepis pusp.a gisca*	*
19	Punchinello	*Zemeros flegyas indicus*	*
5	**Nymphalidae**		
20	Chestnut Tiger	*Parantica sita*	*
21	Eastern Comma	*Polygonia egea*	*
22	Large Silverstripe	*Argynnis children*	*
23	Glassy Tiger	*Graphium cloanthus*	*
24	Indian Tortoiseshell	*Aglais caschmirensis*	*
25	Chocolate Pansy	*Junonia iphita iphita*	*
26	Banded Treebrown	*Lethe confusa*	*
27	Straight-banded Treebrown	*Lethe verma*	*
28	Banded Treebrown	*Lethe confusa*	*

Herpetofauna: No herpetofauna was encountered in Tawang-I project area during field survey. The probable list of amphibians and reptiles was prepared for this site following Ahmed *et al.* (2009 (Appendix II. 3.167).

Birds: The assessment of bird diversity carried out during monsoon and winter seasons in and around this project area revealed the presence of 114 bird species that belonged to 81 genera and 34 families, with a shannon diversity (H') value of 4.1. this indicates a moderate level of species diversity. When seasonal status was compared, richness was higher during monsoon (70 species) than in winter. The abundance of birds (844 birds) was more in post monsoon season (Table II. 3.409).

Migratory status: The migratory and resident status of these bird species showed that most of the birds were residents (84 species) followed by 15 breeding visitors and 14 winter visitors (Table II. 3.409).

Table II. 3.409: Status of birds recorded in Tawang-I project area

Details	Post monsoon	Monsoon	Winter	Overall
Family	27	28	24	34
Genera	43	51	41	81
Species	50	70	47	114
Abundance	844	508	228	1580
Diversity H'	3.7	3.5	3.2	4.1

Migratory Status				
Breeding Visitor	6	12	6	15
Isolated Record	1	0	0	1
Resident	39	49	36	84
Winter Visitor	4	9	5	14

Abundance status: The abundance status of birds was derived by classifying the abundance of bird species into five abundance category (Very Low = 1-25 birds, Low = 26-50, Moderate = 51-75, High = 76-100 and Very High = > 100birds). The details of abundance status are given in the Table II. 3.410.

Table II. 3.410: Number of species and relative % of birds in different abundance classes

Abundance class	No. of species	Relative %
Very low -1 -25 birds	101	88.6
Low -26 -50 birds	8	7.0
Moderate -50 -75 birds	1	0.9
High -76-100 birds	3	2.6
Very high > 100 birds	1	0.9
Total	**114**	**100**

Status of foraging guilds: In Tawang-I HEP site, seven guilds were present, among which insectivores was dominant with 78 species followed by granivores with 14 species , and omnivores with 10 species (Table II. 3.411 and Appendix II. 3.195). This analysis also indicated low diversity of birds in the area.

Table II. 3. 411: Status of foraging guild of birds recorded in Tawang-I project area

Foraging guild	Post monsoon	Monsoon	Winter	Overall
Aquatic feeder	0	0	0	0
Carnivore	3	3	1	5
Frugivore	1	1	0	2
Granivore	5	5	4	14
Insectivore	30	52	35	78
Nectarivore	1	3	2	4
Nucivore	1	0	1	0
Omnivore	9	6	4	10
Piscivore	0	0	0	1

Status of threatened species: The assessment of conservation status of birds in this project area showed that there was no threatened bird species (Appendix II. 3.195).

Mammals: Surveys in and around Tawang-I project site revealed the presences of eight mammalian fauna and each belonging to separate genus and family, which consist of 1 primate, 2 ungulates, 2 rodents and 3 carnivore species (Appendix II. 3.196).

Abundance status: Among the eight species, presence of four species was confirmed based on sighting of 101 animals. Barking Deer (*Muntiacus muntjak*), Wild pig (*Sus scrofa*), Himalayan Palm Civet (*Paguma larvata*), and Jungle cat (*Felis chaus*) were the species recorded based on one to four evidences (Table II. 3).Occurrence of only eight species with 101 sightings of animal clearly showed the moderate potential of the project area to support the mammalian fauna. Further evaluation of species richness of the project area (8 species) with the possible species (28 species) of the Tawang district (Mishra *et al.* 2006) revealed a low species richness, as the project area formed only 27.58% (Appendix II. 3.196).

Status of threatened species: Except the Arunachal Macaque *(M .munzala)* which is Endangered (EN) according to IUCN Red List, rest of the six species of the project area fall under Least Concern (LC) of IUCN and Schedule II and III of WPA (1972) (Table II. 3.412).

Table II. 3.412: Status of mammalian fauna of the proposed Tawang-I HEP area

Sl. No.	Common name	Scientific name	Seasons			Overall	Conservation status	
			PM	M	W		IUCN	WPA
I.	**Cercopithecidae**							
1	Arunachal Macaque	*Macaca munzala*		IE 4 A15 *	IE 1 A 92	IE 5 92	EN	-
II.	**Cervidae**							
2	Barking Deer	*Muntiacus muntjak*		IE-1		IE 1	LC	**III**
III.	**Suidae**							
3	Wild pig	*Sus scrofa*	IE-1		IE 2	IE 3	LC	III
IV.	**Felidae**							
4	Jungle cat	*Felis chaus*		IE-1	IE 3	IE 4	LC	II
V.	**Mustelidae**							
5	Yellow Throated Martin	*Martes flavigula*	A 2			A 2	LC	II
VI.	**Viverridae**							
6	Himalayan Palm Civet	*Paguma larvata*		IE 2		IE2		
VII.	**Sciuridae**							
7	Hoary-bellied Himalayan Squirrel	*Callosciurus pygerythrus*		A 4		A 4	LC	NE
8	Himalayan Stripped Squirrel	*Tamipos macclellandi*		A-2	A 1	A 3	LC	NE
	No of species		**2**	**6**	**4**	**8**		
	Total and types of records		**IE 1 A 2**	**IE 8 A21**	**IE 6 A 93**	**IE 15 A 101**		

IE – Indirect Evidences A-animals sighted, W-Winter, PM-Post monsoon, M-Monsoon, IUCN-Red List, WPA-Wildlife Protection Act, EN-Endangered, LC-Least Concern, NE – Not Evaluated

Faunal status within 500 m of project affected area: This section revealed species richness status of selected faunal groups such as avifauna and mammal species reported within 500 m up and down streams of the barrage and powerhouse sites of the proposed project area. The species richness reported in these specific sites was evaluated based on subjective rating through estimating percent contribution with the overall species list of the project area. If the species richness of barrage and powerhouse contributes 25% of overall list, it was categorised as low, > 25-50% as medium, >50-75% as high and above 75% as high species richness.

Status of avifauna: At Tawang-I barrage site species richness with 34 species is designated as medium species richness area, when compared with the overall list of 114 species reported for the entire project area (29.62%) (Appendix II. 3.197 and 3.198). The powerhouse site with 30 species, may be designated as medium species richness area, when compared with the overall list of 114 species reported for the entire project area (25.86%). No threatened species was found in the project affected areas of Tawang-I HEP site.

Status of mammals: Site specific evaluation of mammalian fauna within 500 m of up and down streams showed occurrence of only 4 species in the barrage site. Among these species, only Arunachal Macaques was recorded based on direct sighting (15 animals), while presence of rest of the three species was ascertained based on seven indirect evidences. In powerhouse area five species were reported based on four indirect evidences and sightings of Himalayan Stripped Squirrels (two individual). Among the species, Arunachal Macaque (*Macaca munzala*) was the only endangered species reported with 15 animals in one group in the vicinity of the barrage site while rest of the six species belong to least concern category of IUCN (Table II. 3.413).

Table II. 3.413: Status of mammalian fauna at barrage and powerhouse sites of the proposed Tawang-I HEP area

Sl. No.	Common name	Species name	Status		CS	
			BS	PHS	IUCN	WPA
1	Arunachal Macaque	*Macaca munzala*	A 15 (1G) IE 2		**EN**	-
2	Barking Deer	*Muntiacus muntjak*		IE 1	LC	**III**
3	Wild pig	*Sus scrofa*	IE 2	IE 1	LC	III
4	Jungle cat	*Felis chaus*	IE 1	IE 1	LC	II
5	Himalayan Palm Civet	*Paguma larvata*		IE 1	LC	II
6	Hoary-bellied Himalayan Squirrel	*Callosciurus pygerythrus*		A2	LC	-

7	*Himalayan Stripped Squirrel*	*Tamipos macclellandi*	A 2		LC	-
	Total no. of species		**4**	**5**		
	Total no. of record		**IE 5, A 17**	**IE 4, A 2**		

IE – Indirect Evidences, A – No of Animals Sighted, BS –Barrage Site, PHS – Powerhouse Site, IUCN-Red List, WPA-Wildlife Protection Act, NT-Near threatened, LC-Least Concern, EN – Endangered, G – No of groups

3.3.9.3 SOCIO-ECONOMIC PROFILE

Information on names of the villages that will get directly affected as well as names of the villages within 10km radius of the project were available, therefore these two categories of villages have been described separately. Further, the results of baseline survey have been described separately for data gathered at the village level and at the HH level.

Village Level Survey-Affected

Profile of the Thirteen Surveyed Villages: The thirteen villages fall under four administrative circles of Jang, Lhau, Mukto and Tawang (Table II. 3.414). The distance of the thirteen villages from the river varies from 1 km–8 km. The circle headquarters of the thirteen villages are within 28 km. Except for two villages, Jangda and Gomkelleng, which are situated more than 90 km from the district headquarters, the remaining seven are situated within 55 km.

Table II. 3.414: Profile of the thirteen surveyed villages

Sl. No.	Village	Circle	Distance of village (in km)		
			River/tributary	Circle HQ	District HQ
1	Gomkang	Tawang	1	19	19
2	Gomkelleng	Mukto	4	13	100
3	Jangda	Lhau	7	15	90
4	Khamba	Lhau	3.5	4	20
5	Kharsa	Jang	2	1	45
6	Kudung	Tawang	2.5	28	28
7	Mirba	Mukto	3	10	55
8	Seru	Tawang	8	16	16
9	Shyro	Lhau	5	7	30
10	Teli	Tawang	2	14	14
11	Tsaikhar	Tawang	3	18	18
12	Yusum	Tawang	3	21	21
13	Yuthembu	Jang	2.5	1	45

Private Land Use Pattern: The details of private land holdings (in hectares) of the the ten villages is given in the Table II. 3.415. The total private land holdings in the studied villages is about 525 ha. Three villages, viz., Jangda, Seru and Yuthembu contribute 66% to the total land holdings in studied villages. In all the villages the proportion of Agricultural land exceeds that of the other land use types, except for Kudung village where forest land exceeds that of Agricultural land. Private forest land also contributes significantly (37%) to the total land holdings of the villages.

Table II. 3.415: Private landuse pattern and their percentage to total private land

Sl. No.	Village	Total private land	Forest cover (ha)	%	Agricultural (ha)	%	Horticulture (ha)	%	Habitation and HG (ha)	%
1	Gomkang	11.34	2.43	21	4.65	41	1.42	12	2.84	25
2	Gomkelleng	–	–	–	–	–	–	–	–	–
3	Jangda	120.00	45.00	38	57.00	48	0.00	0.00	18.00	15
4	Khamba	17.50	4.35	25	7.99	46	1.01	6	4.15	24
5	Kharsa	–	–	–	–	–	–	–	–	–
6	Kudung	21.45	7.59	35	7.28	34	0.00	0	6.58	31
7	Mirba	30.50	12.00	39	18.00	59		0	0.50	2
8	Seru	88.85	34.74	39	40.53	46	7.66	9	5.92	7
9	Shyro	34.26	13.00	38	16.78	49		0	4.48	13
10	Teli	30.57	8.30	27	16.19	53	0.20	1	5.88	19
11	Tsaikhar	–	–	–	–	–	–	–	–	–
12	Yusum	33.53	15.78	47	17.20	51	0.00	0	0.55	2.0
13	Yuthembu	137.00	53.00	39	62.00	45	0.00	–	22.00	16
	Total*	**525.00**	**196.19**		**247.62**		**10.29**		**70.90**	

* Excluding Gomkelleng, Kharsa and Tsaikhar due to non–availability of data

Demography and Literacy Rate: From Table II. 3.416, the following main features emerge. The total number of HHs in the thirteen villages is 742 (number varies from 12 in Gomkang to 107 in Kharsa). The total population is 3400 (1663 males; 1582 females). Only in Gomkang, Mirba, Shyro and Teli the number of females is less than that of the males. The literacy rate ranged from 6.3% in Yusum to 63.6% in Yuthembu. In the remaining surveyed villages the rate is less than 54%. Among males the rate varies from 11.4% in Yusum to 70.8% in Yuthembu and in females it varies from 1.9% in Yusum to 52.5% in Yuthembu.

Table II. 3.416: Demography and literacy rate

Sl. No.	Village	Demography					Literacy rate*		
		Total	Male	Female	Sex ratio (Per 1000 males)	No. of HH	Male	Female	Total
1	Gomkang	52	28	24	857	12	27.8	27.8	**27.8**
2	Gomkelling	159	76	83	1092	36	51.1	36.5	**45.2**
3	Jangda	525	249	276	1108	99	30	41	**30.0**
4	Khamba	154	70	84	1200	36	27.3	22.7	**26.4**
5	Kharsa	468	229	239	1044	107	44.6	37.7	**41.65**
6	Kudung	174	86	88	1023	33	–	–	–
7	Mirba	166	89	77	865	40	43.7	33.3	**39.4**
8	Seru	513	252	261	1035	106	60.4	47.2	**53.4**
9	Shyro	305	159	146	918	56	42.6	38.3	**41.4**
10	Teli	171	86	85	988	35	54.4	42.6	**48**
11	Tsaikhar	115	49	66	1347	34	46.8	15.6	**29.5**
12	Yusum	229	108	121	1120	50	11.4	1.9	**6.3**
13	Yuthembu	369	182	187	1027	98	70.8	52.5	**63.6**
	Total	**3400**	**1663**	**1582**		**742**			

Note: Literacy rate after census 2011; Data not available for Kudung

Number of Livestock: The data pertaining to livestock holdings in thirteen villages (Table II. 3.417) shows that altogether nine different types of animals are domesticated. In none of the villages all the nine animal types were domesticated. In total, 3301 domestic animals are present in the twelve villages (Data for Kharsa village not available). Considerable inter-village variation is observed in total number of animals reared and varies from 23 in Gomkang to 1021 in Jangda. Jangda, Shyro and Yuthembu alone account for 66% of all the animals found in the surveyed villages. Three animals, viz., cattle (60%), sheep (12%) and yak (15%) account for 87% of the total animals (3301).

Table II. 3.417: Number of livestock

Sl. No.	Village	Mithun	Cattle	Yak	Goat	Sheep	Pig	Pony	Poultry	Others	Total
1	Gomkang	0	10	0	0	0	4	0	9	0	**23**
2	Gomkelling	2	60	1	5	10	0	0	0	5	**83**
3	Jangda	0	395	114	37	364	72	10	28	1	**1021**
4	Khamba	0	100	0	7	0	0	6	0	0	**113**
5	Kharsa	–	–	–	–	–	–	–	–	–	–
6	Kudung	0	118	0	12	3	0	2	0	0	**135**
7	Mirba	0	102	67	5	0	0	7	0	0	**181**
8	Seru	17	190	30	4	0	23	1	0	0	**265**
9	Shyro	0	357	69	0	2	29	50	2	0	**509**
10	Teli	59	0	0	0	0	0	0	0	1	**60**
11	Tsaikhar	0	39	0	0	0	0	0	2	0	**41**
12	Yusum	0	181	0	19	0	9	0	2	0	**211**
13	Yuthembu	10	413	224	2	10	0	0	0	0	**659**
	Total*	**88**	**1965**	**505**	**91**	**389**	**137**	**76**	**43**	**7**	**3301**

* Excluding Kharsa due to non–availability of data

Total Estimated Value of Livestock: The monetary value of domesticated animals maintained by the inhabitants of the studied villages has been estimated separately for each animal and for each village (Table II. 3.418). The selling price of different animals was obtained from the knowledgeable persons in the villages. The detailed methodology used in estimating the monetary value of animals has been described in the methodology section of the present report. As expected, there is considerable intra and inter village variation in this respect. The total value of animals numbering 3301 found in the twelve villages has been estimated as 863.74 lakhs. The value varied from 3.55 lakhs in Gomkang to 171.53 lakhs in Jangda. In terms of relative contribution made by different animals to the total value, cattle alone contribute over 591.25 lakhs (68%).

Table II. 3.418: Total estimated value of livestock

Sl. No.	Village	Total estimated value (Lakhs)									
		Mithun	Cattle	Yak	Goat	Sheep	Pig	Pony	Poultry	Others	Total
1	Gomkang	0.00	2.50	0.00	0.00	0.00	1.00	0.00	0.05	0.00	**3.55**
2	Gomkelleng	0.80	15.00	0.25	0.25	0.60	0.00	0.00	0.00	0.75	**17.65**
3	Jangda	0.00	98.75	28.50	1.85	21.84	18.00	2.30	0.14	0.15	**171.53**
4	Khamba	0.00	25.00	0.00	0.35	0.00	0.00	1.38	0.00	0.00	**26.73**
5	Kharsa	–	–	–	–	–	–	–	–	–	–
6	Kudung	0.00	29.50	0.00	0.60	0.18	0.00	0.46	0.00	0.00	**30.74**
7	Mirba	0.00	25.50	16.75	0.25	0.00	0.00	1.61	0.00	0.00	**44.11**
8	Seru	6.80	47.50	7.50	0.20	0.00	5.75	0.23	0.00	0.00	**67.98**
9	Shyro	0.00	89.25	17.25	0.00	0.12	7.25	11.50	0.01	0.00	**125.38**
10	Teli	23.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.15	**23.75**
11	Tsaikhar	0.00	9.75	0.00	0.00	0.00	0.00	0.00	0.01	0.00	**9.76**
12	Yusum	0.00	45.25	0.00	0.95	0.00	2.25	0.00	0.01	0.00	**48.46**
13	Yuthembu	4.00	103.25	56.00	0.10	0.60	0.00	0.00	0.00	0.00	**163.95**
	Total*	**39.2**	**591.25**	**151.25**	**5.05**	**23.94**	**34.25**	**17.48**	**0.27**	**1.05**	**863.74**

* Excluding Kharsa due to non–availability of data

Average Annual Earnings of the Village: The average annual family income varies from 0.87 lakhs in Tsaikhar to 3.62 lakhs in Gomkelleng (Table II. 3.419). The value of total earnings per year in the villages is estimated at 1719.84 lakhs. The contribution made by animal husbandry compared to the other resources, to the total earnings is maximum in the majority of the villages. Of the total annual earnings, animal husbandry contributes 829.67 lakhs (48%). Traditional skills and daily wage labour together contribute over 34%. It is noteworthy that Agriculture contributes only 7.4% of the total annual village earnings.

Table II. 3.419: Average annual earning of the village

Sl. No.	Village	Total earning/year (Rupees in lakh)								Average family Income\ (Rupees in lakh)
		Agricultural	Animal Husbandry	Horticulture	Traditional Skills	Daily Wages	GS	Others*	Total	
1	Gomkang	2.33	4.97	0.71	6.25	4.86	1.68	1.18	**21.97**	1.83
2	Gomkelling	2.25	17.93	0.00	87.75	14.58	4.56	3.19	**130.26**	3.62
3	Jangda	28.50	220.54	0.00	39.75	40.10	14.94	10.46	**354.28**	3.58
4	Khamba	4.00	24.41	0.51	10.00	14.58	4.20	2.94	**60.63**	1.68
5	Kharsa	0.00	116.64	0.00	12.50	43.34	13.74	9.62	**195.83**	1.83
6	Kudung	3.64	29.16	0.00	2.50	13.37	5.16	3.61	**57.44**	1.74
7	Mirba	9.00	39.10	0.00	15.30	16.20	5.34	3.74	**88.67**	2.22
8	Seru	20.26	57.24	3.83	10.80	42.93	15.12	10.58	**160.77**	1.52
9	Shyro	8.39	109.94	0.00	30.00	22.68	9.54	6.68	**187.23**	3.34
10	Teli	8.09	12.96	0.10	5.00	14.18	5.16	3.61	**49.10**	1.40
11	Tsaikhar	2.00	8.86	0.00	0.00	13.77	2.94	2.06	**29.62**	0.87
12	Yusum	8.60	45.58	0.00	61.25	20.25	6.48	4.54	**146.69**	2.93
13	Yuthembu	31.00	142.34	0.00	5.75	39.69	10.92	7.64	**237.35**	2.42
	Total	**128.06**	**829.67**	**5.15**	**286.85**	**300.53**	**99.78**	**69.85**	**1719.84**	**28.98**
	%	**7.4**	**48.2**	**0.3**	**16.7**	**17.5**	**5.8**	**4.1**	**100.0**	

* Other includes artisans, monks, self–employed contractors etc; GS =Government service

Average Annual Expenditure Pattern of a Family: The average annual family expenditure in the surveyed villages varies from 0.85 lakhs in Tsaikhar to 1.53 lakhs in Jangda and Shyro (Table II. 3.420). In general, the expenditure incurred on health and education exceeds that of other type of expenditure across the villages. Expenditure incurred on transport and Food and drinks is also substantial. The total value of average annual expenditure incurred by a family in thirteen villages is 17.02 lakhs.

Table II. 3.420: Average annual expenditure pattern of a family in the villages

Sl. No.	Village	Expenditure/year (Rupees in lakh)				
		Food and drinks	Clothing	Transport	Education and health	Total
1	Gomkang	0.35	0.35	0.27	0.3	**1.27**
2	Gomkelling	0.3	0.25	0.37	0.45	**1.37**
3	Jangda	0.3	0.35	0.4	0.48	**1.53**
4	Khamba	0.3	0.3	0.4	0.45	**1.45**
5	Kharsa	0.3	0.3	0.3	0.3	**1.2**
6	Kudung	0.36	0.3	0.36	0.4	**1.42**
7	Mirba	0.35	0.35	0.27	0.3	**1.27**
8	Seru	0.3	0.25	0.43	0.3	**1.28**
9	Shyro	0.3	0.35	0.4	0.48	**1.53**
10	Teli	0.3	-	0.4	0.6	**1.3**
11	Tsaikhar	0.2	0.2	0.2	0.25	**0.85**
12	Yusum	0.3	0.3	0.2	0.3	**1.1**
13	Yuthembu	0.3	0.3	0.4	0.45	**1.45**
	Total	**3.96**	**3.6**	**4.4**	**5.06**	**17.02**

Water Sources: In Table II. 3.421, data pertaining to the water resources available and their pattern of use in the thirteen villages are presented. Four out of five types of water resources listed in the Table II. 3.421 are available across the studied villages. Four out of thirteen villages use river water. Water from hill stream/springs is used in eleven villages. Khamba depends entirely on hill stream/spring water for various requirements. Tap water is used for various purposes in twelve surveyed villages. In Seru and Shyro pond water is also used and Wells are absent in all the villages.

Table II. 3.421: Water sources in the village

Sl. No.	Village	Rivers				Hill stream/spring				Wells				Ponds				Tap water			
		Drinking water	Domestic use	Livestock use	Agricultural	Drinking water	Domestic use	Livestock use	Agricultural	Drinking water	Domestic use	Livestock use	Agricultural	Drinking water	Domestic use	Livestock use	Agricultural	Drinking water	Domestic use	Livestock use	Agricultural
1	Gomkang					1	1	1										1	1	1	
2	Gomkelling					1	1	1										1	1		
3	Jangda					1	1	1										1	1		
4	Khamba					1	1	1													
5	Kharsa					1	1	1										1	1		
6	Kudung			1	1	1	1	1										1	1		
7	Mirba	1		1		1	1	1										1	1		
8	Seru			1		1	1	1	1							1		1	1		
9	Shyro													1	1	1		1	1	1	
10	Teli					1	1	1										1	1	1	1
11	Tsaikhar																	1	1	1	
12	Yusum			1		1	1	1										1	1		
13	Yuthembu					1	1	1										1	1		
	Total	**1**	**0**	**4**	**1**	**11**	**11**	**11**	**1**	**0**	**0**	**0**	**0**	**1**	**1**	**2**	**0**	**12**	**12**	**4**	**1**

Amenities in the Villages: From Table II. 3.422, it is observed that out of 12 amenities listed, Yuthembu has the maximum 11(92%) number of amenities. In Teli only four amenities (4/12) have been observed. All the villages have electricity, telephone and TV/radio. Traditional health healer is found only in Gomkang village.

Table II. 3.422: Amenities in the villages

Sl. No.	Village	Road connectivity	Health facility (PHC/sub-centre)	Traditional health healer	Veterinary services	Electricity	Fair price shop	Grocery shop	Post office	Bank	School	Telephone/Mobile	TV/Radios
1	Gomkang			√		√	√	√			√	√	√
2	Gomkelling	√	√			√					√	√	√
3	Jangda	√				√					√	√	√
4	Khamba		√		√	√	√	√	√		√	√	√
5	Kharsa	√	√		√	√	√	√	√	√	√	√	√
6	Kudung	√				√		√			√	√	√
7	Mirba	√				√	√	√			√	√	√
8	Seru	√	√			√	√	√			√	√	√
9	Shyro	√				√					√	√	√
10	Teli	√				√						√	√
11	Tsaikhar	√				√					√	√	√
12	Yusum	√				√	√				√	√	√
13	Yuthembu	√	√		√	√	√	√	√	√	√	√	√
	Total	**12**	**5**	**1**	**3**	**13**	**7**	**7**	**3**	**2**	**12**	**13**	**13**

NB: Blank indicates absent

Social Institutions: In none of the thirteen villages all the social institution listed in Table II. 3.423 are present; Kharsa and Shyro have four out of five amenities. Gompa was found in all the studied villages. Self Help Group is present in only one village i.e. Gomkang.

Table II. 3.423: Social institutions in the village

Sl. No.	Village	SHGs	Anganwadis	Community hall	Gompa	Any other	Total
1	Gomkang	√		√	√		**3**
2	Gomkelling		√	√	√		**3**
3	Jangda		√	√	√		**3**
4	Khamba		√	√	√		**3**
5	Kharsa		√	√	√	√	**4**
6	Kudung		√		√		**2**
7	Mirba			√	√		**2**
8	Seru		√	√	√		**3**
9	Shyro		√	√	√	√	**4**
10	Teli		√	√	√		**3**
11	Tsaikhar				√		**1**
12	Yusum		√		√		**2**
13	Yuthembu		√		√	√	**3**
	Total	**1**	**10**	**9**	**13**	**3**	

NB: Blank indicates absent

Occupation Profile: Work force participation is detailed in Table II. 3.424,. The total working population in the studied villages comprises of 3812 (81%) of total population. Of the total workers main workers are 80% while marginal workers are 20%.

Table II. 3.424: Occupation profile of the village

Sl. No.	Village	Population			Workers			Main workers			Marginal workers			Non workers		
		T	M	F	T	M	F	T	M	F	T	M	F	T	M	F
1	Gomkang	36	18	18	92	51	41	85	48	37	7	3	4	60	30	30
2	Gomkelling	155	92	63	50	25	25	44	19	25	6	6	0	50	23	27
3	Jangda	682	406	276	458	289	169	320	252	68	138	37	101	224	117	107
4	Khamba	352	286	66	119	62	57	74	45	29	45	17	28	160	71	89
5	Kharsa	132	72	60	70	33	37	54	26	28	16	7	9	45	13	32
6	Kudung	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
7	Mirba	269	158	111	1533	797	736	1191	732	459	342	65	277	1402	614	788
8	Seru	671	313	358	40	31	9	40	31	9	0	0	0	92	41	51
9	Shyro	636	448	188	62	35	27	35	20	15	27	15	12	61	25	36

10	Teli	173	79	94	458	289	169	320	252	68	138	37	101	224	117	107
11	Tsaikhar	139	62	77	18	15	3	16	15	1	2	0	2	23	9	14
12	Yusum	96	44	52	13	6	7	13	6	7	0	0	0	5	3	2
13	Yuthembu	1363	828	535	899	629	270	867	605	262	32	24	8	693	310	383
	Total*	**4704**	**2806**	**1898**	**3812**	**2262**	**1550**	**3059**	**2051**	**1008**	**753**	**211**	**542**	**3039**	**1373**	**1666**

* Excluding Kudung

Household Level Survey-Affected

Age of the Head of Households: The age of head of HHs across the thirteen surveyed villages varied from 22 in Kharsa and Yuthembu to 98 years in Shyro (Table II. 3.425). As expected and depending on the demographic structure of the villages, considerable variation has been observed between the villages in terms of the age of the Heads of HHs. The age of 37% of heads is over 50 years and 12% of heads age was below 30 years. The average age of heads of HH between villages varied from 43 to 53 (Table II. 3.426).

Table II. 3.425: Distribution of head of the HHs by age across the thirteen project villages

Sl. No.	Village	Up to 30		31–40		41–50		> 50		Total
		n	%	n	%	n	%	n	%	n
1	Gomkang	0	0	5	42	3	25	4	33	**12**
2	Gomkelleng	1	3	7	19	12	33	16	44	**36**
3	Jangda	7	7	19	19	31	31	42	42	**99**
4	Khamba	8	22	7	19	5	14	16	44	**36**
5	Kharsa	18	17	26	24	24	22	39	36	**107**
6	Kudung	3	9	10	30	11	33	9	27	**33**
7	Mirba	4	10	13	33	13	33	10	25	**40**
8	Seru	9	8	22	21	31	29	44	42	**106**
9	Shyro	1	2	17	30	11	20	27	48	**56**
10	Teli	2	6	9	26	8	23	16	46	**35**
11	Tsaikhar	8	24	5	15	10	29	11	32	**34**
12	Yusum	7	14	18	36	13	26	12	24	**50**
13	Yuthembu	20	20	27	28	21	21	30	31	**98**
	Total	**88**	**12**	**185**	**25**	**193**	**26**	**276**	**37**	**742**

Table II. 3.426: Minimum, maximum and average age of head of HHs across the thirteen project villages

Sl. No.	Village	Age range		Average
		From	To	
1	Gomkang	32	63	47
2	Gomkelleng	30	89	53
3	Jangda	25	92	50
4	Khamba	25	80	48
5	Kharsa	22	80	46
6	Kudung	29	97	45
7	Mirba	24	88	45
8	Seru	23	87	49
9	Shyro	30	98	53
10	Teli	26	90	52
11	Tsaikhar	25	72	46
12	Yusum	23	60	43
13	Yuthembu	22	86	46

Gender of the Head of Households: Data on gender of the head of HHs in the thirteen surveyed project villages is given in Table II. 3.427. In all the studied villages the number of males exceeds that of females as head of HHs. Across the surveyed villages 74% of heads were males. Interestingly in all villages there were female HHs head in varying numbers.

Table II. 3.427: Distribution of head of HHs by gender in the thirteen project villages

Sl. No.	Village	Male		Female		Total
		n	%	n	%	n
1	Gomkang	11	92	1	8	**12**
2	Gomkelleng	23	64	13	36	**36**
3	Jangda	65	66	34	34	**99**
4	Khamba	29	81	7	19	**36**
5	Kharsa	84	79	23	21	**107**
6	Kudung	23	70	10	30	**33**

7	Mirba	34	85	6	15	**40**
8	Seru	79	75	27	25	**106**
9	Shyro	45	80	11	20	**56**
10	Teli	27	77	8	23	**35**
11	Tsaikhar	26	76	8	24	**34**
12	Yusum	40	80	10	20	**50**
13	Yuthembu	65	66	33	34	**98**
	Total	**551**	**74**	**191**	**26**	**742**

Ethnicity: All the thirteen villages are predominantly inhabited by Monpa tribals.

Household size: Data from Tables II. 3.428 and 3.429, shows that the HH size varies from 1–12 HHs across the thirteen villages. There is vast variation between the thirteen villages in terms of distribution of HH size. The average HH size varies from five in six villages, four in another six villages and three in one village. Across the studied villages the average HH size is four.

Table II. 3. 428: Distribution of HH size in the thirteen project villages

Sl. No.	Village	1		2		3		4		5		6–8		9 and above		Total
		n	%	n	%	n	%	n	%	n	%	n	%	n	%	n
1	Gomkang	1	8	3	25	0	0	0	0	5	42	3	25	0	0	**12**
2	Gomkelleng	0	0	5	14	8	22	8	22	3	8	11	31	1	3	**36**
3	Jangda	5	5	11	11	6	6	13	13	14	14	39	39	11	11	**99**
4	Khamba	2	6	1	3	8	22	8	22	8	22	9	25	0	0	**36**
5	Kharsa	12	11	8	7	17	16	21	20	19	18	28	26	2	2	**107**
6	Kudung	1	3	1	3	2	6	7	21	11	33	8	24	3	9	**33**
7	Mirba	2	5	3	8	8	20	10	25	10	25	7	18	0	0	**40**
8	Seru	2	2	4	4	19	18	27	25	20	19	29	27	5	5	**106**
9	Shyro	4	7	2	4	9	16	7	13	8	14	19	34	7	13	**56**
10	Teli	2	6	1	3	6	17	7	20	6	17	10	29	3	9	**35**
11	Tsaikhar	0	0	6	18	17	50	5	15	5	15	1	3	0	0	**34**
12	Yusum	1	2	4	8	5	10	15	30	12	24	13	26	0	0	**50**
13	Yuthembu	9	9	14	14	18	18	27	28	16	16	14	14	0	0	**98**
	Total	**41**	**6**	**63**	**8**	**123**	**17**	**155**	**21**	**137**	**18**	**191**	**26**	**32**	**4**	**742**

Table II. 3.429: Minimum, maximum and average HH size across the thirteen project villages

Sl. No.	Village	HH size range		Average HH size
		From	To	
1	Gomkang	1	7	4
2	Gomkelleng	2	9	4
3	Jangda	1	9	5
4	Khamba	1	6	4
5	Kharsa	1	9	4
6	Kudung	1	10	5
7	Mirba	1	7	4
8	Seru	1	10	5
9	Shyro	1	12	5
10	Teli	1	9	5
11	Tsaikhar	2	7	3
12	Yusum	1	8	5
13	Yuthembu	1	8	4
	Total	**1**	**12**	**4**

Education: Relevant data on the education of the head of the HHs in the thirteen project villages is given in Table II. 3.430. It is highly noteworthy that a majority of the heads in studied villages were illiterate (85%). It varied from 65% in Mirba to 100% in Tsaikhar. There were 14 graduate head of HHs (2%) in the studied villages.

Table II. 3.430: Distribution of education of head of HH in the thirteen project villages

Sl. No.	Village	Illiterate		Primary		Upper primary		Secondary		Higher secondary		Graduate or above		Total
		n	%	n	%	n	%	n	%	n	%	n	%	n
1	Gomkang	10	83	0	0	0	0	2	17	0	0	0	0	**12**
2	Gomkelleng	31	86	0	0	1	3	0	0	2	6	2	6	**36**
3	Jangda	84	85	3	3	5	5	4	4	2	2	1	1	**99**
4	Khamba	29	81	0	0	2	6	3	8	1	3	1	3	**36**
5	Kharsa	86	80	1	1	8	7	10	9	1	1	1	1	**107**
6	Kudung	32	97	0	0	0	0	0	0	0	0	1	3	**33**
7	Mirba	26	65	1	3	6	15	5	13	0	0	2	5	**40**
8	Seru	90	85	0	0	4	4	6	6	3	3	3	3	**106**
9	Shyro	41	73	1	2	8	14	5	9	1	2	0	0	**56**
10	Teli	33	94	0	0	1	3	1	3	0	0	0	0	**35**
11	Tsaikhar	34	100	0	0	0	0	0	0	0	0	0	0	**34**
12	Yusum	41	82	0	0	4	8	4	8	0	0	1	2	**50**
13	Yuthembu	91	93	0	0	2	2	2	2	1	1	2	2	**98**
	Total	**628**	**85**	**6**	**1**	**41**	**6**	**42**	**6**	**11**	**1**	**14**	**2**	**742**

Main Occupation of Household Heads: The main occupations of the head of HHs across the thirteen villages were Agriculture, labour, pastoralist and government service, Table II. 3.431 reveal the following:

Agriculture: It varies from 10% in Mirba to 82% in Kudung. 55% of the surveyed head of HHs are engaged in Agricultural.

Labour: Except in Kudung and Yusum, labour has been reported by significant number of HHs (21%) as main mode of occupation.

Pastoralist: 42 HHs (6%) in the surveyed village pursued pastoralism as their main occupation.

Government service: Government servants were reported from all the thirteen villages. Kharteng had the maximum number (20/84) of government employees. Government service constitutes 11% of the main occupation.

Any other occupation: 51 (7%) HHs were engaged in other occupations.

Table II. 3.431: Distribution of head of HHs by main occupation in the thirteen project villages

Sl. No.	Village	Farmer		Labour		Pastoral		Govt. Servant		Others		Total
		n	%	n	%	n	%	n	%	n	%	n
1	Gomkang	3	25	6	50	0	0	3	25	0	0	**12**
2	Gomkelleng	26	72	1	3	0	0	8	22	1	3	**36**
3	Jangda	51	52	15	15	8	8	10	10	15	15	**99**
4	Khamba	23	64	5	14	4	11	3	8	1	3	**36**
5	Kharsa	14	13	81	76	0	0	8	7	4	4	**107**
6	Kudung	27	82	0	0	0	0	2	6	4	12	**33**
7	Mirba	4	10	13	33	11	28	6	15	6	15	**40**
8	Seru	80	75	3	3	1	1	20	19	2	2	**106**
9	Shyro	32	57	7	13	7	13	1	2	9	16	**56**
10	Teli	19	54	11	31	0	0	3	9	2	6	**35**
11	Tsaikhar	27	79	3	9	0	0	3	9	1	3	**34**
12	Yusum	37	74	0	0	0	0	8	16	5	10	**50**
13	Yuthembu	64	65	13	13	11	11	9	9	1	1	**98**
	Total	**407**	**55**	**158**	**21**	**42**	**6**	**84**	**11**	**51**	**7**	**742**

Private Land Holding Pattern: The private land holding pattern in the ten villages comprises of Agricultural land, horticulture land, habitation and home garden land and forest land. Data in respect of this aspect was not available for three villages–Gomkelleng, Kharsa and Tsaikhar. It may be noted here that a majority of the inhabitants of the surveyed villages did not know actual area either in acres or hectares of all categories of land holdings. Therefore, the area reported here should be considered as very rough estimates. Data pertaining to this aspect have been described below.

Agricultural land: Table II. 3.432 revealed that except 73 HHs (13%), all the remaining HHs (87%) in ten surveyed villages owned Agricultural land in varying proportions. A majority of the HHs (39%) owned Agricultural land between 1–2 acres. 12% of HHs owned land which is greater than 2 acres. There exists a striking variation between the villages in terms of Agricultural–land holdings. For example, 72% of the HHs in Jangda own more than one acre of land while 8% of HHs in Gomkang own one acre of land.

Table II. 3.432: Distribution of Agricultural land holding among surveyed HHs in the ten project villages

Sl. No.	Village	0.00 acre		< 1 acre		1–2 acre		> 2 acre	
		n	%	n	%	n	%	n	%
1	Gomkang	4	33	1	8	7	58	0	0
2	Jangda	6	6	22	22	54	55	17	17
3	Khamba	8	22	22	61	5	14	1	3
4	Kudung	11	33	10	30	12	36	0	0
5	Mirba	2	5	23	58	9	23	6	15
6	Seru	27	25	22	21	49	46	8	8
7	Shyro	1	2	27	48	28	50	0	0
8	Teli	7	20	12	34	13	37	3	9
9	Yusum	3	6	26	52	21	42	0	0
10	Yuthembu	4	4	37	38	23	23	34	35
	Total	**73**	**13**	**202**	**36**	**221**	**39**	**69**	**12**

Data in respect of this aspect was not available for three villages–Gomkelleng, Kharsa and Tsaikhar

Horticultural land: 27 HHs across the surveyed villages owned horticulture land. 19 HHs had greater than 1 acre of such land. The area under this category of land holding is about 25 acres (Table II. 3.433).

Table II. 3.433: Distribution of horticultural land among surveyed HHs in the ten project villages

Sl. No.	Village	n	0.00 acre		< 1 acre		1–2 acre		> 2 acre	
			n	%	n	%	n	%	n	%
1	Gomkang	12	9	75	1	8	2	17	0	0
2	Jangda	99	99	100	0	0	0	0	0	0
3	Khamba	36	32	89	3	8	1	3	0	0
4	Kudung	33	33	100	0	0	0	0	0	0
5	Mirba	40	40	100	0	0	0	0	0	0
6	Seru	106	87	82	3	3	15	14	1	1
7	Shyro	56	56	100	0	0	0	0	0	0
8	Teli	35	34	97	1	3	0	0	0	0
9	Yusum	50	50	100	0	0	0	0	0	0
10	Yuthembu	98	98	100	0	0	0	0	0	0
	Total	**565**	**538**	**81**	**8**	**1**	**18**	**3**	**1**	**0**

Gomkelleng, Kharsa and Tsaikhar has no Land Holding Data

***Habitation and home–garden land*:** Data presented in Table II. 3.434 reveals that only 38 HHs (7%) in surveyed villages did not own such land. A majority of HHs (90%) owned less than one acre. 16% of the HHs own land between 1 to 2 acre.

Table II. 3.434: Distribution of habitation and home garden land among surveyed HHs in the ten project villages

Sl. No.	Village	0.00 acre		< 1 acre		1–2 acre		> 2 acre	
		n	%	n	%	n	%	n	%
1	Gomkang	0	0	9	75	3	25	0	0
2	Jangda	6	6	93	94	0	0	0	0
3	Khamba	15	42	21	58	0	0	0	0
4	Kudung	1	3	32	97	0	0	0	0
5	Mirba	0	0	40	100	0	0	0	0
6	Seru	3	3	94	89	9	8	0	0
7	Shyro	2	4	52	93	2	4	0	0
8	Teli	7	20	26	74	2	6	0	0
9	Yusum	4	8	46	92	0	0	0	0
10	Yuthembu	0	0	98	100	0	0	0	0
	Total	**38**	**7**	**51**	**90**	**16**	**3**	**0**	**0**

Data in respect of this aspect was not available for three villages–Gomkelleng, Kharsa and Tsaikhar

Forest land: About 150 HHs (27%) in surveyed villages do not own private forest land (Table II. 3.435). A majority of HHs (45%) owned such land between 1–2 acres. It is noteworthy that only

30 HHs (5%) owned more than 2 acre of forest land. The area under this category of land holding is 488 acre.

Table II. 3.435: Distribution of forest land holding among surveyed HHs in the ten project villages

Sl. No.	Village	0.00 acre		< 1 acre		1–2 acre		> 2 acre	
		n	%	n	%	n	%	n	%
1	Gomkang	5	42	4	33	3	25	0	0
2	Jangda	15	15	15	15	59	60	10	10
3	Khamba	16	44	18	50	2	6	0	0
4	Kudung	9	27	11	33	13	39	0	0
5	Mirba	9	23	23	58	4	10	4	10
6	Seru	44	42	17	16	40	38	5	5
7	Shyro	18	32	12	21	26	46	0	0
8	Teli	15	43	8	23	11	31	1	3
9	Yusum	7	14	23	46	20	40	0	0
10	Yuthembu	12	12	0	0	76	78	10	10
	Total	**150**	**27**	**131**	**23**	**254**	**45**	**30**	**5**

Data in respect of this aspect was not available for three villages–Gomkelleng, Kharsa and Tsaikhar

Total land holdings: From the data presented in Table II. 3.436–3.439, that there are only 15 HHs (3%) that do not own any type of private land. 50% of the HHs owned more than 2 acres of total land. There is striking variation between the HHs within a village as well as between villages in ownership of total land. For example, in Seru inter–HH holdings vary from 0.1 acre to 18.15 acres, whereas in Kudung it varies from 0–4.0 acres. The proportion of Agricultural land compared to other types of land to the total land holdings is greater in a majority of the villages. 742 HHs in the ten villages owned total private land totalling 1302 acres. Out of this Jangda, Seru and Yuthembu accounts for 66% of the total land. Agricultural land accounts for 47% and forest land 37% of total land holdings in the ten villages.

Table II. 3.436: Distribution of total land holding among surveyed HHs in the ten project villages

Sl. No.	Village	0.00 acre		< 1 acre		1–2 acre		> 2 acre	
		n	%	n	%	n	%	n	%
1	Gomkang	0	0	3	25	4	33	5	42
2	Jangda	6	6	7	7	19	19	67	68
3	Khamba	5	14	8	22	20	56	3	8
4	Kudung	1	3	8	24	14	42	10	30
5	Mirba	0	0	14	35	18	45	8	20
6	Seru	0	0	33	31	33	31	40	38
7	Shyro	1	2	25	45	4	7	26	46
8	Teli	1	3	6	17	14	40	14	40
9	Yusum	1	2	7	14	22	44	20	40
10	Yuthembu	0	0	5	5	5	5	88	90
	Total	**15**	**3**	**116**	**21**	**153**	**27**	**281**	**50**

Data in respect of this aspect was not available for three villages–Gomkelleng, Kharsa and Tsaikhar

Table II. 3.437: Minimum, maximum and average land holdings across the ten project villages

Sl. No.	Village	Agricultural land			Horticultural land			Habitation and Home garden land			Forest land			Total land		
		From	To	Avg.	From	To	Avg.	From	To	Avg.	From	To	Avg.	From	To	Avg.
1	Gomkang	0.00	2.00	0.95	0.00	2.00	0.29	0.02	1.00	0.58	0.00	2.00	0.50	**0.02**	**6.00**	**2.33**
2	Jangda	0.00	6.00	1.42	0.00	0.00	0.00	0.00	0.74	0.45	0.00	4.00	1.13	**0.00**	**10.74**	**3.00**
3	Khamba	0.00	3.00	0.55	0.00	1.00	0.07	0.00	0.50	0.28	0.00	1.00	0.30	**0.00**	**4.50**	**1.20**
4	Kudung	0.00	2.00	0.54	0.00	0.00	0.00	0.00	0.75	0.49	0.00	1.50	0.56	**0.00**	**4.00**	**1.60**
5	Mirba	0.00	9.88	1.11	0.00	0.00	0.00	0.02	0.07	0.03	0.00	4.94	0.74	**0.02**	**12.39**	**1.89**
6	Seru	0.00	4.00	0.94	0.00	2.50	0.17	0.00	2.00	0.13	0.00	15.00	0.80	**0.01**	**18.15**	**2.07**
7	Shyro	0.00	2.00	0.74	0.00	0.00	0.00	0.00	1.50	0.20	0.00	1.50	0.56	**0.00**	**4.50**	**1.50**
8	Teli	0.00	5.00	1.14	0.00	0.05	0.01	0.00	1.00	0.41	0.00	4.00	0.58	**0.00**	**6.50**	**2.15**
9	Yusum	0.00	2.00	0.85	0.00	0.00	0.00	0.00	0.05	0.02	0.00	2.00	0.78	**0.00**	**4.04**	**1.65**
10	Yuthembu	0.00	3.75	1.57	0.00	0.00	0.00	0.20	0.74	0.58	0.00	4.00	1.36	**0.20**	**7.49**	**3.51**

Data in respect of this aspect was not available for three villages–Gomkelleng, Kharsa and Tsaikhar

Table II. 3.438: Number of HHs having land types in the ten project villages

Sl. No.	Village	Agricultural land		Horticultural land		Habitation and home–garden land		Forest land	
		n	%	n	%	n	%	n	%
1	Gomkang	8	67	3	25	12	100	7	58
2	Jangda	93	94	0	0	93	94	84	85
3	Khamba	28	78	4	11	21	58	20	56
4	Kudung	22	67	0	0	32	97	24	73
5	Mirba	38	95	0	0	40	100	31	78
6	Seru	79	75	19	18	103	97	62	58
7	Shyro	55	98	0	0	54	96	38	68
8	Teli	28	80	1	3	28	80	20	57
9	Yusum	47	94	0	0	46	92	43	86
10	Yuthembu	94	96	0	0	98	100	86	88
	Total	**492**	**87**	**27**	**5**	**527**	**93**	**415**	**73**

Data in respect of this aspect was not available for three villages–Gomkelleng, Kharsa and Tsaikhar

Table II. 3.439: Distribution of area (in acres) of land holding among HHs in the ten project villages

Sl. No.	Village	Agricultural land		Horticultural land		Habitation and homegarden land		Forest land		Total land
		Area	%	Area	%	Area	%	Area	%	Area
1	Gomkang	12	41	4	12	7	25	6	21	**28**
2	Jangda	141	47	0	0	44	15	112	38	**297**
3	Khamba	20	46	3	6	10	24	11	25	**43**
4	Kudung	18	34	0	0	16	31	19	35	**53**
5	Mirba	45	59	0	0	1	2	30	39	**75**
6	Seru	100	46	19	9	15	7	86	39	**220**
7	Shyro	41	49	0	0	11	13	32	38	**84**
8	Teli	40	53	1	1	15	19	21	27	**76**
9	Yusum	43	51	0	0	1	2	39	47	**83**
10	Yuthembu	154	45	0	0	57	17	133	39	**344**
	Total	**613**	**47**	**25**	**2**	**177**	**14**	**488**	**37**	**1302**

Data in respect of this aspect was not available for three villages–Gomkelleng, Kharsa and Tsaikhar

Livestock Holding: The data presented in Tables II. 3.440–3.442 in respect of distribution of livestock holdings in the thirteen surveyed villages revealed that nine different types of animals are domesticated in surveyed villages (Table II. 3.440). However none of the villages owned all the nine types of animals. In total, 3301 animals have been domesticated in the twelve villages (Table II. 3.441). Considerable inter–village variation is observed in total number of animals reared. It varied from 23 in Gomkang to 1021 in Jangda. Jangda, Shyro, and Yuthembu accounts for 66% of all the animals found in the surveyed villages. Three animals, viz., cattle (61%), Yak (15%) and sheep (12%) account for 88% of the total animals (3301).

Table II. 3.440: Livestock holding by HHs in the twelve project villages

Sl. No.	Village		Mithun	Cattle	Yak	Goat	Sheep	Pig	Pony	Poultry	Others
1	Gomkang	n	0	2	0	0	0	4	0	3	0
		%	0	17	0	0	0	33	0	25	0
2	Gomkelleng	n	1	4	1	1	1	0	0	0	1
		%	3	11	3	3	3	0	0	0	3
3	Jangda	n	0	92	25	22	71	63	2	13	1
		%	0	93	25	22	72	64	2	13	1
4	Khamba	n	0	9	0	2	0	0	1	0	0
		%	0	25	0	6	0	0	3	0	0
5	Kudung	n	0	6	0	6	1	0	1	0	0
		%	0	18	0	18	3	0	3	0	0
6	Mirba	n	0	10	6	1	0	0	1	0	0
		%	0	25	15	3	0	0	3	0	0
7	Seru	n	2	21	1	1	0	23	1	0	0
		%	2	20	1	1	0	22	1	0	0
8	Shyro	n	0	24	10	0	2	29	16	1	0
		%	0	43	18	0	4	52	29	2	0
9	Teli	n	0	10	0	0	0	1	0	0	0

		%	0	29	0	0	0	3	0	0	0
10	Tsaikhar	n	0	2	0	0	0	0	0	1	0
		%	0	6	0	0	0	0	0	3	0
11	Yusum	n	0	13	0	4	0	9	0	1	0
		%	0	26	0	8	0	18	0	2	0
12	Yuthembu	n	2	21	19	1	1	0	0	0	0
		%	2	21	19	1	1	0	0	0	0
	Total	**n**	**5**	**214**	**62**	**38**	**76**	**129**	**22**	**19**	**2**
		%	**1**	**34**	**10**	**6**	**12**	**20**	**3**	**3**	**0**

Data in respect of this aspect was not available for Kharsa

Table II. 3.441: Number of livestock in surveyed HHs across the twelve project villages

Sl. No.	Village		Mithun	Cattle	Yak	Goat	Sheep	Pig	Pony	Poultry	Others	Total
1	Gomkang	LS	0	10	0	0	0	4	0	9	0	**23**
		%	0	43	0	0	0	17	0	39	0	**100**
2	Gomkelleng	LS	2	60	1	5	10	0	0	0	5	**83**
		%	2	72	1	6	12	0	0	0	6	**100**
3	Jangda	LS	0	395	114	37	364	72	10	28	1	**1021**
		%	0	39	11	4	36	7	1	3	0	**100**
4	Khamba	LS	0	100	0	7	0	0	6	0	0	**113**
		%	0	88	0	6	0	0	5	0	0	**100**
5	Kudung	LS	0	118	0	12	3	0	2	0	0	**135**
		%	0	87	0	9	2	0	1	0	0	**100**
6	Mirba	LS	0	102	67	5	0	0	7	0	0	**181**
		%	0	56	37	3	0	0	4	0	0	**100**
7	Seru	LS	17	190	30	4	0	23	1	0	0	**265**
		%	6	72	11	2	0	9	0	0	0	**100**
8	Shyro	LS	0	357	69	0	2	29	50	2	0	**509**
		%	0	70	14	0	0	6	10	0	0	**100**
9	Teli	LS	0	59	0	0	0	1	0	0	0	**60**
		%	0	98	0	0	0	2	0	0	0	**100**
10	Tsaikhar	LS	0	39	0	0	0	0	0	2	0	**41**
		%	0	95	0	0	0	0	0	5	0	**100**
11	Yusum	LS	0	181	0	19	0	9	0	2	0	**211**
		%	0	86	0	9	0	4	0	1	0	**100**
12	Yuthembu	LS	10	413	224	2	10	0	0	0	0	**659**
		%	2	63	34	0	2	0	0	0	0	**100**
	Total	**LS**	**29**	**2024**	**505**	**91**	**389**	**138**	**76**	**43**	**6**	**3301**
		%	**1**	**61**	**15**	**3**	**12**	**4**	**2**	**1**	**0**	**100**

Note: LS–Livestock; Data in respect of this aspect was not available for Kharsa

Table II. 3.442: Distribution of total number of livestock in HHs of the twelve project villages

Sl. No.	Village	0		1–5		6–10		> 10		Total
		n	%	n	%	n	%	n	%	n
1	Gomkang	5	42	5	42	2	17	0	0	**12**
2	Gomkelleng	31	86	1	3	0	0	4	11	**36**
3	Jangda	5	5	25	25	33	33	36	36	**99**
4	Khamba	24	67	2	6	7	19	3	8	**36**
5	Kudung	23	70	5	15	1	3	4	12	**33**
6	Mirba	27	68	3	8	3	8	7	18	**40**
7	Seru	68	64	26	25	5	5	7	7	**106**
8	Shyro	22	39	18	32	3	5	13	23	**56**
9	Teli	24	69	7	20	3	9	1	3	**35**
10	Tsaikhar	31	91	1	3	0	0	2	6	**34**
11	Yusum	27	54	13	26	5	10	5	10	**50**
12	Yuthembu	68	69	7	7	4	4	19	19	**98**
	Total	**355**	**56**	**113**	**18**	**66**	**10**	**101**	**16**	**635**

Data in respect of this aspect was not available for Kharsa

Traditional Skills: Data pertaining to this aspect is presented in Table II. 3.443. In the surveyed village all the six types of crafts are pursued. Weaving is practiced in ten surveyed villages and the total numbers of HH engaged are 155 (26%). A small number of HHs is engaged in other crafts; 32, 6,12, 46 and 36 HHs are engaged in wood carving, Thanka painting, carpet making, bamboo utensils making and paper making respectively.

Table II. 3.443: Distribution of various skills among surveyed HHs in eleven project villages

Sl. No.	Village	Wood carving		Thanka painting		Carpet making		Bamboo utensil		Weaving		Paper making	
		n	%	n	%	n	%	n	%	n	%	n	%
1	Gomkang	4	33	0	0	0	0	0	0	0	0	1	8
2	Gomkelleng	12	33	3	8	8	22	30	83	29	81	35	97
3	Jangda	1	1	0	0	0	0	0	0	53	54	0	0
4	Khamba	0	0	0	0	0	0	1	3	4	11	0	0
5	Kudung	1	3	0	0	0	0	0	0	1	3	0	0
6	Mirba	2	5	0	0	2	5	0	0	8	20	0	0
7	Seru	2	2	2	2	0	0	1	1	6	6	0	0
8	Shyro	5	9	0	0	1	2	8	14	20	36	0	0
9	Teli	1	3	1	3	1	3	0	0	1	3	0	0
10	Yusum	0	0	0	0	0	0	1	2	2	4	0	0
11	Yuthembu	4	4	0	0	0	0	5	5	31	32	0	0
	Total	**32**	**5**	**6**	**1**	**12**	**2**	**46**	**8**	**155**	**26**	**36**	**6**

Data in respect of this aspect was not available for Kharsa and Tsaikhar

River Resources: In Table II. 3.444 data pertaining to the use of various river resources by the inhabitants of the nine surveyed villages is presented. Twelve river resources listed in Table II. 3.444 are being used across the studied villages. Water from river is used by a large number of HHs in the villages for drinking (n=178), domestic use (n=159) and for livestock (n=281). Aquatic fauna is used in only two villages where 35 HHs do fishing. 35 HHs of village Gomkelleng use aquatic flora. It is highly noteworthy that all the 742 HHs in the surveyed villages use river for performing last rites of the dead. A majority of the HHs in most of the surveyed villages use Sand (n=462) and Stone (n=464) from the river bed for self consumption and selling.

Table II. 3.444: Dependence on river resources among surveyed HHs in the thirteen project villages

Sl. No.	Village		Drinking water	Water for domestic use	Water for domestic animal	Fishes	Aquatic flora	Religious	Sand	Stones (boulders)
1	Gomkang	n	0	0	7	0	0	12	12	12
		%	0	0	58	0	0	100	100	100
2	Gomkelleng	n	32	32	5	35	35	36	36	36
		%	89	89	14	97	97	100	100	100
3	Jangda	n	0	0	94	0	0	99	99	99
		%	0	0	95	0	0	100	100	100
4	Khamba	n	0	0	12	0	0	36	36	36
		%	0	0	33	0	0	100	100	100
5	Kharsa	n	107	107	0	0	0	107	0	0
		%	100	100	0	0	0	100	0	0
6	Kudung	n	0	0	10	0	0	33	33	33
		%	0	0	30	0	0	100	100	100
7	Mirba	n	0	0	13	0	0	40	40	40
		%	0	0	33	0	0	100	100	100
8	Seru	n	15	2	38	0	0	106	1	1
		%	14	2	36	0	0	100	1	1
9	Shyro	n	0	0	35	0	0	56	56	56
		%	0	0	63	0	0	100	100	100
10	Teli	n	0	0	11	0	0	35	35	35
		%	0	0	31	0	0	100	100	100
11	Tsaikhar	n	0	0	3	0	0	34	0	0
		%	0	0	9	0	0	100	0	0
12	Yusum	n	0	0	23	0	0	50	49	49
		%	0	0	46	0	0	100	98	98
13	Yuthembu	n	24	18	30	0	0	98	65	67
		%	24	18	31	0	0	100	66	68
	Total	**n**	**178**	**159**	**281**	**35**	**35**	**742**	**462**	**464**
		%	**24**	**21**	**38**	**5**	**5**	**100**	**62**	**63**

Forest Resources: The inhabitants of all the thirteen villages are dependent and use varying degrees of forest resources (Table II. 3.445). All the forest resources listed in Table II. 3.445 are used in varying degrees among the thirteen surveyed villages. Kharsa uses only fuel wood from the forest. Except for ornamental purposes, Gomkelleng uses the rest of the resources. Seven villages use ten and above forest resources. 98% of the HHs in thirteen villages uses fuel wood from the forest. Timber, grazing, stone and sand are used by a large number of HHs in twelve villages. 170 HHs belonging to six villages use forest resources for medicine. Aquatic fauna are also gathered by a small number of HHs. Forest also provides food, edible oils and spices to a substantial number of HHs. It is thus evident from above description that for a majority of the inhabitants of the surveyed villages forest resources play a very significant role to the livelihoods as well as the quality of life of the people.

Table II. 3.445: Dependence on forest resources among surveyed HHs in the thirteen project villages

Sl. No.	Forest resources		Gomkang	Gomkelleng	Jangda	Khamba	Kharsa	Kudung	Mirba	Seru	Shyro	Teli	Tsaikhar	Yusum	Yuthembu	Total
1	Fuel wood	n	12	36	99	36	107	33	40	97	56	35	34	49	90	**724**
		%	100	100	100	100	100	100	100	92	100	100	100	98	92	**98**
2	Timber	n	12	36	99	36	0	33	40	96	56	1	34	49	90	**582**
		%	100	100	100	100	0	100	100	91	100	3	100	98	92	**78**
3	Medicinal plants	n	12	36	0	36	0	33	40	13	0	0	0	0	0	**170**
		%	100	100	0	100	0	100	100	12	0	0	0	0	0	**23**
4	Honey	n	0	36	0	0	0	0	0	3	0	0	0	0	0	**39**
		%	0	100	0	0	0	0	0	3	0	0	0	0	0	**5**
5	Food	n	12	36	99	36	0	33	40	27	0	0	0	49	0	**332**
		%	100	100	100	100	0	100	100	25	0	0	0	98	0	**45**
6	Edible oil	n	0	36	0	0	0	0	0	1	0	0	0	0	0	**37**
		%	0	100	0	0	0	0	0	1	0	0	0	0	0	**5**
7	Ornamental	n	0	0	0	1	0	0	0	0	0	0	0	0	0	**1**
		%	0	0	0	3	0	0	0	0	0	0	0	0	0	**0**
8	Religious	n	12	36	0	36	0	33	40	45	0	1	0	0	64	**267**
		%	100	100	0	100	0	100	100	42	0	3	0	0	65	**36**
9	Fencing	n	0	36	99	0	0	33	0	3	0	0	0	0	84	**255**
		%	0	100	100	0	0	100	0	3	0	0	0	0	86	**34**
10	Handicrafts	n	12	36	0	0	0	0	0	0	0	0	0	0	4	**52**
		%	100	100	0	0	0	0	0	0	0	0	0	0	4	**7**
11	Thatching	n	0	36	0	1	0	0	0	1	0	0	0	49	1	**88**
		%	0	100	0	3	0	0	0	1	0	0	0	98	1	**12**
12	Spices	n	12	33	0	36	0	0	40	48	0	35	0	49	2	**255**
		%	100	92	0	100	0	0	100	45	0	100	0	98	2	**34**
13	Grazing	n	7	5	94	12	0	10	13	38	35	11	3	23	30	**281**
		%	58	14	95	33	0	30	33	36	63	31	9	46	31	**38**
14	Hunting of wild animals	n	0	1	0	0	0	0	0	0	0	0	0	0	2	**3**
		%	0	3	0	0	0	0	0	0	0	0	0	0	2	**0**
15	Fishes	n	0	33	0	0	0	0	0	0	0	0	0	0	1	**34**
		%	0	92	0	0	0	0	0	0	0	0	0	0	1	**5**
16	Water	n	0	33	99	36	0	33	0	50	56	35	0	49	67	**458**
		%	0	92	100	100	0	100	0	47	100	100	0	98	68	**62**
17	Stones	n	12	35	99	36	0	33	40	51	56	35	34	49	92	**572**
		%	100	97	100	100	0	100	100	48	100	100	100	98	94	**77**
18	Sand	n	12	35	99	36	0	33	40	35	56	35	15	49	92	**537**
		%	100	97	100	100	0	100	100	33	100	100	44	98	94	**72**
19	Dyes	n	12	35	0	0	0	0	0	2	0	0	0	49	0	**98**
		%	100	97	0	0	0	0	0	2	0	0	0	98	0	**13**

Water Resources: About 112 HHs (15%) in four villages use river as water sources (Table II. 3.446). Inhabitants of Gomkelleng entirely depend only on river water. The predominant source of water is hill stream/springs as 8/13 villages use this water resource. Shyro is the only village where pond water is used. A small number of HH in Teli village have wells. Among the surveyed villages Hand pumps are used only in Teli. In nine villages a majority of HHs use tap water. Seru and Teli use multiple sources (4 different types) for water requirements.

Table II. 3.446: Dependence on water resources among surveyed HHs in the thirteen project villages

Sl. No.	Village	River		Hill stream/spring		Wells		Ponds		Hand pumps		Tap water	
		n	%	n	%	n	%	n	%	n	%	n	%
1	Gomkang	0	0	12	100	0	0	0	0	0	0	12	100
2	Gomkelleng	36	100	0	0	0	0	0	0	0	0	0	0
3	Jangda	0	0	99	100	0	0	0	0	0	0	99	100
4	Khamba	0	0	36	100	0	0	0	0	0	0	36	100
5	Kharsa	0	0	100	93	0	0	0	0	0	0	0	0
6	Kudung	0	0	33	100	0	0	0	0	0	0	33	100
7	Mirba	0	0	0	0	0	0	0	0	0	0	40	100
8	Seru	1	1	90	85	0	0	0	0	4	4	1	1
9	Shyro	0	0	0	0	0	0	56	100	0	0	56	100
10	Teli	0	0	35	100	3	9	0	0	35	100	35	100
11	Tsaikhar	0	0	0	0	0	0	0	0	0	0	34	100
12	Yusum	49	98	0	0	0	0	0	0	0	0	49	98
13	Yuthembu	26	27	91	93	0	0	0	0	0	0	0	0
	Total	**112**	**15**	**496**	**67**	**3**	**0**	**56**	**8**	**39**	**5**	**395**	**53**

Village Level Survey–Influenced

Profile of the Twelve Surveyed Villages: The twelve villages fall under five administrative circles (Table II. 3.447). They are Thingbu, Lhau, Jang, Tawang and Mukto circle. All villages are situated within 10 km from the river; ten villages are within 4 km. The circle headquarters of the twelve villages are within 18 km. Except Rho which is situated at 100kms from the district headquarters, the remaining eleven are situated within 50 km.

Table II. 3.447: Profile of the twelve surveyed villages

Sl. No.	Village	Circle	Distance of village (in km)		
			River/tributary	Circle HQ	District HQ
1	Dungse	Jang	2	1	45
2	Gemreteng	Lhau	2	4	24
3	Gyada	Tawang	3	18	18
4	Gyankhar	Tawang	1	12	12
5	Hoongla	Lumla	4	4	49
6	Khartuth	Tawang	1	13	13
7	Kregyang	Lhau	2	2	22
8	Lumla	Lumla	10	4	50
9	Menteng	Lhau	2	4	24
10	Regyang	Lhau	2	3	23
11	Rho	Thingbu	8	5	100
12	Thrillam	Lumla	4	17	30

Private Land Use Pattern: Data pertaining to private land holding (in hectares) of 12 villages is given in Table II. 3.448 . The total private land holdings in the studied villages was 385.20 ha. Three villages, viz., Gyankhar, Lumla and Rho contribute 77% to the total land holdings in studied villages. The proportion of Agricultural land exceeds that of the other land use types; except in case of Menteng village where forest cover land exceeds that of Agricultural–land. Private forest land also contributes significantly (26%) to the total land holdings of the villages

Table II. 3.448: Private land use pattern and their percentage to total private land

Sl. No.	Village	Total private land	Forest cover (ha)	%	Agricultural (ha)	%	Horticulture (ha)	%	Habitation and HG (ha)	%
1	Dungse	2.7	0.0	0.0	2.4	89	0.0	0.0	0.3	11
2	Gemreteng	1.7	0.0	0.0	1.7	100	0.0	0.0	0.0	0.0
3	Gyada	–	–	–	–	–	–	–	–	–
4	Gyankhar	85.	20.8	24	45.3	53	12.0	14	7.0	8
5	Hoongla	31.4	0.0	0.0	27.1	86	0.0	86	4.3	14
6	Khartuth	14.2	5.6	40	8.3	58	0.0	0.0	0.2	2
7	Kregyang	11.8	2.2	19	6.0	51	0.0	0.0	3.6	31
8	Lumla	50.6	9.6	19	32.7	65	0.4	1	7.8	15

9	Menteng	2.3	0.9	39	0.8	35	0.0	0.0	0.6	26
10	Regyang	16.8	2.7	16	8.9	53	0.0	0.0	5.2	31
11	Rho	160.0	58.0	36	66.0	41	0.0	0.0	36.0	23
12	Thrillam	8.1	0.0	0.0	7.8	97	0.0	0.0	0.2	3
	Total*	**385.20**	**99.98**		**207.27**		**12.47**		**65.47**	

* Excluding Gyada due to non–availability of data

Demography and Literacy Rate: From Table II. 3.449, it can be seen that the total number of HHs in the twelve villages is 429 (number varies from 3 in Menteng to 85 in Rho). The total population is 1889 (937 males; 952 females). In 5/12 villages the number of females is less than that of the males. The literacy rate ranged from 4.5% in Gyada to 62.8% in Gyankhar. Among males, the rate varies from 10% in Gyada to 71.7% in Khartuth and in case of females it varies from 0.0 % in Gyada to 80% in Gemreteng (Table II. 3.449).

Table II. 3.449: Demography and literacy rate

Sl. No.	Village	Demography					Literacy rate*		
		Total	Male	Female	Sex ratio (Per 1000 males)	No. of HH	Male	Female	Total
1	Dungse	127	68	59	868	36	67.6	54.3	**61.9**
2	Gemreteng	39	23	16	696	9	42.9	80.0	**58.3**
3	Gyada	42	17	25	1680	11	10.0	0.0	**4.5**
4	Gyankhar	383	178	205	1152	65	70.0	56.6	**62.8**
5	Hoongla	229	120	109	908	56	26.0	17.5	**22.0**
6	Khartuth	172	84	88	1048	28	71.7	43.9	**56.3**
7	Kregyang	81	43	38	884	18	40.0	26.5	**31.1**
8	Lumla	242	117	125	1068	57	60.5	46.2	**52.7**
9	Menteng	8	2	6	3000	3	50.0	37.5	**41.7**
10	Regyang	116	58	58	1000	26	57.6	47.9	**55.0**
11	Rho	286	150	136	907	85	58.0	23.0	**45.0**
12	Thrillam	164	77	87	1130	35	51.8	39.7	**45.6**
	Total	**1889**	**937**	**952**		**429**			

*After Census 2011

Number of Livestock: In Table II. 3.450, the details of livestock holding are given for all the 12 villages. Altogether nine different types of animals are domesticated in surveyed villages . In none of the villages all the nine animal types were domesticated. In total, 1054 animals have been domesticated in the twelve villages. Considerable inter–village variation is observed in total number of animals reared. It varied from 8 in Thrillam to 487 in Rho. Gyankhar, Lumla and Rho alone account for 72% of all the animals found in the surveyed villages. Three animals, viz., cattle (52%), Goat (13%) and sheep (15%) account for 80% of the total animals (1054). In four villages Other animals (n=26) are also present.

Table II. 3.450: Number of livestock

Sl. No.	Village	Mithun	Cattle	Yak	Goat	Sheep	Pig	Pony	Poultry	Others	Total
1	Dungse	0	1	0	0	0	0	0	0	9	**10**
2	Gemreteng	0	20	0	0	0	0	0	0	0	**20**
3	Gyada	0	10	0	0	0	0	0	0	0	**10**
4	Gyankhar	0	80	0	10	0	1	0	6	1	**98**
5	Hoongla	1	27	0	23	3	6	7	0	13	**80**
6	Khartuth	0	41	0	0	0	0	0	0	0	**41**
7	Kregyang	0	27	0	0	60	0	0	0	0	**87**
8	Lumla	7	49	0	37	2	13	40	29	0	**177**
9	Menteng	0	10	0	0	0	0	0	0	0	**10**
10	Regyang	0	26	0	0	0	0	0	0	0	**26**
11	Rho	0	255	49	68	85	14	6	7	3	**487**
12	Thrillam	0	3	0	0	5	0	0	0	0	**8**
	Total	**8**	**549**	**49**	**138**	**155**	**34**	**53**	**42**	**26**	**1054**

Total Estimated Value of Livestock: The monetary value of domesticated animals maintained by the inhabitants of the studied villages has been estimated separately for each animal and for each village (Table II. 3.451). The selling price of different animals was obtained from the knowledgeable persons in the villages. The detailed methodology used in estimating the monetary value of animals has been described in the methodology section of the present report. As expected, there is considerable intra–inter village variation in this respect. The total value of animals numbering 1054 found in the twelve villages has been estimated as 193.71 lakhs. The value varied from 1.05 lakhs in Thrillam to 89.87 lakhs in Rho. In terms of relative contribution made by different animals to the total value, cattle alone contribute over 137.25 lakhs (71%).

Table II. 3.451: Total estimated value of livestock

Sl. No.	Village	Total estimated value (Rupees in lakh)									
		Mithun	Cattle	Yak	Goat	Sheep	Pig	Pony	Poultry	Others	Total
1	Dungse	0.00	0.25	0.00	0.00	0.00	0.00	0.00	0.00	1.35	**1.60**
2	Gemreteng	0.00	5.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**5.00**
3	Gyada	0.00	2.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**2.50**
4	Gyankhar	0.00	20.00	0.00	0.50	0.00	0.25	0.00	0.03	0.15	**20.93**
5	Hoongla	0.40	6.75	0.00	1.15	0.18	1.50	1.61	0.00	1.95	**13.54**
6	Khartuth	0.00	10.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**10.25**
7	Kregyang	0.00	6.75	0.00	0.00	3.60	0.00	0.00	0.00	0.00	**10.35**
8	Lumla	2.80	12.25	0.00	1.85	0.12	3.25	9.20	0.15	0.00	**29.62**
9	Menteng	0.00	2.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**2.50**
10	Regyang	0.00	6.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**6.50**
11	Rho	0.00	63.75	12.25	3.40	5.10	3.50	1.38	0.04	0.45	**89.87**
12	Thrillam	0.00	0.75	0.00	0.00	0.30	0.00	0.00	0.00	0.00	**1.05**
	Total	**3.2**	**137.25**	**12.25**	**6.9**	**9.3**	**8.5**	**12.19**	**0.22**	**3.9**	**193.71**

Average Annual Earnings of the Village: From Table II. 3.452, the value of total earnings per year in the villages is estimated 688.43 lakhs. The average annual family income varies from 0.77 in lakhs in Dungse to 2.50 lakhs in Rho. The contribution made by different occupation to the total earnings shows considerable variation between the villages. For example, the contribution made by animal husbandry is maximum in six villages, while wage labour contributes maximum in another six villages. Traditional skills in particular weaving and daily wage labour together contribute over 37%. Across the surveyed villages the contribution of animal husbandry is 33% and Daily wages contributes 25%. It is highly noteworthy that Agricultural contributes only 15% of the total annual village earnings

Table II. 3.452: Average annual earning of the village

Sl. No.	Village	Total earning/year (Rupees in lakh)								Average Family income (Rupees in lakh)
		Agricultural	Animal Husbandry	Horticulture	Traditional Skills	Daily Wages	Govt. Service	Others*	Total	
1	Dungse	1.22	2.16	0.00	3.00	14.58	4.08	2.86	**27.89**	0.77
2	Gemreteng	0.85	4.32	0.00	1.25	3.65	1.38	0.97	**12.41**	1.38
3	Gyada	0.00	2.16	0.00	0.00	4.46	1.50	1.05	**9.17**	0.83
4	Gyankhar	22.67	21.17	6.04	31.00	26.33	10.68	7.48	**125.36**	1.93
5	Hoongla	13.56	17.28	0.00	0.00	22.68	7.20	5.04	**65.76**	1.17
6	Khartuth	4.15	8.86	0.00	10.00	8.10	5.04	3.53	**39.67**	1.58
7	Kregyang	3.00	18.79	0.00	1.25	7.29	2.58	1.81	**34.72**	1.93
8	Lumla	16.39	38.23	0.20	12.50	23.09	7.02	4.91	**102.34**	1.80
9	Menteng	0.40	2.16	0.00	NA	1.22	0.12	0.08	**3.98**	1.33
10	Regyang	4.45	5.62	0.00	NA	10.53	3.48	2.44	**26.51**	1.02
11	Rho	33.00	105.19	0.00	25.00	34.43	9.00	6.30	**212.92**	2.50
12	Thrillam	3.95	1.73	0.00	0.00	14.18	4.62	3.23	**27.70**	0.79
	Total	**103.64**	**227.67**	**6.24**	**84**	**170.54**	**56.7**	**39.7**	**688.43**	**17.03**
	%	**15**	**33**	**1**	**12**	**25**	**8**	**6**	**100**	

* Other includes artisans, monks, self–employed contractors etc; NA =Data not available

Average Annual Expenditure Pattern of a Family: The average annual family expenditure in the surveyed villages varies from 0.80 lakhs in Gyada to 1.70 lakhs in Hoongla (Table II. 3.453). In all the villages the maximum expenditure is incurred on health and education followed by food and drinks and transport. The total value of average annual expenditure incurred by a family in twelve villages is 15.94 lakhs.

Table II. 3.453: Average annual expenditure pattern of a family in a village

Sl. No.	Village	Expenditure/year (Rupees in lakh)				
		Food and drinks	Clothing	Transport	Education and health	Total
1	Dungse	0.30	0.30	0.30	0.30	**1.20**
2	Gemreteng	0.20	0.30	0.25	0.35	**1.10**
3	Gyada	0.20	0.20	0.20	0.20	**0.80**
4	Gyankhar	0.40	0.30	0.36	0.56	**1.62**
5	Hoongla	0.48	0.30	0.40	0.52	**1.70**
6	Khartuth	0.40	0.30	0.35	0.60	**1.65**
7	Kregyang	0.30	0.30	0.36	0.36	**1.32**
8	Lumla	0.36	0.30	0.36	0.45	**1.47**
9	Menteng	0.20	0.20	0.20	0.40	**1.00**
10	Regyang	0.30	0.30	0.36	0.36	**1.32**
11	Rho	0.35	0.35	0.40	0.48	**1.58**
12	Thrillam	0.30	0.20	0.20	0.48	**1.18**
	Total	**3.79**	**3.35**	**3.74**	**5.06**	**15.94**

Water Sources: In Table II. 3.454, data pertaining to the water resources available and their pattern of use in the nine villages are presented. The Table II. 3.454, reveal that all types of water resources listed in the Table II. 3.454 are available in the studied villages. Only three villages are dependent on river water. Three–fourth of the villages depends on water from hill stream/springs. Tap water is used for various purposes in eleven surveyed villages. Pond water is only used in four villages. Two villages Gyada and Thrillam depend only on tap water whereas; wells are present only in one village.

Table II. 3.454: Water sources in the village

Sl. No.	Village	Rivers				Hill stream/spring				Wells				Ponds				Tap water			
		Drinking water	Domestic use	Livestock use	Agricultural	Drinking water	Domestic use	Livestock use	Agricultural	Drinking water	Domestic use	Livestock use	Agricultural	Drinking water	Domestic use	Livestock use	Agricultural	Drinking water	Domestic use	Livestock use	Agricultural
1	Dungse	1		1														1	1	1	
2	Gemreteng					1	1	1						1	1	1		1	1	1	
3	Gyada																	1	1	1	
4	Gyankhar			1	1	1	1	1	1	1	1										
5	Hoongla							1										1	1		
6	Khartuth							1										1	1		
7	Kregyang					1	1	1						1	1			1	1	1	
8	Lumla			1		1	1	1										1	1		
9	Menteng					1	1	1						1	1			1	1	1	
10	Regyang					1	1	1						1	1	1		1	1	1	
11	Rho					1	1	1										1	1		
12	Thrillam																	1	1	1	
	Total	**1**	**0**	**3**	**1**	**7**	**7**	**9**	**1**	**1**	**1**	**0**	**0**	**4**	**3**	**2**	**0**	**11**	**11**	**7**	**0**

Amenities in the Villages: From Table II. 3.455, it is observed that Lumla and Dungse had 9/12 amenities (75%). Only in Dungse, bank and post office were present. Motorable road connectivity is absent in Gyankhar. In Gemreteng, Gyada and Menteng the least number of amenities (4/12) have been observed. All the villages have electricity, telephone and TV/radio. Traditional health healers were absent in all the villages.

Table II. 3.455: Amenities in the villages

Sl. No.	Village	Road connectivity	Health facility (PHC/sub–centre)	Traditional health healer	Veterinary services	Electricity	Fair price shop	Grocery shop	Post office	Bank	School	Telephone/Mobile	TV/Radios
1	Dungse	√	√			√	√	√	√	√		√	√
2	Gemreteng	√				√						√	√
3	Gyada	√				√						√	√
4	Gyankhar					√					√	√	√
5	Hoongla	√				√					√	√	√
6	Khartuth	√				√					√	√	√
7	Kregyang	√				√						√	√
8	Lumla	√	√		√	√	√	√			√	√	√
9	Menteng	√				√						√	√
10	Regyang	√				√						√	√
11	Rho	√	√		√	√					√	√	√
12	Thrillam	√				√					√	√	√
	Total	**11**	**3**	**0**	**2**	**12**	**2**	**2**	**1**	**1**	**6**	**12**	**12**

NB: Blank indicates absent

Social Institutions: In none of the twelve villages listed in Table II. 3.456 all the four social institution are present. Four villages have three social institutions and other four villages have only two social institutions while Khartuth has only one social institution. Three villages lack all the social institutions. Gompa was found in only four villages. SHGs are absent in surveyed villages.

Table II. 3.456: Social institutions in the village

Sl. No.	Village	SHGs	Anganwadis	Community hall	Gompa	Any other	Total
1	Dungse		√	√	√		**3**
2	Gemreteng						**0**
3	Gyada						**0**
4	Gyankhar		√	√			**2**
5	Hoongla		√	√		√	**3**
6	Khartuth			√			**1**
7	Kregyang		√	√			**2**
8	Lumla		√	√	√		**3**
9	Menteng						**0**
10	Regyang		√	√			**2**
11	Rho			√	√	√	**3**
12	Thrillam			√	√		**2**
	Total	**0**	**6**	**9**	**4**	**2**	**–**

NB: Blank indicates absent

Occupation Profile: Work force participation is detailed in Table II. 3.457. The total working population in the studied villages comprises of 1317 (33%) of total population (3937). Of the total workers main workers are 90% while marginal workers are 10%.

Table II. 3.457: Occupation profile of the village

Sl. No.	Village	Population			Workers			Main workers			Marginal workers			Non workers		
		T	**M**	**F**	**T**	**M**	**F**	**T**	**M**	**F**	**T**	**M**	**F**	**T**	**M**	**F**
1	Dungse	1770	1006	764	859	640	219	828	626	202	31	14	17	911	366	545
2	Gemreteng	24	14	10	129	62	67	128	62	66	1	0	1	133	75	58
3	Gyada	44	20	24	10	4	6	10	4	6	0	0	0	15	6	9
4	Gyankhar	239	110	129	114	71	43	74	43	31	40	28	12	121	62	59
5	Hoongla	224	110	114	8	4	4	5	1	4	3	3	0	9	6	3
6	Khartuth	103	46	57	84	48	36	54	40	14	30	8	22	117	54	63
7	Kregyang	74	25	49	6	3	3	4	2	2	2	1	1	6	2	4
8	Lumla	389	177	212	19	11	8	9	8	1	10	3	7	14	5	9
9	Menteng	12	4	8	5	2	3	4	2	2	1	0	1	7	2	5

10	Regyang	180	132	48	21	10	11	21	10	11	0	0	0	19	10	9
11	Rho	652	403	249	21	8	13	10	7	3	11	1	10	16	4	12
12	Thrillam	226	110	116	41	20	21	39	18	21	2	2	0	37	20	17
	Total	**3937**	**2157**	**1780**	**1317**	**883**	**434**	**1186**	**823**	**363**	**131**	**60**	**71**	**1405**	**612**	**793**

Household Level Survey–Influenced

Age of the Head of the Household: Data presented in Tables II. 3.458 and 3.459 in respect of age of head of the HHs in twelve surveyed villages revealed that the age of head of HHs across the twelve surveyed villages varied from 16 years in Kregyang to 90 years in Hoongla. The age of 28% of heads is over 50 years and 14% of heads age was below 30 years. As expected and depending on the demographic structure of the villages, considerable variation has been observed between the villages in terms of the age of the Heads of HHs. It varied from 42 to 64.

Table II. 3.458: Distribution of head of the HHs by age across the twelve project villages

Sl. No.	Village	Up to 30		31–40		41–50		> 50		Total
		n	%	n	%	n	%	n	%	n
1	Dungse	3	8	5	14	14	39	14	39	**36**
2	Gemreteng	0	0	2	22	4	44	3	33	**9**
3	Gyada	2	18	2	18	4	36	3	27	**11**
4	Gyangkhar	2	3	18	28	25	38	20	31	**65**
5	Hoongla	21	38	7	13	14	25	14	25	**56**
6	Khartuth	2	7	10	36	8	29	8	29	**28**
7	Kregyang	3	17	4	22	5	28	6	33	**18**
8	Lumla	8	14	24	42	11	19	14	25	**57**
9	Menteng	0	0	0	0	0	0	3	100	**3**
10	Rengyang	5	19	3	12	10	38	8	31	**26**
11	Rho	8	9	36	42	24	28	17	20	**85**
12	Thrillam	8	23	10	29	5	14	12	34	**35**
	Total	**62**	**14**	**121**	**28**	**124**	**29**	**122**	**28**	**429**

Table II. 3.459: Minimum, maximum and average age of Head of HHs across the twelve project villages

Sl. No.	Village	Age range		Average
		From	To	
1	Dungse	22	74	49
2	Gemreteng	37	70	52
3	Gyada	20	70	47
4	Gyangkhar	25	84	46
5	Hoongla	19	90	42
6	Khartuth	24	76	46
7	Kregyang	16	75	45
8	Lumla	25	85	43
9	Menteng	60	68	64
10	Rengyang	24	80	48
11	Rho	24	78	43
12	Thrillam	24	87	49
	Total	**16**	**90**	**48**

Gender of the Head of Households: Data on gender of the head of HHs in the twelve surveyed project villages is given in Table II. 3.460. As expected, in all the studied villages the number of males exceeds that of females as head of HHs except in Menteng. Across the surveyed villages 79% of heads were males.

Table II. 3.460: Distribution of head of HHs by gender in twelve project villages

Sl. No.	Village	Male		Female		Total
		n	%	n	%	n
1	Dungse	26	72	10	28	**36**
2	Gemreteng	7	78	2	22	**9**
3	Gyada	10	91	1	9	**11**
4	Gyangkhar	53	82	12	18	**65**
5	Hoongla	48	86	8	14	**56**
6	Khartuth	22	79	6	21	**28**
7	Kregyang	11	61	7	39	**18**
8	Lumla	42	74	15	26	**57**
9	Menteng	1	33	2	67	**3**

10	Rengyang	23	88	3	12	**26**
11	Rho	72	85	13	15	**85**
12	Thrillam	22	63	13	37	**35**
	Total	**337**	**79**	**92**	**21**	**429**

Ethnicity: All the twelve villages are predominantly inhabited by Monpa tribals.

Household Size: The HH size varies from one to 13 across the twelve villages. There is vast variation between the twelve villages in terms of distribution of HH size. The average HH size varies from three to six. The average HH size across the studied villages is four (Tables II. 3.461 and 3.462).

Table II. 3. 461: Distribution of HH size in twelve project villages

Sl. No.	Village	1		2		3		4		5		6–8		9 and above		Total
		n	%	n	%	n	%	n	%	n	%	n	%	n	%	n
1	Dungse	6	17	4	11	5	14	10	28	8	22	3	8	0	0	**36**
2	Gemreteng	0	0	1	11	1	11	3	33	3	33	1	11	0	0	**9**
3	Gyada	0	0	1	9	3	27	5	45	1	9	1	9	0	0	**11**
4	Gyangkhar	0	0	4	6	5	8	6	9	17	26	23	35	10	15	**65**
5	Hoongla	5	9	10	18	10	18	9	16	9	16	13	23	0	0	**56**
6	Khartuth	0	0	0	0	1	4	9	32	4	14	8	29	6	21	**28**
7	Kregyang	1	6	4	22	1	6	2	11	5	28	5	28	0	0	**18**
8	Lumla	4	7	6	11	7	12	14	25	12	21	14	25	0	0	**57**
9	Menteng	2	67	0	0	0	0	0	0	0	0	1	33	0	0	**3**
10	Rengyang	2	8	3	12	3	12	5	19	6	23	7	27	0	0	**26**
11	Rho	9	11	8	9	22	26	39	46	4	5	3	4	0	0	**85**
12	Thrillam	1	3	2	6	8	23	4	11	9	26	11	31	0	0	**35**
	Total	**30**	**7**	**43**	**10**	**66**	**15**	**106**	**25**	**78**	**18**	**90**	**21**	**16**	**4**	**429**

Table II. 3.462: Minimum, maximum and average HH size across twelve project villages

Sl. No.	Village	HH size range		Average HH size
		From	To	
1	Dungse	1	6	4
2	Gemreteng	2	7	4
3	Gyada	2	6	4
4	Gyangkhar	2	12	6
5	Hoongla	1	8	4
6	Khartuth	3	13	6
7	Kregyang	1	9	5
8	Lumla	1	8	4
9	Menteng	1	6	3
10	Rengyang	1	8	4
11	Rho	1	7	3
12	Thrillam	1	8	5
	Total	**1**	**13**	**4**

Education: Relevant data on the education of the head of the HHs in the twelve project villages is given in Table II. 3.463. It is noteworthy that a majority of the heads in studied villages were illiterate (82%). It varied from 65% in Lumla to 100% in Dungse, Gyada, and Menteng. There were 13 graduate head of HHs (3%) in the studied villages.

Table II. 3.463: Distribution of education of head of HH in twelve project villages

Sl. No.	Village	Illiterate		Primary		Upper Primary		Secondary		Higher Secondary		Graduate or above		Total
		n	%	n	%	n	%	n	%	n	%	n	%	n
1	Dungse	36	100	0	0	0	0	0	0	0	0	0	0	**36**
2	Gemreteng	8	89	0	0	1	11	0	0	0	0	0	0	**9**
3	Gyada	11	100	0	0	0	0	0	0	0	0	0	0	**11**
4	Gyangkhar	44	68	0	0	4	6	9	14	1	2	7	11	**65**
5	Hoongla	54	96	0	0	1	2	1	2	0	0	0	0	**56**
6	Khartuth	22	79	1	4	0	0	1	4	1	4	3	11	**28**
7	Kregyang	12	67	1	6	2	11	0	0	2	11	1	6	**18**

8	Lumla	37	65	4	7	3	5	10	18	3	5	0	0	**57**
9	Menteng	3	100	0	0	0	0	0	0	0	0	0	0	**3**
10	Rengyang	19	73	1	4	2	8	1	4	2	8	1	4	**26**
11	Rho	74	87	0	0	2	2	5	6	3	4	1	1	**85**
12	Thrillam	31	89	1	3	2	6	1	3	0	0	0	0	**35**
	Total	**351**	**82**	**8**	**2**	**17**	**4**	**28**	**7**	**12**	**3**	**13**	**3**	**429**

Main Occupation of Household Heads: The main occupations of the head of HHs across the twelve villages are Agriculture, labour, pastoralist and government service (Table II. 3.464).
Agriculture: It varies from 29% in Khartuth to 100% in Gyada. 69% of the surveyed head of HHs are engaged in Agricultural.
Labour: labour has been reported by small number of HHs (10%) as main mode of occupation.
Pastoralist: Only in Khartuth one HHs returned pastoralism as main occupation.
Government service: Government servants were reported from nine out of twelve villages. Gyangkhar had the maximum number (26/67) of government employees. Government service constitutes 16% of the main occupations.
Any other occupation: 22 (5%) HHs in six villages were engaged in other occupations.

Table II. 3.464: Distribution of head of HHs by main occupation in twelve project villages

Sl. No.	Village	Farmer		Labour		Pastoral		Govt. servant		Others		Total
		n	%	n	%	n	%	n	%	n	%	n
1	Dungse	23	64	0	0	0	0	5	14	8	22	**36**
2	Gemreteng	8	89	1	11	0	0	0	0	0	0	**9**
3	Gyada	11	100	0	0	0	0	0	0	0	0	**11**
4	Gyangkhar	30	46	5	8	0	0	26	40	4	6	**65**
5	Hoongla	54	96	0	0	0	0	2	4	0	0	**56**
6	Khartuth	8	29	7	25	1	4	6	21	6	21	**28**
7	Kregyang	10	56	6	33	0	0	1	6	1	6	**18**
8	Lumla	47	82	5	9	0	0	3	5	2	4	**57**
9	Menteng	1	33	2	67	0	0	0	0	0	0	**3**
10	Rengyang	19	73	5	19	0	0	2	8	0	0	**26**
11	Rho	66	78	0	0	0	0	19	22	0	0	**85**
12	Thrillam	17	49	14	40	0	0	3	9	1	3	**35**
	Total	**294**	**69**	**45**	**10**	**1**	**0**	**67**	**16**	**22**	**5**	**429**

Private Land Holding Pattern: The private land holding pattern in the eleven villages comprises of Agricultural land, horticulture land, habitation and home garden land and forest land. It may be noted here that a majority of the inhabitants of the surveyed villages did not know actual area either in acres or hectares of all categories of land holdings. Therefore, the area reported here should be considered as very rough estimates. Data pertaining to this aspect have been described below.

Agricultural land: Table II. 3.465 revealed that except 85 HHs (20%), all the remaining HHs (80%) in eleven surveyed villages owned Agricultural land in varying proportions. A majority of the HHs (44%) owned Agricultural land between 1–2 acres. Only 12% of HHs owned land which is greater than 2 acres. There exists a striking variation between the villages in terms of Agricultural land holdings. For example, 97% of the HHs in Rho own more than one acre of land while 89% of HHs in Gemreteng own less than one acre of land.

Table II. 3.465: Distribution of Agricultural land holding among surveyed HHs in eleven project villages

Sl. No.	Village	0.00 acre		< 1 acre		1–2 acre		> 2 acre	
		n	%	n	%	n	%	n	%
1	Dungse	16	44	19	53	1	3	0	0
2	Gemreteng	1	11	8	89	0	0	0	0
3	Gyangkhar	11	17	7	11	34	52	13	20
4	Hoongla	15	27	1	2	38	68	2	4
5	Khartuth	11	39	11	39	4	14	2	7
6	Kregyang	7	39	3	17	8	44	0	0
7	Lumla	16	28	6	11	22	39	13	23
8	Menteng	0	0	2	67	1	33	0	0

9	Rengyang	6	23	8	31	11	42	1	4
10	Rho	2	2	0	0	64	75	19	22
11	Thrillam	0	0	33	94	2	6	0	0
	Total	**85**	**20**	**98**	**23**	**185**	**44**	**50**	**12**

* Data in this respect not available for Gyada

Horticultural land: Data presented in Table Table II. 3.466 only 96% of the HHs does not posses such land. Only 16 HHs of two villages own such land.

Table II. 3.466: Distribution of horticultural land among surveyed HHs in eleven project villages

Sl. No.	Village	0.00 acre		< 1 acre		1–2 acre		> 2 acre	
		n	%	n	%	n	%	n	%
1	Dungse	36	100	0	0	0	0	0	0
2	Gemreteng	9	100	0	0	0	0	0	0
3	Gyangkhar	50	77	3	5	10	15	2	3
4	Hoongla	56	0	0	0	0	0	0	0
5	Khartuth	28	0	0	0	0	0	0	0
6	Kregyang	17	100	0	0	0	0	0	0
7	Lumla	57	98	0	0	1	2	0	0
8	Menteng	3	100	0	0	0	0	0	0
9	Rengyang	26	100	0	0	0	0	0	0
10	Rho	85	100	0	0	0	0	0	0
11	Thrillam	35	0	0	0	0	0	0	0
	Total	**402**	**96**	**3**	**1**	**11**	**3**	**2**	**0**

* Data in this respect not available for Gyada

***Habitation and home–garden land*:** Data presented in Table II. 3.467 show that except in Gemreteng, the remaining surveyed villages had this category of land in varying proportions. Only 13% of HHs (56) in surveyed villages did not own any such land. A majority of HHs (71%) owned less than one acre of such land. Only 16% of the HHs owned between 1 to 2 acre of such land.

Table II. 3.467: Distribution of habitation and home garden land among surveyed HHs in eleven project villages

Sl. No.	Village	0.00 acre		< 1 acre		1–2 acre		> 2 acre	
		n	%	n	%	n	%	n	%
1	Dungse	16	44	20	56	0	0	0	0
2	Gemreteng	9	100	0	0	0	0	0	0
3	Gyangkhar	11	17	42	65	12	18	0	0
4	Hoongla	15	27	41	73	0	0	0	0
5	Khartuth	0	0	28	100	0	0	0	0
6	Kregyang	0	0	18	100	0	0	0	0
7	Lumla	5	9	52	91	0	0	0	0
8	Menteng	0	0	3	100	0	0	0	0
9	Rengyang	0	0	26	100	0	0	0	0
10	Rho	0	0	32	38	53	62	0	0
11	Thrillam	0	0	35	100	0	0	0	0
	Total	**56**	**13**	**297**	**71**	**65**	**16**	**0**	**0**

Forest land: About 170 HHs (41%) in surveyed villages do not own private forest land. A majority of HHs (22%) owned such land between 1 to 2 acres. 27 HHs (6%) owned more than 2 acre of forest land (Table II. 3.468).

Table II. 3.468: Distribution of forest land holding among surveyed HHs in eleven project villages

Sl. No.	Village	0.00 acre		< 1 acre		1–2 acre		> 2 acre	
		n	%	n	%	n	%	n	%
1	Dungse	36	100	0	0	0	0	0	0
2	Gemreteng	9	100	0	0	0	0	0	0
3	Gyangkhar	37	57	8	12	13	20	7	11
4	Hoongla	0	0	0	0	0	0	0	0
5	Khartuth	11	39	11	39	5	18	1	4
6	Kregyang	10	56	5	28	3	17	0	0
7	Lumla	38	67	2	4	15	26	2	4

8	Menteng	0	0	3	100	0	0	0	0
9	Rengyang	15	58	8	31	3	12	0	0
10	Rho	14	16	0	0	54	64	17	20
11	Thrillam	0	0	0	0	0	0	0	0
	Total	**170**	**41**	**37**	**9**	**93**	**22**	**27**	**6**

Total land holdings: From data given in Table II. 3.469–3.472, there are only 37 HHs (9%) that do not own any type of private land. 43% of the HHs owned more than 2 acres of total land. There is striking variation between the HHs within a village as well as between villages in ownership of total land. For example, in Rho inter–HH holdings vary from one acre to 26 acres, whereas in Dungse it varies from zero–1.08 acres. The proportion of Agricultural–land compared to other types of land to the total land holdings is greater in a majority of the villages. The 429 HHs in the eleven villages owned total private land totalling 954 acres. Out of this Jangda, Rho and Yuthembu accounts for 77% of the total land. Agricultural–land accounts for 54% and forest land 26% of total land holdings in the eleven villages.

Table II. 3.469: Distribution of total land holding among surveyed HHs in eleven project villages

Sl. No.	Village	0.00 acre		< 1 acre		1–2 acre		> 2 acre	
		n	%	n	%	n	%	n	%
1	Dungse	16	44	19	53	1	3	0	**0**
2	Gemreteng	1	11	8	89	0	0	0	0
3	Gyangkhar	1	2	12	18	18	28	34	52
4	Hoongla	15	27	1	2	18	32	22	39
5	Khartuth	0	0	14	50	8	29	6	21
6	Kregyang	0	0	7	39	4	22	7	39
7	Lumla	4	7	18	32	7	12	28	49
8	Menteng	0	0	0	0	2	67	1	33
9	Rengyang	0	0	6	23	13	50	7	27
10	Rho	0	0	0	0	10	12	75	88
11	Thrillam	0	0	33	94	1	3	1	3
	Total	**37**	**9**	**118**	**28**	**82**	**20**	**181**	**43**

Table II. 3.470: Minimum, maximum and average land holdings across eleven project villages

Sl. No.	Village	Agricultural land			Horticultural land			Habitation and homegarden land			Forest land			Total land		
		From	To	Avg.	From	To	Avg.	From	To	Avg.	From	To	Avg.	From	To	Avg.
1	Dungse	0.00	1.00	0.16	0.00	0.00	0.00	0.00	0.08	0.02	0.00	0.00	0.00	0.00	1.08	0.19
2	Gemreteng	0.00	0.50	0.43	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50	0.43
3	Gyangkhar	0.00	7.41	1.72	20.00	9.88	0.45	0.00	1.72	0.26	0.00	9.00	0.79	0.00	17.82	3.24
4	Hoongla	0.00	4.00	1.19	0.00	0.00	0.00	0.00	0.49	0.19	0.00	0.00	0.00	0.00	4.49	1.38
5	Khartuth	0.00	4.00	0.73	0.00	0.00	0.00	0.01	0.05	0.02	0.00	3.00	0.50	0.01	5.05	1.25
6	Kregyang	0.00	2.00	0.83	0.00	0.00	0.00	0.50	0.50	0.50	0.00	1.00	0.31	0.50	3.50	1.64
7	Lumla	0.00	4.00	1.42	0.00	1.00	0.02	0.00	0.98	0.33	0.00	5.00	0.41	0.00	8.49	2.19
8	Menteng	0.50	1.00	0.67	0.00	0.00	0.00	0.50	0.50	0.50	0.75	0.75	0.75	1.75	2.25	1.92
9	Rengyang	0.00	2.50	0.85	0.00	0.00	0.00	0.50	0.50	0.50	0.00	1.00	0.26	0.50	4.00	1.61
10	Rho	0.00	12.00	1.94	0.00	0.00	0.00	0.46	2.00	1.04	0.00	12.00	1.69	1.00	26.00	4.68
11	Thrillam	0.50	2.00	0.55	0.00	0.00	0.00	0.01	0.02	0.02	0.00	0.00	0.00	0.52	2.01	0.57

Table II. 3.471: Number of HHs having land types in eleven project villages

Sl. No.	Village	Agricultural land		Horticultural land		Habitation and home garden land		Forest land	
		n	%	n	%	n	%	n	%
1	Dungse	20	56	0	0	20	56	0	0
2	Gemreteng	8	89	0	0	0	0	0	0
3	Gyangkhar	54	83	15	23	54	83	28	43
4	Hoongla	41	73	0	0	41	73	0	0
5	Khartuth	17	61	0	0	28	100	17	61
6	Kregyang	11	61	0	0	18	100	8	44
7	Lumla	41	72	1	2	52	91	19	33
8	Menteng	3	100	0	0	3	100	3	100
9	Rengyang	20	77	0	0	26	100	11	42
10	Rho	83	98	0	0	85	100	71	84

11	Thrillam	35	100	0	0	35	100	0	0
	Total	**333**	**80**	**16**	**4**	**362**	**87**	**157**	**38**

Table II. 3.472: Distribution of area (in acres) of land holding among HHs in eleven project villages

Sl. No.	Village	Agricultural land		Horticultural land		Habitation and home garden land		Forest land		Total land
		Area	%	Area	%	Area	%	Area	%	Area
1	Dungse	6	89	0	0	1	11	0	0	**7**
2	Gemreteng	4	100	0	0	0	0	0	0	**4**
3	Gyangkhar	112	53	30	14	17	8	51	24	**211**
4	Hoongla	67	86	0	0	11	14	0	0	**78**
5	Khartuth	21	58	0	0	1	2	14	40	**35**
6	Kregyang	15	51	0	0	9	31	6	19	**30**
7	Lumla	81	65	1	1	19	15	24	19	**125**
8	Menteng	2	35	0	0	2	26	2	39	**6**
9	Rengyang	22	53	0	0	13	31	7	16	**42**
10	Rho	165	41	0	0	89	22	144	36	**398**
11	Thrillam	20	97	0	0	1	3	0	0	**20**
	Total	**514**	**54**	**31**	**3**	**162**	**17**	**248**	**26**	**954**

Livestock Holding: The data presented in Tables II. 3.473–3.475, shows that nine different types of animals are domesticated in surveyed villages. In none of the villages all the nine animals were domesticated. In total, 1054 domestic animals were reported from the twelve villages. Considerable inter–village variation is observed in total number of animals reared. It varied from 8 in Thrillam to 487 in Rho. Gyankhar, Lumla and Rho alone account for 72% of all the animals found in the surveyed villages. Three animals, viz, cattle (52%), goat (13%) and sheep (15%) account for 80% of the total animals (1054). Mithun, Poultry, Pig, Pony and Yak are also maintained in some villages in small numbers.

Table II. 3.473: Livestock holding by HHs in the twelve project villages

Sl. No.	Village		Mithun	Cattle	Yak	Goat	Sheep	Pig	Pony	Poultry	Others
1	Dungse	n	0	1	0	0	0	0	0	0	3
		%	0	3	0	0	0	0	0	0	8
2	Gemreteng	n	0	3	0	0	0	0	0	0	0
		%	0	33	0	0	0	0	0	0	0
3	Gyada	n	0	1	0	0	0	0	0	0	0
		%	0	9	0	0	0	0	0	0	0
4	Gyangkhar	n	0	24	0	7	0	1	0	3	1
		%	0	37	0	11	0	2	0	5	2
5	Hoongla	n	1	7	0	5	2	6	4	0	6
		%	2	13	0	9	4	11	7	0	11
6	Khartuth	n	0	10	0	0	0	0	0	0	0
		%	0	36	0	0	0	0	0	0	0
7	Kregyang	n	0	3	0	0	1	0	0	0	0
		%	0	17	0	0	6	0	0	0	0
8	Lumla	n	1	17	0	13	1	4	13	7	0
		%	2	30	0	23	2	7	23	12	0
9	Menteng	n	0	1	0	0	0	0	0	0	0
		%	0	33	0	0	0	0	0	0	0
10	Rengyang	n	0	4	0	0	0	0	0	0	0
		%	0	15	0	0	0	0	0	0	0
11	Rho	n	0	30	5	17	20	6	1	2	1
		%	0	35	6	20	24	7	1	2	1
12	Thrillam	n	0	1	0	0	1	0	0	0	0
		%	0	3	0	0	3	0	0	0	0
	Total	**n**	**2**	**102**	**5**	**42**	**25**	**17**	**18**	**12**	**11**
		%	**0.5**	**24**	**1**	**10**	**6**	**4**	**4**	**3**	**3**

Table II. 3.474: Number of livestock in surveyed HHs across the twelve project villages

Sl. No.	Village		Mithun	Cattle	Yak	Goat	Sheep	Pig	Pony	Poultry	Others	Total
1	Dungse	LS	0	1	0	0	0	0	0	0	9	**10**
		% LS	0	10	0	0	0	0	0	0	90	**100**
2	Gemreteng	LS	0	20	0	0	0	0	0	0	0	**20**

		% LS	0	100	0	0	0	0	0	0	0	**100**
3	Gyada	LS	0	10	0	0	0	0	0	0	0	**10**
		%	0	100	0	0	0	0	0	0	0	**100**
4	Gyangkhar	LS	0	80	0	10	0	1	0	6	1	**98**
		%	0	82	0	10	0	1	0	6	1	**100**
5	Hoongla	LS	1	27	0	23	3	6	7	0	13	**80**
		% LS	1	34	0	29	4	8	9	0	16	**100**
6	Khartuth	LS	0	41	0	0	0	0	0	0	0	**41**
		%	0	100	0	0	0	0	0	0	0	**100**
7	Kregyang	LS	0	27	0	0	60	0	0	0	0	**87**
		%	0	31	0	0	69	0	0	0	0	**100**
8	Lumla	LS	7	49	0	37	2	13	40	29	0	**177**
		%	4	28	0	21	1	7	23	16	0	**100**
9	Menteng	LS	0	10	0	0	0	0	0	0	0	**10**
		%	0	100	0	0	0	0	0	0	0	**100**
10	Rengyang	LS	0	26	0	0	0	0	0	0	0	**26**
		%	0	100	0	0	0	0	0	0	0	**100**
11	Rho	LS	0	255	49	68	85	14	6	7	3	**487**
		%	0	52	10	14	17	3	1	1	1	**100**
12	Thrillam	LS	0	3	0	0	5	0	0	0	0	**8**
		%	0	38	0	0	63	0	0	0	0	**100**
	Total	**n**	**8**	**549**	**49**	**138**	**155**	**34**	**53**	**42**	**26**	**1054**
		%	**1**	**52**	**5**	**13**	**15**	**3**	**5**	**4**	**2**	**100**

Note: LS–Livestock

Table II. 3.475: Distribution of total number of livestock in HHs of the twelve project villages

Sl. No.	Village	0		1–5		6–10		> 10		Total
		n	%	n	%	n	%	n	%	n
1	Dungse	33	92	3	8	0	0	0	0	**36**
2	Gemreteng	6	67	1	11	2	22	0	0	**9**
3	Gyada	10	91	0	0	1	9	0	0	**11**
4	Gyangkhar	34	52	26	40	4	6	1	2	**65**
5	Hoongla	35	63	18	32	2	4	1	2	**56**
6	Khartuth	18	64	7	25	2	7	1	4	**28**
7	Kregyang	14	78	0	0	2	11	2	11	**18**
8	Lumla	31	54	14	25	7	12	5	9	**57**
9	Menteng	2	67	0	0	1	33	0	0	**3**
10	Rengyang	22	85	2	8	2	8	0	0	**26**
11	Rho	48	56	9	11	11	13	17	20	**85**
12	Thrillam	33	94	2	6	0	0	0	0	**35**
	Total	**286**	**67**	**82**	**19**	**34**	**8**	**27**	**6**	**429**

Traditional Skills: In the surveyed village five types of crafts given in Table II. 3.476 are pursued. Weaving is practiced in all the six villages and the total number of HHs engaged is 73 (26%). A small number of HHs are engaged in wood carving, carpet making, bamboo utensils making and paper making (Table II. 3.476).

Table II. 3.476: Distribution of various skills among surveyed HHs in the six project villages

Sl. No.	Village	Wood carving		Thanka painting		Carpet making		Bamboo utensils		Weaving		Paper making	
		n	%	n	%	n	%	n	%	n	%	n	%
1	Dungse	0	0	0	0	0	0	0	0	4	11	0	0
2	Gemreteng	0	0	0	0	1	11	0	0	0	0	0	0
3	Gyangkhar	9	14	0	0	3	5	5	8	13	20	1	2
4	Khartuth	0	0	0	0	2	7	0	0	6	21	0	0
5	Lumla	0	0	0	0	0	0	0	0	10	18	0	0
6	Rho	0	0	0	0	0	0	2	2	40	47	0	0
	Total	**9**	**3**	**0**	**0**	**6**	**2**	**7**	**3**	**73**	**26**	**1**	**0**

* Data in this respect not available for Gyada Hoongla, Kregyang, Menteng, Rengyang and Thrillam

River Resources: In Table II. 3.477, the data showed that all the river resources listed are being used across the studied twelve villages. In all villages at least one river resource is used. The dependence of Gyangkhar and Lumla is very high on river resources. 50% of the villages depend only on two river resources. They are water for domestic animals and for disposal of the dead. River resources such as water, sand and stones are used by a large number of HHs. It is highly noteworthy that all the 453 HHs in the surveyed villages use river for performing last rites of the dead. It may be emphasized that aquatic fauna and flora are also used by many HHs in the surveyed villages.

Table II. 3.477: Dependence on river resources among surveyed HHs in the twelve project villages

Sl. No.	Nature of dependence		Dungse	Gemreteng	Gyada	Gyangkhar	Hoongla	Khartuth	Kregyang	Lumla	Menteng	Rengyang	Rho	Thrillam	Total
1	Drinking water	n	0	0	0	17	46	0	0	51	0	0	0	0	**114**
		%	0	0	0	26	82	0	0	89	0	0	0	0	**27**
2	Water for domestic use	n	0	0	0	15	40	0	0	43	0	0	0	0	**98**
		%	0	0	0	23	71	0	0	75	0	0	0	0	**23**
3	Water for domestic animal	n	3	3	1	31	21	10	4	26	1	4	37	2	**143**
		%	8	33	9	48	38	36	22	46	33	15	44	6	**33**
4	Fishes	n	0	0	0	20	0	0	0	1	0	0	0	0	**21**
		%	0	0	0	31	0	0	0	2	0	0	0	0	**5**
5	Aquatic flora	n	0	0	0	3	0	0	0	0	0	2	0	0	**5**
		%	0	0	0	5	0	0	0	0	0	8	0	0	**1**
6	Religious	n	36	9	11	65	56	28	18	57	3	26	85	35	**429**
		%	100	100	100	100	100	100	100	100	100	100	100	100	**100**
7	Sand	n	34	0	0	45	0	28	0	45	0	0	0	0	**152**
		%	94	0	0	69	0	100	0	79	0	0	0	0	**35**
8	Stones (boulders)	n	34	0	0	44	0	28	0	45	0	0	0	0	**151**
		%	94	0	0	68	0	100	0	79	0	0	0	0	**35**
9	Any other	n	0	0	0	3	0	0	0	1	0	0	0	0	**4**
		%	0	0	0	5	0	0	0	2	0	0	0	0	**1**

Forest Resources: The villagers of all the twelve villages are dependent and use varying degrees of forest resources (Table II. 3.478). All forest resources listed in Table II. 3.478 are used in varying degrees among the twelve surveyed villages. Gyada and Thrillam uses the least number of forest resources being 5. Gyangkhar is the only village using all the listed forest resources. Rho, Lumla and Khartuth uses 11, 13 and 12 resources respectively. More than 50% of the HHs in general across the studied villages uses several forest resources such as fuel wood, timber, medicinal plants, food, religion, etc. It is thus evident from above description that for a majority of the inhabitants of the surveyed villages forest resources play a very significant role to the livelihoods as well as the quality of life.

Table II. 3.478: Dependence on forest resources among surveyed HHs in twelve project villages

Sl. No.	Forest resources		Dungse	Gemreteng	Gyada	Gyangkhar	Hoongla	Khartuth	Kregyang	Lumla	Menteng	Rengyang	Rho	Thrillam	Total
1	Fuel wood	n	36	9	11	65	56	28	18	55	3	26	85	35	**427**
		%	100	100	100	100	100	100	100	96	100	100	100	100	**99.5**
2	Timber	n	36	9	11	58	56	28	18	50	0	0	85	35	**386**
		%	100	100	100	89	100	100	100	88	0	0	100	100	**90**
3	Medicinal plants	n	36	3	0	46	0	28	18	18	2	0	0	0	**151**
		%	100	33	0	71	0	100	100	32	67	0	0	0	**35**
4	Honey	n	0	2	0	14	0	0	0	0	0	2	0	0	**18**
		%	0	22	0	22	0	0	0	0	0	8	0	0	**4**
5	Food	n	0	9	0	25	56	28	18	3	3	26	66	35	**269**
		%	0	100	0	38	100	100	100	5	100	100	78	100	**63**
6	Edible oil	n	0	0	0	9	0	0	0	3	0	0	0	0	**12**
		%	0	0	0	14	0	0	0	5	0	0	0	0	**3**
7	Ornamental	n	0	0	0	2	0	0	0	0	0	0	2	0	**4**
		%	0	0	0	3	0	0	0	0	0	0	2	0	**1**
8	Religious	n	36	9	0	62	56	28	18	33	3	26	85	0	**356**
		%	100	100	0	95	100	100	100	58	100	100	100	0	**83**

9	Fencing	n	36	0	0	27	0	28	0	1	0	0	19	0	**111**
		%	100	0	0	42	0	100	0	2	0	0	22	0	**26**
10	Handicrafts	n	0	0	0	10	0	0	0	0	0	0	21	0	**31**
		%	0	0	0	15	0	0	0	0	0	0	25	0	**7**
11	Thatching	n	0	0	0	9	0	0	0	1	0	0	0	0	**10**
		%	0	0	0	14	0	0	0	2	0	0	0	0	**2**
12	Spices	n	0	1	0	28	0	28	0	13	1	3	0	0	**74**
		%	0	11	0	43	0	100	0	23	33	12	0	0	**17**
13	Grazing	n	3	3	1	31	21	10	4	26	1	4	37	2	**143**
		%	8	33	9	48	38	36	22	46	33	15	44	6	**33**
14	Hunting of wild animals	n	0	0	0	1	0	0	0	0	0	0	0	0	**1**
		%	0	0	0	2	0	0	0	0	0	0	0	0	**0**
15	Fishes	n	0	0	0	24	0	0	0	0	0	0	0	0	**24**
		%	0	0	0	37	0	0	0	0	0	0	0	0	**6**
16	Water	n	36	0	0	36	21	10	0	32	0	5	85	0	**225**
		%	100	0	0	55	38	36	0	56	0	19	100	0	**52**
17	Stones	n	36	9	11	51	56	28	18	47	3	26	85	35	**405**
		%	100	100	100	78	100	100	100	82	100	100	100	100	**94**
18	Sand	n	36	9	11	47	56	28	18	45	3	26	19	0	**298**
		%	100	100	100	72	100	100	100	79	100	100	22	0	**69**
19	Dyes	n	0	0	0	3	0	7	0	0	0	0	0	0	**10**
		%	0	0	0	5	0	25	0	0	0	0	0	0	**2**

Water Resources: From Table II. 3.479, it is seen that all five types of water resources listed are available across all the studied villages. Only four villages are dependent on river water. Three–fourth of the villages depends on water from hill stream/springs. Tap water is used for various purposes in eleven surveyed villages. Pond water is only used in four villages. Two villages Gyada and Thrillam depend only on tap water. Wells are present only in Gyangkhar.

Table II. 3.479: Dependence on river resources among surveyed HHs in twelve project villages

Sl. No.	Village	River		Hill stream/spring		Wells		Ponds		Tap water	
		n	%	n	%	n	%	n	%	n	%
1	Dungse	36	100	0	0	0	0	0	0	36	100
2	Gemreteng	0	0	9	100	0	0	9	100	9	100
3	Gyada	0	0	0	0	0	0	0	0	11	100
4	Gyangkhar	9	14	30	46	2	3	0	0	0	0
5	Hoongla	0	0	0	0	0	0	0	0	56	100
6	Khartuth	0	0	28	100	0	0	0	0	28	100
7	Kregyang	0	0	18	100	0	0	18	100	18	100
8	Lumla	2	4	2	4	0	0	0	0	57	100
9	Menteng	0	0	3	100	0	0	3	100	3	100
10	Rengyang	0	0	26	100	0	0	26	100	26	100
11	Rho	85	100	85	100	0	0	0	0	85	100
12	Thrillam	0	0	0	0	0	0	0	0	35	100
	Total	**132**	**31**	**201**	**47**	**2**	**0**	**56**	**13**	**364**	**85**

3.3.10 TAWANG-II

3.3.10.1 PHYSICAL ENVIRONMENT

Geomorphology

The geomorphological features at Tawang-II HEP have been depicted in the toposheet (Figure II. 3.53). The project is located at an elevation of 1536 m on the Tawang river.

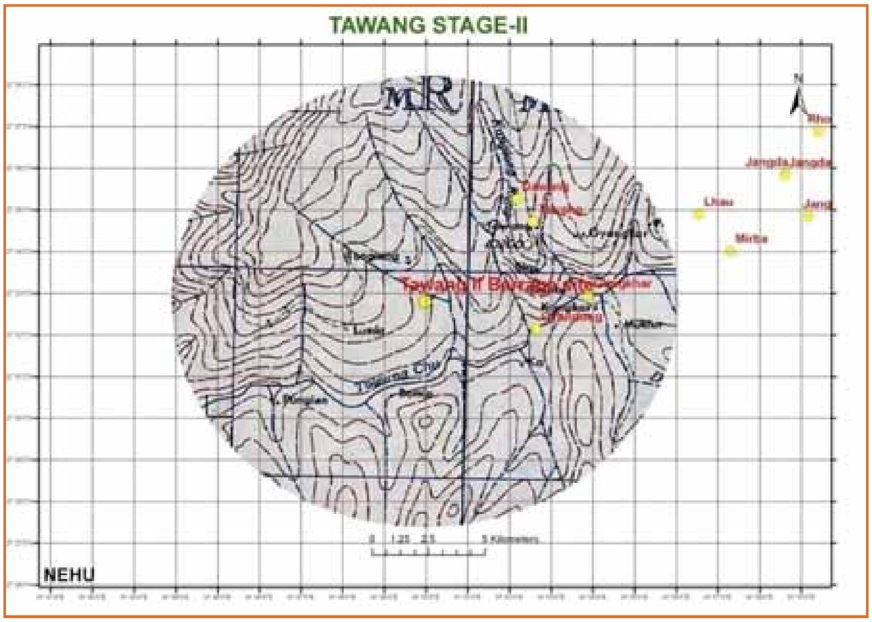


Figure II. 3.53: Contour map of Tawang–II

Geology

The project components are proposed to be constructed within rock types of Sela Group and Lumla Formation. Gneisses with intrusive of leucogranite, pegmatite and amphibolites belonging to Sela Group are disposed in the eastern part of the project while as rock types of Lumla are exposed towards western part where part of HRT and underground powerhouse are proposed. The primary stratification in rock formations is defined by colour and compositional laminations in schistose quartzite of Lumla Formation and in the calc–silicate rocks of the Sela Group. Regional foliation observed in the schist and the gneiss show a swinging trend. South of Jung the schist trend E–W with northerly dips while near the bridge on Tawang Chu, the Foliation trend swings to N–S. The structural elements indicate a regional F2 fold with an easterly plunging antiformal axis passing through Jabrang, Shyaro and north of Jang. Apart from this regional fold, mesoscopic folds of broad open and tight plunging geometry have also been reported from the area. Based on field evidences collected during geological mapping a thrust has also been mapped in the area around Lumla.

Barrage Site: A barrage has been proposed in the straighter course of river about 560 m u/s of confluence of Tawang Chu and Susum Rong. The river valley at this location is wider. Generally, the river channel is occupied by riverine deposits comprising of boulders, cobbles and pebbles in fine to medium sandy matrix. At the proposed axis, rock exposures are seen in left bank above EL 1535 M beyond the riverine terrace. These rock formations consist of quartzo–feldspathic gneisses with quartz veins, leucogranite and bands of mica schist which are strong to very strong and moderately jointed. Right bank is generally occupied by slope wash and occasional nalla fan deposits. Sporadic outcrops of gneiss are seen at higher elevations above EL 1660 M. Keeping in view the overburden deposits a barrage is proposed to be constructed as a diversion structure. The barrage area has been well investigated with a back up of geophysical surveys and drilling. Overburden in the river channel varies from 16–40 m along the axis and 35–37 m along the glacis portion. Permeability of overburden is of the order of 10^{-2} to 10^{-4} cm/sec. A raft type foundation for barrage is proposed to be constructed on permeable foundation comprising of boulders, cobbles and pebbles in medium to fine sandy matrix. *In situ* tests viz., bearing capacity, modulus of sub–grade reaction and tests have been conducted to ascertain the foundation properties. Proposed barrage is a relatively small structure and excavation is limited to overburden only. Since excavation in bedrock is not required, as such no adverse impact is foreseen.

Powerhouse Site: In order to harness the maximum potential of the river, the powerhouse has been proposed near the confluence. An underground powerhouse has been proposed near the confluence of Nyamjang Chu and Tawang Chu. The ridge housing the powerhouse complex shows sparse vegetation mostly in the form of bushes and shrubs with intermittent rock outcrops. Bed rock is generally exposed in this area and occasionally covered by a thin veneer of slope wash. By and large, rock formations exposed in the area comprises of interbanded garnetiferrous quartz mica schist with quartzite and occasional intercalation of gneiss. These rock formations are generally fresh to slightly weathered, moderate to closely jointed and strong in nature. Powerhouse area has been investigated with a backup of geological mapping, drilling and drifting. Powerhouse is suitably located to have sufficient vertical and lateral cover. Moreover orientation of powerhouse has also been optimized so as to make sufficient angle with average orientation of major discontinuity sets. The underground caverns have been planned taking into account the geological conditions, design support and therefore construction of these caverns is not expected to cause any adverse environmental impact.

Reservoir: The reservoir of Tawang Hydroelectric Project, Stage–II (FRL at El. 1536 m) will be a very small water body. It will submerge an area of about 0.06 km^2 only and will extend for a length of about 800 m along the river in a moderate valley. From about 300m upstream of barrage axis, the river follows almost NE–SW course. Overall the terrain is unapproachable except for a few foot paths. River Tawang Chhu being the master drainage system in this area, possibility of water escaping from the reservoir of this valley to the adjoining valley does not exist. No major deposits of economic importance are reported to be present in the reservoir area, nor is any mining activity seen to be going on in the area. By and large the reservoir will remain within the existing flood plain of the river and therefore considerable change around the reservoir periphery is not expected. Further, the reservoir being very small it is not expected to change the seismic pattern of the area.

Head Race Tunnel: In order to harness the head in this stretch of rover a head race tunnel of the project had to be planned in the right bank keeping in view the international border with Bhutan which is located on left bank about 15.5 km downstream of barrage. Along the proposed tunnel route Paleoproterozoic rocks of Sela Group and Mesoproterozoic metasedimentaries of Lumla Formation are exposed. The tunnel route has been investigated with a backup of geological mapping, drilling, drifting and study of imageries. The rock formations in general have undergone several phases of deformation resulting into folding/ warping at several places. Some degree of shearing and fracturation has also resulted from this deformation. Swing in attitude of foliation is a result of these warps. About 7 km stretch of HRT i.e. from Intake shall be housed within quartzo feldpathic gneisses of Sela Group while balance 9 km stretch towards downstream shall be within rock types of Lumla formation. The rock types of Sela group consist of gneisses which are intruded by leucogranites, pegmatites and amphibolites. These occur as lenses and bands of various shapes and sizes. The gneisses are generally, moderately strong to strong and moderately jointed. They are expected to provide fair to good tunneling media barring few stretches of poor rock mass where shearing is expected within the rock mass. The meta–sedimentaries of Lumla formation consists of Quartz–Mica schist, Garnetiferrous mica Schist and interbands of quartzite, quartzites, schist and calc–silicates (marble). The rock mass as a whole is moderate to close jointed and is expected to provide fair to good tunneling media with few stretches of poor rock mass in between. Garnetiferrous mica schist is medium strong to strong, generally closely foliated to moderately jointed in nature. However at places it is quite massive in nature. Generally schists are expected to provide fair tunneling media with some stretches of poor media. Mostly quartzites are schistose in nature, fractured and have undergone high degree of fracturation. However, massive and strong quartzites are also disposed within the area. Quartzites are expected to provide fair to poor tunneling media in general. Strong to very strong, slight to moderately jointed calc–silicate (Marble) may be encountered along the tunnel route. These calc–silicates are expected to generally provide good tunnelling media. Now a 16 Km long tunnel is planned with six intermediate adits. The tunnel layout has been planned within rock formations. Construction of this tunnel will not have any adverse impact on the geomorphology of the area as the head race tunnel is deep seated within the hillsand shall be supported as per design plan.

The area under various geological classes in Tawang–II at barrage and powerhouse sites is presented in Table II. 3.480. The location of Tawang-II barrage site and the impact zone within 10 km radius in Tawang river are depicted in Figures II. 3.54, 3.55 and 3.56.

Table II. 3.480: Area under various geological classes in Tawang–II at barrage and powerhouse sites

Class	Barrage		Powerhouse	
	Area	**%**	**Area**	**%**
Snow covered area	1.73	0.61		
Sela group (Structural hill)	217.43	77.24	5.14	3.21
Stabilised channel bar	1.23	0.44	154.98	96.79
Volcanic sediment (Structural hill)	61.10	21.71		
Total	**281.48**	**100.00**	**160.12**	**100.00**

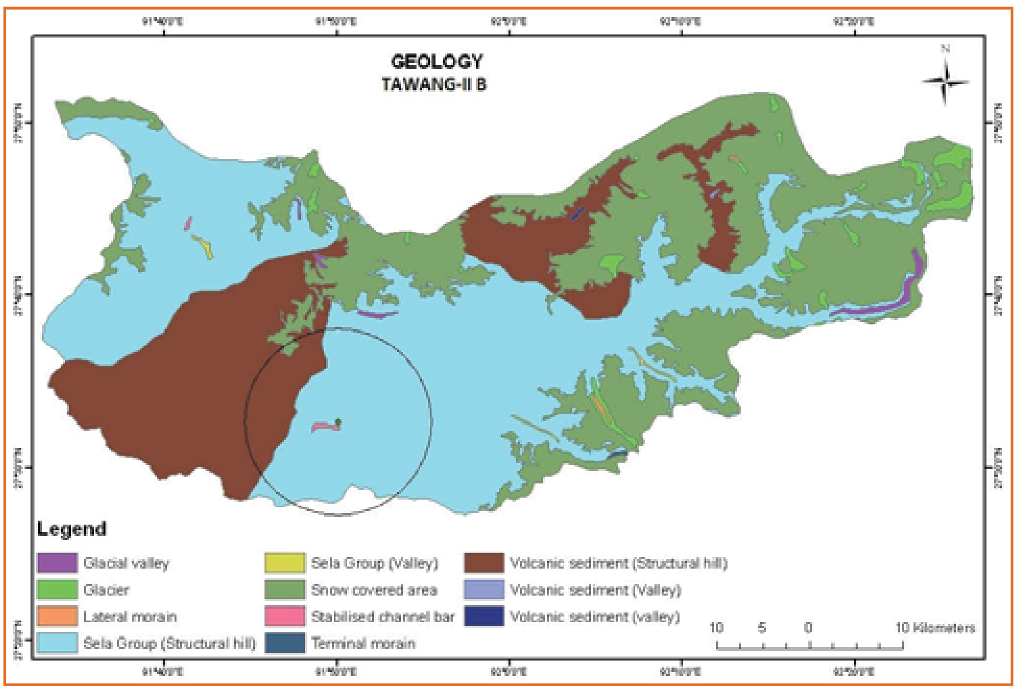


Figure II. 3.54: Geological map of TRB showing location of Tawang–II barrage site

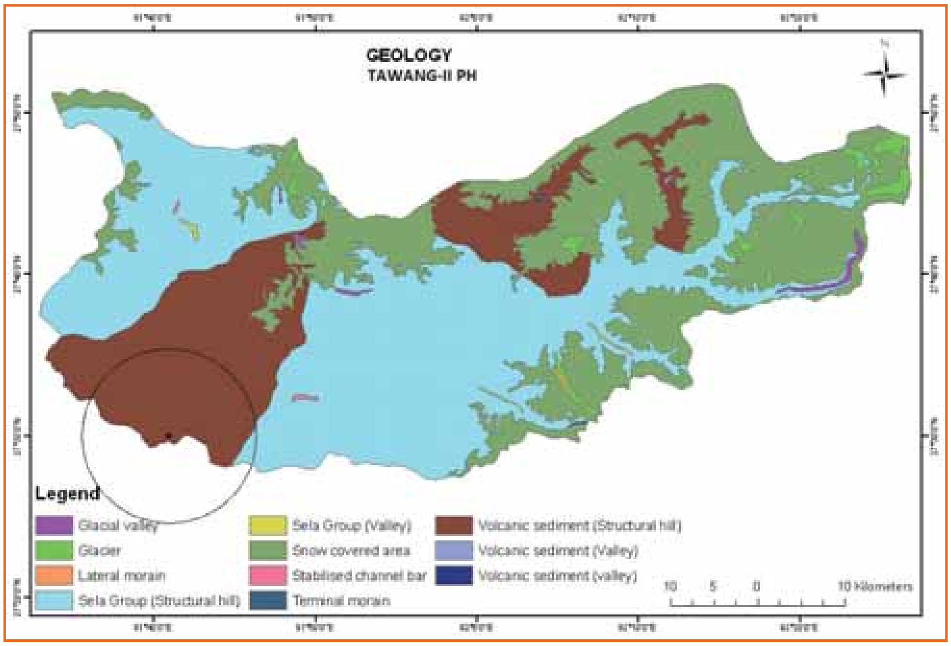


Figure II. 3.55: Geological map of TRB showing location of Tawang–II powerhouse site

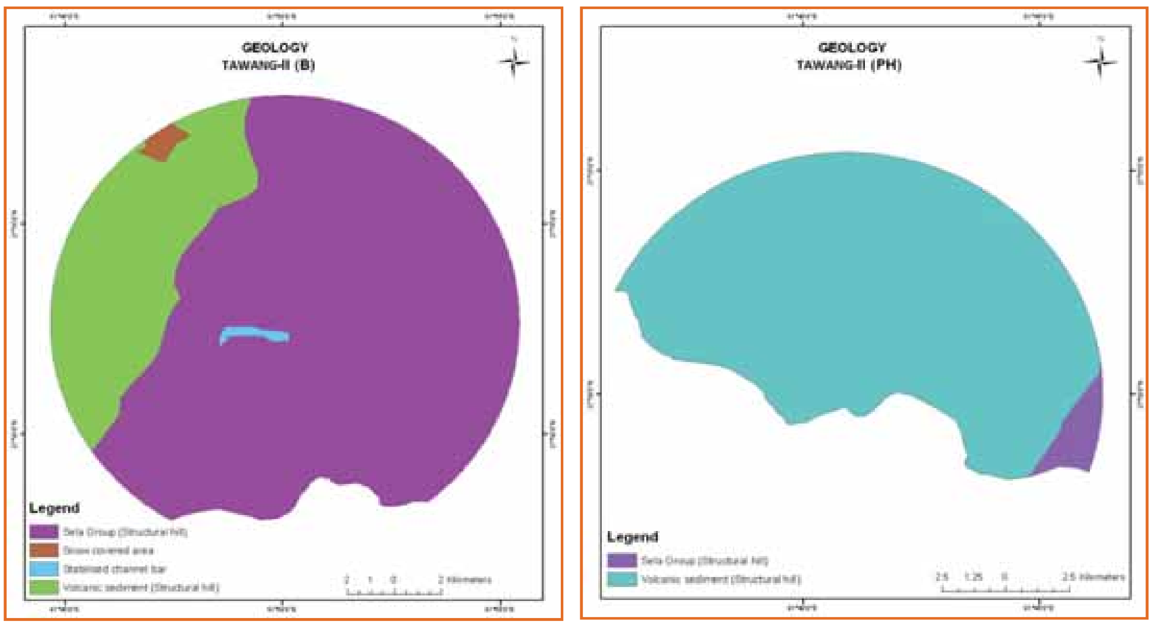


Figure II. 3.56: Geological map of Impact zone (10 km radius) of Tawang–II barrage and powerhouse site in Tawang river valley

Landuse and Land Cover

The total area within 10 km radius of Tawang–II HEP site is 31389.73 ha (Figure II. 3.57). Majority of the area is covered with forest (57.29%) followed by scrubland (36.16%). Grassland covers only 0.04% of the total project area. Waterbody constitute around 4.24% of the total area and cropland occupies only 0.48% . The total area occupied by snow and ice and other builtup area altogether is 1.79% (Table II. 3.481).

Table II. 3.481: Landuse/land cover area of Tawang–II project site

Landuse/land cover category	Area (ha)	%
Forest	17983.1	57.29
Scrubland	11349.5	36.16
Waterbody	1331.53	4.24
Croplands	150.548	0.48
Grasslands	12.735	0.04
Builtuparea	172.44	0.55
Snow and Ice	389.88	1.24
Total	**31389.73**	**100.00**

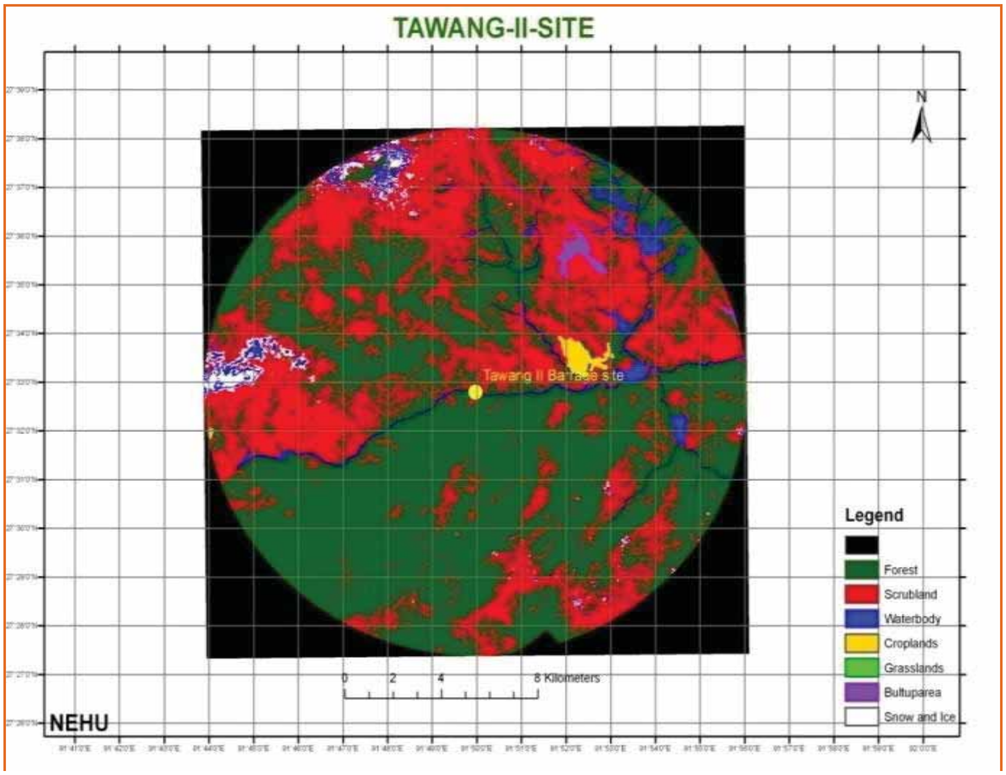


Figure II. 3.57: Landuse/land cover map of Tawang–II project site

Soil

The physico–chemical and biological properties of soil collected from Tawang-II site is presented in Table II. 3.482. The soil was sandy clay, with high porosity and low water holding capacity on account of greater proportion of sand in the soil. The soil was acidic and its other parameters related to concentration of essential macro–nutrients and soil microbial biomass–C and microbial biomass–N was close to Tawang-I; the seasonal trend was also similar to Tawang-I. Seasonal variation in physical, chemical and biological parameters are shown in Table II. 3.483.

Table II. 3.482: Soil physical properties at Tawang–II project site

Site	Texture	WHC (%)	Bulk density (g/cm³)	Porosity (%)
Barrage	Sandy clay	15.59	1.11	58.11
Powerhouse	Sandy clay	20.41	1.12	57.73

Table II. 3.483: Seasonal variation in soil physico–chemical properties at Tawang–II project site

Parameters	Post-monsoon		Monsoon		Winter		Mean	
	B	PH	B	PH	B	PH	B	PH
SMC (%)	30	25	29	27	19	18	26	23
pH	5.4	6.3	5.5	6.4	6.8	6.9	5.9	6.5
Conductivity (µS cm^{-1})	46	43	66	64	49	47	54	51
NH_4^+–N (µg g^{-1})	300	300	500	400	200	200	333	300
NO_3^-–N(µg g^{-1})	19	23	33	39	33	35	28	33
TKN (µg g^{-1}) x10^3	0.500	0.600	0.700	0.800	0.400	0.500	0.530	0.630
Av.P (µg g^{-1})	0.210	0.090	0.240	0.060	0.020	0.050	0.160	0.070
TP (%)	0.120	0.110	0.170	0.150	0.090	0.110	0.130	0.120
SOC (%)	0.001	0.004	0.007	0.008	0.002	0.004	0.000	0.010
Ex. K (µg g^{-1})	60	127	250	390	69	97	126	204
Ex. Mg (%)	0.012	0.041	0.019	0.009	0.015	0.012	0.020	0.020
Ex. Ca (%)	0.168	0.200	0.298	0.286	0.202	0.178	0.220	0.220
Soil microbial biomass–C (µg g^{-1})	18	0	11	2	30	26	20	9
Soil microbial biomass–N (µg g^{-1})	2.00	2.00	1.70	2.00	4.20	3.98	2.60	2.70

(Note: Post-monsoon–October, Monsoon–July, Winter–December); B = Barrage, PH = Powerhouse

Soil Erosion Vulnerability

The area under various soil erosion vulnerable classes of Tawang-II is presented in Table II. 3.484. In the barrage site, out of the total area of 281.48 sq.km, about 4.41% and 16.14% area falls under high and moderately high vulnerable zone, respectively. Whereas, 2.38% and 30.4% of the total area falls under low and moderately low soil erosion vulnerable zone, respectively. The vulnerable area of soil erosion under moderate category was 46.96%.

In the powerhouse site, out of the total area of 160.12 sq.km, only 6.53% area falls under high soil erosion vulnerable zone whereas 28.82% falls under moderately high vulnerable zone. On the other hand, only 2.54% of the total area is covered under low vulnerable zone whereas 26.26% falls under moderately-low vulnerable zone. The vulnerable area under moderate zone covered about 35.86% of the total area. The spatial distribution map of soil erosion vulnerable areas under barrage and powerhouse site of Tawang–II is given in Figure II. 3.58.

Table II. 3.484: Areas under various soil erosion vulnerable zones in Tawang–II at barrage and powerhouse sites

Vulnerability	**Barrage**		**Powerhouse**	
	Area (sq. km)	**%**	**Area (sq. km)**	**%**
High	12.42	4.41	10.45	6.53
Moderately high	45.42	16.14	46.15	28.82
Moderate	131.39	46.68	57.42	35.86
Moderately low	85.56	30.40	42.05	26.26
Low	6.69	2.38	4.06	2.54
Total	**281.48**	**100.00**	**160.12**	**100.00**

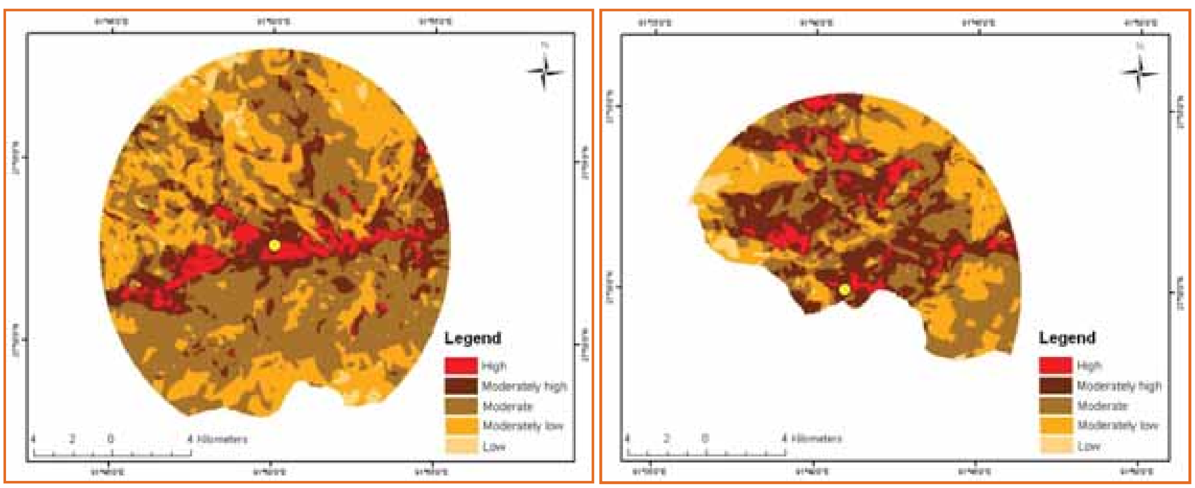


Figure II. 3.58: Spatial distribution of soil erosion vulnerable areas in Tawang–II at barrage and powerhouse sites

Landslide and Erosion Vulnerability

The areas under various landslide and erosion vulnerability classes of Tawang–II are presented in Table II. 3.485. In the influence zone of barrage site, out of the total area of 281.48 sq.km about 1.41% and 0.72% area falls under high and low vulnerable zone, respectively. About 18.38% and 26.9% of the total area falls under moderately-high and moderately-low vulnerable zone, respectively. The vulnerable area under moderate category covered about 52.59% of the total area.

In the influence zone of powerhouse site, out of the total area of 160.12 sq.km, only 0.01% and 3.54% area falls under high and low vulnerable zone, respectively, whereas, about 20.18% and 31.8% of the total area falls under moderately–high and moderately–low category, respectively. The vulnerable area under moderate zone covered about 44.46% of the total area. The spatial distribution map of landslide and erosion vulnerability areas under barrage and powerhouse site of Tawang-II is given in Figure II. 3.59.

Table II. 3.485: Area under various landslide and erosion vulnerability classes in Tawang–II at barrage and powerhouse sites

Vulnerability	Barrage		Powerhouse	
	Area (sq.km)	**%**	**Area (sq.km)**	**%**
High	3.98	1.41	0.02	0.01
Moderately high	51.74	18.38	32.32	20.18
Moderate	148.02	52.59	71.20	44.46
Moderately low	75.71	26.90	50.91	31.80
Low	2.03	0.72	5.67	3.54
Total	**281.48**	**100.00**	**160.12**	**100.00**

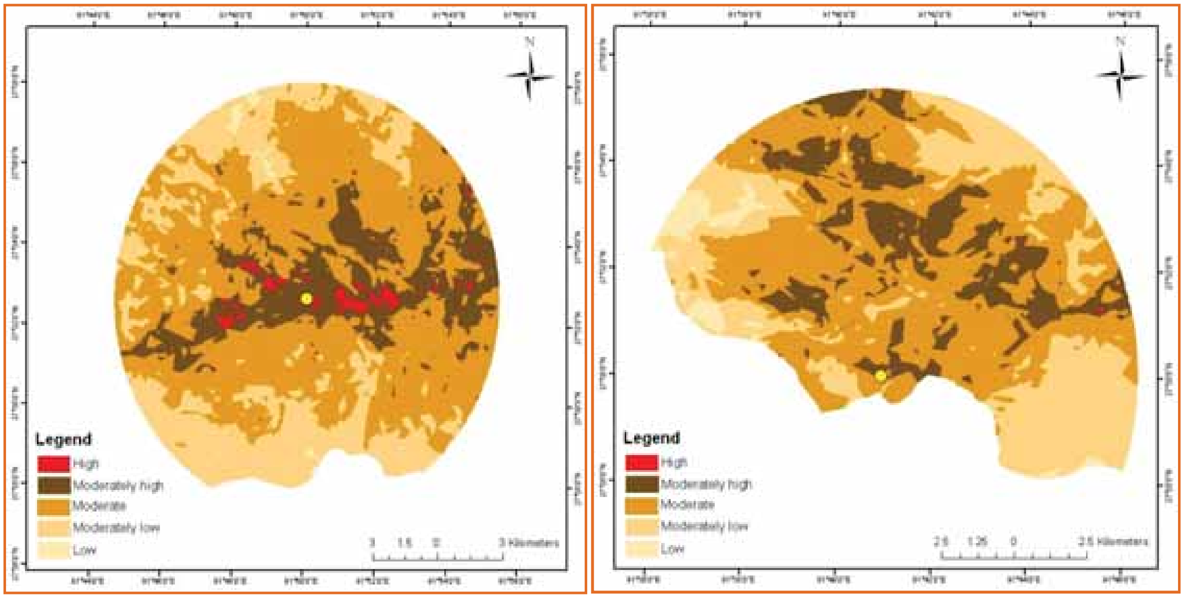


Figure II. 3.59: Area under various erosion and landslide vulnerability classes in Tawang–II at barrage and powerhouse sites

Water

In this site, pH, temperature, and turbidity was high during the monsoon season. Dissolve oxygen (DO), electrical conductivity (EC), and total dissolved solids (TDS) concentration were at minimum level during the monsoon and maximum during winter period. Total hardness and total alkalinity of the river peaked during the winter period and the lowest value was recorded during the Post-monsoon period. Potassium (K^+), TKN, and ammonium nitrogen (NH_4^+–N) concentration in the river water were high in the rainy season as compared to other two seasons. Highest concentration of total phosphorus and nitrate nitrogen was obtained during Post-monsoon period. Maximum primary productivity of the river was recorded during the rainy season and minimum during winter period. Total coliform organism count was maximum during the Post-monsoon period and minimum during the rainy season (Table II. 3.486).

Table II. 3.486: Seasonal variation in physico–chemical and biological properties of water and its primary productivity at Tawang–II site

Parameters	Post-monsoon			Monsoon			Winter		
	B	**PH**	**Mean**	**B**	**PH**	**Mean**	**B**	**PH**	**Mean**
Temperature (°C)	11.20	11.10	11.15	15.20	15.70	15.45	9.20	9.30	9.25
Turbidity (NTU)	0.46	0.55	0.51	1.17	1.22	1.20	0.84	0.86	0.85
pH	7.62	7.59	7.61	7.81	7.88	7.85	7.55	7.54	7.55
Electrical conductivity (µS/cm)	165	164.00	165	144	143.00	144	169	165.00	167
Total dissolved solids (mg/l)	82	82.40	82.10	72	73.00	72.50	84	83.00	83.50
Practical salinity (ppt)	0.10	0.10	0.10	0.08	0.08	0.08	0.08	0.08	0.08
Total alkalinity (mg $CaCO_3$/l)	28	28.00	28.00	36	36.00	36.00	48	48.00	48.00
Total hardness (mg/l)	20	20.23	20.22	37	37.45	37.16	41	40.71	40.75
Chloride (mg Cl^-/l)	9.66	8.99	9.33	8.99	8.99	8.99	5.99	5.99	5.99
Ca^{2+} (mg/l)	4.31	4.32	4.32	8.96	9.11	9.03	9.23	9.22	9.22
Mg^{2+}(mg/l)	2.30	2.29	2.29	3.52	3.57	3.55	4.31	4.30	4.30
K^+ ppm	1.20	1.20	1.20	2.30	2.20	2.25	0.40	0.40	0.40

Na^+ ppm	9.30	8.90	9.10	4.60	4.80	4.70	8.80	8.90	8.85
TKN (mg/l)	0.48	0.48	0.48	0.59	0.59	0.59	0.43	0.46	0.45
NH_4^+ N (mg/l)	0.04	0.04	0.04	0.12	0.12	0.12	0.04	0.04	0.04
NO_3–N (mg/l)	0.34	0.34	0.34	0.24	0.24	0.24	0.34	0.33	0.33
Total phosphorus (mg/l)	0.10	0.10	0.10	0.09	0.09	0.09	0.09	0.09	0.09
GPP (mg C/cm^3/h)	0.36	0.36	0.36	0.55	0.55	0.55	0.31	0.31	0.31
NPP (mg C/cm^3/h)	0.16	0.15	0.15	0.31	0.31	0.31	0.10	0.10	0.10
Dissolved oxygen (mg/l)	11.60	11.50	11.55	10.00	9.80	9.90	12.60	12.50	12.55
Total coliforms (CFU/ml)	69	68.00	68.50	48	55.00	51.50	52	56.00	54.00

Ambient Air Quality

Concentration of PM_{10} and $PM_{2.5}$: PM_{10} concentration at proposed Tawang–II HEP was found ranging from a minimum of 23.5 µg/m^3 at Lumla to a maximum of 33.8 µg/m^3 at Khet bridge. Likewise, $PM_{2.5}$ concentration ranged from a minimum of 25.9 µg/m^3 at Khet bridge to a maximum of 32.2 µg/m^3 at Tawang (Table II. 3.487). The concentration of sulphur-dioxide (SO_2), nitrogen-dioxide (NO_2), ammonia (NH_3) and ground level ozone (O_3) at all the monitored locations were below detectable limits.

Table II. 3.487: Concentration of PM_{10} and $PM_{2.5}$ in air at proposed Tawang–II HEP

Sampling location	Nearest project sites covered	PM_{10} (µg/m^3)	$PM_{2.5}$ (µg/m^3)
Khet Bridge	Tawang–II barrage site	33.8	25.9
Tawang	Tawang–II barrage site	32.9	32.2
Lumla	Tawang–II powerhouse site	23.5	26.9

Ambient air temperature at proposed Tawang–II HEP ranged from a minimum of 3°C at Tawang to a maximum of 12°C at Khet Bridge. Relative humidity ranged between 29% at Lumla to 41% at Khet Bridge. Wind speed was minimum (2.8 km/hr) at Tawang maximum (4.2 km/hr) at Khet bridge. Wind direction varied from NW to SE direction (Table II. 3.488).

Table II. 3.488: Meteorological condition at proposed Tawang–II HEP

Sampling location	Nearest project component covered	Ambient temperature (°C) Min Max	Relative humidity (%)	Wind speed (range in km/hr)	Wind direction
Khet bridge	Tawang–II barrage site	07 12	41	3.6–4.2	NW
Tawang	Tawang–II barrage site	03 07	31	2.8–3.4	NW
Lumla	Tawang–II powerhouse site	08 11	29	3.4–4.1	SE

Noise Level: Noise levels at proposed Tawang–II HEP at 4.00 PM ranged between 24.1 dBA at Lumla and 61.2 dBA at Khet bridge (Table II. 3.489).

Table II. 3.489: Noise level at proposed Tawang–II HEP

Sampling location	Nearest project sites covered	Noise level (dBA) 8.00 AM	Noise level (dBA) 4.00 PM
Khet bridge	Tawang–II barrage site	58.4	61.2
Tawang	Tawang–II barrage site	39.1	41.2
Lumla	Tawang–II powerhouse site	26.2	24.1

3.3.10.2 BIOLOGICAL ENVIRONMENT

Vegetation Types

The project components of Tawang-II HEP are located in montane sub-tropical forest and temperate forest area.

8/B/CI East Himalayan sub-tropical wet hill forest (1000-1800 m): These forests occur in and around 1000 m and extend up to 1800 m elevations. The canopy is comprised of: *Alnus nepalensis, Macaranga denticulata, Castanea sativa, Engelhardtia spicata, Erythrina arborescens, Quercus glauca, Rhus succedanea, Schima wallichii*, *Ficus auriculata, Myrica esculenta*, etc. Medium sized evergreen tree species such as by: *Ficus semicordata,* *Lophopetalum wightianum, Lyonia ovalifolia, Rhus chinensis, Saurauia punduana, Tetracentron sinense, Phyllanthus emblica*, *Rhus javanica, Torricellia tiliifolia* etc., constituted sub-canopy layer. Understory consisted of shrubs such as: *Artimisia nilagarica, Coriaria nepalensis, Elaeagnus parvifolia, Rubus ellipticus, Maesa indica* etc. and climbers. Epiphytes were abundant in the forest.

9CI Himalayan sub-tropical pine forest (1200-1800 m): These forests do not appear in the Champion and Seth classification. However, they occur in and around 1200 m and extend up to 1800 m elevations mostly repalcing the broad-leaved forests following disturbances. The canopy is comprised of *Pinus wallichiana*. However, remnants of broad-leaved forest elements with: *Mallotus philippensis, Pyrus pashia, Albizzia arunachalensis, Prunus cerasoides, Purus* sp., are quite conspicuous. Shrubs were represented by: *Artimisia nilagirica, Coriaria nepalensis, Elaeagnus parvifolia, Rosa* sp., *Rubus ellipticus, Butea buteiformis* and *Viburnum erubescens*. The herbaceous layer constitutes of Climber and epiphytes are not common.

11B/CI East Himalayan wet temperate forest (2000-3000 m): These are mixed evergreen forests with moderate size trees occurring between 1800 and 3000 m altitude. In these forests important tree associates are: *Acer campbellii, Lithocarpus pachyphylla, Prunus cerasoides, Quercus serrata, Rhododendron arboreum, Schima wallichii* and *Tetracentron sinense*. Shrubs are represented by: *Berberis asiatica, Coriaria nepalensis, Elaeagnus parvifolia, Rosa brunonii, Rubus ellipticus* and *Viburnum erubescens*. Climber and epiphytes are not common.

12/C3a East Himalayan mixed coniferous forests (2000-3500 m): These are dense evergreen forests with dominance of oak and rhododendrons. In the upper ridges between 2300-3500 m elevations, silver fir (*Abies densa*) makes appearance as a dominant tree species. With the oak are mixed deciduous trees such as: *Magnolia* sp., *Acer* sp., *Betula alnoides, Alnus nepalensis*, and others to a varying extent. There is usually gregarius undergrowth, usually of bamboo, and in its absence Rhododendron species and other evergreen shrubs such as: *Berberis* sp., *Cotoneaster* sp., *Rhododendron* sp., *Salix* sp., *Thamnocalamus* sp. and *Viburnum* sp. These are laden with many epiphytic mosses and lichens.

12/ISI Alder forest (1800-2200 m): Typically seen as pure stand of *Alnus nepalensis, Populus ciliata*, 20-30 m high, as a strip of varying width along stream sides, spreading out to larger areas, more or less deciduous. In the lower course of the stream where the fringe of Alder is the only remaining tree growth owing to cultivation, there is often an under growth of inedible or thorny shrubs comprising *Berberis, Rubus, Princepia* etc, whilst in the better wooded tracts progression starts early and other species, notably blue pine and other conifers, are usually present.

12/1S2 Riverine blue-pine forest (1800-3000 m): Irregular, often dense stands of *Pinus wallichiana* with occasional *Picea*, *Tsuga, Populus* and *Alnus* with little or no undergrowth at first, but often becoming more open with inedible or thorny shrubs, if grazed.

Plant Diversity

The survey at Rho HEP sites resulted in the documentation of 162 plant species belonging to different groups at the barrage site, powerhouse site and catchment area. A complete list of plant species found in the study area representing different groups such as tree, shrub, herb, climber, orchid, pteridophyte, bryophyte, lichen and fungi along with names is given is presented in Appendix II. 3.117. The number of plant species belonging to different groups is summarized in Table II. 3.490

Table II. 3.490: Plants belonging to different groups recorded from the Tawang-II HEP site

Sl. No.	Plant groups	Number of species		
		Barrage site	Powerhouse site	Catchment area
1	Tree	12	4	13
2	Shrub	19	13	21
3	Herb	40	34	39
4	Climber	13		8
5	Orchid	5		3
6	Pteridophyte	18		13
7	Bryophyte	7		6
8	Lichen	9		8
9	Fungi	12	13	11

At the barrage site,12 tree, 19 shrub, and 40 herb species were recorded and at the powerhouse site 4 tree, 13 shrub, and 34 herb species were recorded. From the catchment area, 13 tree, 21 shrub and 39 herb species were recorded. A total of 13 climber, 5 orchid, 18 pteridophyte,7 bryophyte, 9 lichen and 12 fungus species were recorded from barrage and powerhouse site, whereas from the catchment area 8 climber, 3 orchid, 13 pteridophyte, 6 bryophyte, 8 lichen and 11 fungus species were recorded (Appendix II. 3.118 and 3.119).

Threatened and Endemic Plants

Two endemic species were recorded from the project sites (Table II. 3.491).

Table II. 3.491: Threatened/endemic plants recorded at Tawang-II HEP sites

Species name	Family	Threat status	References
Albizia arunachalensis	Mimosaceae	Endm	
Torricellia tiliifolia	Torricelliaceae	Endm	

Endm= Endemic

Economically Important Species/Plant Resources

The study area is rich in plant resources. A few of the important ones listed in Table II. 3.492 under different groups.

Table II. 3.492: Economically important species/plant resources present at Tawang-II HEP site

Sl. No.	Uses	Species name
1	Timber	*Pinus wallichiana*
2	Fuel	*Quercus griffithii, Q. semicarpifolia, Alnus nepalensis, Rhododendron* sp.,
3	Ornamentals and orchids	*Rhododendron* sp., *Luculia pinceana, Buddleja asiatica*
4	Medicine and aromatics	*Rubia cordifolia, Embelica officinalis, Acorus* sp.
5	Fodder	*Alnus nepalensis, Saurauia nepalensis, Ficus* sp., *Quercus griffithii*
6	Edible	*Prunus* sp, *Rubus ellipticus, Juglans regia, Benthamidia capitata, Elaeagnus* sp., *Embelica officinalis*
7	Fibre and paper	*Daphne papyracea, Sterculia* sp.
8	Bamboos	*Arundinaria* sp., *Phyllostachys* sp.
9	Resins and gums	*Pinus wallichiana*

Vegetation Analysis for Angiosperms and Gymnosperms

The plant community in the barrage, powerhouse and catchment area were studied. At the sites species richness was high. It had 17 tree species, 22 shrub species and 29 herbaceous species (Tables II. 3.493 and 3.494).

Table II. 3.493: Tree and shrub species present near barrage and powerhouse sites in the catchment areas in Tawang-II project

Tree species	Shrub species
Alangium chinensis	*Ardesia crenata*
Albizzia arunachalesis	*Artemesa nelagarica*
Alnus nepalensis	*Boehmeria macrophylla*
Brassaiopsis glomerulata	*Buddlejea asiatica*
Cyathea sp.	*Butea buteformis*
Embelica officinalis	*Coriaria nepalensis*
Ficus auriculata	*Cyathula tomentosa*

Macaranga denticulata	*Debregeasia longifolia*
Merillopanax alpines	*Desmodium* sp.
Pinus wallichiana	*Dobinia vulgaris*
Quercus griffithi	*Elaegnus* sp.
Rhus chinensis	*Flemingia macrophylla*
Saurauia napaulensis	*Girardiana* sp.
Schima wallichi	*Hydrangea* sp.
Toriecellia tilifolia	*Indigofera* sp.
Viburnum foetidum	*Maesea indica*
Wendlandia sp.	*Mussaenda* sp.
	Rubus ellipticus
	Rubus rugosus
	Solanum khasianum
	Urena lobata
	Woodfurdia fructicosa

Table II. 3.494: Herbaceous species present near barrage and powerhouse sites and in the catchment areas at Tawang-II

Herb species		
Achyranthes aspera	*Eupatorium adenophorum*	*Persicaria chinensis*
Ageratum conizoides	*Euphorbia hirta*	*Pimpinella diversifolia*
Anaphalis margrateata	*Fagopyrum esculenta*	*Piper pedicellata*
Bidens pilosa	*Frageria nubicola*	*Plantago major*
Canabis sativus	*Galinsuga parviflora*	*Seigesbeckia orientalis*
Crassocephalum crepidioides	*Geranium* sp.	*Urtica dioca*
Cyanoglossum sp.	*Hydrocotyle nepalensis*	*Verbescum thapsus*
Cymbopogon citratus	*Impatiens* sp.	*Veronia* sp.
Drymaria cordata	*Oxalis corniculata*	*Xanthium sumatranium*
Equisetum diffusum	*Persicaria capitata*	

In general, species richness was high during monsoon season and low during winter season. Alnus *nepalensis* was dominant at barrage site and catchment area, and at the powerhouse site *Embelica officinalis* was the dominant species. Among shrubs, *Artemisia nilagarica* was dominant in all three sites. *Drymaria cordata* was abundant in the barrage site and catchment area, while *Cymbopogon citratus* and *Cannabis sativus* were abundant in the powerhouse site in all three seasons (Appendix II. 3.130).

Highest tree density was recorded in the catchment area, and lowest at powerhouse site. Shrub density was maximum at barrage site and minimum in catchment area (Table II. 3.495). Density of herbaceous species was high at barrage site followed by catchment area and powerhouse site. Density of herbaceous species varied widely among barrage site, powerhouse site, and catchment area (Appendix II. 3.180- 3.188).

Shannon diversity index for tree species was highest in the catchment area (2.67) and followed in decreasing order by barrage site (2.33) and powerhouse site (1.33). For shrub species, highest value (2.75) was obtained in the powerhouse site (Table II. 3.495).

Shannon diversity index for herbs ranged from 2.61- 3.45. The highest diversity was recorded from barrage site during monsoon season and lowest value was recorded from the catchment area during winter season. Overall, species diversity was highest in the catchment area.

Table II. 3.495: Species richness, diversity and dominance of trees and shrubs, and biomass and carbon stock of trees in the community at Tawang-II project site

Parameters	Barrage		Powerhouse		Catchment areas	
	Trees	Shrubs	Trees	Shrubs	Trees	Shrubs
Number of species	12	19	4	22	13	19
Density (ha^{-1})	1572	13040	344	12496	1744	12080
Simpson index of dominance	0.15	0.92	0.28	0.91	0.13	0.92
Shannon index of diversity (H')	2.13	2.67	1.33	2.75	2.28	2.67
Evenness index	0.86	0.76	0.96	0.71	0.89	0.76
Biomass (t/ha)	98.02		33.56			
Carbon (t /ha)	49.01		16.78			

Table II. 3.496: Species richness, diversity and dominance of herbaceous species at Tawang-II project site

Parameters	Barrage			Powerhouse			Catchment areas		
	PM	M	W	PM	M	W	PM	M	W
Number of species	29	40	18	20	33	17	26	38	20
Density (ha $^{-1}$)x10^3	264	535	163	167	386	138	275	562	143
Simpson index of dominance	0.95	0.97	0.93	0.92	0.95	0.91	0.95	0.97	0.94
Shannon index of diversity (H')	3.14	3.56	2.75	2.78	3.25	2.61	3.11	3.53	2.85
Evenness index	0.80	0.88	0.87	0.81	0.78	0.80	0.86	0.90	0.86

PM: Post monsoon; M: Monsoon; W: Winter

Phytoplankton/Periphyton

Fourteen species of phytoplankton/periphyton were recorded from Tawang-II HEP site. The phytoplankton/periphyton community was represented by 12 species of Bacillariophyceae and two species of Cyanobacteria. Species richness was highest in the project affected area with 11 species and minimum with 5 species at the catchment area. Phytoplankton/periphyton density was highest at project affected area (120 individuals/l) and lowest at the catchment area (115individuals/l). Similarly, species diversity index was maximum (H'= 2.05) at the project affected area and minimum (H'= 1.87) at the catchment area (Table II. 3.497).

Table II. 3.497: Density (Individuals/l), species richness and Shannon index of diversity (H') of phytoplankton community in river water at project affected area and catchment area of Tawang-II HEP sites

List of species	Project affected area	Catchment area
Bacillariophyceae		
Achnanthes biporoma	10	
Calothrix sp.		5
Cymbella delicatula		15
Diatoma sp.	10	
Encyonema minutum	30	30
Eunotia exuca		30
Fragillaria vauchaeriae	5	
Gomphonema olivaceoides	5	10
Navicula cryptocephala		10
Navicula cryptotenella	5	
Nitzchia palea	30	10
Rhoicosp.haenia sp.	10	
Cyanobacteria		
Microsp.ora sp.	5	
Sp.*irogyra* sp.	10	5
Total density (Individuals/lit)	**120**	**115**
Species diversity index	**2.05**	**1.87**
Species richness	**10**	**8**

NB: Blank cells indicate absence of Periphyton species

Zooplankton

Study on zooplankton diversity was conducted during monsson and winter seasons,in which only 1 species belonging to viz., Cladocera (*Moina micrura)* and five species from Rotifera were recorded during post-monsoon season (Table II. 3.498)., A rare zooplankton, *Testudinella emarginula* was recorded from the barrage site.

Table II. 3.498: Occurrence of species belonging to Cladocera and Rotifera during monsoon and winter seasons at Tawang-II site

Sl. No.	Taxa	Species	Season	
			Monsoon	Winter
1	Rotifera	*Brachionus quadridentatus* (Hermann, 1783)	–	+
2	Rotifera	*Epiphanes brachionus spinosa* (Rousselet, 1901)	–	+
3	Rotifera	*Lecane papuana* (Murray, 1913)	–	+
4	Rotifera	*Lepadella ovalis* (O.F. Muller, 1786)	–	+
5	Cladocera	*Moina micrura* (Kurz, 1874)	–	+
6	Rotifera	*Testudinella emarginula* (Stenroos, 1898) *	–	+
Total	**2**	**6**	**0**	**6**

*Rare

Fish Fauna

Ten fish species were recorded at Tawang-II HEP site Table II. 3.499.

Table II. 3.499: Fish fauna present and their habitat requirements in Tawang-II HEP area

Family	Species name	Max Length (cm)	Water Depth required (m)	Width of water flow required (m)	Altitude	Substrate
Cyprinidae	*Schizothorax richardsonii*	60.0	2-6	4-5	High and mid	Rocky
	Schizothorax progastus	50.0	1-3	3-4	High and mid	rocky
Cobitidae	*Syncrossus berdmorei*	11.0	0.5-3	1-2	Mid and low	sandy and gravel
	Botia rostrata	20.0	0.5-4	2-3	Mid	Rocky
Bagridae	*Mystus vittatus*	21.0	0.5-4	2-3	Mid and low	Sandy, rocky
Sisoridae	*Erethistoides montana*	4.8	0.5-3	1-2	Mid and low	Gravel
	Euchiloglanis hodgarti	6.5	1-4	1-2	Mid and low	Sandy, rocky
	Exostoma berdmorei	10	2-5	2-3	Mid and low	large rocks
	Gagata cenia	15.0	2-4	2-4	Mid and low	sandy/muddy bottom
	Pseudechneis sulcatus	20.0	2-7	2-4	High, mid and low	gravel, cobble substrate

Soil Fauna

The seasonal variation in soil faunal diversity (Collembola, Acarina and other arthropods) and eveness in litter and soil layer is shown in Tables II. 3.500-3.502.

Table II. 3.500: Seasonal variation in soil faunal diversity (Collembola, Acarina and other arthropods) and equitability in litter and soil layer at Tawang-II site

Soil fauna	Diversity	Post monsoon				Monsoon				Winter			
		Barrage		Powerhouse		Barrage		Powerhouse		Barrage		Powerhouse	
		Litter	Soil	Litter	Soil	Litter	Soil	Litter	Soil	Litter	Soil	Litter	Soil
Collembola	Dominance_D	0.11	0.12	0.15	0.12	0.14	0.16	0.17	0.14	0.12	0.16	1.00	0.56
	Shannon_H	2.31	2.16	1.99	2.22	2.07	1.97	1.84	2.12	2.14	1.89	0.00	0.64
	Evenness_e^H/S	0.91	0.96	0.92	0.92	0.88	0.90	0.90	0.84	0.95	0.95	1.00	0.94
Acarina	Dominance_D	0.10	0.14	0.56	0.36	0.19	0.13	0.23	0.21	0.20	0.22	1.00	0.50
	Shannon_H	2.34	2.02	0.64	1.06	1.73	2.05	1.51	1.58	1.61	1.56	0.00	0.69
	Evenness_e^H/S	0.94	0.94	0.94	0.96	0.94	0.97	0.91	0.97	1.00	0.95	1.00	1.00
Other Arthropods	Dominance_D	0.11	0.12	0.15	0.12	0.14	0.16	0.17	0.14	0.12	0.16	1.00	0.56
	Shannon_H	2.31	2.16	1.99	2.22	2.07	1.97	1.84	2.12	2.14	1.89	0.00	0.64
	Evenness_e^H/S	0.91	0.96	0.92	0.92	0.88	0.90	0.90	0.84	0.95	0.95	1.00	0.94

Table II. 3.501: Mean annual density (number/m^2) of soil fauna in litter and soil layers (0-5 cm) at Tawang-II project site

Soil fauna	Site	Litter layer	Soil layer	Total
Collembola	Barrage	1527	1309	**2836**
	Powerhouse	1418	982	**2400**
Acarina	Barrage	1200	971	**2171**
	Powerhouse	600	457	**1057**
Other Arthropods	Barrage	2218	1636	**3855**
	Powerhouse	1018	1600	**2618**
Total fauna	Barrage	4945	3916	**8862**
	Powerhouse	3036	3039	**6075**

Table II. 3.502: Seasonal variation of soil fauna density (number/m^2) at barrage and powerhouse sites of Tawang-II project

Soil fauna	Site	Post monsoon	Monsoon	Winter	Mean
Collembola	Barrage	13200	12000	6000	**10400**
	Powerhouse	4800	18800	2800	**8800**
Acarina	Barrage	13200	12000	5200	**10133**
	Powerhouse	3200	10400	1200	**4933**
Other arthropods	Barrage	18800	13600	10000	**14133**
	Powerhouse	12800	14400	1600	**9600**

Wildlife

Butterflies: Twenty two species of butterflies belonging to 19 genera and five families were recorded in Tawang-II HEP area. Pieridae and Nymphalidae dominated the sites with nine species each. None of these species belonged to threatened category (Table II. 3.503).

Table II. 3.503: Butterflies recorded in Tawang-II HEP area

Sl. No.	Family common name	Scientific name	Project area
I.	**Hesperiidae**		
1	Lucas' Ace	*Sovia lucasii magna*	*
II.	**Papilionidae**		
2	Common Bluebottle	*Graphium sarpedon sarpedon*	*
3	Indian Purple Emperor	*Mimathyma ambica*	*
III.	**Pieridae**		
4	Spotless Grass Yellow	*Eurema laeta*	*
5	Small Grass Yellow	*Eurema brigitta rubella*	*
6	Indian Cabbage White	*Pieris canidia indica*	*
7	Green-veined White	*Pieris napi montana*	*
8	Green vein White	*Pieris melete*	*
9	Plain Sulphur	*Dercas lycorias*	*
10	Spotted Sawtooth	*Prioneris thestylis thestylis*	*
IV.	**Lycaenidae**		
11	Pale Hedgeblue	*Udara dilecta*	*
12	Large Hedgeblue	*Celastrina hugeli oreana*	*
13	Common Flash	*Rapala nissa ratna*	*
14	Common Hedgeblue	*Acytolepis pusp.a gisca*	*
15	Punchinello	*Zemeros flegyas indicus*	*
V.	**Nymphalidae**		
16	Large Threering	*Ypthima nareda*	*
17	Large Silverstripe	*Argynnis children*	*
18	Glassy Tiger	*Graphium cloanthus*	*
19	Indian Tortoiseshell	*Aglais caschmirensis*	*
20	Chocolate Pansy	*Junonia iphita iphita*	*
21	Banded Treebrown	*Lethe confusa*	*
22	Straight-banded Treebrown	*Lethe verma*	*

Herpetofauna: No herpetofauna was encountered in Rho project area during field survey. The probable list of amphibians and reptiles for this site was prepared following Ahmed *et al.* (2009 (Appendix II. 3.167).

Birds: The assessment of bird diversity was carried out during monsoon and winter seasons in and around this project area which revealed the presence of 136 birds species belonging to 83 genera and 37 families. The Shannon diversity (H') value of 4.3 indicates a moderate level of species diversity. When seasonal status was compared, richness was highest during winter (93 species) and lowest during monsoon (54 species). (Table II. 3.504 and Appendix II. 3.199). The abundance of birds (901 birds) was higher in winter season.

Migratory status: The migratory and resident status of these bird species showed that most of the birds were residents (94 species) followed by 21 breeding visitors and 17 winter visitors (Table II. 3.504).

Table II. 3.504: Status of birds recorded in Tawang-II HEP area

Details	Post monsoon	Monsoon	Winter	Overall
Family	25	24	31	37
Genera	44	40	61	83
Species	56	54	93	136
Abundance	853	313	901	2067
Diversity H'	3.8	3.7	3.8	4.3
Migratory status				
Breeding visitor	6	9	14	21
Isolated record	1	0	2	1
Resident	39	35	67	97
Winter visitor	4	10	10	17

Abundance status: The abundance status of birds was derived by classifying the abundance of bird species into five abundance category (Very Low = 1-25 birds, Low = 26-50, Moderate = 51-75, High = 76-100 and Very High = > 100birds). The details of abundance status are given in the Table II. 3.505.

Table II. 3.505: Number of species and relative % of birds in different abundance classes

Abundance class	No. of species	Relative %
Very Low -1 -25 birds	113	83.1
Low -26 -50 birds	16	11.8
Moderate -50 -75 birds	4	2.9
High -76-100 birds	1	0.7
Very high > 100 birds	2	1.5
Total	**136**	**100.0**

Status of foraging guilds: In Tawang-II HEP site, eight different foraging guilds were present, among which insectivore were predominant with 86 species followed by 17 species of omnivores and with 11 species each of carnivores and granivores (Table II. 3.506 and Appendix II. 3.199). This analysis also indicated low diversity of birds in the area. Record of more number of carnivores, which includes the birds of prey or raptors that feed on other animals and scavenge on dead animals shows the availability of habitat for this group of birds in addition to showing the significance of this area as it harbours the species that are at the top of the food web. The dominance of insectivores exhibits the importance and diverse nature of this site for this natural pest / insect controllers.

Table II. 3.506: Status of foraging guild of birds recorded in Tawang-II HEP area

Foraging guild	Post monsoon	Monsoon	Winter	Overall
Aquatic Feeder	1	0	0	1
Carnivore	1	2	9	11
Frugivore	2	1	3	4
Granivore	6	5	8	11
Insectivore	32	36	60	86
Nectarivore	2	2	3	5
Nucivore	1	0	1	1
Omnivore	11	8	9	17
Piscivore	0	0	0	0

Status of threatened species: The assessment of conservation status of birds in this project area showed that there was no threatened bird species (Appendix II. 3.199).

Mammals: Three surveys in and around the Tawang-II project site revealed the presence of 12 mammalian fauna, and each belonging to separate genus and family, which consists of four groups viz., primate, ungulates, carnivores and rodents (Appendix II. 3.200).

Abundance status: Among the 12 species, presence of all 12 species in the project area was confirmed based on sighting of 70 animals and 45 indirect evidences. Among these, five species were sighted and the rest were recorded based on indirect evidence. Record of 12 species was based on 45 indirect evidences and a total of 70 animals enumerated by direct sighting showed that the project area supports moderate level of species richness. Further evaluation of species richness of the project area (12 species) with the possible species (28 species) of the Tawang district (Mishra *et al.* 2006) also revealed the low species richness, as the species recorded in the project area formed only 41.37 % (Appendix II. 3.200).

Status of threatened species: In this project area out of four reported as threatened species (Arunachal Macaque, Capped Langur and Dhole) three fall under Endangered (EN) and one under vulnerable category; and rest eight species under Least Concern (LC) as per IUCN and schedule I and II of WPA (Table II. 3.507).

Table II. 3.507: Status of mammalian fauna reported in the Tawang-II HEP area

Sl. No.	Common name	Scientific name	Seasons			Overall	Conservation status	
			PM	M	W		IUCN	WPA
I.	**Cercopithecidae**							
1	Arunachal Macaque	*Macaca munzala*	IE 3	IE 3 A15	IE 1 A 35	IE 7 A 50	EN	-
2	Capped Langur	*Trachypithecus pileatus*	IE 1 A 13	IE 1		IE 2 A 13	EN	I
II.	**Cervidae**							
3	Barking Deer	*Muntiacus muntjak*	IE 4	IE 2		IE 6	LC	III
III.	**Suidae**							
4	Wild pig	*Sus scrofa*	IE 3		IE 5	IE8	LC	III
IV.	**Ursidae**							
5	Himalayan Black Bear	*Ursus thibetanus*	IE 2			IE 2	VU	II
V.	**Canidae**							
6	Dhole	*Cuon alpines*			IE 1	IE 1	EN	II
VI.	**Felidae**							
7	Jungle cat	*Felis chaus*	IE 3	IE 2	IE 9	IE 14	LC	II
8	Leopard Cat	*Prionailurus bengalensis*	IE 1		IE 1		LC	-
VII.	**Mustelidae**							
9	Yellow Throated Martin	*Martes flavigula*	A 2			A 2	LC	II
VIII.	**Viverridae**							
10	Himalayan Palm Civet	*Paguma larvata*	IE 3	IE 1		IE 4	LC	II
IX.	**Sciuridae**							
11	Hoary-bellied Himalayan Squirrel	*Callosciurus pygerythrus*	A1	A 2		A 3	LC	NE
12	Himalayan Stripped Squirrel	*Tamipos macclellandi*		A 2		A 2	LC	NE
	No of species		**10**	**7**	**5**	**12**		
	Total and types of records		**IE 20 A 16**	**IE 8 A 19**	**IE 17 A35**	**IE 45 A 70**		

IE – Indirect Evidences A-animals sighted, W-Winter, PM-Post monsoon, M-Monsoon, IUCN-Red List, WPA-Wildlife Protection Act, EN-Endangered, Vu-Vulnerable, LC-Least Concern, NE – Not Evaluated

Faunal status within 500 m of project affected area: This section revealed species richness status of selected faunal groups such as avifauna and mammal species reported within 500m up and down streams of the barrage and powerhouse site of the proposed project site. The species richness reported in those specific sites was evaluated based on subject rating by estimating percent contribution with the overall species list of the project area. If the species richness of barrage and powerhouse list contributes 25% of overall list, categorised as low, > 25-50% as medium, >50-75% as high and above 75% as high species richness.

Status of avifauna: At Tawang-II barrage site, birds species richness with 25 species, may be designated as low species richness area, when compared with the overall list of 134 species reported for the entire project area (18.38%) (Appendix II. 3.201 and 3.202). The Tawang-II powerhouse site with 16 species, may be designated as low species richness area, when compared with the overall list of 134 species reported for the entire project area (11.76%). No threatened species were recorded in Tawang-II HEP sites.

Status of mammals: Site specific evaluation of mammalian fauna within 500 m of up and down streams showed occurrence of only four species in the barrage site. The species were recorded based on indirect evidences. In powerhouse area, only two species were reported based on four indirect evidences. Only Arunachal Macaques, falls under endangered species listed by IUCN. The rest are categorised under LC (IUCN) and schedule II and III (WPA, 1972) (Table II. 3.508).

Table II. 3.508: Status of mammalian fauna at barrage and powerhouse sites of the proposed Tawang-II HEP site

Common name	Species name	Status		Conservation status	
		BS	PHS	IUCN	WPA
Arunachal Macaque	*Macaca munzala*		IE 2	**EN**	-
Barking Deer	*Muntiacus muntjak*	IE1		LC	III
Wild pig	*Sus scrofa*	IE 2		LC	III
Jungle cat	*Felis chaus*	IE2		LC	II
Himalayan Palm Civet	*Paguma larvata*	IE 2	IE 2	LC	II
Total no. of species		**4**	**2**		
Total no. of record		**IE 7**	**IE 4**		

IE – Indirect Evidences, A – No of Animals Sighted, BS –Barrage Site, PHS – Powerhouse Site, IUCN-Red List, WPA-Wildlife Protection Act, LC-Least Concern, EN – Endangered

3.3.10.3 SOCIO–ECONOMIC PROFILE

Information on names of the villages that will get directly affected as well as names of the villages falling in 10 km radius of the project were available, therefore these two categories of villages have been described separately. Further, the results of baseline survey have been described separately for data gathered at the village and HH level.

Village Level Survey–Affected

Profile of the Seven Surveyed Villages: The seven villages fall under two administrative circles of Lumla and Tawang (Table II. 3.509). All villages are situated within a distance of 10 km from the river. The circle headquarters of six villages are within 17 km except Kudung, which is situated at a distance of 28 km from Circle HQ. All studied village are situated within 53 km from the district head quarters.

Table II. 3.509: Profile of the twelve surveyed villages

Sl. No.	Village	Circle	Distance of village (in km)		
			River/Tributary	Circle HQ	District HQ
1	Dugumba	Lumla	5	5.7	52
2	Hoongla	Lumla	4	4	49
3	Kudung	Tawang	2.5	28	28
4	Lumla	Lumla	10	4	50
5	Poito	Lumla	7	8	53
6	Sazo	Lumla	7	7	52
7	Thrillam	Lumla	4	17	30

Private Land Use Pattern: The details of private land holding (in hectares) of the seven villages are given in the Table II. 3.510. The total private land holdings in the studied villages are about 159.14 ha. Three villages, viz., Lumla, Hoongla and Sazo contribute 68% to the total land holdings in studied villages. In all the villages, the proportion of agricultural land exceeds that of the other land use types; except in case of Kudung village where forest land exceeds that of agricultural land. Private forest land (14%) and habitation and home garden land (15%) also contribute significantly to the total land holdings of the villages.

Table II. 3.510: Private land use pattern and their percentage to total private land

Sl. No.	Name of village	Total private land	Forest cover (ha)	%	Agriculture (ha)	%	Horticulture (ha)	%	Habitation and HG (ha)	%
1	Dugumba	15.30	4.54	30	8.03	53	1.40	53	1.31	9
2	Hoongla	31.43	0.00	0	27.11	86	0.00	86	4.32	14
3	Kudung	21.45	7.59	35	7.28	34	0.00	0.0	6.58	31
4	Lumla	50.64	9.61	19	32.78	65	0.40	1.0	7.84	15
5	Poito	5.90	0.00	0.0	5.65	96	0.00	96	0.25	4
6	Sazo	26.25	0.00	0.0	22.26	85	0.00	85	3.99	15
7	Thrillam	8.17	0.00	0.0	7.89	97	0.00	0.0	0.28	3
	Total	**159.14**	**21.74**	**84**	**111**	**516**	**1.8**	**321**	**24.57**	**91**

HG = Home–gardens

Demography and Literacy Rate: From Table II. 3.511, the following main features emerge. The total number of HHs in the seven villages is 263 (number varies from 15 in Dugumba to 57 in Lumla). The total population is 1387 (691 males; 696 females). In four villages, the number of females is less than that of the males. The literacy rate ranged from 20% in Dugumba to 62.8% in Thrillam. Among males the rate varies from 17.1% in Dugumba to 70.0% in Thrillam and in females it varies from 17.5% in Hoongla to 56.6% in Thrillam.

Table II. 3.511: Demography and literacy rate

Sl. No.	Village	Demography					Literacy rate*		
		Total	Male	Female	Sex ratio (Per 1000 males)	No. of HH	Male	Female	Total
1	Dugumba	65	34	31	912	15	17.1	22.4	**20.0**
2	Hoongla	229	120	109	908	56	26.0	17.5	**22.0**
3	Kudung	174	86	88	1023	33	NA	NA	**NA**
4	Lumla	242	117	125	1068	57	60.5	46.2	**52.7**
5	Poito	81	41	40	976	22	NA	NA	**NA**
6	Sazo	213	115	98	852	45	26.0	18.3	**22.4**
7	Thrillam	383	178	205	1152	35	70.0	56.6	**62.8**
	Total	**1387**	**691**	**696**		**263**			

NA = Data not available

Number of Livestock: The data presented in the Table II. 3.512, reveals that eight different types of animals are reared in surveyed villages. In none of the villages all the eight animal types were domesticated. In total, 561 animals are reared in the seven villages. Considerable inter–village variation is observed in total number of animals reared. It varied from 8 in Thrillam to 177 in Lumla. Kudung, Lumla and Sazo account for 72% of all the animals found in the surveyed villages. Three animals, viz., cattle (39%), Goat (23%) and other animals (10%) account for 72% of the total animals (561). It is highly noteworthy that in none of the studied villages Yak has been reared.

Table II. 3.512: Number of livestock

Sl. No.	Village	Mithun	Cattle	Goat	Sheep	Pig	Pony	Poultry	Others	Total
1	Dugumba	9	3	18	0	3	0	12	0	**45**
2	Hoongla	1	27	23	3	6	7	0	13	**80**
3	Kudung	0	118	12	3	0	2	0	0	**135**
4	Lumla	7	49	37	2	13	40	29	0	**177**
5	Poito	0	19	5	0	0	0	0	0	**24**
6	Sazo	0	1	34	0	16	0	0	41	**92**
7	Thrillam	0	3	0	5	0	0	0	0	**8**
	Total	**17**	**220**	**129**	**13**	**38**	**49**	**41**	**54**	**561**

Total Estimated Value of Livestock: The monetary value of domesticated animals maintained by the inhabitants of the studied villages has been estimated separately for each animal and for each village (Table II. 3.513). The detailed methodology used in estimating the monetary value of animals has been described in the Methodology section of the present report. As expected, there is considerable intra and inter village variation in this respect. The total value of animals numbering 561 found in the seven villages has been estimated as 98.11 lakhs. The value varied from 1.05 lakhs in Thrillam to 30.74 lakhs in Kudung. In terms of relative contribution made by different animals to the total value, cattle alone contribute over 55 lakhs (56%).

Table II. 3.513: Total estimated value of livestock

Sl. No.	Village	Total estimated value (Rupees in lakh)								
		Mithun	Cattle	Goat	Sheep	Pig	Pony	Poultry	Others	Total
1	Dugumba	3.60	0.75	0.90	0.00	0.75	0.00	0.06	0.00	**6.06**
2	Hoongla	0.40	6.75	1.15	0.18	1.50	1.61	0.00	1.95	**13.54**
3	Kudung	0.00	29.50	0.60	0.18	0.00	0.46	0.00	0.00	**30.74**
4	Lumla	2.80	12.25	1.85	0.12	3.25	9.20	0.15	0.00	**29.62**
5	Poito	0.00	4.75	0.25	0.00	0.00	0.00	0.00	0.00	**5.00**
6	Sazo	0.00	0.25	1.70	0.00	4.00	0.00	0.00	6.15	**12.10**
7	Thrillam	0.00	0.75	0.00	0.30	0.00	0.00	0.00	0.00	**1.05**
	Total	**6.8**	**55**	**6.45**	**0.78**	**9.5**	**11.27**	**0.21**	**8.1**	**98.11**

Average Annual Earnings of the Village: The value of total earnings per year in the seven villages is estimated 384.98 lakhs (Table II. 3.514). Average annual family income varies from 0.79 in lakhs in Thrillam to 2.35 lakhs in Dugumba. The contribution made by different occupation to the total earnings shows considerable variation between the villages. For example, the contribution made by animal husbandry is maximum in four villages, while wage labour in another three villages. Across the surveyed villages the contribution of animal husbandry is 31% and Daily wages contribute 27%. It is highly noteworthy that agriculture contributes only 14% of the total annual village earnings.

Table II. 3.514: Average annual earning of the village

Sl. No.	Village	Total earning/year (Rupees in lakh)								Average family income (Rupees in lakh)
		Agriculture	Animal husbandry	Horticulture	Traditional skills	Daily wages	Govt. service	Others*	Total	
1	Dugumba	4.02	9.72	0.70	11.25	6.08	2.04	1.43	**35.23**	2.35
2	Hoongla	13.56	17.28	0.00	0.00	22.68	7.20	5.04	**65.76**	1.17
3	Kudung	3.64	29.16	0.00	2.50	13.37	5.16	3.61	**57.44**	1.74
4	Lumla	16.35	38.23	0.20	12.50	23.09	7.02	4.91	**102.30**	1.79
5	Poito	2.83	5.18	0.00	6.25	8.91	2.46	1.72	**27.35**	1.24
6	Sazo	11.13	19.87	2.00	6.25	18.23	6.90	4.83	**69.20**	1.54
7	Thrillam	3.95	1.73	0.00	0.00	14.18	4.62	3.23	**27.70**	0.79
	Total	**55.48**	**121.17**	**2.9**	**38.75**	**106.54**	**35.4**	**24.77**	**384.98**	**10.62**

* Other includes artisans, monks, self–employed contractors etc.

Average Annual Expenditure Pattern of a Family: The average annual family expenditure in the surveyed villages varies from 1.18 lakhs in Thrillam to 1.70 lakhs in Hoongla (Table II. 3.515). In all the villages maximum expenditure is incurred on health and education followed by food and drinks, transport and clothing. The total value of average annual expenditure incurred by a family in twelve villages is 9.8 lakhs.

Table II. 3.515: Average annual expenditure pattern of a family in village

Sl. No.	Village	Expenditure/ year (Rupees in lakh)				
		Food and drinks	Clothing	Transport	Education and health	Total
1	Dugumba	0.30	0.30	0.30	0.40	**1.30**
2	Hoongla	0.48	0.30	0.40	0.52	**1.70**
3	Kudung	0.36	0.30	0.36	0.40	**1.42**
4	Lumla	0.36	0.30	0.36	0.45	**1.47**
5	Poito	0.32	0.30	0.30	0.35	**1.27**
6	Sazo	0.32	0.36	0.30	0.48	**1.46**
7	Thrillam	0.30	0.20	0.20	0.48	**1.18**
	Total	**2.44**	**2.06**	**2.22**	**3.08**	**9.8**

Water Sources: In Table II. 3.516, data pertaining to the water resources available and their pattern of use in the ten villages are presented. The surveyed villages depend on three water resources, viz., river, hill stream/spring and tap water. Only two villages are dependent on river water. Five villages depend on water from hill stream/springs. Tap water is used for various purposes in all seven surveyed villages. Pond water and wells were not present in the surveyed villages. Two villages Dugumba and Thrillam depend only on tap water.

Table II. 3.516: Water sources in the village

Sl. No.	Village	River				Hill stream/spring				Wells				Ponds				Tap water			
		Drinking water	Domestic use	Livestock use	Agriculture	Drinking water	Domestic use	Livestock use	Agriculture	Drinking water	Domestic use	Livestock use	Agriculture	Drinking water	Domestic use	Livestock use	Agriculture	Drinking water	Domestic use	Livestock use	Agriculture
1	Dugumba																	1	1	1	
2	Hoongla							1										1	1		
3	Kudung			1	1	1	1	1										1	1		
4	Lumla			1		1	1	1										1	1		
5	Poito							1										1	1		
6	Sazo							1										1	1		
7	Thrillam																	1	1	1	
	Total	**0**	**0**	**2**	**1**	**2**	**2**	**5**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**7**	**7**	**2**	**0**

Amenities in the villages: Data presented in Table II. 3.517 showed that out of 12 amenities, Lumla has the maximum number of 9 (75%) amenities. In Dugumba and Poito the least number of amenities (4/12) have been observed. All the villages have motorable road, electricity, telephone and TV/radio. Traditional health healers, post office and bank are absent in all the villages. Five villages had schools.

Table II. 3.517: Amenities in the villages

Sl. No.	Village	Road connectivity	Health facility (PHC/ sub–centre)	Traditional health healer	Veterinary services	Electricity	Fair price shop	Grocery shop	Post office	Bank	School	Telephone/Mobile	TV/ Radios
1	Dugumba	√				√						√	√
2	Hoongla	√				√					√	√	√
3	Kudung	√				√		√			√	√	√
4	Lumla	√	√		√	√	√	√			√	√	√
5	Poito	√				√						√	√
6	Sazo	√				√					√	√	√
7	Thrillam	√				√					√	√	√
	Total	**7**	**1**	**0**	**1**	**7**	**1**	**2**	**0**	**0**	**5**	**7**	**7**

NB: Blank indicates absent

Social Institutions: In none of the seven villages all the four social institutions listed in Table II. 3.518 are present. Two villages have three social institutions and the remaining villages have two each. Gompa was found in five villages. SHGs are absent in surveyed villages. Community hall was present in six villages out of seven.

Table II. 3.518: Social institutions in the village

Sl. No.	Village	SHGs	Anganwadis	Community hall	Gompa	Any other	Total
1	Dugumba		√	√			**2**
2	Hoongla		√	√		√	**3**
3	Kudung		√		√		**2**
4	Lumla		√	√	√		**3**
5	Poito			√	√		**2**
6	Sazo			√	√		**2**
7	Thrillam			√	√		**2**
	Total	**0**	**4**	**6**	**5**	**1**	**–**

NB: Blank indicates absent

Occupation Profile: In Table II. 3.519, work force participation in seven villages has been presented. The total working population in the studied villages comprises of 469 (40%) of total population (1187). Of the total workers main workers are 92% while marginal workers are 8%.

Table II. 3.519: Occupation profile of the village

Sl. No.	Village	Population			Workers			Main Workers			Marginal Workers			Non Workers		
		T	M	F	T	M	F	T	M	F	T	M	F	T	M	F
1	Dugumba	161	76	85	116	53	63	113	52	61	3	1	2	102	42	60
2	Hoongla	224	110	114	8	4	4	5	1	4	3	3	0	9	6	3
3	Kudung	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
4	Lumla	389	177	212	19	11	8	9	8	1	10	3	7	14	5	9
5	Poito	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
6	Sazo	187	100	87	285	227	58	265	211	54	20	16	4	212	56	156
7	Thrillam	226	110	116	41	20	21	39	18	21	2	2	0	37	20	17
	Total	**1187**	**573**	**614**	**469**	**315**	**154**	**431**	**290**	**141**	**38**	**25**	**13**	**374**	**129**	**245**

Household Level Survey–Affected

Age of the Head of the Household: The age of head of HHs across the seven surveyed villages varied from 19 in Hoongla to 97 years in Kudung. The age of 29% of heads is over 50 years and 23% of heads age was below 30 years (Tables II. 3.520). As expected and depending on the demographic structure of the villages, considerable variation has been observed between the villages in terms of the age of the Heads of HHs. The average age of heads of HH varied from 42 to 49 (Tables II. 3.520 and 3.521).

Table II. 3.520: Distribution of head of the HHs by age across the seven project villages

Sl. No.	Village	Up to 30		31–40		41–50		> 50		Total
		n	%	n	%	n	%	n	%	n
1	Dugumba	5	33	0	0	5	33	5	33	**15**
2	Hoongla	21	38	7	13	14	25	14	25	**56**
3	Kudung	3	9	10	30	11	33	9	27	**33**
4	Lumla	8	14	24	42	11	19	14	25	**57**
5	Poito	3	14	6	27	6	27	7	32	**22**
6	Sazo	12	27	10	22	9	20	14	31	**45**
7	Thrillam	8	23	10	29	5	14	12	34	**35**
	Total	**60**	**23**	**67**	**25**	**61**	**23**	**75**	**29**	**263**

Table II. 3.521: Minimum, maximum and average age of head of HHs across the seven project villages

Sl. No.	Village	Age range		Average
		From	To	
1	Dugumba	20	78	46
2	Hoongla	19	90	42
3	Kudung	29	97	45
4	Lumla	25	85	43
5	Poito	22	81	47
6	Sazo	21	65	43
7	Thrillam	24	87	49

Gender of the Head of Households: Data on gender of the head of HHs in the seven surveyed project villages is given in Table II. 3.522. As expected, in all the studied villages the number of males exceeds that of females as head of HHs. Across the surveyed villages 80% of heads were males.

Table II. 3.522: Distribution of head of HHs by gender in the seven project villages

Sl. No.	Village	Male		Female		Total
		n	%	n	%	n
1	Dugumba	12	80	3	20	**15**
2	Hoongla	48	86	8	14	**56**
3	Kudung	23	70	10	30	**33**
4	Lumla	42	74	15	26	**57**
5	Poito	22	100	0	0	**22**
6	Sazo	41	91	4	9	**45**
7	Thrillam	22	63	13	37	**35**
	Total	**210**	**80**	**53**	**20**	**263**

Ethnicity: All the seven villages are predominantly inhabited by Monpa tribals.

Household Size: The HH size varies from one to 10 across the seven villages. There is vast variation between the seven villages in terms of distribution of HH size. The average HH size varies from four (in four villages) to five (in three villages). Across the studied villages the average HH size is four (Tables II. 3.523 and 3.524).

Table II. 3.523: Distribution of HH size in the seven project villages

Sl. No.	Village	1		2		3		4		5		6–8		9 and above		Total
		n	%	n	%	n	%	n	%	n	%	n	%	n	%	n
1	Dugumba	2	13	2	13	2	13	1	7	2	13	6	40	0	0	**15**
2	Hoongla	5	9	10	18	10	18	9	16	9	16	13	23	0	0	**56**
3	Kudung	1	3	1	3	2	6	7	21	11	33	8	24	3	9	**33**
4	Lumla	4	7	6	11	7	12	14	25	12	21	14	25	0	0	**57**
5	Poito	1	5	4	18	6	27	4	18	5	23	2	9	0	0	**22**
6	Sazo	1	2	3	7	8	18	12	27	3	7	17	38	1	2	**45**
7	Thrillam	1	3	2	6	8	23	4	11	9	26	11	31	0	0	**35**
	Total	**15**	**6**	**28**	**11**	**43**	**16**	**51**	**19**	**51**	**19**	**71**	**27**	**4**	**2**	**263**

Table II. 3.524: Minimum, maximum and average HH size across the seven project villages

Sl. No.	Village	HH size range		Average HH size
		From	To	
1	Dugumba	1	7	4
2	Hoongla	1	8	4
3	Kudung	1	10	5
4	Lumla	1	8	4
5	Poito	1	7	4
6	Sazo	1	9	5
7	Thrillam	1	8	5
	Total	**1**	**10**	**4**

Education: Relevant data on the education of the head of the HHs in the seven project villages is given in Table II. 3.525. It is highly noteworthy that, a majority of the heads in studied villages were illiterate (84%). It varied from 65% in Lumla to 100% in Dugumba. There was only 1 head of HHs in Kudung who was graduate.

Table II. 3.525: Distribution of education of head of HH in the seven project villages

Sl. No.	Village	Illiterate		Primary		Upper Primary		Secondary		Higher Secondary		Graduate or above		Total
		n	%	n	%	n	%	n	%	n	%	n	%	n
1	Dugumba	15	100	0	0	0	0	0	0	0	0	0	0	**15**
2	Hoongla	54	96	0	0	1	2	1	2	0	0	0	0	**56**
3	Kudung	32	97	0	0	0	0	0	0	0	0	1	3	**33**
4	Lumla	37	65	4	7	3	5	10	18	3	5	0	0	**57**
5	Poito	19	86	0	0	1	5	2	9	0	0	0	0	**22**
6	Sazo	33	73	2	4	4	9	5	11	1	2	0	0	**45**
7	Thrillam	31	89	1	3	2	6	1	3	0	0	0	0	**35**
	Total	**221**	**84**	**7**	**3**	**11**	**4**	**19**	**7**	**4**	**2**	**1**	**0**	**263**

Main Occupation of Household Heads: The main occupations of the head of HHs across the seven villages are agriculture, labour, pastoralism and government service. Data presented in Table II. 3.526 reveal the following:

Agriculture: It varies from 49% in Thrillam to 96% in Hoongla. 81% of the surveyed head of HHs are engaged in agriculture.

Labour: 25 HHs (10%) in Lumla, Sazo and Thrillam reported labour as main mode of occupation.

Pastoralist: Pastoralism as main occupation is absent in the surveyed villages.

Government service: Government servants totalling 16 (6%) were found in all the seven villages.

Any other occupation: About 8 (3%) HHs was engaged in other occupations.

Table II. 3.526: Distribution of head of HHs by main occupation in the seven project villages

Sl. No.	Village	Farmer		Labour		Pastoral		Govt Servant		Others		Total
		n	%	n	%	n	%	n	%	n	%	n
1	Dugumba	13	87	0	0	0	0	2	13	0	0	**15**
2	Hoongla	54	96	0	0	0	0	2	4	0	0	**56**
3	Kudung	27	82	0	0	0	0	2	6	4	12	**33**
4	Lumla	47	82	5	9	0	0	3	5	2	4	**57**
5	Poito	19	86	0	0	0	0	2	9	1	5	**22**
6	Sazo	37	82	6	13	0	0	2	4	0	0	**45**
7	Thrillam	17	49	14	40	0	0	3	9	1	3	**35**
	Total	**214**	**81**	**25**	**10**	**0**	**0**	**16**	**6**	**8**	**3**	**263**

Private Land Holding Pattern: The private land holding pattern in the seven villages comprises of agricultural land, horticulture land, habitation and home garden and forest land. It may be noted here that a majority of the inhabitants of the surveyed villages did not know actual area either in acres or hectares of all categories of land holdings. Therefore, the area reported here should be considered as very rough estimates. Data pertaining to this aspect have been described below.

Agricultural land: Table II. 3.527 reavealed that except 56 HHs (21%), all the remaining HHs (79%) in seven surveyed villages owned agricultural land in varying proportions. A majority of the HHs (43%) owned agricultural land rnging between 1 to 2 acres. Only 8% of HHs owned land which is more than 2 acres. There exists a striking variation between the villages in terms of agricultural landholdings. For example, 72% of the HHs in Hoongla own more than one acre of land while 94% of HHs in Thrillam own less than one acre of land.

Table II. 3.527: Distribution of agricultural land holding among surveyed HHs in the seven project villages

Sl. No.	Village	0.00 acre		< 1 acre		1–2 acre		> 2 acre	
		n	%	n	%	n	%	n	%
1	Dugumba	2	13	5	33	4	27	4	27
2	Hoongla	15	27	1	2	38	68	2	4
3	Kudung	11	33	10	30	12	36	0	0
4	Lumla	16	28	6	11	22	39	13	23
5	Poito	4	18	12	55	5	23	1	5
6	Sazo	8	18	5	11	31	69	1	2
7	Thrillam	0	0	33	94	2	6	0	0
	Total	**56**	**21**	**72**	**27**	**114**	**43**	**21**	**8**

Horticultural land: Three HHs in two villages Dugumba and Lumla owned four acres of horticultural land (Table II. 3.528).

Table II. 3.528: Distribution of horticultural land among surveyed HHs in the seven project villages

Sl. No.	Village	0.00 acre		< 1 acre		1–2 acre		> 2 acre	
		n	%	n	%	n	%	n	%
1	Dugumba	13	87	0	0	1	7	1	7
2	Hoongla	0	0	0	0	0	0	0	0
3	Kudung	0	0	0	0	0	0	0	0
4	Lumla	56	98	0	0	1	2	0	0
5	Poito	0	0	0	0	0	0	0	0
6	Sazo	45	100	0	0	0	0	0	0
7	Thrillam	0	0	0	0	0	0	0	0
	Total	**114**	**43**	**0**	**0**	**2**	**1**	**1**	**0**

***Habitation and home–garden land*:** Data presented in Table II. 3.529 shows that only 15% of HHs (40) in surveyed villages did not own any such land. A majority of HHs (84%) owned less than one acre. 1% of the HHs owned between 1 to 2 acre of such land. The total area under this category is 61 acres.

Table II. 3.529: Distribution of habitation and home garden land among surveyed HHs in the seven project villages

Sl. No.	Village	0.00 acre		< 1 acre		1–2 acre		> 2 acre	
		n	%	n	%	n	%	n	%
1	Dugumba	9	60	4	27	2	13	0	0
2	Hoongla	15	27	41	73	0	0	0	0
3	Kudung	1	3	32	97	0	0	0	0
4	Lumla	5	9	52	91	0	0	0	0
5	Poito	2	9	20	91	0	0	0	0
6	Sazo	8	18	37	82	0	0	0	0
7	Thrillam	0	0	35	100	0	0	0	0
	Total	**40**	**15**	**221**	**84**	**2**	**1**	**0**	**0**

Forest land: 93 HHs (35%) in surveyed villages do not own private forest land. A majority of HHs (20%) owned such land between 1–2 acres. Only 3 (1%) HHs owned more than 2 acre of forest land (Table II. 3.530). The total area under this category is 79 acre for all the surveyed villages.

Table II. 3.530: Distribution of forest land holding among surveyed HHs in the seven project villages

Sl. No.	Village	0.00 acre		< 1 acre		1–2 acre		> 2 acre	
		n	%	n	%	n	%	n	%
1	Dugumba	8	53	5	33	1	7	1	7
2	Hoongla	0	0	0	0	0	0	0	0
3	Kudung	9	27	11	33	13	39	0	0
4	Lumla	38	67	2	4	15	26	2	4

5	Poito	19	86	3	14	0	0	0	0
6	Sazo	19	42	3	7	23	51	0	0
7	Thrillam	0	0	0	0	0	0	0	0
	Total	**93**	**35**	**24**	**9**	**52**	**20**	**3**	**1**

Private land holdings: Data given in Tables II. 3.531–3.534 showed that there are 31 HHs (12%) that do not own any type of private land. 35% of the HHs owned more than 2 acres of private land. There is striking variation between the HHs within a village as well as between villages in ownership of total land. For example, in dugumba inter HH holdings vary from 0–11.11 acres, whereas in Poito it varies from 0–2.52 acres. The proportion of agricultural land compared to other types of land to the total land holdings is greater in a majority of the villages. The 263 HHs in the seven villages owned total private land totalling 418 acres. Out of this Hoongla, Lumla and Sazo account for 71% of the total land. Agricultural land accounts for 65% and forest land 19% of total land holdings in the seven villages.

Table II. 3.531: Distribution of private land holding among surveyed HHs in the seven project villages

Sl. No.	Village	0.00 acre		< 1 acre		1–2 acre		> 2 acre	
		n	%	n	%	n	%	n	%
1	Dugumba	1	7	5	33	4	27	5	33
2	Hoongla	15	27	1	2	18	32	22	39
3	Kudung	1	3	8	24	14	42	10	30
4	Lumla	4	7	18	32	7	12	28	49
5	Poito	2	9	13	59	5	23	2	9
6	Sazo	8	18	1	2	11	24	25	56
7	Thrillam	0	0	33	94	1	3	1	3
	Total	**31**	**12**	**79**	**30**	**60**	**23**	**93**	**35**

Table II. 3.532: Minimum, maximum and average land holdings across the seven project villages

Sl. No.	Village	Agricultural land			Horticultural land			Habitation and homegarden land			Forest land			Total land		
		From	To	Avg.	From	To	Avg.	From	To	Avg.	From	To	Avg.	From	To	Avg.
1	Dugumba	0.00	4.94	1.32	0.00	2.47	0.23	0.00	1.23	0.22	0.00	2.47	0.29	**0.00**	**11.11**	**2.06**
2	Hoongla	0.00	4.00	1.19	0.00	0.00	0.00	0.00	0.49	0.19	0.00	0.00	0.00	**0.00**	**4.49**	**1.38**
3	Kudung	0.00	2.00	0.54	0.00	0.00	0.00	0.00	0.75	0.49	0.00	1.50	0.56	**0.00**	**4.00**	**1.60**
4	Lumla	0.00	4.00	1.42	0.00	1.00	0.02	0.00	0.98	0.33	0.00	5.00	0.41	**0.00**	**8.49**	**2.19**
5	Poito	0.00	2.47	0.63	0.00	0.00	0.00	0.00	0.25	0.02	0.00	0.50	0.06	**0.00**	**2.52**	**0.73**
6	Sazo	0.00	3.00	1.22	0.00	0.00	0.00	0.00	0.38	0.22	0.00	2.00	0.68	**0.00**	**4.38**	**2.12**
7	Thrillam	0.50	2.00	0.55	0.00	0.00	0.00	0.01	0.02	0.02	0.00	0.00	0.00	**0.52**	**2.01**	**0.57**

Table II. 3.533: Number of HHs having land types in the seven project villages

Sl. No.	Village	Agricultural land		Horticultural land		Habitation and home garden land		Forest land	
		n	%	n	%	n	%	n	%
1	Dugumba	13	87	2	13	6	40	7	47
2	Hoongla	41	73	0	0	41	73	0	0
3	Kudung	22	67	0	0	32	97	24	73
4	Lumla	41	72	1	2	52	91	19	33
5	Poito	18	82	0	0	20	91	3	14
6	Sazo	37	82	0	0	37	82	26	58
7	Thrillam	35	100	0	0	35	100	0	0
	Total	**207**	**79**	**3**	**1**	**223**	**85**	**79**	**30**

Table II. 3.534: Distribution of area (in acres) of land holding among HHs in the seven project villages

Sl. No.	Village	Agricultural land		Horticultural land		Habitation and Homegarden land		Forest land		Total land
		Area	%	Area	%	Area	%	Area	%	Area
1	Dugumba	20	64	3	11	3	11	4	14	**31**
2	Hoongla	67	86	0	0	11	14	0	0	**78**
3	Kudung	18	34	0	0	16	31	19	35	**53**
4	Lumla	81	65	1	1	19	15	24	19	**125**
5	Poito	14	87	0	0	1	4	2	9	**16**
6	Sazo	55	58	0	0	10	10	31	32	**95**
7	Thrillam	20	97	0	0	1	3	0	0	**20**
	Total	**274**	**66**	**4**	**1**	**61**	**15**	**79**	**19**	**418**

Livestock Holding: The data presented in Tables II. 3.535–3.537 showing distribution of livestock holdings in the seven surveyed villages exhibits that eight different types of animals are reared in surveyed villages. However none of the villages owned all the eight animal types. Altogether 516 animals are reared in the seven villages. Considerable inter–village variation is observed in total number of animals reared. It varied from 8 in Thrillam to 177 in Lumla. Kudung, Lumla and Sazo account for 72% of all the animals found in the surveyed villages. Three animals, viz, cattle (39%), Goat (23%) and other animals (10%) account for 72% of the total animals (516). 59% (154) of the HHs did not own any animals; whereas 4% HHs owned more than 10 animals. In two villages other animals (n=54) are also present. It may be noted that in none of the studied villages Yak has been reared.

Table II. 3.535: Livestock holding by HHs in the seven project villages

Sl. No.	Livestock		Dugumba	Hoongla	Kudung	Lumla	Poito	Sazo	Thrillam	Total
1	Mithun	n	5	1	0	1	0	0	0	**7**
		%	33	2	0	2	0	0	0	**3**
2	Cattle	n	3	7	6	17	5	1	1	**40**
		%	20	13	18	30	23	2	3	**15**
3	Goat	n	6	5	6	13	2	15	0	**47**
		%	40	9	18	23	9	33	0	**18**
4	Sheep	n	0	2	1	1	0	0	1	**5**
		%	0	4	3	2	0	0	3	**2**
5	Pig	n	3	6	0	4	0	16	0	**29**
		%	20	11	0	7	0	36	0	**11**
6	Pony	n	0	4	1	13	0	0	0	**18**
		%	0	7	3	23	0	0	0	**7**
7	Poultry	n	1	0	0	7	0	0	0	**8**
		%	7	0	0	12	0	0	0	**3**
8	Others	n	0	6	0	0	0	24	0	**30**
		%	0	11	0	0	0	53	0	**11**

Table II. 3.536: Number of livestock in surveyed HHs across the seven project villages

Sl. No.	Livestock	Dugumba		Hoongla		Kudung		Lumla		Poito		Sazo		Thrillam		Total	
		LS	**%**	**LS**	**%**	**LS**	**%**	**LS**	**%**	**LS**	**%**	**LS**	**%**	**LS**	**%**	**LS**	**%**
1	Mithun	9	20	1	1	0	0	7	4	0	0	0	0	0	0	**8**	**2**
2	Cattle	3	7	27	34	118	87	49	28	19	79	1	1	3	38	**217**	**42**
3	Goat	18	40	23	29	12	9	37	21	5	21	34	37	0	0	**111**	**22**
4	Sheep	0	0	3	4	3	2	2	1	0	0	0	0	5	63	**13**	**3**
5	Poultry	12	27	0	0	0	0	29	16	0	0	0	0	0	0	**29**	**6**
6	Others	0	0	13	16	0	0	0	0	0	0	41	45	0	0	**54**	**10**
7	Pig	3	7	6	8	0	0	13	7	0	0	16	17	0	0	**35**	**7**
8	Pony	0	0	7	9	2	1	40	23	0	0	0	0	0	0	**49**	**9**
	Total livestock	**45**	**100**	**80**	**100**	**135**	**100**	**177**	**100**	**24**	**100**	**92**	**100**	**8**	**100**	**516**	**100**

Note: LS–Livestock

Table II. 3.537: Distribution of total number of livestock in HHs of the seven project villages

Sl. No.	Village	0		1–5		6–10		> 10		Total
		n	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**n**
1	Dugumba	5	33	8	53	1	7	1	7	**15**
2	Hoongla	35	63	18	32	2	4	1	2	**56**
3	Kudung	23	70	5	15	1	3	4	12	**33**
4	Lumla	31	54	14	25	7	12	5	9	**57**
5	Poito	16	73	4	18	2	9	0	0	**22**
6	Sazo	11	24	32	71	2	4	0	0	**45**
7	Thrillam	33	94	2	6	0	0	0	0	**35**
	Total	**154**	**59**	**83**	**32**	**15**	**6**	**11**	**4**	**263**

Traditional Skills: Data pertaining to this aspect is given in Table II. 3.538. It may be noted that data on this aspect was not available for three villages, viz., Thrillam, Hoongla and Sazo. In the surveyed village four types of crafts are pursued. Weaving is practiced in all surveyed villages and the total number of HHs engaged is 18 (14%). A small number of HHs are engaged in other crafts; three HHs in wood carving, one HH in carpet making and one HH in bamboo utensil making.

Table II. 3.538: Distribution of various skills among surveyed HHs in the six project villages

Sl. No.	Village	Wood carving		Thanka painting		Carpet making		Bamboo usevensil		Weaving		Paper making	
		n	%	n	%	n	%	n	%	n	%	n	%
1	Dugumba	1	7	0	0	1	7	1	7	3	20	0	0
2	Kudung	1	3	0	0	0	0	0	0	1	3	0	0
3	Lumla	0	0	0	0	0	0	0	0	10	18	0	0
4	Poito	1	5	0	0	0	0	0	0	4	18	0	0
	Total	**3**	**2**	**0**	**0**	**1**	**1**	**1**	**1**	**18**	**14**	**0**	**0**

Data in traditional skills is not available for Thrillam, Hoongla and Sazo villages

River Resources: Eight river resources listed in Table II. 3.539, were being used across the studied villages. Water from river is used by a large number of HHs in the villages for drinking (n=155), domestic use (n=93) and for livestock (n=107). It may be emphasized that while aquatic fauna is used in only one village, the aquatic flora is not used by any of seven villages. It is noteworthy that all the 263 HHs in the surveyed villages use river for performing last rites of the dead. More than 50% of the surveyed HHs use sand and stone from the river bed for self consumption and selling.

Table II. 3.539: Dependence on river resources among surveyed HHs in the seven project villages

Sl. No.	Village	Drinking water		Water for domestic use		Water for livestock		Aquatic fauna		Aquatic flora		Religious		Sand		Stone		Any other	
		n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
1	Dugumba	13	87	8	53	10	67	0	0	0	0	15	100	0	0	1	7	0	0
2	Hoongla	46	82	40	71	21	38	0	0	0	0	56	100	0	0	0	0	0	0
3	Kudung	0	0	0	0	10	30	0	0	0	0	33	100	33	100	33	100	0	0
4	Lumla	51	89	43	75	26	46	1	2	0	0	57	100	45	79	45	79	1	2
5	Poito	0	0	0	0	6	27	0	0	0	0	22	100	22	100	22	100	0	0
6	Sazo	45	100	0	0	34	76	0	0	0	0	45	100	45	100	45	100	0	0
7	Thrillam	0	0	2	6	0	0	0	0	0	0	35	100	0	0	0	0	0	0
	Total	**155**	**59**	**93**	**35**	**107**	**41**	**1**	**0**	**0**	**0**	**263**	**100**	**145**	**55**	**146**	**56**	**1**	**0**

Forest Resources: The villagers of all the seven villages are dependent in use in varying degrees of forest resources (Table II. 3.540). 14 usages listed in Table II. 3.540 are utilized in varying degrees among the seven surveyed villages. Dugumba and Thrillam uses the least number of 5 forest resources. Lumla uses 13 resources. More than 50% of the HHs five forest resources,viz., fuel wood, timber, religion, stone and sand. Three forest resources, viz., fuel wood, grazing and stones are used by the inhabitants of all the seven villages. Significant number across the studied villages uses forest resources for food and medicine. It is thus evident from above description that for a majority of the inhabitants of the surveyed villages forest resources play a very significant role to the livelihoods as well as the quality of life of the people.

Table II. 3.540: Dependence on forest resources among surveyed HHs in the seven project villages

Sl. No.	Forest resources	Dugumba		Hoongla		Kudung		Lumla		Poito		Sazo		Thrillam		Total	
		n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
1	Fuel wood	15	100	56	100	33	100	55	96	22	100	45	100	35	100	**261**	**99**
2	Timber	0	0	56	100	33	100	50	88	0	0	0	0	35	100	**174**	**66**
3	Medicinal plants	0	0	0	0	33	100	18	32	0	0	45	100	0	0	**96**	**37**
4	Honey	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**	**0**
5	Food	0	0	56	100	33	100	3	5	0	0	0	0	35	100	**127**	**48**
6	Edible oil	0	0	0	0	0	0	3	5	0	0	0	0	0	0	**3**	**1**
7	Ornamental	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**	**0**
8	Religious	0	0	56	100	33	100	33	58	22	100	45	100	0	0	**189**	**72**
9	Fencing	0	0	0	0	33	100	1	2	0	0	0	0	0	0	**34**	**13**
10	Handicrafts	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**	**0**
11	Thatching	0	0	0	0	0	0	1	2	0	0	0	0	0	0	**1**	**0.4**
12	Spices	0	0	0	0	0	0	13	23	0	0	0	0	0	0	**13**	**5**

13	Grazing	10	67	21	38	10	30	26	46	6	27	34	76	2	6	**109**	**41**
14	Hunting of wild animals	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**	**0**
15	Fishes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**	**0**
16	Water	1	7	21	38	33	100	32	56	22	100	0	0	0	0	**109**	**41**
17	Stones	3	20	56	100	33	100	47	82	22	100	45	100	35	100	**241**	**92**
18	Sand	0	0	56	100	33	100	45	79	22	100	45	100	0	0	**201**	**76**
19	Dyes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**	**0**

Water Resources: 47 HHs (18%) of Lumla and Sazo use river water. 35 HHs belonging to Lumla and Kudung village, use water from hill stream/springs. All the HHs (263) of seven villages uses tap water for their water requirements (Table II. 3.541).

Table II. 3.541: Dependence on water resources among surveyed HHs in the seven project villages

Sl. No.	Village	River		Hill stream/spring		Wells		Ponds		Hand pumps		Tap water
		n	%	n	%	n	%	n	%	n	%	n
1	Dugumba	0	0	0	0	0	0	0	0	0	0	15
2	Hoongla	0	0	0	0	0	0	0	0	0	0	56
3	Kudung	0	0	33	100	0	0	0	0	0	0	33
4	Lumla	2	4	2	4	0	0	0	0	0	0	57
5	Poito	0	0	0	0	0	0	0	0	0	0	22
6	Sazo	45	100	0	0	0	0	0	0	0	0	45
7	Thrillam	0	0	0	0	0	0	0	0	0	0	35
	Total	**47**	**18**	**35**	**13**	**0**	**0**	**0**	**0**	**0**	**0**	**263**

Village Level Survey–Influenced

Profile of the Fifteen Surveyed Villages: The fifteen villages fall under four administrative circles of Lumla Lhau, Tawang and Dudunghar (Table II. 3.542). Of all the villages 5 are situated within a distance of 8 km from the river and remaining ten villages are situated within 5kms. The circle headquarters of all the fifteen villages are within 20 km. The villages are situated within 66 km from the district headquarters.

Table II. 3.542: Profile of the fifteen surveyed villages

Sl. No.	Village	Circle	Distance of village (in km)		
			River/Tributary	Circle HQ	District HQ
1	Baghar	Lumla	6	13	61
2	Gemreteng	Lhau	2	4	24
3	Gomkang	Tawang	1	19	19
4	Gyada	Tawang	3	18	18
5	Gyankhar	Tawang	1	12	12
6	Kharteng	Lumla	7	14	62
7	Maio	Lumla	2	4	46
8	Menteng	Lhau	2	4	24
9	Nam Tsering	Dudunghar	0	20	66
10	Pharmey	Lumla	7	5	51
11	Phomang	Lumla	5	12	61
12	Seru	Tawang	8	16	16
13	Sherbang	Lumla	4	11	55
14	Yabab	Lumla	5	12	57
15	Yusum	Tawang	3	21	21

Private Land Use Pattern: Table II. 3.543 presents details of private land holdings (in hectares) of all the fourteen villages. The total private land holdings in the studied villages are about 498.57 ha. Four villages, viz., Gyankhar, Kharteng, Seru and Sherbang contribute 62% to the total land holdings in studied villages. In all the villages the proportion of agricultural land exceeds that of the other land use types. Private forest land also contributes significantly (28%) to the total land holdings of the villages.

Table II. 3. 543: Private land use pattern and their percentage to total private land

Sl. No.	Village	Total private land	Forest cover (ha)	%	Agriculture (ha)	%	Horticulture (ha)	%	Habitation and HG (ha)	%
1	Baghar	25.60	7.49	29	15.78	62	0.61	2	1.72	7
2	Gemreteng	1.70	0.00	0.0	1.7	100	0.00	0	0.00	0
3	Gomkang	11.34	2.43	21	4.65	41	1.42	12	2.84	25
4	Gyankhar	85.30	20.83	24	45.35	53	12.07	14	7.05	8
5	Kharteng	76.53	25.28	33	45.79	60	0.00	0	5.46	7
6	Maio	20.24	3.97	20	9.50	47	2.00	47	4.77	24
7	Menteng	2.33	0.91	39	0.81	35	0.00	0	0.61	26
8	Nam Tsering	14.33	0.92	6	13.07	91	0.30	91	0.04	0
9	Pharmey	44.14	7.32	17	20.65	47	8.45	47	7.73	18
10	Phomang	25.12	6.68	27	13.76	55	0.00	0	4.69	19
11	Seru	88.85	34.74	39	40.53	46	7.66	9	5.92	7
12	Sherbang	60.79	10.76	18	44.11	73	0.00	0	5.92	10
13	Yabab	8.77	0.67	8	6.27	72	0.20	72	1.62	18
14	Yusum	33.53	15.78	47	17.20	51	0.00	0	0.55	2
	Total*	**498.57**	**137.78**	**328**	**279.17**	**833**	**32.71**	**294**	**48.92**	**171**

* Excluding Gyada due to non–availability of data.

Demography and Literacy Rate: The total number of HHs in the fifteen villages is 633 (number varies from 3 in Menteng to 107 in Kharteng) with a total population is 3042 (1496 males; 1391 females). In eight villages the number of females is less than that of the males. In the remaining villages the reverse is true. The literacy rate ranged from 4.5% in Gyada to 62.8% in Gyankhar. Among males the rate varies from 5.9% in Pharmey to 70.0% in Gyankhar and in females it varies from 0.0 % in Gyada to 80% in Gemreteng (Table II. 3.544).

Table II. 3.544: Demography and literacy rate

Sl. No.	Village	Demography					Literacy rate*		
		Total	Male	Female	Sex ratio (Per 1000 males)	No. of HH	Male	Female	Total
1	Baghar	260	117	143	1222	59	14.7	8.1	**11.0**
2	Gemreteng	39	23	16	696	9	42.9	80.0	**58.3**
3	Gomkang	52	28	24	857	12	27.8	27.8	**27.8**
4	Gyada	42	17	25	1680	11	10.0	0.0	**4.5**
5	Gyankhar	383	178	205	1152	65	70.0	56.6	**62.8**
6	Kharteng	452	221	231	1045	107	37.4	33.7	**35.3**
7	Maio	108	57	51	895	23	NA	NA	**NA**
8	Menteng	8	2	6	3000	3	50.0	37.5	**41.7**
9	Nam Tsering	263	138	125	906	52	34.6	23.5	**29.8**
10	Pharmey	149	76	73	961	33	36.0	14	**26.3**
11	Phomang	233	117	116	991	49	5.9	10.1	**8.2**
12	Seru	513	252	106	421	106	60.4	47.2	**53.4**
13	Sherbang	248	131	117	893	40	32.6	22	**27**
14	Yabab	63	31	32	1032	14	16.7	10.8	**13.4**
15	Yusum	229	108	121	1120	50	11.4	1.9	**6.3**
	Total	**3042**	**1496**	**1391**		**633**			

* After Census 2011; NA = Data not available

Number of Livestock: Nine different types of animals are domesticated in surveyed villages (Table II. 3.545). In none of the villages all the nine animal types were domesticated. Altogether 1426 animals are reared in the fifteen villages. Considerable inter nvillage variation is observed in total number of animals reared. It varied from 9 in Nam tsering to 265 in Seru. Baghar, Kharteng, Seru, Sherbang and Yusum account for 57% of all the animals found in the surveyed villages. Three animals, viz, cattle (63%), Goat (15%) and pig (7%) account for 85% of the total animals (Table II. 3.545).

Table II. 3.545: Number of livestock

Sl.No.	Village	Mithun	Cattle	Yak	Goat	Sheep	Pig	Pony	Poultry	Others	Total
1	Baghar	0	52	0	32	0	17	0	34	0	**135**
2	Gemreteng	0	20	0	0	0	0	0	0	0	**20**
3	Gomkang	0	10	0	0	0	4	0	9	0	**23**
4	Gyada	0	10	0	0	0	0	0	0	0	**10**
5	Gyankhar	0	80	0	10	0	1	0	6	1	**98**

6	Kharteng	0	111	0	55	0	5	0	0	1	**172**
7	Maio	0	4	40	3	3	5	3	1	0	**59**
8	Menteng	0	10	0	0	0	0	0	0	0	**10**
9	Nam Tsering	0	6	0	3	0	0	0	0	0	**9**
10	Pharmey	0	55	0	39	0	20	28	13	0	**155**
11	Phomang	0	37	0	19	0	16	0	10	0	**82**
12	Seru	17	190	30	4	0	23	1	0	0	**265**
13	Sherbang	0	118	0	31	5	1	0	6	0	**161**
14	Yabab	0	11	0	4	0	0	0	1	0	**16**
15	Yusum	0	181	0	19	0	9	0	2	0	**211**
	Total	**17**	**895**	**70**	**219**	**8**	**101**	**32**	**82**	**2**	**1426**

Total Estimated Value of Livestock: The monetary value of domesticated animals maintained by the inhabitants of the studied villages has been estimated separately for each animal and for each village (Table II. 3.546). The selling price of different animals was obtained from the knowledgeable persons in the villages. The detailed methodology used in estimating the monetary value of animals has been described in the methodology section of the present report. As expected, there is considerable intra and inter village variation in this respect. The total value of animals numbering 1426 found in the fifteen villages has been estimated as 292.82 lakhs. The value varied from 1.65 lakhs in Nam tsering to 67.98 lakhs in Seru. In terms of relative contribution made by different animals to the total value, cattle alone contribute over 223.75 lakhs (76%).

Table II. 3.546: Total estimated value of livestock

Sl. No.	Village	Total estimated value (Rupees in lakh)									
		Mithun	**Cattle**	**Yak**	**Goat**	**Sheep**	**Pig**	**Pony**	**Poultry**	**Others**	**Total**
1	Baghar	0.00	13.00	0.00	1.60	0.00	4.25	0.00	0.17	0.00	**19.02**
2	Gemreteng	0.00	5.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**5.00**
3	Gomkang	0.00	2.50	0.00	0.00	0.00	1.00	0.00	0.05	0.00	**3.55**
4	Gyada	0.00	2.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**2.50**
5	Gyankhar	0.00	20.00	0.00	0.50	0.00	0.25	0.00	0.03	0.15	**20.93**
6	Kharteng	0.00	27.75	0.00	2.75	0.00	1.25	0.00	0.00	0.15	**31.90**
7	Maio	0.00	1.00	10.00	0.15	0.18	1.25	0.69	0.01	0.00	**13.28**
8	Menteng	0.00	2.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**2.50**
9	Nam Tsering	0.00	1.50	0.00	0.15	0.00	0.00	0.00	0.00	0.00	**1.65**
10	Pharmey	0.00	13.75	0.00	1.95	0.00	5.00	6.44	0.07	0.00	**27.21**
11	Phomang	0.00	9.25	0.00	0.95	0.00	4.00	0.00	0.05	0.00	**14.25**
12	Seru	6.80	47.50	7.50	0.20	0.00	5.75	0.23	0.00	0.00	**67.98**
13	Sherbang	0.00	29.50	0.00	1.55	0.30	0.25	0.00	0.03	0.00	**31.63**
14	Yabab	0.00	2.75	0.00	0.20	0.00	0.00	0.00	0.01	0.00	**2.96**
15	Yusum	0.00	45.25	0.00	0.95	0.00	2.25	0.00	0.01	0.00	**48.46**
	Total	**6.80**	**223.75**	**17.5**	**10.95**	**0.48**	**25.25**	**7.36**	**0.43**	**0.30**	**292.82**

Average Annual Earnings of the Village: Average total earnings per year in the villages is estimated 1057.32 lakhs (Table II. 3.547). Average annual family income varies from 0.83 lakhs in Gyada to 2.93 lakhs in Yusum. The contribution made by different occupations to the total earnings shows considerable variation between the villages. 70 % of the annual earnings across the villages are due to animal husbandry, traditional skills and daily wages. Across the surveyed villages the contribution of animal husbandry is 29%. It is noteworthy that agriculture contributes only 13% of the total annual village earnings.

Table II. 3.547: Average annual earning of the village

Sl. No.	Name of village	Total earning/year (Rupees in lakh)								Average family income (Rupees in lakh)
		Agriculture	**Animal husbandry**	**Horticulture**	**Traditional skills**	**Daily wages**	**Govt. service**	**Others***	**Total**	
1	Baghar	8.00	29.16	0.30	5.00	23.90	7.02	4.91	**78.29**	1.33
2	Gemreteng	0.85	4.32	0.00	1.25	3.65	1.38	0.97	**12.41**	1.38
3	Gomkang	2.33	4.97	0.71	6.25	4.86	1.68	1.18	**21.97**	1.83
4	Gyada	0.00	2.16	0.00	0.00	4.46	1.50	1.05	**9.17**	0.83
5	Gyankhar	22.67	21.17	6.04	31.00	26.33	10.68	7.48	**125.36**	1.93

6	Kharteng	21.50	37.15	0.00	28.75	43.34	13.26	9.28	**153.28**	1.43
7	Maio	4.75	12.74	1.00	0.85	9.32	3.42	2.39	**34.47**	1.50
8	Menteng	0.40	2.16	0.00	–	1.22	0.12	0.08	**3.98**	1.33
9	Nam Tsering	6.54	1.94	0.15	6.00	21.06	8.28	5.80	**49.77**	0.96
10	Pharmey	10.32	33.48	4.22	8.75	13.37	4.56	3.19	**77.90**	2.36
11	Phomang	6.85	17.71	0.00	5.00	19.85	7.02	4.91	**61.34**	1.25
12	Seru	20.26	57.24	3.83	10.80	42.93	15.12	10.58	**160.77**	1.52
13	Sherbang	22.06	34.78	0.00	15.00	16.20	7.86	5.50	**101.39**	2.53
14	Yabab	3.14	3.46	0.10	5.00	5.67	1.86	1.30	**20.53**	1.47
15	Yusum	8.60	45.58	0.00	61.25	20.25	6.48	4.54	**146.69**	2.93
	Total	**138.2**	**308.0**	**16.3**	**184.9**	**256.4**	**90.2**	**63.1**	**1057.3**	**24.5**

* Other includes artisans, monks, self–employed contractors etc.

Average Annual Expenditure Pattern of a Family: The average annual family expenditure in the surveyed villages varies from 0.80 lakhs in Gyada to 1.62 lakhs in Sherbang and Gyangkhar (Table II. 3.548). In a majority of the villages the maximum expenditure is incurred on health and education followed by food and drinks, transport clothing. The total value of average annual expenditure incurred by a family in fifteen villages is 15.94 lakhs.

Table II. 3.548: Average annual expenditure pattern of a family in village

Sl. No.	Village	Expenditure/ year (Rupees in lakh)				
		Food and drinks	Clothing	Transport	Education and health	Total
1	Baghar	0.42	0.30	0.30	0.48	**1.50**
2	Gemreteng	0.20	0.30	0.25	0.35	**1.10**
3	Gomkang	0.35	0.35	0.27	0.30	**1.27**
4	Gyada	0.20	0.20	0.20	0.20	**0.80**
5	Gyankhar	0.40	0.30	0.36	0.56	**1.62**
6	Kharteng	0.30	0.30	0.36	0.48	**1.44**
7	Maio	0.32	0.30	0.36	0.36	**1.34**
8	Menteng	0.20	0.20	0.20	0.40	**1.00**
9	Nam Tsering	0.30	0.25	0.37	0.45	**1.37**
10	Pharmey	0.35	0.36	0.30	0.42	**1.43**
11	Phomang	0.30	0.20	0.30	0.40	**1.20**
12	Seru	0.30	0.25	0.43	0.30	**1.28**
13	Sherbang	0.42	0.36	0.36	0.48	**1.62**
14	Yabab	0.30	0.36	0.36	0.48	**1.50**
15	Yusum	0.30	0.30	0.20	0.30	**1.10**
	Total	**4.66**	**4.33**	**4.62**	**5.96**	**19.57**

Water Sources: All types of water resources listed in the Table II. 3.549, are available in the studied villages. Eight villages are dependent on river water. Kharteng depends only on river water. 11/15 villages depend on water from hill stream/springs. Tap water is used for various purposes in thirteen surveyed villages. Pond water is only used in four villages. Gyada depend only on tap water. Wells are present only in three villages.

Table II. 3.549: Water sources in the village

Sl. No.	Village	Rivers				Hill stream/spring				Wells				Ponds				Tap water			
		Drinking water	Domestic use	Livestock use	Agriculture	Drinking water	Domestic use	Livestock use	Agriculture	Drinking water	Domestic use	Livestock use	Agriculture	Drinking water	Domestic use	Livestock use	Agriculture	Drinking water	Domestic use	Livestock use	Agriculture
1	Baghar	1		1		1	1	1						1	1	1		1	1		
2	Gemreteng					1	1	1						1	1	1		1	1	1	
3	Gomkang					1	1	1										1	1	1	
4	Gyada																	1	1	1	
5	Gyankhar	1		1	1	1	1	1	1	1	1										
6	Kharteng	1		1	1		1												1	1	
7	Maio	1	1				1														
8	Menteng					1	1	1										1	1	1	

9	Nam Tsering	1	1	1			1											1	1		
10	Pharmey						1											1	1	1	
11	Phomang	1		1		1		1						1	1			1	1		
12	Seru		1	1		1	1	1	1						1			1	1		
13	Sherbang									1	1	1						1	1	1	
14	Yabab									1	1	1						1	1	1	
15	Yusum		1	1		1		1										1	1		
	Total	**6**	**4**	**8**	**2**	**8**	**11**	**8**	**2**	**3**	**3**	**2**	**0**	**3**	**4**	**3**	**0**	**12**	**13**	**8**	

Amenities in the Villages: Out of 12 amenities listed in Table II. 3.550, Yusum has the maximum number of 11 (92%) amenities. There are several villages which have only few amenities. For example six villages have only four amenities each. Fair price shop and grocery shop are present in three villages each, whereas post office and bank occur only in one village i.e. Yusum. Three amenities, viz., electricity, telephone and TV/radio are found in all the villages. Traditional health healers are present in two villages (Table II. 3.550).

Table II. 3.550: Amenities in the villages

Sl. No	Village	Road connectivity	Health facility (PHC/ sub–centre)	Traditional health healer	Veterinary services	Electricity	Fair price shop	Grocery shop	Post office	Bank	School	Telephone/Mobile	TV/ Radios
1	Baghar	√				√					√	√	√
2	Gemreteng	√				√						√	√
3	Gomkang			√		√	√	√			√	√	√
4	Gyada	√				√						√	√
5	Gyankhar					√					√	√	√
6	Kharteng	√		√		√					√	√	√
7	Maio	√				√						√	√
8	Menteng	√				√						√	√
9	Nam Tsering	√				√					√	√	√
10	Pharmey	√				√						√	√
11	Phomang	√				√					√	√	√
12	Seru	√	√			√	√	√			√	√	√
13	Sherbang	√				√					√	√	√
14	Yabab	√				√					√	√	√
15	Yusum	√	√		√	√	√	√	√	√	√	√	√
	Total	**13**	**2**	**2**	**1**	**15**	**3**	**3**	**1**	**1**	**10**	**15**	**15**

NB: Blank indicates absent

Social Institutions: In none of the fifteen villages all the four social institutions listed in Table II. 3.551 are present. Gemreteng, Gyada and Menteng lack all the amenities listed in Table II. 3.551. Considerable variation is observed between the villages in terms of availability of social institution. Gompa was found in only seven villages. SHGs are found in two surveyed villages.

Table II. 3.551: Social institutions in the village

Sl. No.	Village	SHGs	Anganwadis	Community hall	Gompa	Any other	Total
1	Baghar		√	√			**2**
2	Gemreteng						**0**
3	Gomkang	√		√	√		**3**
4	Gyada						**0**
5	Gyankhar		√	√			**2**
6	Kharteng	√	√		√		**3**
7	Maio		√	√	√		**3**
8	Menteng						**0**
9	Nam Tsering		√				**1**
10	Pharmey			√	√		**2**
11	Phomang		√	√	√		**3**
12	Seru		√	√	√		**3**
13	Sherbang		√	√			**2**
14	Yabab		√	√			**2**
15	Yusum		√		√		**2**
	Total	**2**	**10**	**9**	**7**	**0**	

NB: Blank indicates absent

Occupation Profile: Work force participation is detailed in Table II. 3.552, The total working population in the studied villages comprises of 1521 (58%) of total population (2634). Of the total workers main workers are 80% while marginal workers are 20%.

Table II. 3.552: Occupation profile of the village

Sl. No.	Village	Population			Workers			Main workers			Marginal workers			Non workers		
		T	M	F	T	M	F	T	M	F	T	M	F	T	M	F
1	Baghar	218	95	123	116	53	63	113	52	61	3	1	2	102	42	60
2	Gemreteng	24	14	10	129	62	67	128	62	66	1	0	1	133	75	58
3	Gomkang	36	18	18	92	51	41	85	48	37	7	3	4	60	30	30
4	Gyada	44	20	24	10	4	6	10	4	6	0	0	0	15	6	9
5	Gyankhar	239	110	129	114	71	43	74	43	31	40	28	12	121	62	59
6	Kharteng	453	195	258	102	50	52	89	46	43	13	4	9	223	98	125
7	Maio	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
8	Menteng	12	4	8	5	2	3	4	2	2	1	0	1	7	2	5
9	Nam Tsering	235	133	102	68	32	36	67	32	35	1	0	1	66	20	46
10	Pharmey	114	64	50	34	22	12	28	21	7	6	1	5	31	14	17
11	Phomang	184	85	99	54	28	26	53	28	25	1	0	1	40	17	23
12	Seru	671	313	358	40	31	9	40	31	9	0	0	0	92	41	51
13	Sherbang	189	89	100	733	511	222	501	405	96	232	106	126	630	317	313
14	Yabab	119	54	65	11	3	8	11	3	8	0	0	0	8	3	5
15	Yusum	96	44	52	13	6	7	13	6	7	0	0	0	5	3	2
	Total*	**2634**	**1238**	**1396**	**1521**	**926**	**595**	**1216**	**783**	**433**	**305**	**143**	**162**	**1533**	**730**	**803**

* Excluding Maio due to non–availability of data

Household Level Survey–Influenced

Age of the Head of the Household: Data presented in Tables II. 3.553 and 3.554 in respect of age of head of the HHs in fifteen surveyed villages revealed that the age of head of HHs across the fifteen surveyed villages varied from 19 in Yabab to 87 years in Seru. The age of 35% of heads is over 50 years while 14% of heads were below 30 years. Considerable variation in average age of heads of HH between villages was seen from 41 to 64.

Table II. 3.553: Distribution of head of the HHs by age across the fifteen project villages

Sl. No.	Village	Up to 30		31–40		41–50		> 50		Total
		n	%	n	%	n	%	n	%	n
1	Baghar	14	24	18	31	6	10	21	36	**59**
2	Gemreteng	0	0	2	22	4	44	3	33	**9**
3	Gomkang	0	0	5	42	3	25	4	33	**12**
4	Gyada	2	18	2	18	4	36	3	27	**11**
5	Gyankhar	2	3	18	28	25	38	20	31	**65**
6	Kharteng	17	16	22	21	24	22	44	41	**107**
7	Maio	4	17	9	39	6	26	4	17	**23**
8	Menteng	0	0	0	0	0	0	3	100	**3**
9	Nam Tsering	9	17	11	21	13	25	19	37	**52**
10	Pharmey	10	30	8	24	8	24	7	21	**33**
11	Phomang	11	22	12	24	11	22	15	31	**49**
12	Seru	9	8	22	21	31	29	44	42	**106**
13	Sherbang	2	5	14	35	11	28	13	33	**40**
14	Yabab	2	14	2	14	2	14	8	57	**14**
15	Yusum	7	14	18	36	13	26	12	24	**50**
	Total	**89**	**14**	**163**	**26**	**161**	**25**	**220**	**35**	**633**

Table II. 3.554: Minimum, maximum and average age of head of HHs across the fifteen project villages

Sl. No.	Village	Age range		Average
		From	To	
1	Baghar	21	80	44
2	Gemreteng	37	70	52
3	Gomkang	32	63	47
4	Gyada	20	70	47
5	Gyankhar	25	84	46
6	Kharteng	20	86	47
7	Maio	21	78	41
8	Menteng	60	68	64
9	Nam Tsering	23	81	46
10	Pharmey	23	83	43

11	Phomang	21	80	44
12	Seru	23	87	49
13	Sherbang	22	65	46
14	Yabab	19	69	51
15	Yusum	23	60	43
	Total	**19**	**87**	**47**

Gender of the Head of Households: Data on gender of the heads of HHs in the fifteen surveyed project villages is given in Table II. 3.555. In all the studied villages the number of males exceeds that of females as head of HHs except in Menteng. Yabab has equal number of male and female. Across the surveyed villages 81% of heads were males.

Table II. 3.555: Distribution of head of HHs by gender in the fifteen project villages

Sl. No.	Village	Male		Female		Total
		n	%	n	%	n
1	Baghar	44	75	15	25	**59**
2	Gemreteng	7	78	2	22	**9**
3	Gomkang	11	92	1	8	**12**
4	Gyada	10	91	1	9	**11**
5	Gyankhar	53	82	12	18	**65**
6	Kharteng	89	83	18	17	**107**
7	Maio	21	91	2	9	**23**
8	Menteng	1	33	2	67	**3**
9	Nam Tsering	47	90	5	10	**52**
10	Pharmey	28	85	5	15	**33**
11	Phomang	41	84	8	16	**49**
12	Seru	79	75	27	25	**106**
13	Sherbang	34	85	6	15	**40**
14	Yabab	7	50	7	50	**14**
15	Yusum	40	80	10	20	**50**
	Total	**512**	**81**	**121**	**19**	**633**

Ethnicity: All the fifteen villages are predominantly inhabited by Monpa tribals.

Household Size: The HH size varies from 1 to 12 across the fifteen villages. There is vast variation between the fifteen villages in terms of distribution of HH size. The average HH size varies from three in Menteng to six in Gyankhar and Sherbang. Across the studied villages the average HH size is five (Tables II. 3.556 and 3.557).

Table II. 3.556: Distribution of HH size in the fifteen project villages

Sl. No.	Village	1		2		3		4		5		6–8		9 and above		Total
		n	%	n	%	n	%	n	%	n	%	n	%	n	%	n
1	Baghar	8	14	5	8	9	15	7	12	10	17	20	34	0	0	**59**
2	Gemreteng	0	0	1	11	1	11	3	33	3	33	1	11	0	0	**9**
3	Gomkang	1	8	3	25	0	0	0	0	5	42	3	25	0	0	**12**
4	Gyada	0	0	1	9	3	27	5	45	1	9	1	9	0	0	**11**
5	Gyankhar	0	0	4	6	5	8	6	9	17	26	23	35	10	15	**65**
6	Kharteng	10	9	20	19	10	9	21	20	16	15	27	25	3	3	**107**
7	Maio	1	4	1	4	4	17	6	26	3	13	7	30	1	4	**23**
8	Menteng	2	67	0	0	0	0	0	0	0	0	1	33	0	0	**3**
9	Nam Tsering	5	10	1	2	7	13	6	12	8	15	22	42	3	6	**52**
10	Pharmey	6	18	2	6	5	15	3	9	5	15	10	30	2	6	**33**
11	Phomang	8	16	2	4	2	4	13	27	6	12	16	33	2	4	**49**
12	Seru	2	2	4	4	19	18	27	25	20	19	29	27	5	5	**106**
13	Sherbang	0	0	3	8	3	8	2	5	7	18	19	48	6	15	**40**
14	Yabab	0	0	2	14	3	21	3	21	2	14	3	21	1	7	**14**
15	Yusum	1	2	4	8	5	10	15	30	12	24	13	26	0	0	**50**
	Total	**44**	**7**	**53**	**8**	**76**	**12**	**117**	**18**	**115**	**18**	**195**	**31**	**33**	**5**	**633**

Table II. 3.557: Minimum, maximum and average HH size across the fifteen project villages

Sl. No.	Village	HH size range		Average HH size
		From	To	
1	Baghar	1	8	4
2	Gemreteng	2	7	4
3	Gomkang	1	7	4
4	Gyada	2	6	4
5	Gyankhar	2	12	6
6	Kharteng	1	9	4
7	Maio	1	9	5
8	Menteng	1	6	3
9	Nam Tsering	1	9	5
10	Pharmey	1	10	5
11	Phomang	1	11	5
12	Seru	1	10	5
13	Sherbang	2	10	6
14	Yabab	2	9	5
15	Yusum	1	8	5
	Total	**1**	**12**	**5**

Education: Relevant data on the education of the head of the HHs in the fifteen project villages is given in Table II. 3.558. It is noteworthy that a majority of the heads in studied villages were illiterate (84%). It varied from 58% in Pharmey to 100% in Gyada, Menteng and Yabab. There were 16 head of HHs (3%) in the studied villages who were Graduates.

Table II. 3.558: Distribution of education of head of HH in the fifteen project villages

Sl. No.	Village	Illiterate		Primary		Upper Primary		Secondary		Higher Secondary		Graduate or above		Total
		n	%	n	%	n	%	n	%	n	%	n	%	n
1	Baghar	58	98	0	0	0	0	1	2	0	0	0	0	**59**
2	Gemreteng	8	89	0	0	1	11	0	0	0	0	0	0	**9**
3	Gomkang	10	83	0	0	0	0	2	17	0	0	0	0	**12**
4	Gyada	11	100	0	0	0	0	0	0	0	0	0	0	**11**
5	Gyankhar	44	68	0	0	4	6	9	14	1	2	7	11	**65**
6	Kharteng	95	89	0	0	1	1	5	5	3	3	3	3	**107**
7	Maio	15	65	0	0	2	9	3	13	1	4	2	9	**23**
8	Menteng	3	100	0	0	0	0	0	0	0	0	0	0	**3**
9	Nam Tsering	41	79	2	4	1	2	7	13	1	2	0	0	**52**
10	Pharmey	19	58	0	0	6	18	7	21	1	3	0	0	**33**
11	Phomang	48	98	0	0	0	0	1	2	0	0	0	0	**49**
12	Seru	90	85	0	0	4	4	6	6	3	3	3	3	**106**
13	Sherbang	36	90	0	0	2	5	1	3	1	3	0	0	**40**
14	Yabab	14	100	0	0	0	0	0	0	0	0	0	0	**14**
15	Yusum	41	82	0	0	4	8	4	8	0	0	1	2	**50**
	Total	**533**	**84**	**2**	**0**	**25**	**4**	**46**	**7**	**11**	**2**	**16**	**3**	**633**

Main Occupation of Household Heads: The main occupations of the head of HHs across the fifteen villages are agriculture, labour, pastoralist and government service. Table II. 3.559 reveal the following:

Agriculture: It varies from 25% in Gomkang to 100% in Gyada and Phomang. 78% of the surveyed head of HHs are engaged in agriculture.

Labour: Except in six villages, in the remaining villages labour has been reported by small number of HHs (4%) as main mode of occupation.

Pastoralist: Only in Seru, one HH returned pastoralism as main occupation.

Government service: Government servants were reported from ten villages. Gyankhar had the maximum number (26/84) of government employees. Government service constitutes 13% of the main occupations.

Any other occupation: 32 HHs (5%) were engaged in other occupations.

Table II. 3.559: Distribution of head of HHs by main occupation in the fifteen project villages

Sl. No.	Village	Farmer		Labour		Pastoral		Govt Servant		Others		Total
		n	%	n	%	n	%	n	%	n	%	n
1	Baghar	45	76	2	3	0	0	2	3	10	17	**59**
2	Gemreteng	8	89	1	11	0	0	0	0	0	0	**9**
3	Gomkang	3	25	6	50	0	0	3	25	0	0	**12**
4	Gyada	11	100	0	0	0	0	0	0	0	0	**11**
5	Gyankhar	30	46	5	8	0	0	26	40	4	6	**65**
6	Kharteng	88	82	2	2	0	0	16	15	1	1	**107**
7	Maio	17	74	0	0	0	0	3	13	3	13	**23**
8	Menteng	1	33	2	67	0	0	0	0	0	0	**3**
9	Nam Tsering	47	90	0	0	0	0	3	6	2	4	**52**
10	Pharmey	30	91	1	3	0	0	1	3	1	3	**33**
11	Phomang	49	100	0	0	0	0	0	0	0	0	**49**
12	Seru	80	75	3	3	1	1	20	19	2	2	**106**
13	Sherbang	33	83	2	5	0	0	2	5	3	8	**40**
14	Yabab	13	93	0	0	0	0	0	0	1	7	**14**
15	Yusum	37	74	0	0	0	0	8	16	5	10	**50**
	Total	**492**	**78**	**24**	**4**	**1**	**0**	**84**	**13**	**32**	**5**	**633**

Private Land Holding Pattern: The private land holding pattern in the fifteen villages comprises of agricultural land, horticulture land, habitation and home garden land and forest land. It may be noted here that a majority of the inhabitants of the surveyed villages did not know actual area either in acres or hectares of all categories of land holdings. Therefore, the area reported here should be considered as very rough estimates. Data pertaining to this aspect have been described below.

Agricultural land: Table II. 3.560 revealed that except 149 HHs (24%), all the remaining HHs (76%) in fourteen surveyed villages owned agricultural land in varying proportions. A majority of the HHs (45%) owned agricultural landbetween 1–2 acres. Only 11% of HHs owned land which is greater than 2 acres (Table II. 3.560).

Table II. 3.560: Distribution of agricultural land holding among surveyed HHs in the fourteen project villages

Sl. No.	Village	0.00 acre		< 1 acre		1–2 acre		> 2 acre	
		n	%	n	%	n	%	n	%
1	Baghar	9	15	21	36	29	49	0	0
2	Gemreteng	1	11	8	89	0	0	0	0
3	Gomkang	4	33	1	8	7	58	0	0
4	Gyankhar	11	17	7	11	34	52	13	20
5	Kharteng	37	35	6	6	42	39	22	21
6	Maio	12	52	2	9	5	22	4	17
7	Menteng	0	0	2	67	1	33	0	0
8	Nam Tsering	11	21	22	42	19	37	0	0
9	Pharmey	10	30	3	9	8	24	12	36
10	Phomang	14	29	2	4	33	67	0	0
11	Seru	27	25	22	21	49	46	8	8
12	Sherbang	10	25	3	8	19	48	8	20
13	Yabab	0	0	3	21	11	79	0	0
14	Yusum	3	6	26	52	21	42	0	0
	Total	**149**	**24**	**128**	**21**	**278**	**45**	**67**	**11**

Data in this respect is not available for Gyada

Horticultural land: 60 HHs in nine villages own 81 acres of horticultural land (Table II. 3.561).

Table II. 3.561: Distribution of horticultural land among surveyed HHs in the fourteen project villages

Sl. No.	Village	n	0.00 acre		< 1 acre		1–2 acre		> 2 acre	
			n	%	n	%	n	%	n	%
1	Baghar	59	57	97	1	2	1	2	0	0
2	Gemreteng	9	9	100	0	0	0	0	0	0
3	Gomkang	12	9	75	1	8	2	17	0	0
4	Gyankhar	65	50	77	3	5	10	15	2	3
5	Kharteng	107	107	100	0	0	0	0	0	0
6	Maio	23	22	96	0	0	0	0	1	4
7	Menteng	3	3	100	0	0	0	0	0	0
8	Nam Tsering	52	51	98	1	2	0	0	0	0
9	Pharmey	33	16	48	7	21	7	21	3	9

10	Phomang	49	49	100	0	0	0	0	0	0
11	Seru	106	87	82	3	3	15	14	1	1
12	Sherbang	40	39	98	0	0	0	0	1	3
13	Yabab	14	13	93	1	7	0	0	0	0
14	Yusum	50	50	100	0	0	0	0	0	0
	Total	**622**	**562**	**90**	**17**	**3**	**35**	**6**	**8**	**1**

Data in this respect is not available for Gyada

Habitation and homegarden land: Data presented in Table II. 3.562 reveal that 13/14 surveyed villages had this category of land in varying proportions. Only 199 of HHs (32%) in surveyed villages did not own any such land. A majority of HHs (57%) owned less than one acre of such land. 10% of the HHs owned such land ranging from 1 to2 acre. Total area under this category of land type is 121 acres.

Table II. 3.562: Distribution of habitation and homegarden land among surveyed HHs in the fourteen project villages

Sl. No.	Village	0.00 acre		< 1 acre		1–2 acre		> 2 acre	
		n	%	n	%	n	%	n	%
1	Baghar	3	5	56	95	0	0	0	0
2	Gemreteng	9	100	0	0	0	0	0	0
3	Gomkang	0	0	9	75	3	25	0	0
4	Gyankhar	11	17	42	65	12	18	0	0
5	Kharteng	93	87	1	1	13	12	0	0
6	Maio	2	9	13	57	8	35	0	0
7	Menteng	0	0	3	100	0	0	0	0
8	Nam Tsering	51	98	1	2	0	0	0	0
9	Pharmey	1	3	24	73	8	24	0	0
10	Phomang	1	2	48	98	0	0	0	0
11	Seru	3	3	94	89	9	8	0	0
12	Sherbang	14	35	14	35	10	25	2	5
13	Yabab	7	50	6	43	1	7	0	0
14	Yusum	4	8	46	92	0	0	0	0
	Total	**199**	**32**	**357**	**57**	**64**	**10**	**2**	**0**

Data in this respect is not available for Gyada

Forest land: 285 HHs (46%) in the surveyed villages do not own private forest land (Table II. 3.563). A majority of HHs (28%) owned such land between 1 and 2 acres. It is noteworthy that only 17 (3%) HHs owned more than 2 acre of forest land. Area under this category of land type is 353 acres.

Table II. 3.563: Distribution of forest land holding among surveyed HHs in the fourteen project villages

Sl. No.	Village	0.00 acre		< 1 acre		1–2 acre		> 2 acre	
		n	%	n	%	n	%	n	%
1	Baghar	21	36	38	64	0	0	0	0
2	Gemreteng	9	100	0	0	0	0	0	0
3	Gomkang	5	42	4	33	3	25	0	0
4	Gyankhar	37	57	8	12	13	20	7	11
5	Kharteng	44	41	4	4	58	54	1	1
6	Maio	18	78	0	0	4	17	1	4
7	Menteng	0	0	3	100	0	0	0	0
8	Nam Tsering	52	100	0	0	0	0	0	0
9	Pharmey	14	42	3	9	13	39	3	9
10	Phomang	16	33	33	67	0	0	0	0
11	Seru	44	42	17	16	40	38	5	5
12	Sherbang	16	40	6	15	18	45	0	0
13	Yabab	2	14	4	29	8	57	0	0
14	Yusum	7	14	23	46	20	40	0	0
	Total	**285**	**46**	**143**	**23**	**177**	**28**	**17**	**3**

Data in this respect is not available for Gyada

Total land holdings: Data given in Tables II. 3.564–3.567 showed that there are only 56 HHs (9%) that do not own any type of private land. 33% of the HHs own more than 2 acres of total land. There is striking variation between the HHs within a village as well as between villages in ownership of total land. For example, in Seru inter–HH holdings vary from 0.01 acre to 18.15 acres, whereas in Gemreteng it varies from 0–0.50 acres. The proportion of agricultural landcompared to other types of land to the total land holdings is greater in a majority of the villages. The fourteen villages owned total private land totalling 1245 acres. Out of this Gyankhar, Kharteng, Seru and Sherbang accounts for 62% of the total land. Agricultural land accounts for 55% and forest land 28% of total land holdings in the eight villages.

Table II. 3.564: Distribution of total land holding among surveyed HHs in the fourteen project villages

Sl. No.	Village	0.00 acre		< 1 acre		1–2 acre		> 2 acre	
		n	%	n	%	n	%	n	%
1	Baghar	3	5	16	27	37	63	3	5
2	Gemreteng	1	11	8	89	0	0	0	0
3	Gomkang	0	0	3	25	4	33	5	42
4	Gyankhar	1	2	12	18	18	28	34	52
5	Kharteng	35	33	2	2	19	18	51	48
6	Maio	2	9	10	43	6	26	5	22
7	Menteng	0	0	0	0	2	67	1	33
8	Nam Tsering	10	19	23	44	19	37	0	0
9	Pharmey	0	0	12	36	5	15	16	48
10	Phomang	1	2	13	27	35	71	0	0
11	Seru	0	0	33	31	33	31	40	38
12	Sherbang	2	5	6	15	6	15	26	65
13	Yabab	0	0	1	7	6	43	7	50
14	Yusum	1	2	7	14	22	44	20	40
	Total	**56**	**9**	**146**	**23**	**212**	**34**	**208**	**33**

Data in this respect is not available for Gyada

Table II. 3.565: Minimum, maximum and average land holdings across the fourteen project villages

Sl. No.	Village	Agricultural land			Horticultural land			Habitation and Homegarden land			Forest land			Total land		
		From	To	Avg.	From	To	Avg.	From	To	Avg.	From	To	Avg.	From	To	Avg.
1	Baghar	0.00	1.50	0.66	0.00	1.00	0.03	0.00	0.50	0.07	0.00	0.50	0.31	**0.00**	**2.67**	**1.07**
2	Gemreteng	0.00	0.50	0.43	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**	**0.50**	**0.43**
3	Gomkang	0.00	2.00	0.95	0.00	2.00	0.29	0.02	1.00	0.58	0.00	2.00	0.50	**0.02**	**6.00**	**2.33**
4	Gyankhar	0.00	7.41	1.72	20.00	9.88	0.45	0.00	1.72	0.26	0.00	9.00	0.79	**0.00**	**17.82**	**3.24**
5	Kharteng	0.00	4.94	1.05	0.00	0.00	0.00	0.00	1.00	0.12	0.00	2.47	0.58	**0.00**	**6.94**	**1.77**
6	Maio	0.00	8.00	1.02	0.00	4.94	0.21	0.00	2.00	0.51	0.00	6.18	0.44	**0.00**	**14.82**	**2.19**
7	Menteng	0.50	1.00	0.67	0.00	0.00	0.00	0.50	0.50	0.50	0.75	0.75	0.75	**1.75**	**2.25**	**1.92**
8	Nam Tsering	0.00	2.00	0.60	0.00	0.75	0.01	0.00	0.10	0.00	0.00	0.00	0.00	**0.00**	**2.00**	**0.64**
9	Pharmey	0.00	4.94	1.55	0.00	4.94	0.63	0.00	1.00	0.58	0.00	4.94	0.74	**0.39**	**11.88**	**3.50**
10	Phomang	0.00	1.00	0.69	0.00	0.00	0.00	0.00	0.50	0.23	0.00	0.50	0.33	**0.00**	**1.75**	**1.26**
11	Seru	0.00	4.00	0.94	0.00	2.50	0.17	0.00	2.00	0.13	0.00	15.00	0.80	**0.01**	**18.15**	**2.07**
12	Sherbang	0.00	4.00	1.45	0.00	3.00	0.08	0.00	3.00	0.50	0.00	2.00	0.61	**0.00**	**7.02**	**2.64**
13	Yabab	0.50	2.00	1.10	0.00	0.50	0.03	0.00	1.00	0.28	0.00	1.00	0.71	**0.50**	**3.50**	**2.14**
14	Yusum	0.00	2.00	0.85	0.00	0.00	0.00	0.00	0.05	0.02	0.00	2.00	0.78	**0.00**	**4.04**	**1.65**

Data in this respect is not available for Gyada

Table II. 3.566: Number of HHs having land types in the fourteen project villages

Sl. No.	Village	Agricultural land		Horticultural land		Habitation and home garden land		Forest land	
		n	%	n	%	n	%	n	%
1	Baghar	50	85	2	3	56	95	38	64
2	Gemreteng	8	89	0	0	0	0	0	0
3	Gomkang	8	67	3	25	12	100	7	58
4	Gyankhar	54	83	15	23	54	83	28	43
5	Kharteng	70	65	0	0	14	13	63	59
6	Maio	11	48	1	4	21	91	5	22
7	Menteng	3	100	0	0	3	100	3	100
8	Nam Tsering	42	81	1	2	1	2	0	0
9	Pharmey	23	70	17	52	32	97	19	58
10	Phomang	35	71	0	0	48	98	33	67

11	Seru	79	75	19	18	103	97	62	58
12	Sherbang	30	75	1	3	26	65	24	60
13	Yabab	14	100	1	7	7	50	12	86
14	Yusum	47	94	0	0	46	92	43	86
	Total	**474**	**76**	**60**	**10**	**423**	**68**	**337**	**54**

Data in this respect is not available for Gyada

Table II. 3.567: Distribution of area (in acres) of land holding among HHs in the fourteen project villages

Sl. No.	Village	Agricultural land		Horticultural land		Habitation and homegarden land		Forest land		Total land
		Area	%	Area	%	Area	%	Area	%	Area
1	Baghar	39	62	2	2	4	7	19	29	**63**
2	Gemreteng	4	100	0	0	0	0	0	0	**4**
3	Gomkang	12	41	4	12	7	25	6	21	**28**
4	Gyankhar	112	53	30	14	17	8	51	24	**211**
5	Kharteng	113	60	0	0	14	7	62	33	**189**
6	Maio	23	47	5	10	12	23	10	20	**50**
7	Menteng	2	35	0	0	2	26	2	39	**6**
8	Nam Tsering	32	97	1	2	0	0	0	0	**33**
9	Pharmey	51	44	21	18	19	17	25	21	**116**
10	Phomang	34	55	0	0	12	19	17	27	**62**
11	Seru	100	46	19	9	15	7	86	39	**220**
12	Sherbang	109	73	0	0	15	10	27	18	**150**
13	Yabab	16	52	1	2	4	13	10	33	**30**
14	Yusum	43	51	0	0	1	2	39	47	**83**
	Total	**690**	**55**	**81**	**6**	**121**	**10**	**353**	**28**	**1245**

Data in this respect is not available for Gyada

Livestock Holding: The distribution of livestock holdings in the fifteen surveyed villages is shown in Tables II. 3.568–3.570. Nine different types of animals are domesticated in surveyed villages. However, none of the villages owned all the nine types of animals. Altogether 1426 animals are reared in the villages. Considerable inter–village variation is observed in total number of animals reared. It varied from 9 in Nam Tsering to 265 in Seru. Kharteng, Pharmey, Seru and Yusum account for 56% of all the animals found in the surveyed villages. Three animals, viz, cattle (63%), Goat (15%) and Pig (7%) account for 85% of the total animals (1426). 59% of the HHs (373) did not own any animals; whereas 5% of the HHs (29) owned more than 10 animals.

Table II. 3.568: Livestock holding by HHs in the fifteen project villages

Sl. No.	Village		Mithun	Cattle	Yak	Goat	Sheep	Pig	Pony	Poultry	Others
1	Baghar	n	0	20	0	14	0	17	0	14	0
		%	0	34	0	24	0	29	0	24	0
2	Gemreteng	n	0	3	0	0	0	0	0	0	0
		%	0	33	0	0	0	0	0	0	0
3	Gomkang	n	0	2	0	0	0	4	0	3	0
		%	0	17	0	0	0	33	0	25	0
4	Gyada	n	0	1	0	0	0	0	0	0	0
		%	0	9	0	0	0	0	0	0	0
5	Gyankhar	n	0	24	0	7	0	1	0	3	1
		%	0	37	0	11	0	2	0	5	2
6	Kharteng	n	0	27	0	13	0	5	0	0	1
		%	0	25	0	12	0	5	0	0	1
7	Maio	n	0	3	1	1	1	4	1	1	0
		%	0	13	4	4	4	17	4	4	0
8	Menteng	n	0	1	0	0	0	0	0	0	0
		%	0	33	0	0	0	0	0	0	0
9	Nam Tsering	n	0	5	0	2	0	0	0	0	0
		%	0	10	0	4	0	0	0	0	0
10	Pharmey	n	0	13	0	9	0	19	13	3	0
		%	0	39	0	27	0	58	39	9	0
11	Phomang	n	0	15	0	11	0	16	0	6	0
		%	0	31	0	22	0	33	0	12	0
12	Seru	n	2	21	1	1	0	23	1	0	0
		%	2	20	1	1	0	22	1	0	0

13	Sherbang	n	0	16	0	6	1	1	0	1	0
		%	0	40	0	15	3	3	0	3	0
14	Yabab	n	0	5	0	2	0	0	0	1	0
		%	0	36	0	14	0	0	0	7	0
15	Yusum	n	0	13	0	4	0	9	0	1	0
		%	0	26	0	8	0	18	0	2	0
	Total	n	**2**	**169**	**2**	**70**	**2**	**99**	**15**	**33**	**2**
		%	**0.3**	**27**	**0.3**	**11**	**0.3**	**16**	**2**	**5**	**0.3**

Table II. 3.569: Number of livestock in surveyed HHs across the fifteen project villages

Sl. No.	Village		Mithun	Cattle	Yak	Goat	Sheep	Pig	Pony	Poultry	Others	Total
1	Baghar	LS	0	52	0	32	0	17	0	34	0	**135**
		%	0	39	0	24	0	13	0	25	0	**100**
2	Gemreteng	LS	0	20	0	0	0	0	0	0	0	**20**
		%	0	100	0	0	0	0	0	0	0	**100**
3	Gomkang	LS	0	10	0	0	0	4	0	9	0	**23**
		%	0	43	0	0	0	17	0	39	0	**100**
4	Gyada	LS	0	10	0	0	0	0	0	0	0	**10**
		%	0	100	0	0	0	0	0	0	0	**100**
5	Gyankhar	LS	0	80	0	10	0	1	0	6	1	**98**
		%	0	82	0	10	0	1	0	6	1	**100**
6	Kharteng	LS	0	111	0	55	0	5	0	0	1	**172**
		%	0	65	0	32	0	3	0	0	1	**100**
7	Maio	LS	0	4	40	3	3	5	3	1	0	**59**
		%	0	7	68	5	5	8	5	2	0	**100**
8	Menteng	LS	0	10	0	0	0	0	0	0	0	**10**
		%	0	100	0	0	0	0	0	0	0	**100**
9	Nam Tsering	LS	0	6	0	3	0	0	0	0	0	**9**
		%	0	67	0	33	0	0	0	0	0	**100**
10	Pharmey	LS	0	55	0	39	0	20	28	13	0	**155**
		%	0	35	0	25	0	13	18	8	0	**100**
11	Phomang	LS	0	37	0	19	0	16	0	10	0	**82**
		%	0	45	0	23	0	20	0	12	0	**100**
12	Seru	LS	17	190	30	4	0	23	1	0	0	**265**
		%	6	72	11	2	0	9	0	0	0	**100**
13	Sherbang	LS	0	118	0	31	5	1	0	6	0	**161**
		%	0	73	0	19	3	1	0	4	0	**100**
14	Yabab	LS	0	11	0	4	0	0	0	1	0	**16**
		%	0	69	0	25	0	0	0	6	0	**100**
15	Yusum	LS	0	181	0	19	0	9	0	2	0	**211**
		%	0	86	0	9	0	4	0	1	0	**100**
	Total	**LS**	**17**	**895**	**70**	**219**	**8**	**101**	**32**	**82**	**2**	**1426**
		%	**1**	**63**	**5**	**15**	**1**	**7**	**2**	**6**	**0.1**	**100**

Note: LS–Livestock

Table II. 3.570: Distribution of total number of livestock in HHs of the fifteen project villages

Sl. No.	Village	0		1–5		6–10		> 10		Total
		n	%	n	%	n	%	n	%	n
1	Baghar	26	44	25	42	6	10	2	3	**59**
2	Gemreteng	6	67	1	11	2	22	0	0	**9**
3	Gomkang	5	42	5	42	2	17	0	0	**12**
4	Gyada	10	91	0	0	1	9	0	0	**11**
5	Gyankhar	34	52	26	40	4	6	1	2	**65**
6	Kharteng	67	63	27	25	10	9	3	3	**107**
7	Maio	16	70	5	22	1	4	1	4	**23**
8	Menteng	2	67	0	0	1	33	0	0	**3**
9	Nam Tsering	45	87	7	13	0	0	0	0	**52**
10	Pharmey	11	33	9	27	7	21	6	18	**33**
11	Phomang	28	57	15	31	6	12	0	0	**49**
12	Seru	68	64	26	25	5	5	7	7	**106**
13	Sherbang	21	53	6	15	9	23	4	10	**40**
14	Yabab	7	50	6	43	1	7	0	0	**14**
15	Yusum	27	54	13	26	5	10	5	10	**50**
	Total	**373**	**59**	**171**	**27**	**60**	**9**	**29**	**5**	**633**

Traditional Skills: In the surveyed village six types of crafts are pursued. Weaving is practiced in eleven villages involving 52 HHs (8%). Wood carving is pursued in eight villages. 25 HHs (4%) are engaged in this craft. A small number of HHs is engaged in Thanka painting, carpet making, bamboo utensil making and paper making (Table II. 3.571).

Table II. 3.571: Distribution of various skills among surveyed HHs in the fifteen project villages

Sl. No.	Village	Wood carving		Thanka painting		Carpet making		Bamboo utensils		Weaving		Paper making	
		n	%	n	%	n	%	n	%	n	%	n	%
1	Baghar	0	0	0	0	0	0	0	0	2	3	0	0
2	Gemreteng	0	0	0	0	1	11	0	0	0	0	0	0
3	Gomkang	4	33	0	0	0	0	0	0	0	0	1	8
4	Gyankhar	9	14	0	0	3	5	5	8	13	20	1	2
5	Kharteng	4	4	0	0	2	2	6	6	11	10	0	0
6	Maio	1	4	0	0	0	0	0	0	1	4	0	0
7	Nam Tsering	1	2	1	2	1	2	0	0	1	2	0	0
8	Pharmey	0	0	0	0	0	0	0	0	7	21	0	0
9	Phomang	0	0	0	0	0	0	0	0	2	4	0	0
10	Seru	2	2	2	2	0	0	1	1	6	6	0	0
11	Sherbang	2	5	0	0	3	8	2	5	5	13	0	0
12	Yabab	2	14	0	0	0	0	0	0	2	14	0	0
13	Yusum	0	0	0	0	0	0	1	2	2	4	0	0
	Total	**25**	**4**	**3**	**0.5**	**10**	**2**	**15**	**2**	**52**	**8**	**2**	**0.3**

River Resources: In Table II. 3.572, data pertaining to the use of various river resources by the inhabitants of the fifteen surveyed villages is presented. All the river resources listed in Table II. 3.572, are being used across the studied villages. Water from river is used by a large number of HHs in the villages for drinking (n=321), domestic use (n=112) and for livestock (n=261). Aquatic fauna is used by a small number of HHs in Maio, Gyangkhar and Kharteng. 122 HHs of four villages use aquatic flora. The villages are Baghar, Gyangkhar, Maio and Phomang. It is highly noteworthy that all the HHs totalling 633 in the surveyed villages use river for performing last rites of the dead. A majority of the HHs in most of the surveyed villages use Sand (n=380) and Stone (n=374) from the river bed for self consumption and selling.

Table II. 3.572: Dependence on river resources among surveyed HHs in the fifteen project villages

Sl. No.	Village		Drinking water	Water for domestic use	Water for domestic animal	Fishes	Aquatic flora	Religious	Sand	Stones (boulders)	Any other
1	Baghar	n	59	0	34	0	59	59	59	59	0
		%	100	0	58	0	100	100	100	100	0
2	Gemreteng	n	0	0	3	0	0	9	0	0	0
		%	0	0	33	0	0	100	0	0	0
3	Gomkang	n	0	0	7	0	0	12	12	12	0
		%	0	0	58	0	0	100	100	100	0
4	Gyada	n	0	0	1	0	0	11	0	0	0
		%	0	0	9	0	0	100	0	0	0
5	Gyankhar	n	17	15	31	20	3	65	45	44	3
		%	26	23	48	31	5	100	69	68	5
6	Kharteng	n	107	75	40	1	0	107	94	91	3
		%	100	70	37	1	0	100	88	85	3
7	Maio	n	22	20	7	19	11	23	19	17	2
		%	96	87	30	83	48	100	83	74	9
8	Menteng	n	0	0	1	0	0	3	0	0	0
		%	0	0	33	0	0	100	0	0	0
9	Nam Tsering	n	52	0	7	0	0	52	52	52	0
		%	100	0	13	0	0	100	100	100	0
10	Pharmey	n	0	0	22	0	0	33	0	0	0
		%	0	0	67	0	0	100	0	0	0
11	Phomang	n	49	0	21	0	49	49	49	49	0
		%	100	0	43	0	100	100	100	100	0
12	Seru	n	15	2	38	0	0	106	1	1	0
		%	14	2	36	0	0	100	1	1	0

13	Sherbang	n	0	0	19	0	0	40	0	0	0
		%	0	0	48	0	0	100	0	0	0
14	Yabab	n	0	0	7	0	0	14	0	0	0
		%	0	0	50	0	0	100	0	0	0
15	Yusum	n	0	0	23	0	0	50	49	49	0
		%	0	0	46	0	0	100	98	98	0
	Total	**n**	**321**	**112**	**261**	**40**	**122**	**633**	**380**	**374**	**8**
		%	**51**	**18**	**41**	**6**	**19**	**100**	**60**	**59**	**1**

Forest Resources: The villagers of all the fifteen villages are dependent on forest resources (Table II. 3.573). Forest resources listed in Table II. 3.573 are used in varying degrees among the fifteen surveyed villages. Considerable variation is observed between uses of number of forest resources. There are six villages which use more than ten resources. All the fifteen villages, gather fuel wood, graze their animals and gather stone from forest. Five resources, viz., timber, food, spices, water and sand are used in more than ten villages. 300 HHs belonging to nine villages use forest resources for medicine. Aquatic fauna are also gathered by a small number of HHs of Maio and Gyangkhar. Forest also provides honey, edible oils, spices, etc. to a substantial number of HHs. It is thus evident from above description that for a majority of the inhabitants of the surveyed villages, forest resources play a very significant role to the livelihoods, as well as the quality of life of the people.

Table II. 3.573: Dependence on forest resources among surveyed HHs in the fifteen project villages

Sl. No.	Forest resources		Baghar	Gemreteng	Gomkang	Gyada	Gyankhar	Kharteng	Maio	Menteng	Nam Tsering	Pharmey	Phomang	Seru	Sherbang	Yabab	Yusum	Total
1	Fuel wood	n	59	9	12	11	65	106	15	3	52	19	49	97	40	14	49	**600**
		%	100	100	100	100	100	99	65	100	100	58	100	92	100	100	98	**95**
2	Timber	n	59	9	12	11	58	1	21	0	52	0	49	96	0	0	49	**417**
		%	100	100	100	100	89	1	91	0	100	0	100	91	0	0	98	**66**
3	Medicinal plants	n	59	3	12	0	46	102	14	2	0	0	49	13	0	0	0	**300**
		%	100	33	100	0	71	95	61	67	0	0	100	12	0	0	0	**47**
4	Honey	n	0	2	0	0	14	51	1	0	0	0	0	3	0	0	0	**71**
		%	0	22	0	0	22	48	4	0	0	0	0	3	0	0	0	**11**
5	Food	n	59	9	12	0	25	102	11	3	52	33	49	27	40	14	49	**485**
		%	100	100	100	0	38	95	48	100	100	100	100	25	100	100	98	**77**
6	Edible oil	n	0	0	0	0	9	1	2	0	0	0	0	1	0	0	0	**13**
		%	0	0	0	0	14	1	9	0	0	0	0	1	0	0	0	**2**
7	Ornamental	n	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	**2**
		%	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	**0.3**
8	Religious	n	59	9	12	0	62	84	8	3	0	33	49	45	40	14	0	**418**
		%	100	100	100	0	95	79	35	100	0	100	100	42	100	100	0	**66**
9	Fencing	n	59	0	0	0	27	1	19	0	0	0	49	3	0	0	0	**158**
		%	100	0	0	0	42	1	83	0	0	0	100	3	0	0	0	**25**
10	Handicrafts	n	0	0	12	0	10	0	7	0	0	0	0	0	0	0	0	**29**
		%	0	0	100	0	15	0	30	0	0	0	0	0	0	0	0	**5**
11	Thatching	n	0	0	0	0	9	0	6	0	0	0	0	1	0	0	49	**65**
		%	0	0	0	0	14	0	26	0	0	0	0	1	0	0	98	**10**
12	Spices	n	0	1	12	0	28	2	9	1	0	33	0	48	40	14	49	**237**
		%	0	11	100	0	43	2	39	33	0	100	0	45	100	100	98	**37**
13	Grazing	n	34	3	7	1	31	40	7	1	7	22	21	38	19	7	23	**261**
		%	58	33	58	9	48	37	30	33	13	67	43	36	48	50	46	**41**
14	Hunting of wild animals	n	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	**2**
		%	0	0	0	0	2	0	4	0	0	0	0	0	0	0	0	**0.3**
15	Fishes	n	0	0	0	0	24	0	19	0	0	0	0	0	0	0	0	**43**
		%	0	0	0	0	37	0	83	0	0	0	0	0	0	0	0	**7**
16	Water	n	59	0	0	0	36	27	16	0	0	33	49	50	40	14	49	**373**
		%	100	0	0	0	55	25	70	0	0	100	100	47	100	100	98	**59**
17	Stones	n	59	9	12	11	51	25	17	3	52	33	49	51	40	14	49	**475**
		%	100	100	100	100	78	23	74	100	100	100	100	48	100	100	98	**75**
18	Sand	n	0	9	12	11	47	23	18	3	52	0	0	35	0	0	49	**259**
		%	0	100	100	100	72	21	78	100	100	0	0	33	0	0	98	**41**

19	Dyes	n	0	0	12	0	3	0	1	0	0	0	0	2	40	14	49	**121**
		%	0	0	100	0	5	0	4	0	0	0	0	2	100	100	98	**19**

Water Resources: All types of water resources listed in the Table II. 3.574 are available across the studied villages. Eight villages depend on river water. 11/15 villages depend on water from hill stream/springs. Tap water is used for various purposes in thirteen surveyed villages. Pond water is only used in four villages. Hand pump is only used in one village. Gyada depend only on tap water. Wells are present only in three villages.

Table II. 3.574: Dependence on water resources among surveyed HHs in the fifteen project villages

Sl. No.	Village	River		Hill stream/spring		Wells		Ponds		Hand pumps		Tap water	
		n	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**
1	Baghar	59	100	59	100	0	0	59	100	0	0	59	100
2	Gemreteng	0	0	9	100	0	0	9	100	0	0	9	100
3	Gomkang	0	0	12	100	0	0	0	0	0	0	12	100
4	Gyada	0	0	0	0	0	0	0	0	0	0	11	100
5	Gyankhar	9	14	30	46	2	3	0	0	0	0	0	0
6	Kharteng	105	98	103	96	0	0	0	0	0	0	65	61
7	Maio	21	91	14	61	0	0	0	0	0	0	0	0
8	Menteng	0	0	3	100	0	0	3	100	0	0	3	100
9	Nam Tsering	52	100	52	100	0	0	0	0	0	0	52	100
10	Pharmey	0	0	33	100	0	0	0	0	0	0	33	100
11	Phomang	49	100	49	100	0	0	49	100	0	0	49	100
12	Seru	1	1	90	85	0	0	0	0	4	4	1	1
13	Sherbang	0	0	0	0	40	100	0	0	0	0	40	100
14	Yabab	0	0	0	0	14	100	0	0	0	0	14	100
15	Yusum	49	98	0	0	0	0	0	0	0	0	49	98
	Total	**345**	**55**	**454**	**72**	**56**	**9**	**120**	**19**	**4**	**1**	**397**	**63**

3.3.11 NYAMJANG CHU

3.3.11.1 PHYSICAL ENVIRONMENT

Geomorphology

The geomorphological features of Nyamjang chu HEP is depicted in the toposheet (Figure II. 3.60). The project is located at an elevation of 2115 m on Nyamjangchu river.

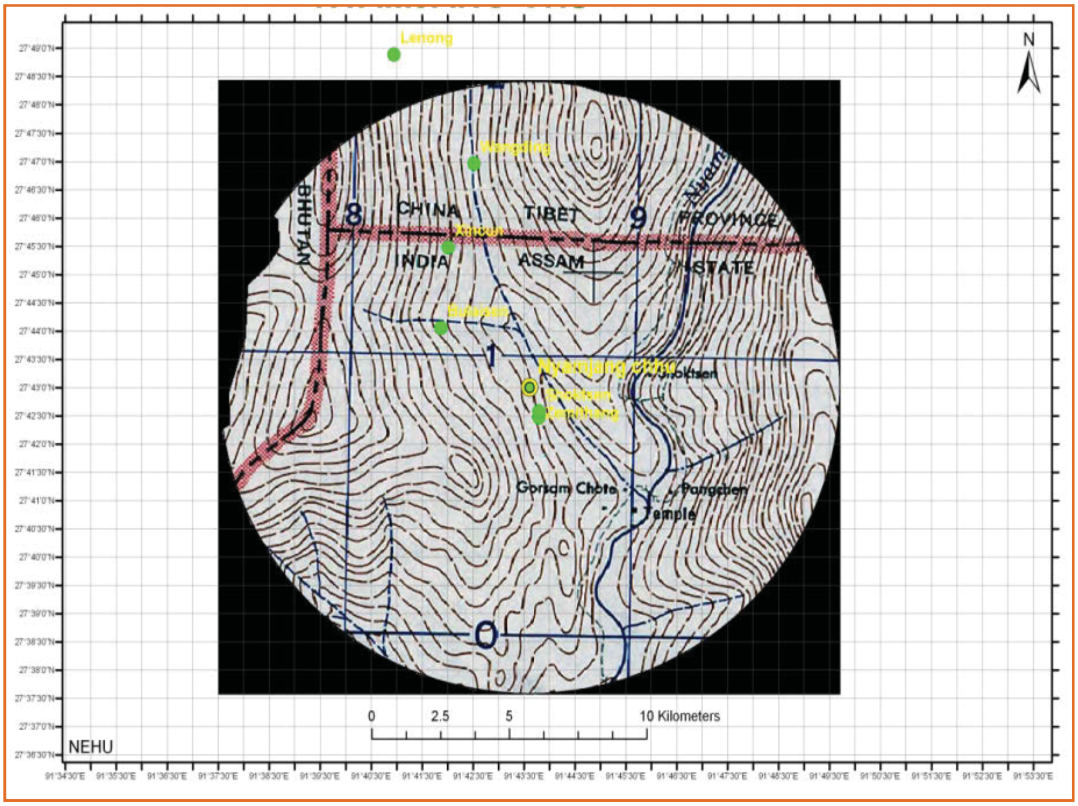


Figure II. 3.60: Contour map of Nyamjang chu

Geology

The geology of the project site is represented by quartz–biotite gneiss (QBG) belonging to Precambrian Sela Group towards upstream, and an interbedded sequence of quartzite (IQS) and schist of Precambrian Lumla/Rupa Group towards downstream. The QBG is a fairly uniform, medium to coarse grained, well foliated rock. It shows gneissose texture with alternate bands of mainly quartz feldspar and micas aong with accessories. The IQS are 10 m to over 40 m thick and are associated with thin interbands of grey quartzite. Occasionally, thin bands of carbonaceous schist and calcitic marble also occur.

At the barrage site, the river is flat and very wide up to 200 m. River bed exposes black fine silty sand with high content of micaceous minerals. Boulders composed mostly of quartzite and gneiss and ranging in size from a few centimeter to a few meters are seen in the river bed area. Gneissic rocks are best exposed on the right bank. On the left bank, gneisses are exposed only along the deeply incised nallas. River bed bore hole (98 m deep) information indicate presence of overburden consisting of boulders of biotite, gneisses with quartz content and blackish medium to fine silty sand up to a depth of 7.5 m and followed by only sand without boulder up to a depth of 91.5 m. Rocks consisting of biotite gneisses with quartz content have been encountered after the depth of 91.5 m. Whereas, in the other bore hole in river bed rock were encountered at a depth of 49 m overlain by blackish medium to fine silty sand and then boulders.

Table II. 3.575: Area under various geological classes in the 10 km radius of the barrage site of Nyamjang chu project

Class	Area	%
Snow covered area	0.85	0.30
Snow covered area	1.37	0.48
Snow covered area	0.39	0.14
Snow covered area	18.81	6.55
Glacial valley	0.59	0.20
Glacier	0.92	0.32
Sela group (Valley)	1.24	0.43
Stabilised channel bar	0.41	0.14
Sela group (Structural hill)	190.77	66.39
Volcanic sediment (Structural hill)	71.37	24.84
Glacial valley	0.62	0.22
Total	**287.36**	**100.00**

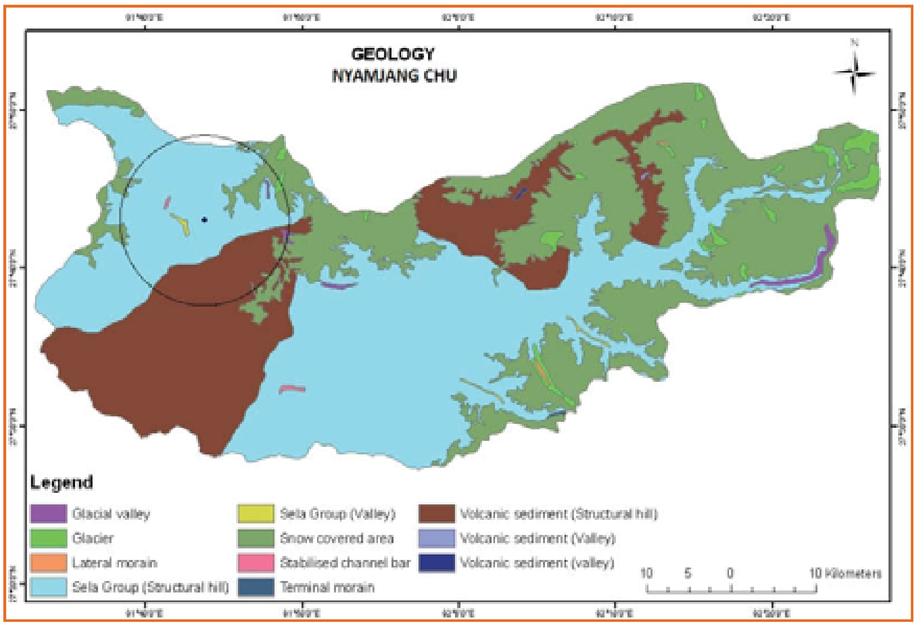


Figure II. 3.61: Geological map of TRB showing location of Nyamjang chu project site

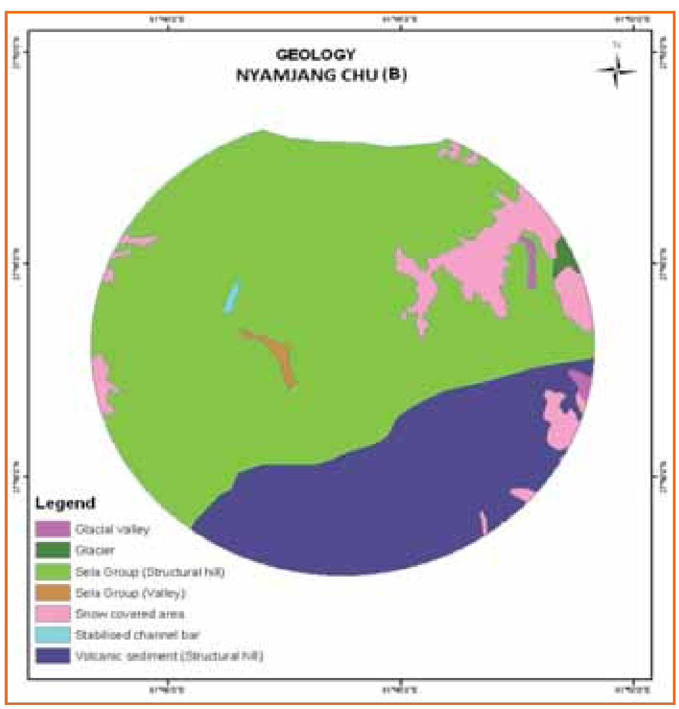


Figure II. 3.62: Geological map of impact zone (10 km radius) of Nyamjang chu barrage site in Tawang river valley

Landuse and Land Cover

The total area within 10 km radius of Nyamjang chu HEP site is 31443.93 ha (Figure II. 3.63). Majority of the area is covered with forest (50.33%) followed by scrubland (32.78%). Cropland covers only 0.02%, waterbody constitutes around 11.15%, and grassland occupies only 0.30% of the total area. The total area occupied by snow and ice and other builtup area altogether is 5.42% (Table II. 3.576).

Table II. 3.576: Landuse/land cover area of Nyamjang chu project sites

Land category	Area (ha)	%
Forest	15826.77	50.33
Scrubland	10306.485	32.78
Waterbody	3507.1425	11.15
Croplands	6.4125	0.02
Grasslands	94.0725	0.30
Bultuparea	48.78	0.16
Snow and Ice	1654.2675	5.26
Total	**31443.93**	**100.00**

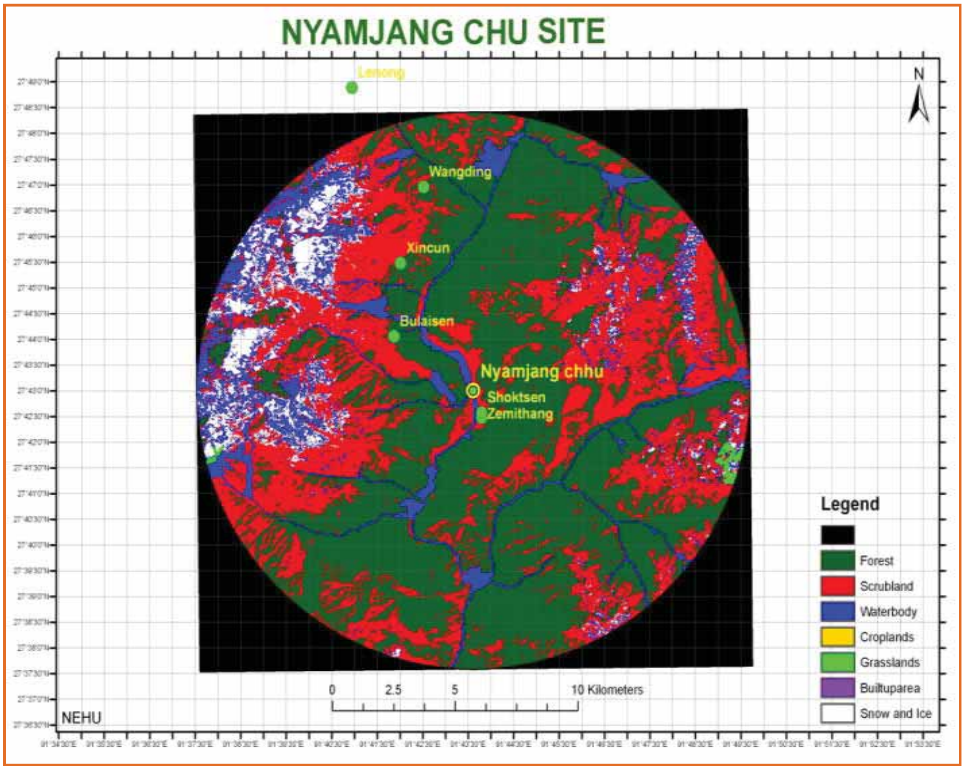


Figure II. 3.63: Landuse/land cover map of Nyamjang chu project site

Soil

The soil in this site was loamy sand, and the water holding capacity and porosity values were at moderate level (Table II. 3.577). Unlike other sites, the soil reaction was neutral but most of the other parameters indicate that the fertility level is low. The only exceptions were conductivity and ammonium nitrogen. All the above parameters differed from barrage to powerhouse sites Table II. 3.578.

Table II. 3.577: Soil physical properties at Nyamjang chu project sites

Site	Texture	WHC (%)	Bulk density (g/cm³)	Porosity (%)
Barrage	Loamy sand	30.69	1.63	38.49
Powerhouse	Loamy sand	25.50	1.68	36.60

Table II. 3.578: Seasonal variation in soil physico–chemical properties at Nyamjang chu project sites during monsoon season

Parameters	Barrage	Powerhouse
SMC (%)	30	27
pH	7.2	7.3
Conductivity ($\mu S\ cm^{-1}$)	280	121
NH_4^+–N ($\mu g\ g^{-1}$)	357	400
NO_3^-–N ($\mu g\ g^{-1}$)	34	46
TKN ($\mu g\ g^{-1}$) x10^3	0.65	0.80
Av.P ($\mu g\ g^{-1}$)	0.04	0.06
TP (%)	0.13	0.15
SOC (%)	0.100	0.008
Ex. K ($\mu g\ g^{-1}$)	399	390
Ex. Mg (%)	0.010	0.009
Ex. Ca (%)	0.210	0.286
Soil microbial biomass–C ($\mu g\ g^{-1}$)	19.34	16.23
Soil microbial biomass–N ($\mu g\ g^{-1}$)	2.56	2.00

Note: B = barrage, PH = powerhouse

Soil Erosion Vulnerability

The area under various soil erosion vulnerable classes in the influence zone of the barrage site of Nyamjang chu is presented in Table II. 3.579. Out of the total area of 287.36 sq.km, only 1.74% area falls under high soil erosion vulnerable zone, while 21.73% falls under moderately high vulnerable zone. About 9.08% of the total area is covered under low vulnerable zone whereas 22.54% falls under moderately–low vulnerable zone. The soil erosion vulnerable area under moderate category covered about 44.9% of the total area. The spatial distribution map of soil erosion vulnerable areas in the influence zone of the barrage site of Nyamjang chu is presented in Figure II. 3.64.

Table II. 3.579: Areas under various soil erosion vulnerable zones in Nyamjang chu at barrage site

Vulnerability	Area (sq. km)	%
High	5.01	1.74
Moderately high	62.45	21.73
Moderate	129.02	44.90
Moderately low	64.77	22.54
Low	26.11	9.08
Total	**287.36**	**100.00**

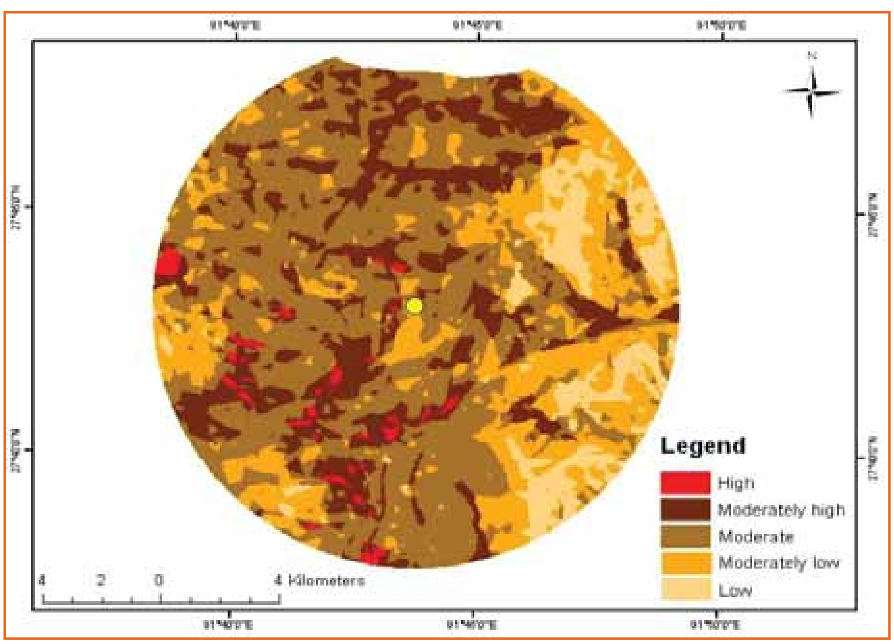


Figure II. 3.64: Spatial distribution of soil erosion vulnerable areas in the influence zone of Nyamjang chu barrage site

Landslide and Erosion Vulnerability

The area under various landslide and erosion vulnerability classes within the influence zone of barrage site of Nyamjang chu is presented in Table II. 3.580. Out of the total area of 287.36 sq. km, the lowest area of landslide and erosion vulnerability was covered under high category with only 0.04% followed by moderately high category with 4.05% of the total area. About 9.37% and 34.59% of the total area falls under low and moderate classes, respectively. The highest area of landslide and erosion vulnerability was covered under moderately low category covering about 51.95% of the total area. The spatial distribution map of landslide and erosion vulnerability areas within the influence zone of barrage site of Nyamjang chu is presented in Figure II. 3.65.

Table II. 3.580: Area under various landslide and erosion vulnerability classes in Nyamjang chu at barrage site

Vulnerability	Area (sq.km)	%
High	0.12	0.04
Moderately high	11.63	4.05
Moderate	99.39	34.59
Moderately low	149.27	51.95
Low	26.94	9.37
Total	**287.36**	**100.00**

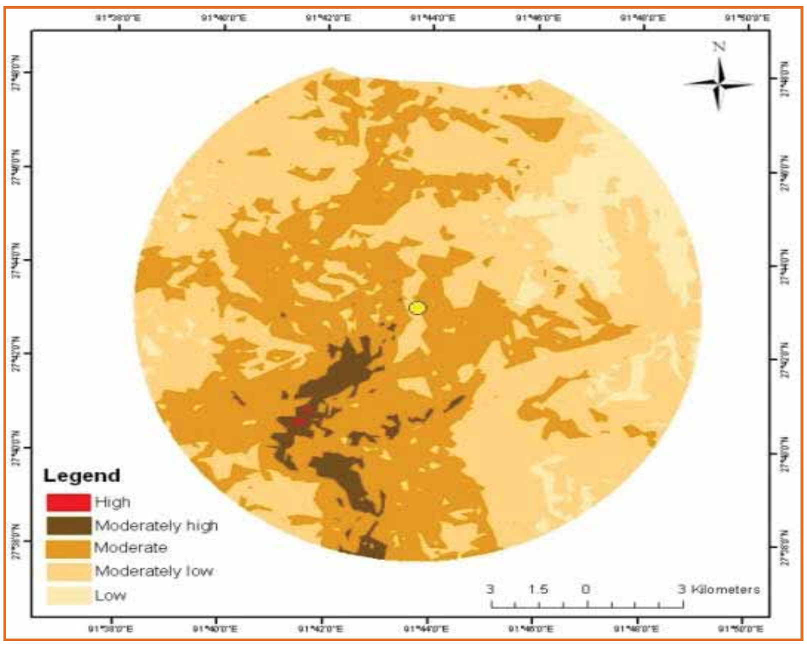


Figure II. 3.65: Area under various erosion and landslide vulnerability classes in the influence zone of Nyamjang chu barrage site

Water

Data on river water properties pertaining to post-monsoon and winter season were obtained from secondary sources. The monsoon data presented in Table II. 3.581 shows similarity with other sites from where data from all three seasons are available. The water was slightly alkaline with pH ranging between 8.18 and 8.24, and total alkalinity value was 30 mg $CaCO_3$/l. The electrical conductivity and total dissolved solids were fairly high as compared to other sites. Primary productivity and dissolved oxygen values were also comparable to other sites. The coliform count was at intermediate level considering the values obtained from other sites (Table II. 3.581).

Table II. 3.581: Physico-chemical and biological properties of water and its primary productivity during monsoon season at Nyamjang chu site

Parameters	Barrage	Powerhouse	Mean
Temperature (˚C)	15.2	15.10	15.15
Turbidity (NTU)	0.97	1.84	1.41
pH	8.24	8.18	8.21
Electrical conductivity (µS/cm)	123.00	110.00	117
Total dissolved solids (mg/l)	63.00	57.00	60.00

Practical salinity (ppt)	0.07	0.07	0.07
Total alkalinity (mg $CaCO_3$/l)	32.00	28.00	30.00
Total hardness (mg/l)	37.54	38.15	37.85
Chloride (mg Cl^-/l)	16.99	17.99	17.49
Ca^{2+} (mg/l)	9.72	9.88	9.80
Mg^{2+} (mg/l)	3.23	3.27	3.25
K^+ ppm	0.50	0.40	0.45
Na^+ ppm	13.00	14.00	13.50
TKN (mg/l)	0.43	0.47	0.45
NH_4^+ N (mg/l)	0.15	0.18	0.17
NO_3–N (mg/l)	0.18	0.21	0.20
Total phosphorus (mg/l)	0.08	0.08	0.08
GPP (mg C/cm^3/h)	0.47	0.47	0.47
NPP (mg C/cm^3/h)	0.23	0.23	0.23
Dissolved oxygen (mg/l)	10.00	10.40	10.20
Total coliforms (CFU/ml)	21	25	23.00
BOD_5 (mg/l)	1.1–1.5	1.1–1.5	

Ambient Air Quality

Concentration of PM_{10} and $PM_{2.5}$: PM_{10} concentration at proposed Tsa chu was 5µg/m^3 and $PM_{2.5}$ concentration was 26.9µg/m^3 (Table II. 3.582). The concentration of sulphur–dioxide (SO_2), nitrogen–dioxide (NO_2), ammonia (NH_3), and ground level ozone (O_3) at all the monitored locations were below detectable limits.

Table II. 3.582: Concentration of PM_{10} and $PM_{2.5}$ in air at proposed Nyamjang chu HEP site

Sampling location	Nearest project component covered	PM_{10} (µg/m^3)	$PM_{2.5}$ (µg/m^3)
Lumla	Nyamjang chu powerhouse site	23.5	26.9

Meteorological variables for Nyamjang chu HEP could be monitored only at Lumla location (Table II. 3.583).

Table II. 3.583: Meteorological condition at proposed Nyamjang chu HEP site

Project name	Sampling location	Nearest project site covered	Ambient temperature (°C) min max	Relative humidity (%)	Wind speed (range in km/hr)	Wind direction
Nyamjang chu	Lumla	Nyamjang chu powerhouse site	08 11	29	3.4–4.1	SE

Noise Level: Noise level measured at Lumla near proposed Nyamjang chu HEP was 24.1 dBA at 4.00 PM and 26.2 dBA at 8.00 AM (Table II. 3.585).

Table II. 3.584: Noise level at proposed Nyamjang chu HEP site

Sampling location	Nearest project site covered	Noise level (dBA) 8.00 AM	Noise level (dBA) 4.00 PM
Lumla	Nyamjang chu powerhouse site	26.2	24.1

3.3.11.2 BIOLOGICAL ENVIRONMENT

Vegetation Types

The project components of Nyamjang chu HEP are located in montane sub-tropical, temperate and sub-alpine climatic zones. The vegetation types within 10 km radius are:

8/B/CI East Himalayan sub-tropical broad-leaved forest (1000-1800 m): These forests occur in and around 1000 m and extend up to 1800 m elevations. The canopy is comprised of: *Alnus nepalensis, Macaranga denticulata, Castanea sativa, Engelhardtia spicata, Erythrina arborescens, Quercus glauca, Rhus succedanea, Schima wallichii*, *Ficus auriculata, Myrica esculenta*, etc. Medium sized evergreen tree species such as by: *Ficus semicordata, Lophopetalum wightianum, Lyonia ovalifolia, Rhus chinensis, Saurauia punduana, Tetracentron sinense, Phyllanthus emblica*, *Rhus javanica, Torricellia tiliifolia* etc., constituted sub canopy layer. Understory consisted of shrubs such as *Artimisia nilagarica, Coriaria nepalensis,* *Elaeagnus parvifolia, Rubus ellipticus, Maesa indica* etc., and climbers. Epiphytes were abundant in the forest.

Eastern Himalayan sub-tropical pine forest (1200-1800 m): These forests do not appear in the Champion and Seth classification. However, they occur in and around 1200 m and extend up to 1800 m elevations mostly repalcing the broad-leaved forests following disturbances. The canopy is comprised of: *Pinus wallichiana*. However, remnants of broad-leaved forest elements with *Mallotus philippensis, Pyrus pashia, Albizzia arunachalensis, Prunus cerasoides, Purus* sp., are quite conspicuous. Shrubs were represented by *Artimisia nilagirica, Coriaria nepalensis, Elaeagnus parvifolia, Rosa* sp., *Rubus ellipticus, Butea buteiformis* and *Viburnum erubescens*. The herbaceous layer constitutes of Climber and epiphytes are not common.

11B/CI East Himalayan wet temperate forest (2000-3000 m): These are mixed evergreen forests with moderate size trees occurring between 1800 and 3000 m altitude. In these forests important tree associates are *Acer campbellii, Lithocarpus pachyphylla, Prunus cerasoides, Quercus serrata, Rhododendron arboreum, Schima wallichii* and *Tetracentron sinense*. Shrubs are represented by *Berberis asiatica, Coriaria nepalensis, Elaeagnus parvifolia, Rosa brunonii, Rubus ellipticus* and *Viburnum erubescens*. Climber and epiphytes are not common.

12/C3a East Himalayan mixed coniferous forests (2000-3500 m): These are dense evergreen forests with dominance of oak and rhododendrons. In the upper ridges between 2300-3500 m elevations, silver fir (*Abies densa*) makes appearance as a dominant tree species. With the oak are mixed deciduous trees such as *Magnolia* sp., *Acer* sp., *Betula alnoides, Alnus nepalensis*, and others to a varying extent. There is usually gregarius undergrowth, usually of bamboo, and in its absence Rhododendron species and other evergreen shrubs such as *Berberis* sp., *Cotoneaster* sp., *Rhododendron* sp., *Salix* sp., *Thamnocalamus* sp. and *Viburnum* sp. These are laden with many epiphytic mosses and lichens.

12/ISI Alder forest (1800-2200 m): Typically seen as pure stand of *Alnus nepalensis, Populus ciliata*, 20-30 m high, as a strip of varying width along stream sides, spreading out to larger areas, more or less deciduous. In the lower course of the stream where the fringe of *Alnus* is the only remaining tree growth owing to cultivation, there is often an under growth of inedible or thorny shrubs comprising *Berberis, Rubus, Princepia* etc, whilst in the better wooded tracts progression starts early and other species, notably blue pine and other conifers, are usually present.

12/1S2 Riverine blue-pine forest (1800-3000 m): Irregular, often dense stands of *Pinus wallichiana* with occasional *Picea*, *Tsuga, Populus* and *Alnus* with little or no undergrowth at first, but often becoming more open with inedible or thorny shrubs, if grazed.

14/1SI Hippophae forest (3500-3750 m): A more or less pure thicket of *Hippophae salicifolia* with some admixture or undergrowth of *Salix* sp., *Myricaria* sp., and occasional *Populus ciliata* at the lower elevation and tufts of grass and herbs such as *Thymus, Epilobium*.

Plant Diversity

A total of 165 plant species belonging to different groups were recorded from the barrage and powerhouse sites, and the catchment area. A complete list of plant species found in the study area representing different groups such as tree, shrub, herb, climbers, orchids, pteridophytes, bryophytes, lichens, and fungi is presented in Appendix II. 3.130. The number of plant species belonging to different groups is summarized in Table II. 3.585.

Table II. 3.585: Plants belonging to different groups recorded from the HEP sites

Sl. No.	Plant groups	Number of species		
		Barrage site	Powerhouse site	Catchment area
1	Tree	8	6	12
2	Shrub	7	11	10
3	Herb	38	17	39
4	Climbers	9		8
5	Orchids	4		3
6	Pteridophytes	14		10
7	Bryophytes	6		4
8	Lichens	11		9
9	Fungi	17	15	14

The trees are laden with a variety of non-vascular epiphytes such as lichens, mosses, and ferns. In the barrage site, 8 tree, 7 shrub, and 38 herb species were recorded. In the powerhouse site, 6 tree, 11 shrub, and 17 herb species were recorded, while in the catchment area 12 tree, 10 shrub and 39 herb species were recorded. A total of 9 climber, 4 orchid, 14 pteridophyte, 6 bryophytes, 11 lichen, and 17 fungi species were recorded from barrage and powerhouse site, whereas from the catchment area 8 climber, 3 orchid, 10 pteridophyte, 4 bryophyte, 9 lichen and 14 fungi species were recorded (Appendix II. 3.131 and 3.132).

Threatened and Endemic Plants

No threatened species was recorded within the project site.

Economically Important Species/Plant Resources

The study area is rich in plant resources. Some important species are listed in Table II. 3.586.

Table II. 3.586: Economically important species/plant resources present in the project sites

Sl. No.	Resource groups	Species name
1	Timber	*Pinus wallchiana, Abies densa, Larix griffithiana, Populus ciliata, Betula alnoides, Magnolia campbelii, Juglans regia*
2	Fuel	*Quercus griffithii, Q. semicarpifolia, Q. lanuginosa, Alnus nepalensis, salix* sp., *Rhododendron* sp.
3	Ornamentals and orchids	*Rhododendron* sp., *Primula* sp., *Luculia pinceana, Sedum multicaule, Pedicularis* sp, *Cymbidium* sp., *Hydrangea* sp., *Inula* sp., *Aster* sp., *Senecio* sp., *Satyrium* sp., *Begonia* sp., *Impatiens* sp., *Salix*
4	Medicine and aromatics	*Rubia cordifolia, Swertia chirayita, Berberis* sp., *Aconitum* sp., *Acorus* sp., *Bergenia ligulata*
5	Fodder	*Saurauia nepalensis, Ficus* sp., *Bauhinia* sp., *Quercus griffithii, Villebrunea* sp.
6	Edible	*Pyrus pasha, pyrus communis, Prunus* sp., *Rubus ellipticus, Juglans regia, Benthamidia capitata, Emblica officinalis, Dendrocalamus hamiltonii, Wallichia diandra, Elaeagnus* sp.
7	Fibre and paper	*Daphne papyracea, Sterculia* sp., *Trema orientalis,*
8	Bamboos	*Arundinaria* sp., *Chimonomabusa* sp., *Schizostachyum* sp., *Dendrocalamus* sp., *bambusa* sp., *Phyllostachys* sp.
9	Resins and gums	*Pinus wallichiana, Cordia* sp.

Vegetation Analysis for Angiosperms and Gymnosperms

The plant community in the barrage and powerhouse sites, and the catchment area was composed of 18 tree, 18 shrub and 57 herbaceous species (Table II. 3.587 and 3.588).

Table II. 3.587: Tree and shrub species identified at barrage and powerhouse sites, and in the catchment area in Nyamjangchu project area

Tree	Shrub
Albizia lucida	*Artemisia nilagirica*
Alnus nepalensis	*Cotoneaster* sp.
Betula alnoides	*Debregaesia longifolia*
Cryptomeria japonica	*Drynaria propinqua*
Cupressus sp.	*Elaeagnus* sp.
Erythirina arborescens	*Gaultheria fragrantissima*
Ilex sp.	*Mesea indica*
Juglans regia	*Mussaenda roxburghii*

Lyonia ovalifolia	*Neillia thyrsiflora*
Macaranga denticulata	*Plectranthus coetsa*
Morus sp.	*Prinsepia utilis*
Populus gamblei	*Rhus javanica*
Quercus griffithii	*Rubus ellipticus*
Rhododendron campanulatum	*Rubus hypergyrus*
Rhododendron maddeni	*Rubus rugosus*
Rhododendron nerifolium	*Saccharum spontaneum*
Salix sp.	*Spiraea canescens*
Schima khasiana	*Viburnum erubescens*

Table II. 3.588: Herbaceous species recorded at barrage and powerhouse sites, and in the catchment area of Nyamjangchu project area

Herb		
Aconogonum sp.	*Gerardinia heterophylla*	*Plantago major*
Anaphalis triplinervis	*Gnaphalium* sp.	*Poa annua*
Anemone vitifolia	*Heracleum* sp.	*Polygonum capitatum*
Axonopus compressus	*Houttuynia cordata*	*Potentilla fulgens*
Bidens pilosa	*Hydrocotyle javanica*	*Pouzolzia hirta*
Bistorta sp.	*Inula cappa*	*Pouzolzia* sp.
Blechnum sp.	*Lepisorus nudus*	*Pteridium aquilinum*
Cannabis sativa	*Leucas ciliata*	*Ranunculus scleratus*
Capsella bursa-pastoris	*Lycopodium clavatum*	*Rosa sericea*
Centella asiatica	*Mazus surculosus*	*Rubia cordifolia*
Cirsium sp.	*Nicandra physaloides*	*Rumex nepalensis*
Corydalis rutifolia	*Oenanthe* sp.	*Sedum multicaule*
Cynoglossum furcatum	*Oxalis corniculata*	*Selaginella* sp.
Equisetum sp.	*Parochetus communis*	*Smythea* sp.
Fagopyrum dibotrys	*Parthenocisus himalayana*	*Solanum viarum*
Fragaria indica	*Paspalum* sp.	*Stellaria* sp.
Galinsoga parvifolia	*Periploca* sp.	*Urtica dioca*
Gallium asperifolium	*Pilea lineolatum*	*Viola* sp.
Geranium nepalense	*Piptanthus nepalensis*	*Vittaria* sp.

Floristic study was carried out only in the monsoon season, and the data for the same is presented in Appendix II. 3.133-3.141, Appendix II. 3.142, and Table II. 3.589. Density of herbaceous species varied widely between barrage and powerhouse sites, and the catchment area. Shannon index of general diversity for tree species in the community was highest at barrage site (H' = 1.77), followed by powerhouse site (H' = 1.45) and catchment area (H' = 1.14). For shrub species highest Shannon diversity value was obtained for catchment area (H' = 2.03), followed by powerhouse site (H' = 1.90) and barrage sites (H' = 1.48). Diversity index for herbaceous ranged from H'= 1.77 to H' = 3.30. Overall, barrage and catchment area had highest species diversity (Table II. 3.589).

Table II. 3.589: Species richness, diversity and dominance of trees, shrubs, herbs, and carbon stock of trees at Nyamjang chu area

Parameters	Barrage			Powerhouse			Catchment area		
	Tree	Shrub	Herb	Tree	Shrub	Herb	Tree	Shrub	Herb
Number of species	8	7	38	6	11	17	12	10	38
Density (ha^{-1})	260	1690	759	385	490	369	350	2680	710
Simpson index of dominance	0.23	0.71	0.94	0.31	0.76	0.92	0.01	0.84	0.95
Shannon index of diversity (H')	1.77	1.48	3.26	1.45	1.90	2.70	1.14	2.03	3.30
Evenness index	0.85	0.62	0.68	0.81	0.61	0.88	0.46	0.76	0.71
Carbon (t/ha)							56.32		

Phytoplankton/Periphyton

In total, 7 species of phytoplankton/periphyton were recorded from the project area. The phytoplankton/periphyton community was represented by 2 species of Cyanophyceae, and 5 species of Bacillariophyceae. Species richness was highest at the project affected area with 5 species, and minimum with 3 species at the catchment area. Phytoplankton/periphyton density was highest at project affected area (45 individuals/l) and lowest at the catchment area (30 individuals/l). Similarly, species diversity index was slightly higher i.e., H'= 0.52 at the project affected area and it was H'= 0.50 at the catchment area (Table II. 3.590).

Table II. 3.590: Density (Individuals/l), species richness and Shannon index of diversity (H') of phytoplankton community in river water at project affected area and Catchment area of Nyamjang chu

List of species	Project affected area	Catchment area
Cyanophyceae		
Aphanocapsa sp.		15
Oscillatoria sp.	20	
Bacillariophyceae		
Achnanthidium rivulare	5	
Cymbella affinis	10	
Cymbella tumida		5
Encyonema minutum	5	10
Synedra ulna	5	
Total density (Individuals/lit)	**45**	**30**
Species diversity index	**0.52**	**0.5**
Species richness	**5**	**3**

NB: Blank cells indicate absence of Periphyton species

Zooplankton

Study on zooplankton diversity was conducted during monsoon season in Nyamjang chu area. Eighteen species were recorded, out of which 5 species belonged to Cladocera and 13 species to Rotifera. *Lecane* of Rotifera was the dominant genus followed by *Macrothrix* (Table II. 3.591). Four rare species of zooplankton were recorded from catchment site, namely, *Keratella serrulata, Notholca squamula, Lecane signifera* and *Trichocerca bidens.* No rare species was recorded either from barrage site or powerhouse site.

Table II. 3.591: Occurrence of species belonging to Cladocera and Rotifera during monsoon season at Nyamjangchu site

Sl. No.	Taxa	Species
1	Rotifera	*Brachionus quadridentatus* (Hermann, 1783)
2	Cladocera	*Daphnia (Ctenodaphnia) tibetana* (Sars, 1903)
3	Rotifera	*Epiphanes brachionus spinosa* (Rousselet, 1901)
4	Rotifera	*Euchlanis dilatata* (Ehrenberg, 1832)
5	Cladocera	*Karualona karua* (King, 1853)
6	Rotifera	*Keratella serrulata* (Ehrenberg, 1838) *
7	Cladocera	*Leberis diaphanus* (King, 1853) s. lat
8	Rotifera	*Lecane bulla* (Gosse, 1851)
9	Rotifera	*Lecane closterocerca* (Schmarda, 1859)
10	Rotifera	*Lecane lunaris* (Ehrenberg, 1832)
11	Rotifera	*Lecane papuana* (Murray, 1913)
12	Rotifera	*Lecane signifera* (Jennings, 1896) *
13	Rotifera	*Lepadella ovalis* (O.F. Muller, 1786)
14	Cladocera	*Macrothrix laticornis* (Fischer, 1857) s. lat.
15	Cladocera	*Macrothrix spinosa* (King, 1853)
16	Rotifera	*Notholca squamula* (O.F. Muller, 1786) *
17	Rotifera	*Testudinella patina* (Hermann, 1783)
18	Rotifera	*Trichocerca bidens* (Lucks, 1912) *
Total	**2**	**18**

*Rare

Fish Fauna

Three fish species were recorded at Nyamjang chu HEP site. The details are given in the Table II. 3.592.

Table II. 3.592: Fish fauna present in Nyamjang chu HEP site

Family	Species name	Max Length (cm)	Water depth required (m)	Width of water flow required (m)	Altitude	Substrate
Bagridae	*Mystus vittatus*	21.0	0.5-4	2-3	Mid and low	Sandy, rocky
Amblycipitidae	*Amblyceps mangois*	12.5	0.5-3	1-2	Mid and low	Pebbly beds
Sisoridae	*Exostoma berdmorei*	10	2-5	2-3	Mid and low	Large rocks

Soil Fauna

The seasonal variation of soil faunal diversity (Collembola, Acarina and other arthropods) and equitability in litter and soil layer is shown in Table II. 3.593-3.595.

Table II. 3.593: Diversity and equitability in litter and soil layer of soil fauna (Collembola, Acarina and other arthropods) at Nyamjang chu site during monsoon season

Soil fungi	Diversity	Barrage		Powerhouse	
		Litter	Soil	Litter	Soil
Collembola	Dominance_D	0.17	0.13	0.13	0.16
	Shannon_H	1.84	2.05	2.11	2.03
	Evenness_e^H/S	0.90	0.97	0.92	0.85
Acarina	Dominance_D	0.13	0.23	0.13	0.14
	Shannon_H	2.05	1.51	2.11	2.01
	Evenness_e^H/S	0.97	0.91	0.91	0.93
Other Arthropods	Dominance_D	0.16	0.15	0.10	0.10
	Shannon_H	1.96	1.98	2.29	2.36
	Evenness_e^H/S	0.89	0.90	0.99	0.96

Table II. 3.594: Mean annual density (number/m^2) of soil fauna in litter and soil layer (0-5 cm) at Nyamjang chu site

Soil fungi	Site	Litter layer	Soil layer	Total
Collembola	Barrage	1200	1636	**2836**
	Powerhouse	1382	1236	**2618**
Acarina	Barrage	943	914	**1857**
	Powerhouse	914	800	**1714**
Other Arthropods	Barrage	1564	1709	**3273**
	Powerhouse	1236	1600	**2836**
Total fauna	Barrage	3707	4259	**7966**
	Powerhouse	3532	3636	**7168**

Table II. 3.595: Variation of soil fauna density (number/m^2) at barrage and powerhouse site of Nyamjang chu during monsoon season

Soil fungi	Site	Density (number/m^2)
Collembola	Barrage	17200
	Powerhouse	15200
Acarina	Barrage	12400
	Powerhouse	11200
Other arthropods	Barrage	16000
	Powerhouse	15600

Wildlife

Butterflies: The status of butterflies in Nyamjang chu project area, revealed the presence of 20 species belonging to 19 genera and five families. The family Pieridae was the dominant, and was represented by five species. These 20 species did not include any of the threatened species (Table II. 3.596).

Table II. 3.596: Butterflies recorded in Nyamjang chu HEP area

Sl. No.	Family/common name	Scientific name	Project area
I.	**Hesperiidae**		
1	Lucas' Ace	*Sovia lucasii magna*	*
II.	**Papilionidae**		
2	Common Peacock	*Papilio polyctor ganesa*	*
3	Golden Birdwing	*Troides aeacus aeacus*	*
4	Common Bluebottle	*Graphium sarpedon sarpedon*	*
5	Indian Purple Emperor	*Mimathyma ambica*	*
III.	**Pieridae**		
6	Dark Jezebel	*Delias berinda*	*
7	Spotless Grass Yellow	*Eurema laeta*	*
8	Small Grass Yellow	*Eurema brigitta rubella*	*
9	Green vein White	*Pieris melete*	*
10	Plain Sulphur	*Dercas lycorias*	*
11	Spotted Sawtooth	*Prioneris thestylis thestylis*	*
IV.	**Lycaenidae**		
12	Peablue	*Lampides boeticus*	*
13	Green Sapphire	*Heliophorus moore*	*

14	Common Flash	*Rapala nissa ratna*	*
15	Common Hedgeblue	*Acytolepis puspa gisca*	*
16	Chocolate Royal	*Remelana jangala*	*
V.	**Nymphalidae**		
17	Chestnut Tiger	*Parantica sita*	*
18	Large Threering	*Ypthima nareda*	*
19	Large Silverstripe	*Argynnis children*	*
20	Blue Admiral	*Kaniska canace*	*

Herpetofauna: The probable list of amphibians and reptiles was prepared following Ahmed *et al.* (2009), as the surveys carried out during the monsoon season did not result in reporting of any herpetofauna (Appendix II. 3.167).

Birds: The assessment of birds in and around the project area was carried out only during the monsoon season. The survey revealed presence of 86 species of birds belonging to 64 genera and 33 families. The Shannon diversity was 3.8. Comparison between seasons could not be made, since only monsoon survey was done due to some administrative reasons (Table II. 3.597**)**.

Migratory status: The migratory and resident status of these bird species showed that most of the birds were residents (57 species), followed by 18 breeding visitors, and 11 winter visitors respectively (Table II. 3.597).

Table II. 3.597: Status of birds recorded in Nyamjang chu project area

Details	Post monsoon	Monsoon	Winter	Overall
Family	-	33	-	33
Genera	-	64	-	64
Species	-	86	-	86
Abundance	-	668	-	668
Diversity H'	-	3.8	-	3.8
Migratory status				
Breeding visitor	-	18	-	18
Isolated record	-	0	-	0
Resident	-	57	-	57
Winter visitor	-	11	-	11

Abundance status: The abundance status of birds was derived by classifying the abundance of bird species into five abundance category (Very Low = 1-25 birds, Low = 26-50, Moderate = 51-75, High = 76-100 and Very High = > 100birds). The details of abundance status are given in the Table II. 3.598.

Table II. 3.598: No. of species and relative % of birds in different abundance classes

Abundance class	No. of species	Relative %
Very low -1 -25 birds	80	93.0
Low -26 -50 birds	5	5.8
Moderate -50 -75 birds	1	1.2
High -76-100 birds	0	0
Very high > 100 birds	0	0
Total	**86**	**100.0**

Status of foraging guilds: The survey revealed that there were seven different foraging guilds, among which insectivore were the most dominant with 60 species followed by 11 species of omnivores and eight species of granivores (Table II. 3.599 and Appendix II. 3.203). The high representation of insectivores exhibit the importance and diverse nature of this site for this natural pest/insect controllers.

Table II. 3.599: Status of foraging guild of birds recorded in Nyamjang chu project area

Foraging guild	Post monsoon	Monsoon	Winter	Overall
Aquatic Feeder	-	-	0	0
Carnivore	-	-	2	2
Frugivore	-	-	1	1
Granivore	-	-	8	8
Insectivore	-	-	60	60

Nectarivore	-	-	3	3
Nucivore	-	-	1	1
Omnivore	-	-	11	11
Piscivore	-	-	0	0

Status of threatened species: The assessment of birds in this project area showed that there was no threatened bird species, either placed in the IUCN Red List or in the Wildlife Protection Act (1972). However, it is important to mention here that the study did not cover all seasons. Discussion with World Wide Fund (WWF), Tezpur, revealed that five black-necked cranes (*Grus nigricollis*), were recorded in this project area during the winter of 2013. The population of black-necked crane recorded for the past five years by WWF Tezpur in the Nyamjang chu project area are given in the Table II. 3.600.

Table II. 3.600: No. of Black-necked crane recorded in the Nyamjang chu area during winter of 2009-10 to 2013-14- Nyamjangchu project area

Year	No. of Birds	Remarks
2009-2010	3	All Adults
2010-2011	7	Six Adults and one Juvenile
2011-2012	4	All Adults
2012-2013	2	All Adults
2013-2014	5	All Adults

Source: WWF Tezpur, Assam

Mammals: The survey in and around the Nyamjang chu HEP area during monsoon season revealed the presence of 12 mammalian fauna belonging to separate genus and family. This list consists of four animal groups such as primate, ungulate, carnivore and rodents, among which the carnivores dominated with five species (Table II. 3.601 and Appendix II. 3.204).

Abundance status: Presence of all 12 species of the project area was confirmed based on sightings of 16 animals and 30 indirect evidences. Among these, three species were sighted and the 11 species were recorded based on the indirect evidence. Arunachal Macaque *(M. munzala)* was represented by 12 monkeys in one group followed by two barking deers and two Hoary-bellied Himalayan Squirrels. The 30 indirect evidences included two stuffed animals of Red Panda *(Ailurus fulgens*) (Table II. 3.). Record of 12 species with 30 indirect evidences and 16 animals showed that the project area supports moderate level of species richness (Table II. 3.601 and Appendix II. 3.204).

Status of threatened species: Three species of conservation significance were recorded. These species includes Arunachal Macaque (*M. munzala*), Capped langur (*Trachypithecus pileatus*), and Red Panda (*Ailurus fulgens*). Only Arunachal Macaque fall under endangered and Schedule I species of IUCN and WPA 1972, while Capped Langur and Red Panda falls under vulnerable category of IUCN and Schedule I of WPA (Table II. 3.601).

Table II. 3.601: Status of mammalian fauna reported in the Nyamjang chu HEP area

Sl. No.	Common name	Scientific name	Seasons			Overall	Conservation status	
			PM	M	W		IUCN	WPA
1	**Cercopithecidae**							
1	Arunachal Macaque	*Macaca munzala*	IE 3, A 12			IE 3, A 12	EN	-
2	Capped Langur	*Trachypithecus pileatus*	IE 2			IE 2	VU	I
II	**Ailuridae**							
3	Red panda	*Ailurus fulgens*	IE 2 **			IE 2 **	VU	I
III	**Bovidae**							
4	Himalayan goral	*Naemorhedus goral*	IE 2			IE 2		
IV	**Cervidae**							
5	Barking Deer	*Muntiacus muntjak*	A 2, IE 3			A 2, IE 3	LC	III
V	**Suidae**							
6	Wild pig	*Sus scrofa*	IE-6			IE-6	LC	III
VI	**Felidae**							
7	Jungle cat	*Felis chaus*	IE 2			IE 2	LC	II

8	Leopard Cat	*Prionailurus bengalensis*	IE 1		IE 1	LC	-
VII	**Mustelidae**						
9	Yellow Throated Martin	*Martes flavigula*	IE 2		IE 2	LC	II
VIII	**Viverridae**						
10	Himalayan Palm Civet	*Paguma larvata*	IE 3		IE 3	LC	II
IX	**Sciuridae**						
11	Hoary-bellied Himalayan Squirrel	*Callosciurus pygerythrus*	A2		A2	LC	NE
X	**Hystricidae**						
12	Indian Porcupine	*Hystrix indica*	IE 2		IE2		
	No of species		**13**		**13**		
	Total and types of records		**IE30 A 16**		**IE30 A 16**		

IE – Indirect Evidences A-animals sighted, W-Winter, PM-Post monsoon, M-Monsoon, IUCN-Red List, WPA-Wildlife Protection Act, EN-Endangered, Vu-Vulnerable, LC-Least Concern, NE – Not Evaluated , ** Stuffed animal of two Red panda was reported

Status of avifauna: Thirty eight species of birds belonging to 33 genera and 20 families were observed in and around the proposed barrage site (i.e., 500 m on either side). This site specific list contributed 44.18 % of the total 86 species recorded for the whole project area, and fall under medium species richness category. This study list did not include any threatened species. However, the construction of the barrage would lead to submergence of the habitat of a highly threatened Black-necked Crane species. Further, this area has also been identified as an Important Bird Area (IBA – India, 2004). The bird species richness around the proposed powerhouse site of Nyamjang chu HEP was 29 with a diversity of 3.0, thus showing that the species were less evenly distributed. Further, this site contributed only 33.72 % of the total 86 species reported from the entire project area. This list did not include any threatened bird species (Appendix II. 3.205 and 3.206).

Status of mammals: Evaluation of mammalian faunal status in the close vicinity of 500 m on either side of the streams of barrage and powerhouse sites of Nyamjang chu project showed the presence of five species at barrage site and three species at powerhouse site. Overall, none of species were reported based on sighting of animals. Conservation status of these species showed that all the species fall under Least Concern category of IUCN and Schedule II–IV under WPA (Table II. 3.602).

Table II. 3.602: Status of mammalian fauna at barrage and powerhouse sites of the proposed Nyamjang chu HEP area

Common name	Species name	Status		Conservation status	
		BS	PHS	IUCN	WPA
Barking Deer	*Muntiacus muntjak*	IE 1		LC	**III**
Wild pig	*Sus scrofa*	IE 1		LC	III
Jungle cat	*Felis chaus*	IE 2	IE 2	LC	II
Indian Porcupine	*Hystrix indica*	IE 1	IE1	LC	IV
Yellow Throated Martin	*Martes flavigula*	IE 1		LC	II
Himalayan palm civet	*Paguma larvata*		IE	LC	II
Total no. of species		**5**	**3**		
Total no. of record		**IE 6**	**IE4**		

IE – Indirect Evidences, A – No of Animals Sighted, BS –Barrage Site, PHS – Powerhouse Site, IUCN-Red List, WPA-Wildlife Protection Act, LC-Least Concern, EN – Endangered

3.3.11.3 SOCIO–ECONOMIC PROFILE

Information on names of the villages that will get directly affected as well as names of the villages falling in 10 km radius of the project was available; therefore these two categories of villages have been described separately. Further, the results of baseline survey have been described separately for data gathered at the village and HH level.

Village Level Survey –Affected

Profile of the Nine Project Affected Villages: All the nine surveyed villages fall under Lumla and Zimithang administrative circles (Table II. 3.603). The distance of the nine villages from the river varies from 1 km to 10 km. The circle headquarters of all the ten villages are within 22 km. Lumpo, Muchut, and Kelenteng are situated at more than 75 km from the district headquarters, while the remaining six are situated within 70 km.

Table II. 3.603: Profile of the nine project affected villages

Sl. No.	Village	Circle	Distance of village (in km)		
			River/Tributary	Circle HQ	District HQ
1	Baghar	Lumla	6	13	61
2	BTK	Zimithang	0	10	66
3	Kelenteng	Zimithang	0	3	76
4	Kharteng	Lumla	7	14	62
5	Lumla	Lumla	10	4	50
6	Lumpo	Zimithang	2	22	96
7	Mu chut	Zimithang	1	15	88
8	Phomang	Lumla	5	12	61
9	Sherbang	Lumla	4	11	55

Private Land Use Pattern: Table II. 3.604 provides details of private land holdings (in hectares) of the nine villages. The total private land holdings in the studied villages are about 350.24 ha. Three villages, namely, Kharteng, Lumla and Sherbang contribute 54% to the total land holdings in studied villages. In all the villages, the proportion of agricultural land exceeds that of the other land use types; except in case of BTK village, where habitation and home garden land exceeds that of agricultural land. Private forest land also contributes substantially (28%) to the total land holdings of the villages.

Table II. 3.604: Private land use pattern and their percentage to total private land

Sl. No.	Name of village	Total private land	Forest cover (ha)	%	Agriculture (ha)	%	Horticulture (ha)	%	Habitation and HG (ha)	%
1	Baghar	25.60	7.49	29	15.78	62	0.61	2	1.72	7
2	BTK	12.34	1.21	10	1.62	13	1.21	10	8.30	67
3	Kelenteng	47.96	20.03	42	25.90	54	0.40	1	1.62	3
4	Kharteng	76.53	25.28	33	45.79	60	0.00	0	5.46	7
5	Lumla	50.64	9.61	19	32.78	65	0.40	1	7.84	15
6	Lumpo	31.29	9.51	30	15.18	48	0.00	0	6.60	21
7	Mu chut	19.97	7.39	37	11.13	56	0.00	0	1.46	7
8	Phomang	25.12	6.68	27	13.76	55	0.00	0	4.69	19
9	Sherbang	60.79	10.76	18	44.11	73	0.00	0	5.92	10
	Total	**350.24**	**97.96**	**28**	**206.05**	**59**	**2.62**	**1**	**43.61**	**12**

Demography and Literacy Rate: As seen from Table II. 3.605, the total number of HHs in the nine villages is 453 (number varies from 24 in Kregyang to 107 in Kharteng). The total population is 2176 (1058 males; 1118 females). In Phomang and Sherbang, the number of females is less than that of the males. In the remaining villages the reverse is seen. The literacy rate ranged from 10.7% in Kelenteng to 52.7% in Lumla. In the remaining surveyed villages the rate is less than 37%. Among males the rate varies from 5.9% in Phomang to 60.5% in Lumla and in females it varies from 8.1% in Baghar to 46.2% in Lumla.

Table II. 3.605: Demography and literacy rate (*After Census 2011)

Sl. No.	Name of village	Demography					Literacy rate*		
		Total	Male	Female	Sex ratio (Per 1000 males)	No. of HH	Male	Female	Total
1	Baghar	260	117	143	1222	59	14.7	8.1	**11**
2	BTK	116	57	59	1035	24	36.5	24.2	**30.4**
3	Kelenteng	184	82	102	1244	35	15.5	6.8	**10.7**
4	Kharteng	452	221	231	1045	107	37.4	33.7	**35.3**
5	Lumla	242	117	125	1068	57	60.5	46.2	**52.7**
6	Lumpo	301	148	153	1034	49	60	40	**37**
7	Mu chut	140	68	72	1059	33	42.4	27.2	**34.5**
8	Phomang	233	117	116	991	49	5.9	10.1	**8.2**
9	Sherbang	248	131	117	893	40	32.6	22	**27**
	Total	**2176**	**1058**	**1118**		**453**			

Number of Livestock: Nine different types of animals are domesticated in surveyed villages (Table II. 3.606). In none of the villages all the nine type of animals were domesticated. In total, 1707 domestic animals have been reported from the nine villages. Considerable inter–village variation is observed in total number of animals reared. It varied from 23 in BTK to 456 in Kelenteng. Kelenteng and Lumpo alone accounts for 49% of all the animals found in the surveyed villages. Three animals, viz, cattle (70%), Goat (11%) and poultry (5%) account for 86% of the total animals (1707).

Table II. 3.606: Number of livestock

Sl.No.	Village	Mithun	Cattle	Yak	Goat	Sheep	Pig	Pony	Poultry	Others	Total
1	Baghar		52		32		17		34		**135**
2	BTK	4	16						3		**23**
3	Kelenteng		349	60	4	43					**456**
4	Kharteng		111		55		5			1	**172**
5	Lumla	7	49		37	2	13	40	29		**177**
6	Lumpo		357	16	1	12					**386**
7	Mu chut		113		2						**115**
8	Phomang		37		19		16		10		**82**
9	Sherbang		118		31	5	1		6		**161**
	Total	**11**	**1202**	**76**	**181**	**62**	**52**	**40**	**82**	**1**	**1707**

Total Estimated Value of Livestock: The monetary value of domesticated animals maintained by the inhabitants of the studied villages has been estimated separately for each animal and for each village (Table II. 3.607). The detailed methodology used in estimating the monetary value of animals has been described in the methodology section of the present report. As expected, there is considerable intra and inter village variation in this respect. The total value of animals numbering 1707 found in the nine villages has been estimated as 359.44 lakhs. The value varied from 5.62 lakhs in BTK to 105.03 lakhs in Kelenteng. In terms of relative contribution made by different animals to the total value, cattle alone contribute over 300.50 lakhs (86%).

Table II. 3.607: Total estimated value of livestock

Sl. No.	Village	Total estimated value (Rupees in lakh)									
		Mithun	Cattle	Yak	Goat	Sheep	Pig	Pony	Poultry	Others	Total
1	Baghar	0.00	13.00	0.00	1.60	0.00	4.25	0.00	0.17	0.00	**19.02**
2	BTK	1.60	4.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	**5.62**
3	Kelenteng	0.00	87.25	15.00	0.20	2.58	0.00	0.00	0.00	0.00	**105.03**
4	Kharteng	0.00	27.75	0.00	2.75	0.00	1.25	0.00	0.00	0.15	**31.90**
5	Lumla	2.80	12.25	0.00	1.85	0.12	3.25	9.20	0.15	0.00	**29.62**
6	Lumpo	0.00	89.25	4.00	0.05	0.72	0.00	0.00	0.00	0.00	**94.02**
7	Mu chut	0.00	28.25	0.00	0.10	0.00	0.00	0.00	0.00	0.00	**28.35**
8	Phomang	0.00	9.25	0.00	0.95	0.00	4.00	0.00	0.05	0.00	**14.25**
9	Sherbang	0.00	29.50	0.00	1.55	0.30	0.25	0.00	0.03	0.00	**31.63**
	Total	**4.40**	**300.5**	**19.00**	**9.05**	**3.72**	**13.00**	**9.20**	**0.42**	**0.15**	**359.44**

Average Annual Earnings of the Village: The average annual family income varies from 1.25 in lakhs in Phomang to 4.57 lakhs in Kelenteng (Table II. 3.608). The value of total earnings per year in the villages is estimated 912.56 lakhs. The contribution made by animal husbandry compared to the other resources, to the total earnings is maximum in a majority of the villages. Of the total annual earnings, animal husbandry contributes 395.72 lakhs (43%). Traditional skills in particular weaving and daily wage labour together contribute over 34%. It is highly noteworthy that agriculture contributes only 11% of the total annual village earnings

Table II. 3.608: Average annual earning of the village

Sl. No	Village	Total earning/year (Rupees in lakh)								Average family income (Rupees in lakh)
		Agriculture	Animal husbandry	Horticulture	Traditional skills	Daily wages	GS	Others*	Total	
1	Baghar	8.00	29.16	0.30	5.00	23.90	7.02	4.91	**78.29**	1.33
2	BTK	0.81	4.97	0.61	11.25	9.72	3.42	2.39	**33.16**	1.38
3	Kelenteng	12.50	98.50	0.20	26.25	14.18	4.92	3.44	**159.99**	4.57
4	Kharteng	21.50	37.15	0.00	28.75	43.34	13.26	9.28	**153.28**	1.43
5	Lumla	16.35	38.23	0.20	12.50	23.09	7.02	4.91	**102.30**	1.79
6	Lumpo	7.00	83.38	0.00	11.00	19.85	8.88	6.22	**136.32**	2.78

7	Mu chut	5.95	51.84	0.00	8.40	13.37	4.08	2.86	**86.49**	2.62
8	Phomang	6.85	17.71	0.00	5.00	19.85	7.02	4.91	**61.34**	1.25
9	Sherbang	22.06	34.78	0.00	15.00	16.20	7.86	5.50	**101.39**	2.53
	Total	**101.02**	**395.72**	**1.31**	**123.15**	**183.5**	**63.48**	**44.42**	**912.56**	**19.68**

* Other includes artisans, monks, self–employed contractors etc; GS = Government Service

Average Annual Expenditure Pattern of a Family: Average annual family expenditure in the surveyed villages varies from 1.18 lakhs in Kelenteng to 1.62 lakhs in Sherbang (Table II. 3.609). For all the villages in general, the maximum expenditure is incurred on health and education followed by food drinks and transport. The total value of average annual expenditure incurred by a family in nine villages is 12.71 lakhs.

Table II. 3.609: Average annual expenditure pattern of a family in village

Sl. No.	Village	Expenditure/ year (Rupees in lakh)				
		Food and drinks	**Clothing**	**Transport**	**Education and health**	**Total**
1	Baghar	0.42	0.30	0.30	0.48	**1.50**
2	BTK	0.30	0.36	0.40	0.40	**1.46**
3	Kelenteng	0.30	0.20	0.20	0.48	**1.18**
4	Kharteng	0.30	0.30	0.36	0.48	**1.44**
5	Lumla	0.36	0.30	0.36	0.45	**1.47**
6	Lumpo	0.36	0.36	0.30	0.44	**1.46**
7	Mu chut	0.30	0.30	0.30	0.48	**1.38**
8	Phomang	0.30	0.20	0.30	0.40	**1.20**
9	Sherbang	0.42	0.36	0.36	0.48	**1.62**
	Total	**3.06**	**2.68**	**2.88**	**4.09**	**12.71**

Water Sources: In Table II. 3.610, data pertaining to the available water resources and their pattern of use in the nine villages are presented. All five types of water resources listed in the Table II. 3.610 are available in the studied villages. In all villages except in Kelenteng, Kharteng and Sherbang, water from hill stream/spring (s) is used for domestic purposes as well as for the domestic animals. Tap water is used for domestic purposes in all surveyed villages except in Kharteng, where the inhabitants depend entirely on river to meet their water requirements. Pond water is also used in three villages. It may be highlighted that Sherbang is the only village where well water is used.

Table II. 3.610: Water sources in the villages

		River				**Hill stream/spring**				**Wells**				**Ponds**				**Tap Water**			
Sl. No.	**Village**	**Drinking water**	**Domestic use**	**Livestock use**	**Agriculture**	**Drinking water**	**Domestic use**	**Livestock use**	**Agriculture**	**Drinking water**	**Domestic use**	**Livestock use**	**Agriculture**	**Drinking water**	**Domestic use**	**Livestock use**	**Agriculture**	**Drinking water**	**Domestic use**	**Livestock use**	**Agriculture**
1	Baghar	1		1		1	1	1						1	1	1		1	1		
2	BTK	1	1	1		1	1	1										1	1		
3	Kelenteng	1	1	1										1	1	1		1	1		
4	Kharteng	1		1	1																
5	Lumla			1		1	1	1										1	1		
6	Lumpo	1		1		1	1	1										1	1		
7	Mu chut	1	1	1	1	1	1	1										1	1	1	
8	Phomang	1		1		1		1						1	1			1	1		
9	Sherbang									1	1	1						1	1	1	
	Total	**7**	**3**	**8**	**2**	**6**	**5**	**6**	**0**	**1**	**1**	**1**	**0**	**3**	**3**	**2**	**0**	**8**	**8**	**2**	**0**

Amenities in the Villages: Data presented in Table II. 3.611 reveals that out of 12 amenities listed in Table II. 3.611, Lumla has the maximum number of 9 (75%) amenities. In BTK and Kelenteng the least number of amenities (4/12) have been observed. All the villages have motorable road, electricity, telephone and TV/radio. Traditional health healers are found in Kharteng and Lumpo villages.

Table II. 3. 611: Amenities in the villages

Sl. No.	Village	Road connectivity	Health facility (PHC/ sub-centre)	Traditional health healer	Veterinary services	Electricity	Fair price shop	Grocery shop	Post office	Bank	School	Telephone/Mobile	TV/ Radios
1	Baghar	√				√					√	√	√
2	BTK	√				√						√	√
3	Kelenteng	√				√						√	√
4	Kharteng	√		√		√					√	√	√
5	Lumla	√	√		√	√	√	√			√	√	√
6	Lumpo	√		√		√					√	√	√
7	Mu chut	√				√					√	√	√
8	Phomang	√				√					√	√	√
9	Sherbang	√				√					√	√	√
	Total	**9**	**1**	**2**	**1**	**9**	**1**	**1**	**0**	**0**	**7**	**9**	**9**

NB: Blank indicates absent

Social Institutions: In none of the nine villages all the four social institution listed in Table II. 3.612 are present. Five villages have three social institutions and two villages have two social institutions. Two villages lack all the social institutions. Gompa was found in five villages. SHGs are present in only one village i.e. Kharteng.

Table II. 3.612: Social institutions in the village

Sl. No.	Village	SHGs	Anganwadis	Community hall	Gompa	Any Other	Total
1	Baghar		√	√			2
2	BTK						0
3	Kelenteng						0
4	Kharteng	√	√		√		3
5	Lumla		√	√	√		3
6	Lumpo		√	√	√		3
7	Mu chut		√	√	√		3
8	Phomang		√	√	√		3
9	Sherbang		√	√			2
	Total	**1**	**7**	**6**	**5**	**0**	**–**

NB: Blank indicates absent

Occupation Profile: In Table II. 3.613, work force participation for nine villages has been presented. The total working population in the studied villages comprises of 1342 (63%) of total population. Of the total workers, main workers are 77% while marginal workers are 23%.

Table II. 3.613: Occupation profile of the village

Sl. No.	Village	Population			Workers			Main workers			Marginal workers			Non workers		
		T	**M**	**F**	**T**	**M**	**F**	**T**	**M**	**F**	**T**	**M**	**F**	**T**	**M**	**F**
1	Baghar	218	95	123	116	53	63	113	52	61	3	1	2	102	42	60
2	BTK	125	63	62	68	34	34	44	31	13	24	3	21	57	29	28
3	Kelenteng	131	58	73	209	111	98	181	100	81	28	11	17	139	62	77
4	Kharteng	453	195	258	102	50	52	89	46	43	13	4	9	223	98	125
5	Lumla	389	177	212	19	11	8	9	8	1	10	3	7	14	5	9
6	Lumpo	254	128	126	41	30	11	37	29	8	4	1	3	39	15	24
7	Mu chut	177	85	92	0	0	0	0	0	0	0	0	0	0	0	0
8	Phomang	184	85	99	54	28	26	53	28	25	1	0	1	40	17	23
9	Sherbang	189	89	100	733	511	222	501	405	96	232	106	126	630	317	313
	Total	**2120**	**975**	**1145**	**1342**	**828**	**514**	**1027**	**699**	**328**	**315**	**129**	**186**	**1244**	**585**	**659**

Household Level Survey–Affected

Age of the Head of the Household: Data presented in Tables II.614 and 3.615 in respect of age of head of the HHs in nine surveyed villages reveal the following main features: The age of heads of the HHs across the nine surveyed villages varied from 19 years in Lumpo to 86 years in Kharteng. The age of 33% of HH heads is over 50 years, and 20% of heads were below 30 years. The average age of heads of HH among villages varied from 40 to 48 (Table II. 3.615)

Table II. 3.614: Distribution of head of the HHs by age across the nine project villages

Sl. No.	Village	Upto 30		31–40		41–50		> 50		Total
		n	%	n	%	n	%	n	%	n
1	Baghar	14	24	18	31	6	10	21	36	**59**
2	BTK	4	17	7	29	3	13	10	42	**24**
3	Kelenteng	10	29	11	31	7	20	7	20	**35**
4	Kharteng	17	16	22	21	24	22	44	41	**107**
5	Lumla	8	14	24	42	11	19	14	25	**57**
6	Lumpo	9	18	12	24	9	18	19	39	**49**
7	Mu chut	14	42	4	12	8	24	7	21	**33**
8	Phomang	11	22	12	24	11	22	15	31	**49**
9	Sherbang	2	5	14	35	11	28	13	33	**40**
	Total	**89**	**20**	**124**	**27**	**90**	**20**	**150**	**33**	**453**

Table II. 3.615: Minimum, maximum and average age of head of HHs across nine project villages

Sl. No.	Village	Age range		Average
		From	To	
1	Baghar	21	80	44
2	BTK	22	71	47
3	Kelenteng	20	67	40
4	Kharteng	20	86	47
5	Lumla	25	85	43
6	Lumpo	19	83	48
7	Mu chut	22	85	41
8	Phomang	21	80	44
9	Sherbang	22	65	46

Gender of the Head of Households: Data on gender of the HHs in the nine surveyed project villages is given in Table II. 3.616. As expected, in all the studied villages the number of males exceeds that of females as head of HHs except in case of Kelenteng. Across the surveyed villages 75% of heads were males. Strikingly in Kelenteng, 77% the head of HHs were females (cf Table II. 3.616 of Part I).

Table II. 3.616: Distribution of head of HHs by gender in nine project villages

Sl. No.	Village	Male		Female		Total
		n	%	n	%	n
1	Baghar	44	75	15	25	**59**
2	BTK	21	88	3	13	**24**
3	Kelenteng	8	23	27	77	**35**
4	Kharteng	89	83	18	17	**107**
5	Lumla	42	74	15	26	**57**
6	Lumpo	39	80	10	20	**49**
7	Mu chut	20	61	13	39	**33**
8	Phomang	41	84	8	16	**49**
9	Sherbang	34	85	6	15	**40**
	Total	**338**	**75**	**115**	**25**	**453**

Ethnicity: All the nine villages are predominantly inhabited by Monpa tribals.

Household Size: As evident from Tables II. 3.617 and 3.618, the HH size varies from one to 13 across the nine villages. There is vast variation between the nine villages in terms of distribution of HH size. The average HH size varies from four in four villages, five in three villages and six in two. Across the studied villages the average HH size is five.

Table II. 3.617: Distribution of HH size in the nine project villages

Sl. No.	Village	1		2		3		4		5		6–8		9 and above		Total
		n	%	n	%	n	%	n	%	n	%	n	%	n	%	n
1	Baghar	8	14	5	8	9	15	7	12	10	17	20	34	0	0	**59**
2	BTK	0	0	2	8	2	8	5	21	9	38	6	25	0	0	**24**
3	Kelenteng	3	9	2	6	3	9	5	14	5	14	15	43	2	6	**35**
4	Kharteng	10	9	20	19	10	9	21	20	16	15	27	25	3	3	**107**
5	Lumla	4	7	6	11	7	12	14	25	12	21	14	25	0	0	**57**
6	Lumpo	0	0	2	4	3	6	7	14	6	12	24	49	7	14	**49**
7	Mu chut	1	3	2	6	7	21	9	27	7	21	7	21	0	0	**33**
8	Phomang	8	16	2	4	2	4	13	27	6	12	16	33	2	4	**49**
9	Sherbang	0	0	3	8	3	8	2	5	7	18	19	48	6	15	**40**
	Total	**34**	**8**	**44**	**10**	**46**	**10**	**83**	**18**	**78**	**17**	**148**	**33**	**20**	**4**	**453**

Table II. 3.618: Minimum, maximum and average HH size across the nine project villages

Sl. No.	Village	HH size range		Average HH size
		From	To	
1	Baghar	1	8	4
2	BTK	2	8	5
3	Kelenteng	1	13	5
4	Kharteng	1	9	4
5	Lumla	1	8	4
6	Lumpo	2	13	6
7	Mu chut	1	7	4
8	Phomang	1	11	5
9	Sherbang	2	10	6

Education: Relevant data on the educational status of the head of the HHs in the nine project villages is given in Table II. 3.619. It is noteworthy that, a majority of the heads in studied villages were illiterate (85%). It varied from 65% in Lumla to 98% in Baghar and Phomang. There were 6 head of HHs (1%) in the studied villages who were Graduates.

Table II. 3.619: Distribution of education of head of HH in the nine project villages

Sl. No.	Village	Illiterate		Primary		Upper Primary		Secondary		Higher Secondary		Graduate or above		Total
		n	%	n	%	n	%	n	%	n	%	n	%	n
1	Baghar	58	98	0	0	0	0	1	2	0	0	0	0	**59**
2	BTK	22	92	0	0	1	4	0	0	1	4	0	0	**24**
3	Kelenteng	26	74	0	0	2	6	3	9	1	3	3	9	**35**
4	Kharteng	95	89	0	0	1	1	5	5	3	3	3	3	**107**
5	Lumla	37	65	4	7	3	5	10	18	3	5	0	0	**57**
6	Lumpo	40	82	0	0	3	6	5	10	1	2	0	0	**49**
7	Mu chut	24	73	2	6	3	9	4	12	0	0	0	0	**33**
8	Phomang	48	98	0	0	0	0	1	2	0	0	0	0	**49**
9	Sherbang	36	90	0	0	2	5	1	3	1	3	0	0	**40**
	Total	**386**	**85**	**6**	**1**	**15**	**3**	**30**	**7**	**10**	**2**	**6**	**1**	**453**

Main Occupation of Household Heads: The main occupations of the head of HHs across the nine villages are agriculture, labour, pastoralism, and government service. Table II. 3.620 reveals the following:

Agriculture: It varies from 39% in Lumpo to 100% in Phomang. 75% of the surveyed head of HHs are engaged in agriculture.

Labour: Except in Phomang, in the remaining villages labour has been reported by small number of HHs (6%) as main mode of occupation.

Pastoralism: 12 HHs (3%) in BTK, Kelenteng and Lumpo returned pastoralism as main occupation.

Government service: Government servants were reported from all the nine villages except in Phomang. Kharteng had the maximum number (16/37) of government employees. Government service constitutes 8% of the main occupations.

Any other occupation: 40 (9%) HHs was engaged in other occupations.

Table II. 3.620: Distribution of head of HHs by main occupation in nine project villages

Sl. No.	Village	Farmer		Labour		Pastoral		Govt Servant		Others*		Total
		n	%	n	%	n	%	n	%	n	%	n
1	Baghar	45	76	2	3	0	0	2	3	10	17	**59**
2	BTK	13	54	1	4	1	4	3	13	6	25	**24**
3	Kelenteng	22	63	3	9	2	6	5	14	3	9	**35**
4	Kharteng	88	82	2	2	0	0	16	15	1	1	**107**
5	Lumla	47	82	5	9	0	0	3	5	2	4	**57**
6	Lumpo	19	39	8	16	9	18	3	6	10	20	**49**
7	Mu chut	22	67	3	9	0	0	3	9	5	15	**33**
8	Phomang	49	100	0	0	0	0	0	0	0	0	**49**
9	Sherbang	33	83	2	5	0	0	2	5	3	8	**40**
	Total	**338**	**75**	**26**	**6**	**12**	**3**	**37**	**8**	**40**	**9**	**453**

* Other includes artisans, monks, self–employed contractors etc.

Private Land Holding Pattern: The private land holding pattern in the nine villages comprises of agricultural land, horticulture land, habitation and home garden land, and forest land. It may be noted here that, a majority of the inhabitants of the surveyed villages did not know the actual area, either in acres or hectares, of all categories of land holdings. Therefore, the area reported here should be considered as very rough estimates. Data pertaining to this aspect have been described below.

Agricultural land: An examination of data given in Table II. 3.621 reveal that, except 119 HHs (26%), all the remaining HHs (74%) in nine surveyed villages owned agricultural land in varying proportions. A majority of the HHs (45%) owned agricultural land between 1–2 acres. Only 12% of HHs owned land which is greater than 2 acres. There exists a striking variation between the villages in terms of agricultural land holdings. For example, 25% of the HHs in Kharteng own more than one acre of land while 1% of HHs in BTK own one acre of land.

Table II. 3.621: Distribution of agricultural land holding among surveyed HHs in the nine project villages

Sl. No.	Village	0.00 acre		< 1 acre		1–2 acre		> 2 acre	
		n	%	n	%	n	%	n	%
1	Baghar	9	15	21	36	29	49	0	0
2	BTK	22	92	0	0	2	8	0	0
3	Kelenteng	1	3	1	3	24	69	9	26
4	Kharteng	37	35	6	6	42	39	22	21
5	Lumla	16	28	6	11	22	39	13	23
6	Lumpo	7	14	17	35	23	47	2	4
7	Mu chut	3	9	19	58	9	27	2	6
8	Phomang	14	29	2	4	33	67	0	0
9	Sherbang	10	25	3	8	19	48	8	20
	Total	**119**	**26**	**75**	**17**	**203**	**45**	**56**	**12**

***Horticultural land*:** Seven HHs (2%) belonging to five out of the nine villages, owned horticultural land (Table II. 3.622).

Table II. 3.622: Distribution of horticultural land among surveyed HHs in the nine project villages

Sl. No.	Village	0.00 acre		< 1 acre		1–2 acre		> 2 acre	
		n	%	n	%	n	%	n	%
1	Baghar	57	97	1	2	1	2	0	0
2	BTK	22	92	0	0	2	8	0	0
3	Kelenteng	34	97	0	0	1	3	0	0
4	Kharteng	0	0	0	0	0	0	0	0
5	Lumla	56	98	0	0	1	2	0	0
6	Lumpo	0	0	0	0	0	0	0	0
7	Mu chut	0	0	0	0	0	0	0	0
8	Phomang	0	0	0	0	0	0	0	0
9	Sherbang	39	98	0	0	0	0	1	3
	Total	**208**	**46**	**1**	**0**	**5**	**1**	**1**	**0**

Habitation and home–garden land: Data presented in Table II. 3623 reveals that all the surveyed villages had this category of land in varying proportions. Only 38% of HHs (173) in surveyed villages did not own any such land. A majority of HHs (51%) owned less than one acre while 11% of the HHs owned 1 to 2 acre of such land.

Table II. 3.623: Distribution of habitation and home garden land among surveyed HHs in the nine project villages

Sl. No.	Village	0.00 acre		< 1 acre		1–2 acre		> 2 acre	
		n	%	n	%	n	%	n	%
1	Baghar	3	5	56	95	0	0	0	0
2	BTK	8	33	0	0	16	67	0	0
3	Kelenteng	31	89	0	0	4	11	0	0
4	Kharteng	93	87	1	1	13	12	0	0
5	Lumla	5	9	52	91	0	0	0	0
6	Lumpo	14	29	29	59	6	12	0	0
7	Mu chut	4	12	29	88	0	0	0	0
8	Phomang	1	2	48	98	0	0	0	0
9	Sherbang	14	35	14	35	10	25	2	5
	Total	**173**	**38**	**229**	**51**	**49**	**11**	**2**	**0**

Forest land: From data given in Table II. 3.624, about 189 HHs (42%) in surveyed villages do not own private forest land. A majority of HHs (31%) owned such land between 1–2 acres. It is noteworthy that, only 7 (2%) HHs owned more than 2 acre of forest land.

Table II. 3.624: Distribution of forest land holding among surveyed HHs in the nine project villages

Sl. No.	Village	0.00 acre		< 1 acre		1–2 acre		> 2 acre	
		n	%	n	%	n	%	n	%
1	Baghar	21	36	38	64	0	0	0	0
2	BTK	23	96	0	0	0	0	1	4
3	Kelenteng	5	14	1	3	26	74	3	9
4	Kharteng	44	41	4	4	58	54	1	1
5	Lumla	38	67	2	4	15	26	2	4
6	Lumpo	20	41	15	31	14	29	0	0
7	Mu chut	6	18	18	55	9	27	0	0
8	Phomang	16	33	33	67	0	0	0	0
9	Sherbang	16	40	6	15	18	45	0	0
	Total	**189**	**42**	**117**	**26**	**140**	**31**	**7**	**2**

Total land holdings: The data given in Table II. 3.625–3.628 reveals that there are only 55 HHs (12%) that do not own any type of private land. 34% of the HHs owned more than 2 acres of total land. There is striking variation between the HHs within a village as well as between villages in ownership of total land. For example, in Kelenteng, inter–HH holdings vary from zero acre to ten acres, whereas in Phomang it varies from 0 to 1.75 acres. The proportion of agricultural land compared to other types of land to the total land holdings is greater in a majority of the villages. The 453 HHs in the nine villages owned total private land totalling 865 acres. Out of this, Jangda, Rho, and Yuthembu, accounts for 67% of the total land. Agricultural land accounts for 59% and forest land 28% of total land holdings in the eight villages.

Table II. 3.625: Distribution of total land holding among surveyed HHs in the nine project villages

Sl. No.	Village	0.00 acre		< 1 acre		1–2 acre		> 2 acre	
		n	%	n	%	n	%	n	%
1	Baghar	3	5	16	27	37	63	3	5
2	BTK	7	29	0	0	15	63	2	8
3	Kelenteng	1	3	0	0	13	37	21	60
4	Kharteng	35	33	2	2	19	18	51	48
5	Lumla	4	7	18	32	7	12	28	49
6	Lumpo	2	4	14	29	15	31	18	37
7	Mu chut	0	0	9	27	17	52	7	21
8	Phomang	1	2	13	27	35	71	0	0
9	Sherbang	2	5	6	15	6	15	26	65
	Total	**55**	**12**	**78**	**17**	**164**	**36**	**156**	**34**

Table II. 3.626: Minimum, maximum and average land holdings across the nine project villages

Sl. No.	Village	Agricultural land			Horticultural land			Habitation and Home garden land			Forest land			Total land		
		From	To	Avg.	From	To	Avg.	From	To	Avg.	From	To	Avg.	From	To	Avg.
1	Baghar	0.00	1.50	0.66	0.00	1.00	0.03	0.00	0.50	0.07	0.00	0.50	0.31	**0.00**	**2.67**	**1.07**
2	BTK	0.00	2.00	0.17	0.00	1.50	0.13	0.00	2.00	0.85	0.00	3.00	0.13	**0.00**	**8.00**	**1.27**
3	Kelenteng	0.00	4.00	1.82	0.00	1.00	0.03	0.00	1.00	0.11	0.00	6.00	1.41	**0.00**	**10.00**	**3.38**
4	Kharteng	0.00	4.94	1.05	0.00	0.00	0.00	0.00	1.00	0.12	0.00	2.47	0.58	**0.00**	**6.94**	**1.77**
5	Lumla	0.00	4.00	1.42	0.00	1.00	0.02	0.00	0.98	0.33	0.00	5.00	0.41	**0.00**	**8.49**	**2.19**
6	Lumpo	0.00	2.50	0.76	0.00	0.00	0.00	0.00	2.00	0.33	0.00	1.50	0.47	**0.00**	**4.00**	**1.57**
7	Mu chut	0.00	4.00	0.83	0.00	0.00	0.00	0.00	0.50	0.10	0.00	2.00	0.55	**0.03**	**6.25**	**1.49**
8	Phomang	0.00	1.00	0.69	0.00	0.00	0.00	0.00	0.50	0.23	0.00	0.50	0.33	**0.00**	**1.75**	**1.26**
9	Sherbang	0.00	4.00	1.45	0.00	3.00	0.08	0.00	3.00	0.50	0.00	2.00	0.61	**0.00**	**7.02**	**2.64**

Table II. 3.627: Number of HHs having land types in the nine project villages

Sl. No.	Village	Agricultural land		Horticultural land		Habitation and home garden land		Forest land	
		n	%	n	%	n	%	n	%
1	Baghar	50	85	2	3	56	95	38	64
2	BTK	2	8	2	8	16	67	1	4
3	Kelenteng	34	97	1	3	4	11	30	86
4	Kharteng	70	65	0	0	14	13	63	59

5	Lumla	41	72	1	2	52	91	19	33
6	Lumpo	42	86	0	0	35	71	29	59
7	Mu chut	30	91	0	0	29	88	27	82
8	Phomang	35	71	0	0	48	98	33	67
9	Sherbang	30	75	1	3	26	65	24	60
	Total	**334**	**74**	**7**	**2**	**280**	**62**	**264**	**58**

Table II. 3.628: Distribution of area (in acres) of land holding among HHs in the nine project villages

Sl. No.	Village	Agricultural land		Horticultural land		Habitation and homegarden land		Forest land		Total land
		Area	%	Area	%	Area	%	Area	%	Area
1	Baghar	39	62	2	2	4	7	19	29	**63**
2	BTK	4	13	3	10	21	67	3	10	**31**
3	Kelenteng	64	54	1	1	4	3	50	42	**119**
4	Kharteng	113	60	0	0	14	7	62	33	**189**
5	Lumla	81	65	1	1	19	15	24	19	**125**
6	Lumpo	38	49	0	0	16	21	24	30	**77**
7	Mu chut	28	56	0	0	4	7	18	37	**49**
8	Phomang	34	55	0	0	12	19	17	27	**62**
9	Sherbang	109	73	0	0	15	10	27	18	**150**
	Total	**509**	**59**	**7**	**1**	**108**	**12**	**242**	**28**	**865**

Livestock Holding: Tables II. 3.629–3.630 presents the data with respect to distribution of livestock holdings in the nine surveyed villages. Nine different types of animals are domesticated in surveyed villages. However, none of the villages owned all the nine animals. Altogether, 1707 animals have been domesticated in the nine villages. Considerable inter–village variation is observed in total number of animals reared. It varied from 23 in BTK to 456 in Kelenteng. Kelenteng and Lumpo alone accounts for 49% of all the animals found in the surveyed villages. Three animals, viz., cattle (53%), Yak (17%) and sheep (17%) account for 88% of the total animals (3063). 52% (235) of the HHs did not own any animals; whereas 11% HHs owned more than 10 animals. Three animals, viz, cattle (70%), Goat (11%) and poultry (5%) account for 86% of the total animals (1707).

Table II. 3.629: Number of HHs and number of livestock in surveyed HHs across the nine project villages

Sl. No.	Livestock		Baghar	BTK	Kelenteng	Kharteng	Lumla	Lumpo	Mu chut	Phomang	Sherbang	Total
1	Mithun	LS	0	4	0	0	7	0	0	0	0	**11**
		%	0	17	0	0	4	0	0	0	0	**1**
		n	0	1	0	0	1	0	0	0	0	**2**
		%	0	4	0	0	2	0	0	0	0	**0.4**
2	Cattle	LS	52	16	349	111	49	357	113	37	118	**1202**
		%	39	70	77	65	28	92	98	45	73	**70**
		n	20	2	29	27	17	27	13	15	16	**166**
		%	34	8	83	25	30	55	39	31	40	**37**
3	Yak	LS	0	0	60	0	0	16	0	0	0	**76**
		%	0	0	13	0	0	4	0	0	0	**4**
		n	0	0	1	0	0	3	0	0	0	**4**
		%	0	0	3	0	0	6	0	0	0	**1**
4	Goat	LS	32	0	4	55	37	1	2	19	31	**181**
		%	24	0	1	32	21	0	2	23	19	**11**
		n	14	0	1	13	13	1	2	11	6	**61**
		%	24	0	3	12	23	2	6	22	15	**13**
5	Sheep	LS	0	0	43	0	2	12	0	0	5	**62**
		%	0	0	9	0	1	3	0	0	3	**4**
		n	0	0	4	0	1	1	0	0	1	**7**
		%	0	0	11	0	2	2	0	0	3	**2**
6	Pig	LS	17	0	0	5	13	0	0	16	1	**52**
		%	13	0	0	3	7	0	0	20	1	**3**
		n	17	0	0	5	4	0	0	16	1	**43**
		%	29	0	0	5	7	0	0	33	3	**9**
7	Pony	LS	0	0	0	0	40	0	0	0	0	**40**
		%	0	0	0	0	23	0	0	0	0	**2**
		n	0	0	0	0	13	0	0	0	0	**13**
		%	0	0	0	0	23	0	0	0	0	**3**
8	Poultry	LS	34	3	0	0	29	0	0	10	6	**82**
		%	25	13	0	0	16	0	0	12	4	**5**
		n	14	1	0	0	7	0	0	6	1	**29**
		%	24	4	0	0	12	0	0	12	3	**6**
9	Others	LS	0	0	0	1	0	0	0	0	0	**1**

		%	0	0	0	1	0	0	0	0	0	**0**
		n	0	0	0	1	0	0	0	0	0	**1**
		%	0	0	0	1	0	0	0	0	0	**0**
	Total	**LS**	**135**	**23**	**456**	**172**	**177**	**386**	**115**	**82**	**161**	**1707**

Note: LS–Livestock, n= Number of HHs

Table II. 3.630: Distribution of total number of livestock in HHs of the nine project villages

Sl. No.	Village	0		1–5		6–10		> 10		Total
		n	%	n	%	n	%	n	%	n
1	Baghar	26	44	25	42	6	10	2	3	**59**
2	BTK	21	88	1	4	2	8	0	0	**24**
3	Kelenteng	1	3	7	20	9	26	18	51	**35**
4	Kharteng	67	63	27	25	10	9	3	3	**107**
5	Lumla	31	54	14	25	7	12	5	9	**57**
6	Lumpo	21	43	3	6	9	18	16	33	**49**
7	Mu chut	19	58	4	12	6	18	4	12	**33**
8	Phomang	28	57	15	31	6	12	0	0	**49**
9	Sherbang	21	53	6	15	9	23	4	10	**40**
	Total	**235**	**52**	**102**	**23**	**64**	**14**	**52**	**11**	**453**

Traditional Skills: In the surveyed village, five types of crafts as given in Table II. 3.631 are pursued. Weaving is practiced in all the nine villages, and the total number of HHs engaged are 52 (11%). A small number of HHs are engaged in other crafts i.e., 12, 6, 20, 3 HHs are engaged in wood carving, carpet making, bamboo utensils and paper making respectively.

Table II. 3.631: Distribution of various skills among surveyed HHs in the nine project villages

Sl. No.	Village	Wood carving		Thanka painting		Carpet making		Bamboo utensil		Weaving		Paper making	
		n	%	n	%	n	%	n	%	n	%	n	%
1	Baghar	0	0	0	0	0	0	0	0	2	3	0	0
2	BTK	0	0	0	0	0	0	1	4	7	29	1	4
3	Kelenteng	1	3	0	0	1	3	10	29	9	26	0	0
4	Kharteng	4	4	0	0	2	2	6	6	11	10	0	0
5	Lumla	0	0	0	0	0	0	0	0	10	18	0	0
6	Lumpo	4	8	0	0	0	0	1	2	4	8	2	4
7	Mu chut	1	3	0	0	0	0	0	0	2	6	0	0
8	Phomang	0	0	0	0	0	0	0	0	2	4	0	0
9	Sherbang	2	5	0	0	3	8	2	5	5	13	0	0
	Total	**12**	**3**	**0**	**0**	**6**	**1**	**20**	**4**	**52**	**11**	**3**	**1**

River Resources: In Table II. 3.632, data pertaining to the use of various river resources by the inhabitants of the nine surveyed villages is presented. All the nine river resources listed in Table II. 3.632 are being used across the studied nine villages. Five river resources, viz., drinking water, aquatic flora, religion, sand and stone are used by a significant number (more than 50%) of HHs in the surveyed villages. There is vast inter–village variation in terms of number of river resources used. For example, in Kelenteng, Kharteng, and Lumla, 8/9 resources are used, whereas in Sherbang only two resources are used. It is highly noteworthy that, all the 453 HHs in the surveyed villages use river for performing last rites of the dead. It may be emphasized that while aquatic fauna is used in two villages, the aquatic flora is used by all the HHs of five villages.

Table II. 3.632: Dependence on river resources among surveyed HHs in the nine project villages

Sl. No.	River resources		Baghar	BTK	Kelenteng	Kharteng	Lumla	Lumpo	Mu chut	Phomang	Sherbang	Total
1	Drinking water	n	59	0	35	107	51	49	33	49	0	**383**
		%	100	0	100	100	89	100	100	100	0	**85**
2	Water for domestic use	n	0	0	35	75	43	0	33	0	0	**186**
		%	0	0	100	70	75	0	100	0	0	**41**
3	Water for livestock	n	34	3	34	40	26	28	14	21	19	**219**
		%	58	13	97	37	46	57	42	43	48	**48**
4	Aquatic fauna	n	0	0	0	1	1	0	0	0	0	**2**
		%	0	0	0	1	2	0	0	0	0	**0.4**
5	Aquatic flora	n	59	0	35	0	0	49	33	49	0	**225**
		%	100	0	100	0	0	100	100	100	0	**50**

6	Religion	n	59	24	35	107	57	49	33	49	40	**453**
		%	100	100	100	100	100	100	100	100	100	**100**
7	Sand	n	59	23	35	94	45	49	33	49	0	**387**
		%	100	96	100	88	79	100	100	100	0	**85**
8	Stone	n	59	23	35	91	45	49	33	49	0	**384**
		%	100	96	100	85	79	100	100	100	0	**85**
9	Any other	n	0	0	35	3	1	49	0	0	0	**88**
		%	0	0	100	3	2	100	0	0	0	**19**

Forest Resources: The inhabitants of all the nine villages are dependent on forest resources (Table II. 3.633). 15 usages listed in Table II. 3.633 are used in varying degrees among the nine surveyed villages. BTK uses the least number of forest resources. Kharteng and Lumla use 13 resources. More than 50% of the HHs in general, across the studied villages, use six forest resources–fuel wood, timber, medicinal, food, religion, fencing, water, stones and sand. 76% of the HHs belonging to seven villages use forest resources for medicine. It is thus evident from above description that, for a majority of the inhabitants of the surveyed villages, forest resources play a very significant role to the livelihoods as well as the quality of life of the people.

Table II. 3.633: Dependence on forest resources among surveyed HHs in the nine project villages

Sl. No.	Forest resources		Baghar	BTK	Kelenteng	Kharteng	Lumla	Lumpo	Mu chut	Phomang	Sherbang	Total
1	Fuel wood	n	59	24	35	106	55	49	33	49	40	**450**
		%	100	100	100	99	96	100	100	100	100	**99**
2	Timber	n	59	22	35	1	50	49	33	49	0	**298**
		%	100	92	100	1	88	100	100	100	0	**66**
3	Medicinal plants	n	59	0	35	102	18	49	33	49	0	**345**
		%	100	0	100	95	32	100	100	100	0	**76**
4	Honey	n	0	0	0	51	0	0	0	0	0	**51**
		%	0	0	0	48	0	0	0	0	0	**11**
5	Food	n	59	11	35	102	3	49	33	49	40	**381**
		%	100	46	100	95	5	100	100	100	100	**84**
6	Edible oil	n	0	0	0	1	3	0	0	0	0	**4**
		%	0	0	0	1	5	0	0	0	0	**1**
7	Ornamental	n	0	0	0	0	0	0	0	0	0	**0**
		%	0	0	0	0	0	0	0	0	0	**0**
8	Religious	n	59	10	35	84	33	49	33	49	40	**392**
		%	100	42	100	79	58	100	100	100	100	**87**
9	Fencing	n	59	0	35	1	1	49	33	49	0	**227**
		%	100	0	100	1	2	100	100	100	0	**50**
10	Handicrafts	n	0	0	0	0	0	0	0	0	0	**0**
		%	0	0	0	0	0	0	0	0	0	**0**
11	Thatching	n	0	0	0	0	1	0	0	0	0	**1**
		%	0	0	0	0	2	0	0	0	0	**0**
12	Spices	n	0	0	35	2	13	49	33	0	40	**172**
		%	0	0	100	2	23	100	100	0	100	**38**
13	Grazing	n	34	3	34	40	26	28	14	21	19	**219**
		%	58	13	97	37	46	57	42	43	48	**48**
14	Hunting of wild animals	n	0	0	0	0	0	0	0	0	0	**0**
		%	0	0	0	0	0	0	0	0	0	**0**
15	Fishes	n	0	0	0	0	0	0	0	0	0	**0**
		%	0	0	0	0	0	0	0	0	0	**0**
16	Water	n	59	0	35	27	32	49	33	49	40	**324**
		%	100	0	100	25	56	100	100	100	100	**72**
17	Stones	n	59	17	35	25	47	49	33	49	40	**354**
		%	100	71	100	23	82	100	100	100	100	**78**
18	Sand	n	0	17	35	23	45	49	33	0	0	**202**
		%	0	71	100	21	79	100	100	0	0	**45**
19	Dyes	n	0	0	19	0	0	8	2	0	40	**69**
		%	0	0	54	0	0	16	6	0	100	**15**

Water Resources: All the villages (76% of the HHs), except Sherbang, use river water (Table II. 3.634). Inhabitants of Kharteng use only river water. Out of 453 HHs in the study area, 197

HHs (43%) of six villages use hill stream/spring water. Except in Kelenteng, Kharteng and Sherbang, remaining villages use hill stream/spring(s) as the main source of water. All the HHs in Sherbang use only well and tap water for their water requirements. All the HHs in three out of nine use pond water.

Table II. 3.634: Dependence on water resources among surveyed HHs in the nine project villages

Sl. No.	Village	River		Hill stream/spring		Wells		Ponds		Hand pumps		Tap water	
		n	%	n	%	n	%	n	%	n	%	n	%
1	Baghar	59	100	59	100	0	0	59	100	0	0	59	100
2	BTK	13	54	5	21	0	0	0	0	0	0	23	96
3	Kelenteng	35	100	0	0	0	0	35	100	0	0	35	100
4	Kharteng	105	98	0	0	0	0	0	0	0	0	0	0
5	Lumla	2	4	2	4	0	0	0	0	0	0	57	100
6	Lumpo	49	100	49	100	0	0	0	0	0	0	49	100
7	Mu chut	33	100	33	100	0	0	0	0	0	0	33	100
8	Phomang	49	100	49	100	0	0	49	100	0	0	49	100
9	Sherbang	0	0	0	0	40	100	0	0	0	0	40	100
	Total	**345**	**76**	**197**	**43**	**40**	**9**	**143**	**32**	**0**	**0**	**345**	**76**

Village Level Survey–Influenced

Profile of the Thirteen Surveyed Villages: All the thirteen villages fall under Lumla, Dudunghar, and Zimithang administrative circles (Table II. 3.635). The distance of the thirteen villages from the river varies from 0.5 km to 7 km. The circle headquarters of the ten villages are within 20 km. From the district headquarters all the villages are situated within 76 km, the nearest being Maio (46 km) and farthest is Dung village (76 km).

Table II. 3.635: Profile of the thirteen surveyed villages

Sl. No.	Village	Circle	Distance of village (in km)		
			River/Tributary	Circle HQ	District HQ
1	Brokentheng	Zimithang	0.5	3	70
2	Dugumba	Lumla	5	5.7	52
3	Dung	Zimithang	0	3	76
4	Gorsam	Zimithang	0	8	68
5	Hoongla	Lumla	4	4	49
6	Kharman	Zimithang	0.5	2	75
7	Maio	Lumla	2	4	46
8	Nam Tsering	Dudunghar	0	20	66
9	Pharmey	Lumla	7	5	51
10	Poito	Lumla	7	8	53
11	Sazo	Lumla	7	7	52
12	Yabab	Lumla	5	12	57
13	Zimithang	Zimithang	1	0	73

Private Land Use Pattern: In Table II. 3.636, details of private land holdings (in hectares) of the thirteen villages are given. The total private land holdings in the studied villages are about 254.07 ha. Four villages, viz., Hoongla, Kharman, Pharmey, and Sazo, contribute 56% to the total land holdings in studied villages. In all the villages, the proportion of agricultural land exceeds that of the other land use types, except in Zimithang, where both the forest cover and habitation and home garden land are more than agricultural land. Total agricultural land across the studied villages contributes 66% to total land holdings. Private forest land contributes only 10% to the total land holdings of the villages. Contribution of habitation and home garden land is 18%.

Table II. 3.636: Private land use pattern and their percentage to total private land

Sl. No.	Village	Total private land	Forest cover (ha)	%	Agriculture (ha)	%	Horticulture (ha)	%	Habitation and HG (ha)	%
1	Brokentheng	6.97	0.00	0	5.97	86	1.00	14	0.00	0
2	Dugumba	15.30	4.54	30	8.03	53	1.40	53	1.31	9
3	Dung	11.80	0.00	0	11.80	100	0.00	00	0.00	0
4	Gorsam	15.20	0.72	5	9.41	62	0.40	62	4.67	31
5	Hoongla	31.43	0.00	0	27.11	86	0.00	86	4.32	14
6	Kharman	39.95	0.00	0	26.51	66	0.00	66	13.44	34

7	Maio	20.24	3.97	20	9.50	47	2.00	47	4.77	24
8	Nam Tsering	14.33	0.92	6	13.07	91	0.30	91	0.04	0
9	Pharmey	44.14	7.32	17	20.65	47	8.45	47	7.73	18
10	Poito	5.90	0.00	0	5.65	96	0.00	96	0.25	4
11	Sazo	26.25	0.00	0	22.26	85	0.00	85	3.99	15
12	Yabab	8.77	0.67	8	6.27	72	0.20	72	1.62	18
13	Zimithang	13.79	7.03	51	1.28	9	1.21	9	4.27	31
	Total	**254.07**	**25.17**	**10**	**167.51**	**66**	**14.96**	**6**	**46.41**	**18**

HG = Home–gardens

Demography and Literacy Rate: The total number of HHs in the thirteen villages is 378 (number varies from 8 in Dung to 56 in Hoongla). The total population is 1719 (860 males; 859 females). In six villages, the number of females is greater than that of the males. Male number exceeds females in remaining five villages. The literacy rate ranged from 2% in Brokentheng to 38% in Zimithang. In all the surveyed villages, the literacy rate is less than 38%. Among males, the rate varies from 4% in Brokentheng to 42% in Zimithang; and in females, it varies from 0% in Brokentheng to 32% in Zimithang (Table II. 3.637).

Table II. 3.637: Demography and literacy rate

Sl. No.	Village	Demography					Literacy rate*		
		Total	Male	Female	Sex ratio (Per 1000 males)	No. of HH	Male	Female	Total
1	Brokentheng	48	23	25	1087	15	4	0	**2**
2	Dugumba	65	34	31	912	15	17.1	22.4	**20**
3	Dung	44	21	23	1095	8	4.2	3.3	**3.7**
4	Gorsam	116	50	66	1320	23	30.2	18.3	**23.3**
5	Hoongla	229	120	109	908	56	26	17.5	**22**
6	Kharman	224	109	115	1055	44	9.5	0.8	**4.5**
7	Maio	108	57	51	895	23	NA	NA	**NA**
8	Nam Tsering	263	138	125	906	52	34.6	23.5	**29.8**
9	Pharmey	149	76	73	961	33	36	14	**26.3**
10	Poito	81	41	40	976	22	NA	NA	**NA**
11	Sazo	213	115	98	852	45	26	18.3	**22.4**
12	Yabab	63	31	32	1032	14	16.7	10.8	**13.4**
13	Zimithang	116	45	71	1578	28	42	32	**38**
	Total	**1719**	**860**	**859**		**378**			

*After Census 2011; NA =data not available

Number of Livestock: The details of livestock holding for the thirteen villages are given in Table II. 3.638. Nine different types of animals are domesticated in thirteen surveyed villages. However, in none of the villages, all the nine animal types were domesticated. Altogether, 1311 animals are reared in the villages. Considerable inter-village variation is observed in total number of animals reared. It varied from 9 in Nam Tsering to 611 in Kharman. Kharman alone accounts for 47% of all the animals found in the surveyed villages. Three animals, viz, cattle (69%), goat (10%) and yak (7%) account for 86% of the total animals (1311).

Table II. 3.638: Number of livestock

Sl. No.	Village	Mithun	Cattle	Yak	Goat	Sheep	Pig	Pony	Poultry	Others	Total
1	Brokentheng		30								**30**
2	Dugumba	9	3		18		3		12		**45**
3	Dung		95								**95**
4	Gorsam		45								**45**
5	Hoongla	1	27		23	3	6	7		13	**80**
6	Kharman		558	53							**611**
7	Maio		4	40	3	3	5	3	1		**59**
8	Nam Tsering		6		3						**9**
9	Pharmey		55		39		20	28	13		**155**
10	Poito		19		5						**24**
11	Sazo		1		34		16			41	**92**
12	Yabab		11		4				1		**16**
13	Zimithang		35			15					**50**
	Total	**10**	**889**	**93**	**129**	**21**	**50**	**38**	**27**	**54**	**1311**

Total Estimated Value of Livestock: The monetary value of domesticated animals maintained by the inhabitants of the studied villages has been estimated separately for each animal and for each village (Table II. 3.639). The detailed methodology used in estimating the monetary value of animals has been described in the methodology section of this document. As expected, there is considerable intra–inter village variation in this respect. The total value of animals numbering 1311 found in the thirteen villages has been estimated as 286.7 lakhs. The value varied from 1.65 lakhs in Nam Tsering to 152.75 lakhs in Kharman. In terms of relative contribution made by different animals to the total value, cattle and Yak together contribute over 245.50 lakhs (86%).

Table II. 3.639: Total estimated value of livestock

Sl. No.	Village	Total estimated value (Lakhs.)									
		Mithun	Cattle	Yak	Goat	Sheep	Pig	Pony	Poultry	Others	Total
1	Brokentheng	0.00	7.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**7.50**
2	Dugumba	3.60	0.75	0.00	0.90	0.00	0.75	0.00	0.06	0.00	**6.06**
3	Dung	0.00	23.75	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**23.75**
4	Gorsam	0.00	11.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**11.25**
5	Hoongla	0.40	6.75	0.00	1.15	0.18	1.50	1.61	0.00	1.95	**13.54**
6	Kharman	0.00	139.50	13.25	0.00	0.00	0.00	0.00	0.00	0.00	**152.75**
7	Maio	0.00	1.00	10.00	0.15	0.18	1.25	0.69	0.01	0.00	**13.28**
8	Nam Tsering	0.00	1.50	0.00	0.15	0.00	0.00	0.00	0.00	0.00	**1.65**
9	Pharmey	0.00	13.75	0.00	1.95	0.00	5.00	6.44	0.07	0.00	**27.21**
10	Poito	0.00	4.75	0.00	0.25	0.00	0.00	0.00	0.00	0.00	**5.00**
11	Sazo	0.00	0.25	0.00	1.70	0.00	4.00	0.00	0.00	6.15	**12.10**
12	Yabab	0.00	2.75	0.00	0.20	0.00	0.00	0.00	0.01	0.00	**2.96**
13	Zimithang	0.00	8.75	0.00	0.00	0.90	0.00	0.00	0.00	0.00	**9.65**
	Total	**4.00**	**222.25**	**23.25**	**6.45**	**1.26**	**12.50**	**8.74**	**0.15**	**8.10**	**286.7**

Average Annual Earnings of the Village: The Average annual family income varies from 0.96 in lakhs in Nam Tsering to 4.91 lakhs in Dung (Table II. 3.640). The value of total earnings per year in the villages is estimated 703.64 lakhs. The contribution made by different sources varies between the villages. For example, animal husbandry contributed the most to the total earnings in the six villages, compared to the other resources. In Nam Tsering the contribution of wage labour is maximum. Of the total annual earnings, animal husbandry contributes 283.17 lakhs (40%) followed by daily wages (22%) and traditional skills (12%). It is highly noteworthy that, agriculture contributes only 11.8% of the total annual village earnings.

Table II. 3.640: Average annual earning of the village

Sl. No.	Village	Total earning/year (Rupees in lakh)								Average family income (Rupees in lakh)
		Agricul-ture	Animal husbandry	Horti–culture	Traditional skills	Daily wages	GS	Others*	Total	
1	Brokentheng	2.99	6.48	0.50	8.00	6.08	1.38	0.97	**26.39**	1.76
2	Dugumba	4.02	9.72	0.70	11.25	6.08	2.04	1.43	**35.23**	2.35
3	Dung	5.90	20.52	0.00	7.50	3.24	1.26	0.88	**39.30**	4.91
4	Gorsam	4.70	9.72	0.20	3.75	9.32	3.00	2.10	**32.79**	1.43
5	Hoongla	13.56	17.28	0.00	0.00	22.68	7.20	5.04	**65.76**	1.17
6	Kharman	13.25	131.98	0.00	16.80	17.82	6.54	4.58	**190.97**	4.34
7	Maio	4.75	12.74	1.00	0.85	9.32	3.42	2.39	**34.47**	1.50
8	Nam Tsering	6.54	1.94	0.15	6.00	21.06	8.28	5.80	**49.77**	0.96
9	Pharmey	10.32	33.48	4.22	8.75	13.37	4.56	3.19	**77.90**	2.36
10	Poito	2.83	5.18	0.00	6.25	8.91	2.46	1.72	**27.35**	1.24
11	Sazo	11.13	19.87	2.00	6.25	18.23	6.90	4.83	**69.20**	1.54
12	Yabab	3.14	3.46	0.10	5.00	5.67	1.86	1.30	**20.53**	1.47
13	Zimithang	0.64	10.80	0.61	6.00	11.34	2.70	1.89	**33.98**	1.21
	Total	**83.77**	**283.17**	**9.48**	**86.4**	**153.12**	**51.6**	**36.12**	**703.64**	**26.24**

* Other includes artisans, monks, self–employed contractors etc; GS = Government Service

Average Annual Expenditure Pattern of a Family: The average annual family expenditure in the surveyed villages varies from 1.15 lakhs in Gorsam to 1.70 lakhs in Hoongla Table II. 3.641. It is interesting that there is significant inter village variation in pattern of expenditure on different categories. However in most of the villages the maximum expenditure is incurred on health and education followed by food and drinks and transport. The total value of average annual expenditure incurred by a family in thirteen villages is 17.70 lakhs.

Table II. 3.641: Average annual expenditure pattern of a family in village

Sl. No.	Village	Expenditure/ year (Rupees in lakh)				
		Food and drinks	Clothing's	Transport	Education and health	Total
1	Brokentheng	0.30	0.30	0.36	0.28	**1.24**
2	Dugumba	0.30	0.30	0.30	0.40	**1.30**
3	Dung	0.30	0.20	0.20	0.48	**1.18**
4	Gorsam	0.30	0.20	0.20	0.45	**1.15**
5	Hoongla	0.48	0.30	0.40	0.52	**1.70**
6	Kharman	0.30	0.30	0.30	0.36	**1.26**
7	Maio	0.32	0.30	0.36	0.36	**1.34**
8	Nam Tsering	0.30	0.25	0.37	0.45	**1.37**
9	Pharmey	0.35	0.36	0.30	0.42	**1.43**
10	Poito	0.32	0.30	0.30	0.35	**1.27**
11	Sazo	0.32	0.36	0.30	0.48	**1.46**
12	Yabab	0.30	0.36	0.36	0.48	**1.50**
13	Zimithang	0.36	0.30	0.36	0.48	**1.50**
	Total	**4.25**	**3.83**	**4.11**	**5.51**	**17.70**

Water Sources: In Table II. 3.642 data pertaining to the water resources available and their pattern of use in the thirteen villages are presented. All five types of water source, viz., river, hill stream/springs, wells, pond and tap water are available in the studied villages. Eight out of thirteen villages use river water. Water from hill stream/springs is used in seven villages. Tap water is used for various purposes in twelve surveyed villages. Pond water is found only in Dung. Only in Yabab well water is used.

Table II. 3.642: Water sources in the village

Sl. No.	Village	Rivers				Hill stream/spring				Wells				Ponds				Tap water			
		Drinking water	Domestic use	Livestock use	Agriculture	Drinking water	Domestic use	Livestock use	Agriculture	Drinking water	Domestic use	Livestock use	Agriculture	Drinking water	Domestic use	Livestock use	Agriculture	Drinking water	Domestic use	Livestock use	Agriculture
1	Brokentheng	1	1	1		1	1											1	1		
2	Dugumba																	1	1	1	
3	Dung	1	1	1										1	1	1		1	1		
4	Gorsam	1	1	1		1	1	1										1	1		
5	Hoongla																	1	1		
6	Kharman	1		1		1	1											1	1	1	
7	Maio	1	1			1	1														
8	Nam Tsering	1	1	1		1	1											1	1		
9	Pharmey					1	1											1	1	1	
10	Poito																	1	1		
11	Sazo	1	1															1	1		
12	Yabab									1	1	1						1	1	1	
13	Zimithang	1	1	1		1	1	1										1	1		
	Total	**8**	**7**	**6**		**7**	**7**	**2**		**1**	**1**	**1**		**1**	**1**	**1**		**12**	**12**	**4**	

Amenities in the Villages: In none of the village all amenities were observed (Table II. 3.643). Zimithang has the maximum number of 9 amenities from a total of 12. Four amenities i.e., Health facility (PHC/ sub–centre), Veterinary services, Fair price shop and Grocery shop, were found only in Zimithang among the surveyed villages. However, all the villages have motorable road, electricity, telephone and TV/radio. Only in the village Kharman, traditional healer was found. It may be highlighted that, in seven out of thirteen villages schools were not observed.

Table II. 3.643: Amenities in the villages

Sl. No.	Village	Road connectivity	Health facility (PHC/ sub–centre)	Traditional health healer	Veterinary services	Electricity	Fair price shop	Grocery shop	Post office	Bank	School	Telephone/ Mobile	TV/ Radios
1	Brokentheng	√				√						√	√
2	Dugumba	√				√						√	√
3	Dung	√				√						√	√
4	Gorsam	√				√						√	√
5	Hoongla	√				√					√	√	√
6	Kharman	√		√		√					√	√	√
7	Maio	√				√						√	√
8	Nam Tsering	√				√					√	√	√
9	Pharmey	√				√						√	√
10	Poito	√				√						√	√
11	Sazo	√				√					√	√	√
12	Yabab	√				√					√	√	√
13	Zimithang	√	√		√	√	√	√			√	√	√
	Total	**13**	**1**	**1**	**1**	**13**	**1**	**1**	**0**	**0**	**6**	**13**	**13**

NB: Blank indicates absent

Social Institutions: In none of the thirteen villages all the four social institution listed in Table II. 3.644 are present. Five villages, namely, Brokentheng, Hoongla, Kharman, Maio, and Zimithang, had three social institutions each. It is highly noteworthy that, none of the social institutions were found in Dung and Gorsam. Except in six villages all the other villages have Gompa. SHGs are absent in all the villages.

Table II. 3.644: Social institutions in the village

Sl. No.	Village	SHGs	Anganwadis	Community hall	Gompa	Any Other	Total
1	Brokentheng		√	√	√		**3**
2	Dugumba		√	√			**2**
3	Dung						**0**
4	Gorsam						**0**
5	Hoongla		√	√		√	**3**
6	Kharman		√	√	√		**3**
7	Maio		√	√	√		**3**
8	Nam Tsering		√				**1**
9	Pharmey			√	√		**2**
10	Poito			√	√		**2**
11	Sazo			√	√		**2**
12	Yabab		√	√			**2**
13	Zimithang		√	√	√		**3**
	Total	**0**	**8**	**10**	**7**	**1**	

NB: Blank indicates absent

Occupation Profile: In Table II. 3.645 work force participation in eleven villages has been presented. The total working population in the studied villages comprises of 1181 (67%) of total population (1775). Of the total workers main workers are 95% while marginal workers are 5%.

Table II. 3.645: Occupation profile of the village

Sl. No.	Village	Population			Workers			Main workers			Marginal workers			Non workers		
		T	M	F	T	M	F	T	M	F	T	M	F	T	M	F
1	Brokentheng	42	21	21	27	12	15	13	9	4	14	3	11	15	9	6
2	Dugumba	161	76	85	116	53	63	113	52	61	3	1	2	102	42	60
3	Dung	54	24	30	65	28	37	63	27	36	2	1	1	54	26	28
4	Gorsam	103	43	60	52	20	32	52	20	32	0	0	0	36	19	17
5	Hoongla	224	110	114	8	4	4	5	1	4	3	3	0	9	6	3
6	Kharman	200	84	116	41	23	18	38	21	17	3	2	1	11	6	5
7	Maio	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
8	Nam Tsering	235	133	102	68	32	36	67	32	35	1	0	1	66	20	46
9	Pharmey	114	64	50	34	22	12	28	21	7	6	1	5	31	14	17
10	Poito	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
11	Sazo	187	100	87	285	227	58	265	211	54	20	16	4	212	56	156
12	Yabab	119	54	65	11	3	8	11	3	8	0	0	0	8	3	5
13	Zimithang	336	200	136	474	310	164	467	309	158	7	1	6	178	93	85
	Total*	**1775**	**909**	**866**	**1181**	**734**	**447**	**1122**	**706**	**416**	**59**	**28**	**31**	**722**	**294**	**428**

* Excluding Maio and Poito due to non–availability of data.

Household Level Survey–Influenced

Age of the Head of the Household: Data presented in Tables II. 3.646 and 3.647 reveal that, the age of head of HHs across the thirteen surveyed villages varied from 19–90 years in Hoongla. The age of 30% of heads is over 50 years, and 27% of heads age was below 30 years. The average age of heads of HH between villages varied from 37 in Dung to 51 in Yabab.

Table II. 3.646: Distribution of head of the HHs by age across the thirteen project villages

Sl. No.	Village	Upto 30		31–40		41–50		> 50		Total
		n	%	n	%	n	%	n	%	n
1	Brokenthang	6	40	4	27	3	20	2	13	**15**
2	Dugumba	5	33	0	0	5	33	5	33	**15**
3	Dung	3	38	2	25	2	25	1	13	**8**
4	Gorsam	5	22	5	22	7	30	6	26	**23**
5	Hoongla	21	38	7	13	14	25	14	25	**56**
6	Kharman	16	36	12	27	3	7	13	30	**44**
7	Maio	4	17	9	39	6	26	4	17	**23**
8	Nam Tsering	9	17	11	21	13	25	19	37	**52**
9	Pharmey	10	30	8	24	8	24	7	21	**33**
10	Poito	3	14	6	27	6	27	7	32	**22**
11	Sazo	12	27	10	22	9	20	14	31	**45**
12	Yabab	2	14	2	14	2	14	8	57	**14**
13	Zimithang HQ	6	21	6	21	2	7	14	50	**28**
	Total	**102**	**27**	**82**	**22**	**80**	**21**	**114**	**30**	**378**

Table II. 3.647: Minimum, maximum and average age of head of HHs across the thirteen project villages

Sl. No.	Village	Age range		Average
		From	To	
1	Brokenthang	28	70	38
2	Dugumba	20	78	46
3	Dung	23	55	37
4	Gorsam	25	67	43
5	Hoongla	19	90	42
6	Kharman	20	84	42
7	Maio	21	78	41
8	Nam Tsering	23	81	46
9	Pharmey	23	83	43
10	Poito	22	81	47
11	Sazo	21	65	43
12	Yabab	19	69	51
13	Zimithang HQ	25	77	48

Gender of the Head of Households: Data on gender of the HHs in the thirteen surveyed project villages is given in Table II. 3.648. As expected, in all the studied villages, the number of males exceeds that of females as head of HHs, except in Yabab, where it is equal. Across the surveyed villages 82% of heads were males.

Table II. 3.648: Distribution of head of HHs by gender in the thirteen project villages

Sl. No.	Village	Male		Female		Total
		n	%	n	%	n
1	Brokenthang	11	73	4	27	**15**
2	Dugumba	12	80	3	20	**15**
3	Dung	8	100	0	0	**8**
4	Gorsam	15	65	8	35	**23**
5	Hoongla	48	86	8	14	**56**
6	Kharman	33	75	11	25	**44**
7	Maio	21	91	2	9	**23**
8	Nam Tsering	47	90	5	10	**52**
9	Pharmey	28	85	5	15	**33**
10	Poito	22	100	0	0	**22**
11	Sazo	41	91	4	9	**45**
12	Yabab	7	50	7	50	**14**
13	Zimithang HQ	16	57	12	43	**28**
	Total	**309**	**82**	**69**	**18**	**378**

Ethnicity: All the thirteen villages are predominantly inhabited by Monpa tribals.

Household Size: Tables II. 3.649 and 3.650 shows that the HH size varies from 1 to 11 across the thirteen villages. There is vast variation between the thirteen villages in terms of distribution of HH size. The average HH size varies from three to six. Across the studied villages the average HH size is four.

Table II. 3.649: Distribution of HH size in the thirteen project villages

Sl. No.	Village	1		2		3		4		5		6–8		9 and above		Total
		n	%	n	%	n	%	n	%	n	%	n	%	n	%	n
1	Brokenthang	1	7	1	7	7	47	6	40	0	0	0	0	0	0	**15**
2	Dugumba	2	13	2	13	2	13	1	7	2	13	6	40	0	0	**15**
3	Dung	0	0	0	0	1	13	1	13	2	25	4	50	0	0	**8**
4	Gorsam	0	0	1	4	4	17	4	17	7	30	6	26	1	4	**23**
5	Hoongla	5	9	10	18	10	18	9	16	9	16	13	23	0	0	**56**
6	Kharman	0	0	2	5	9	20	7	16	5	11	20	45	1	2	**44**
7	Maio	1	4	1	4	4	17	6	26	3	13	7	30	1	4	**23**
8	Nam Tsering	5	10	1	2	7	13	6	12	8	15	22	42	3	6	**52**
9	Pharmey	6	18	2	6	5	15	3	9	5	15	10	30	2	6	**33**
10	Poito	1	5	4	18	6	27	4	18	5	23	2	9	0	0	**22**
11	Sazo	1	2	3	7	8	18	12	27	3	7	17	38	1	2	**45**
12	Yabab	0	0	2	14	3	21	3	21	2	14	3	21	1	7	**14**
13	Zimithang HQ	6	21	2	7	2	7	6	21	5	18	6	21	1	4	**28**
	Total	**28**	**7**	**31**	**8**	**68**	**18**	**68**	**18**	**56**	**15**	**116**	**31**	**11**	**3**	**378**

Table II. 3.650: Minimum, maximum and average HH size across the thirteen project villages

Sl. No.	Village	HH size range		Average HH size
		From	To	
1	Brokenthang	1	4	3
2	Dugumba	1	7	4
3	Dung	3	8	6
4	Gorsam	2	9	5
5	Hoongla	1	8	4
6	Kharman	2	9	5
7	Maio	1	9	5
8	Nam Tsering	1	9	5
9	Pharmey	1	10	5
10	Poito	1	7	4
11	Sazo	1	9	5
12	Yabab	2	9	5
13	Zimithang HQ	1	11	4
	Total	**1**	**11**	**4**

Education: Relevant data on the education of the head of the HHs in the thirteen project villages is given in Table II. 3.651. It is noteworthy that, 78% of the heads in studied villages were illiterate. The rate varied from 61% in Gorsam to 100% in Dugumba and Yabab. There were only 4 head of HHs (1%) in the studied villages who were graduates.

Table II. 3.651: Distribution of education of head of HH in the thirteen project villages

Sl. No.	Village	Illiterate		Primary		Upper Primary		Secondary		Higher Secondary		Graduate or above		Total
		n	%	n	%	n	%	n	%	n	%	n	%	n
1	Brokenthang	12	80	0	0	0	0	3	0	0	0	0	0	**15**
2	Dugumba	15	100	0	0	0	0	0	0	0	0	0	0	**15**
3	Dung	5	63	0	0	2	25	1	13	0	0	0	0	**8**
4	Gorsam	14	61	0	0	1	4	6	26	2	9	0	0	**23**
5	Hoongla	54	96	0	0	1	2	1	2	0	0	0	0	**56**
6	Kharman	35	80	0	0	2	5	7	16	0	0	0	0	**44**
7	Maio	15	65	0	0	2	9	3	13	1	4	2	9	**23**
8	Nam Tsering	41	79	2	4	1	2	7	13	1	2	0	0	**52**
9	Pharmey	19	58	0	0	6	18	7	21	1	3	0	0	**33**
10	Poito	19	86	0	0	1	5	2	9	0	0	0	0	**22**
11	Sazo	33	73	2	4	4	9	5	11	1	2	0	0	**45**
12	Yabab	14	100	0	0	0	0	0	0	0	0	0	0	**14**
13	Zimithang HQ	18	64	0	0	1	4	6	21	1	4	2	7	**28**
	Total	**294**	**78**	**4**	**1**	**21**	**6**	**48**	**13**	**7**	**2**	**4**	**1**	**378**

Main Occupation of Household Heads: The main occupations of the head of HHs across the thirteen villages are: agriculture, labour, pastoralism, and government service. (Table II. 3.652) reveals the following:

Agriculture: It varies from 25% in Zimithang to 100% in Dung. 74% of the surveyed head of HHs are engaged in agriculture.

Labour: Labour has been reported in five villages by small number of HHs (10%) as main mode of occupation.

Pastoralism: It is highly noteworthy that, out of thirteen villages only Kharman is engaged in pastoralism.

Government service: Government servants were reported from eleven out of thirteen villages. Zimithang had the maximum number (8/31) of government employees. Government service constitutes 8% of the main occupations.

***Any other occupation*:** 20 HHs (5%) were engaged in other occupations.

Table II. 3.652: Distribution of head of HHs by main occupation in the thirteen project villages

Sl. No.	Village	Farmer		Labour		Pastoral		Govt. servant		Others		Total
		n	%	n	%	n	%	n	%	n	%	n
1	Brokenthang	13	87	0	0	0	0	1	7	1	7	**15**
2	Dugumba	13	87	0	0	0	0	2	13	0	0	**15**
3	Dung	8	100	0	0	0	0	0	0	0	0	**8**
4	Gorsam	6	26	10	43	0	0	5	22	2	9	**23**
5	Hoongla	54	96	0	0	0	0	2	4	0	0	**56**
6	Kharman	15	34	13	30	12	27	2	5	2	5	**44**
7	Maio	17	74	0	0	0	0	3	13	3	13	**23**
8	Nam Tsering	47	90	0	0	0	0	3	6	2	4	**52**
9	Pharmey	30	91	1	3	0	0	1	3	1	3	**33**
10	Poito	19	86	0	0	0	0	2	9	1	5	**22**
11	Sazo	37	82	6	13	0	0	2	4	0	0	**45**
12	Yabab	13	93	0	0	0	0	0	0	1	7	**14**
13	Zimithang HQ	7	25	6	21	0	0	8	29	7	25	**28**
	Total	**279**	**74**	**36**	**10**	**12**	**3**	**31**	**8**	**20**	**5**	**378**

Private Land Holding Pattern: The private land holding pattern in the thirteen villages comprises of agricultural land, horticulture land, habitation and home garden land, and forest land. It may be noted here that, a majority of the inhabitants of the surveyed villages did not know actual area either in acres or hectares of all categories of land holdings. Therefore, the area reported here should be considered as very rough estimates. Data pertaining to this aspect have been described below.

Agricultural land: Except 95 HHs (25%), all the remaining HHs (75%) in the thirteen surveyed villages owned agricultural land in varying proportions (Table II. 3.653). A majority of the HHs (47%) owned agricultural land between 1–2 acres. Only 10% of HHs owned land which is greater than 2 acres. Striking intra and inter–village variation is observed in terms of agricultural land holding.

Table II. 3.653: Distribution of agricultural land holding among surveyed HHs in the thirteen project villages

Sl. No.	Village	0.00 acre		< 1 acre		1–2 acre		> 2 acre	
		n	%	n	%	n	%	n	%
1	Brokenthang	3	20	0	0	12	80	0	0
2	Dugumba	2	13	5	33	4	27	4	27
3	Dung	0	0	0	0	1	13	7	88
4	Gorsam	8	35	5	22	8	35	2	9
5	Hoongla	15	27	1	2	38	68	2	4
6	Kharman	1	2	3	7	34	77	6	14
7	Maio	12	52	2	9	5	22	4	17
8	Nam Tsering	11	21	22	42	19	37	0	0
9	Pharmey	10	30	3	9	8	24	12	36
10	Poito	4	18	12	55	5	23	1	5
11	Sazo	8	18	5	11	31	69	1	2
12	Yabab	0	0	3	21	11	79	0	0
13	Zimithang HQ	21	75	6	21	1	4	0	0
	Total	**95**	**25**	**67**	**18**	**177**	**47**	**39**	**10**

Horticultural land: 27 HHs belonging to eight villages out of the thirteen owned horticultural land. The area under this category is 37 acres (Table II. 3.654).

Table II. 3.654: Distribution of horticultural land among surveyed HHs in the thirteen project villages

Sl. No.	Village	n	0.00 acre		< 1 acre		1–2 acre		> 2 acre	
			n	%	n	%	n	%	n	%
1	Brokenthang	15	14	93	0	0	0	0	1	7
2	Dugumba	15	13	87	0	0	1	7	1	7
3	Dung	8	8	100	0	0	0	0	0	0
4	Gorsam	23	22	96	0	0	1	4	0	0
5	Hoongla	56	56	100	0	0	0	0	0	0
6	Kharman	44	44	100	0	0	0	0	0	0
7	Maio	23	22	96	0	0	0	0	1	4
8	Nam Tsering	52	51	98	1	2	0	0	0	0
9	Pharmey	33	16	48	7	21	7	21	3	9
10	Poito	22	22	100	0	0	0	0	0	0
11	Sazo	45	45	100	0	0	0	0	0	0
12	Yabab	14	13	93	1	7	0	0	0	0
13	Zimithang HQ	28	25	89	2	7	1	4	0	0
	Total	**378**	**351**	**92**	**11**	**3**	**10**	**3**	**6**	**2**

Habitation and home–garden land: Data presented in Table II. 3.655 reveals that, eleven out of thirteen villages have this category of land in varying proportions. 118 HHs (31%) in surveyed villages did not own any such land. A majority of HHs (51%) owned less than one acre of such land while 16% of the HHs owned such land between 1 to 2 acres. The total area under this category is 115 acres.

Table II. 3.655: Distribution of habitation and home garden land among surveyed HHs in the thirteen project villages

Sl. No.	Village	0.00 acre		< 1 acre		1–2 acre		> 2 acre	
		n	%	n	%	n	%	n	%
1	Brokenthang	15	100	0	0	0	0	0	0
2	Dugumba	9	60	4	27	2	13	0	0
3	Dung	0	0	0	0	0	0	0	0
4	Gorsam	3	13	13	57	7	30	0	0
5	Hoongla	15	27	41	73	0	0	0	0
6	Kharman	3	7	16	36	25	57	0	0
7	Maio	2	9	13	57	8	35	0	0
8	Nam Tsering	51	98	1	2	0	0	0	0
9	Pharmey	1	3	24	73	8	24	0	0
10	Poito	2	9	20	91	0	0	0	0
11	Sazo	8	18	37	82	0	0	0	0
12	Yabab	7	50	6	43	1	7	0	0
13	Zimithang HQ	2	7	18	64	8	29	0	0
	Total	**118**	**31**	**193**	**51**	**59**	**16**	**0**	**0**

***Forest land*:** The main features observed from data given in Table II. 3.656 showed that, 186 HHs (49%) in surveyed villages do not own private forest land. A majority of HHs (24%) owned such land between 1–2 acres. It is noteworthy that, only 16 (4%) HHs owned more than 2 acre of forest land. The area under this category is 177 acres.

Table II. 3.656: Distribution of forest land holding among surveyed HHs in the thirteen project villages

Sl. No.	Village	0.00 acre		< 1 acre		1–2 acre		> 2 acre	
		n	%	n	%	n	%	n	%
1	Brokenthang	15	100	0	0	0	0	0	0
2	Dugumba	8	53	5	33	1	7	1	7
3	Dung	0	0	0	0	3	38	5	63
4	Gorsam	10	43	3	13	8	35	2	9
5	Hoongla	0	0	0	0	0	0	0	0
6	Kharman	3	7	8	18	29	66	4	9
7	Maio	18	78	0	0	4	17	1	4
8	Nam Tsering	52	100	0	0	0	0	0	0
9	Pharmey	14	42	3	9	13	39	3	9
10	Poito	19	86	3	14	0	0	0	0
11	Sazo	19	42	3	7	23	51	0	0
12	Yabab	2	14	4	29	8	57	0	0
13	Zimithang HQ	26	93	2	7	0	0	0	0
	Total	**186**	**49**	**31**	**8**	**89**	**24**	**16**	**4**

Total land Holdings: The data given in Table II. 3.657–3.660 shows that, there are 43 HHs (11%) that do not own any type of private land. 36% of the HHs owned more than 2 acres of total land. There is striking variation between the HHs within a village as well as between villages in ownership of total land. For example, in Maio inter–HH holdings vary from 0–14.82 acres, whereas in Nam Tsering it varies from 0–2 acres. The proportion of agricultural land compared to other types of land to the total land holdings is greater in twelve villages. The 378 HHs in the thirteen villages owned total private land totalling 743 acres. Out of this, Pharmey, Kharman, and Sazo accounts for 49% of the total land. Agricultural land accounts for 56% and forest land 24% of total land holdings.

Table II. 3.657: Distribution of total land holding among surveyed HHs in the thirteen project villages

Sl. No.	Village	0.00 acre		< 1 acre		1–2 acre		> 2 acre	
		n	%	n	%	n	%	n	%
1	Brokenthang	3	20	0	0	11	73	1	7
2	Dugumba	1	7	5	33	4	27	5	33
3	Dung	0	0	0	0	0	0	8	100
4	Gorsam	2	9	7	30	3	13	11	48
5	Hoongla	15	27	1	2	18	32	22	39
6	Kharman	0	0	2	5	10	23	32	73
7	Maio	2	9	10	43	6	26	5	22
8	Nam Tsering	10	19	23	44	19	37	0	0
9	Pharmey	0	0	12	36	5	15	16	48
10	Poito	2	9	13	59	5	23	2	9
11	Sazo	8	18	1	2	11	24	25	56
12	Yabab	0	0	1	7	6	43	7	50
13	Zimithang HQ	0	0	18	64	9	32	1	4
	Total	**43**	**11**	**93**	**25**	**107**	**28**	**135**	**36**

Table II. 3.658: Minimum, maximum and average land holdings across the thirteen project villages

Sl. No.	Village	Agricultural land			Horticultural land			Habitation and homegarden land			Forest land			Total land		
		From	To	Avg.	From	To	Avg.	From	To	Avg.	From	To	Avg.	From	To	Avg.
1	Brokenthang	0.00	1.23	0.98	0.00	2.47	0.16	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**	**3.70**	**1.15**
2	Dugumba	0.00	4.94	1.32	0.00	2.47	0.23	0.00	1.23	0.22	0.00	2.47	0.29	**0.00**	**11.11**	**2.06**
3	Dung	2.00	4.94	3.64	0.00	0.00	0.00	0.00	0.00	0.00	1.00	4.94	2.97	**3.47**	**9.88**	**6.61**
4	Gorsam	0.00	4.00	1.01	0.00	1.00	0.04	0.00	1.00	0.50	0.00	4.00	0.89	**0.00**	**9.00**	**2.45**
5	Hoongla	0.00	4.00	1.19	0.00	0.00	0.00	0.00	0.49	0.19	0.00	0.00	0.00	**0.00**	**4.49**	**1.38**
6	Kharman	0.00	3.00	1.50	0.00	0.00	0.00	0.00	2.00	0.75	0.00	4.00	1.16	**0.13**	**8.00**	**3.40**
7	Maio	0.00	8.00	1.02	0.00	4.94	0.21	0.00	2.00	0.51	0.00	6.18	0.44	**0.00**	**14.82**	**2.19**
8	Nam Tsering	0.00	2.00	0.60	0.00	0.75	0.01	0.00	0.10	0.00	0.00	0.00	0.00	**0.00**	**2.00**	**0.64**
9	Pharmey	0.00	4.94	1.55	0.00	4.94	0.63	0.00	1.00	0.58	0.00	4.94	0.74	**0.39**	**11.88**	**3.50**
10	Poito	0.00	2.47	0.63	0.00	0.00	0.00	0.00	0.25	0.02	0.00	0.50	0.06	**0.00**	**2.52**	**0.73**
11	Sazo	0.00	3.00	1.22	0.00	0.00	0.00	0.00	0.38	0.22	0.00	2.00	0.68	**0.00**	**4.38**	**2.12**
12	Yabab	0.50	2.00	1.10	0.00	0.50	0.03	0.00	1.00	0.28	0.00	1.00	0.71	**0.50**	**3.50**	**2.14**
13	Zimithang HQ	0.00	1.00	0.11	0.00	2.00	0.11	0.00	1.50	0.38	0.00	0.50	0.02	**0.04**	**3.10**	**0.62**

Table II. 3.659: Number of HHs having land types in the thirteen project villages

Sl. No.	Village	Agricultural land		Horticultural land		Habitation and home garden land		Forest land	
		n	%	n	%	n	%	n	%
1	Brokenthang	12	80	1	7	0	0	0	0
2	Dugumba	13	87	2	13	6	40	7	47
3	Dung	8	100	0	0	0	0	8	100
4	Gorsam	15	65	1	4	20	87	13	57
5	Hoongla	41	73	0	0	41	73	0	0
6	Kharman	43	98	0	0	41	93	41	93
7	Maio	11	48	1	4	21	91	5	22
8	Nam Tsering	42	81	1	2	1	2	0	0
9	Pharmey	23	70	17	52	32	97	19	58
10	Poito	18	82	0	0	20	91	3	14
11	Sazo	37	82	0	0	37	82	26	58
12	Yabab	14	100	1	7	7	50	12	86
13	Zimithang HQ	7	30	3	13	26	113	2	9
	Total	**284**	**75**	**27**	**7**	**252**	**67**	**136**	**36**

Table II. 3.660: Distribution of area (in acres) of land holding among HHs in the thirteen project villages

Sl. No.	Village	Agricultural land		Horticultural land		Habitation and home garden land		Forest land		Total land
		Area	%	Area	%	Area	%	Area	%	Area
1	Brokenthang	15	86	2	14	0	0	0	0	**17**
2	Dugumba	20	64	3	11	3	11	4	14	**31**
3	Dung	29	55	0	0	0	0	24	45	**53**
4	Gorsam	23	41	1	2	12	20	21	36	**56**
5	Hoongla	67	86	0	0	11	14	0	0	**78**
6	Kharman	66	44	0	0	33	22	51	34	**150**
7	Maio	23	47	5	10	12	23	10	20	**50**
8	Nam Tsering	32	97	1	2	0	0	0	0	**33**
9	Pharmey	51	44	21	18	19	17	25	21	**116**
10	Poito	14	87	0	0	1	4	2	9	**16**
11	Sazo	55	58	0	0	10	10	31	32	**95**
12	Yabab	16	52	1	2	4	13	10	33	**30**
13	Zimithang HQ	3	18	3	17	11	61	1	3	**17**
	Total	**414**	**56**	**37**	**5**	**115**	**15**	**177**	**24**	**743**

Livestock Holding: The data presented in Tables II 3.661–3.663 in respect of distribution of livestock holdings in the thirteen surveyed villages reveals that, nine different types of animals are domesticated in surveyed villages. However, none of the villages owned all the nine animal types. In total, 1311 animals are reared in the thirteen villages (Table II. 3.661). Considerable inter village variation is observed in total number of animals reared. It varied from 9 in Nam Tsering to 611 in Kharman. Kharman and Pharmey accounts for 58% of all the animals found in the surveyed villages. Three animals, viz, cattle (68%), Yak (7%) and goat (10%) account for 85% of the total animals (1311). 54% of the HHs (204) did not own any animals; whereas 11% HHs owned more than 10 animals.

Table II. 3.661: Livestock holding by HHs in the thirteen project villages

Sl. No.	Village		Mithun	Cattle	Yak	Goat	Sheep	Pig	Pony	Poultry	Others
1	Brokenthang	n	0	4	0	0	0	0	0	0	0
		%	0	27	0	0	0	0	0	0	0
2	Dugumba	n	5	3	0	6	0	3	0	1	0
		%	33	20	0	40	0	20	0	7	0
3	Dung	n	0	8	0	0	0	0	0	0	0
		%	0	100	0	0	0	0	0	0	0
4	Gorsam	n	0	5	0	0	0	0	0	0	0
		%	0	22	0	0	0	0	0	0	0
5	Hoongla	n	1	7	0	5	2	6	4	0	6
		%	2	13	0	9	4	11	7	0	11
6	Kharman	n	0	38	3	0	0	0	0	0	0
		%	0	86	7	0	0	0	0	0	0
7	Maio	n	0	3	1	1	1	4	1	1	0
		%	0	13	4	4	4	17	4	4	0
8	Nam Tsering	n	0	5	0	2	0	0	0	0	0
		%	0	10	0	4	0	0	0	0	0
9	Pharmey	n	0	13	0	9	0	19	13	3	0
		%	0	39	0	27	0	58	39	9	0
10	Poito	n	0	5	0	2	0	0	0	0	0
		%	0	23	0	9	0	0	0	0	0
11	Sazo	n	0	1	0	15	0	16	0	0	24
		%	0	2	0	33	0	36	0	0	53
12	Yabab	n	0	5	0	2	0	0	0	1	0
		%	0	36	0	14	0	0	0	7	0
13	Zimithang HQ	n	0	6	0	0	1	0	0	0	0
		%	0	21	0	0	4	0	0	0	0
	Total	**n**	**6**	**103**	**4**	**42**	**4**	**48**	**18**	**6**	**30**
		%	**2**	**27**	**1**	**11**	**1**	**13**	**5**	**2**	**8**

Table II. 3.662: Number of livestock in surveyed HHs across the thirteen project villages

Sl. No.	Village		Mithun	Cattle	Yak	Goat	Sheep	Pig	Pony	Poultry	Others	Total
1	Brokenthang	LS	0	30	0	0	0	0	0	0	0	**30**
		%	0	100	0	0	0	0	0	0	0	**100**
2	Dugumba	LS	9	3	0	18	0	3	0	12	0	**45**
		%	20	7	0	40	0	7	0	27	0	**100**
3	Dung	LS	0	95	0	0	0	0	0	0	0	**95**
		%	0	100	0	0	0	0	0	0	0	**100**
4	Gorsam	LS	0	45	0	0	0	0	0	0	0	**45**
		%	0	100	0	0	0	0	0	0	0	**100**
5	Hoongla	LS	1	27	0	23	3	6	7	0	13	**80**
		%	1	34	0	29	4	8	9	0	16	**100**
6	Kharman	LS	0	558	53	0	0	0	0	0	0	**611**
		%	0	91	9	0	0	0	0	0	0	**100**
7	Maio	LS	0	4	40	3	3	5	3	1	0	**59**
		%	0	7	68	5	5	8	5	2	0	**100**
8	Nam Tsering	LS	0	6	0	3	0	0	0	0	0	**9**
		%	0	67	0	33	0	0	0	0	0	**100**
9	Pharmey	LS	0	55	0	39	0	20	28	13	0	**155**
		%	0	35	0	25	0	13	18	8	0	**100**
10	Poito	LS	0	19	0	5	0	0	0	0	0	**24**
		%	0	79	0	21	0	0	0	0	0	**100**
11	Sazo	LS	0	1	0	34	0	16	0	0	41	**92**
		%	0	1	0	37	0	17	0	0	45	**100**
12	Yabab	LS	0	11	0	4	0	0	0	1	0	**16**
		%	0	69	0	25	0	0	0	6	0	**100**
13	Zimithang HQ	LS	0	35	0	0	15	0	0	0	0	**50**
		%	0	70	0	0	30	0	0	0	0	**100**
	Total	**LS**	**10**	**889**	**93**	**129**	**21**	**50**	**38**	**27**	**54**	**1311**
		%	**1**	**68**	**7**	**10**	**2**	**4**	**3**	**2**	**4**	**100**

Note: LS–Livestock

Table II. 3.663: Distribution of total number of livestock in HHs of the thirteen project villages

Sl. No.	Village	0		1–5		6–10		> 10		Total
		n	%	n	%	n	%	n	%	n
1	Brokenthang	12	80	1	7	1	7	1	7	**15**
2	Dugumba	5	33	8	53	1	7	1	7	**15**
3	Dung	0	0	2	25	2	25	4	50	**8**
4	Gorsam	18	78	0	0	5	22	0	0	**23**
5	Hoongla	35	63	18	32	2	4	1	2	**56**
6	Kharman	6	14	2	5	11	25	25	57	**44**
7	Maio	16	70	5	22	1	4	1	4	**23**
8	Nam Tsering	45	87	7	13	0	0	0	0	**52**
9	Pharmey	11	33	9	27	7	21	6	18	**33**
10	Poito	16	73	4	18	2	9	0	0	**22**
11	Sazo	11	24	32	71	2	4	0	0	**45**
12	Yabab	7	50	6	43	1	7	0	0	**14**
13	Zimithang HQ	22	79	1	4	4	14	1	4	**28**
	Total	**204**	**54**	**95**	**25**	**39**	**10**	**40**	**11**	**378**

Traditional Skills: From Table II. 3.664, it was observed that in the surveyed village five types of crafts given in Table II. 3.664 are pursued. Weaving is practiced in ten villages involving 38 HHs (10%). Wood carving is pursued in eight villages. 13 HHs (3%) are engaged in this craft. A small number of HHs is engaged in Thanka painting, carpet making and bamboo utensil making.

Table II. 3.664: Distribution of various skills among surveyed HHs in the thirteen project villages

Sl. No.	Village	Wood carving		Thanka painting		Carpet making		Bamboo utensils		Weaving		Paper making	
		n	%	n	%	n	%	n	%	n	%	n	%
1	Brokenthang	4	27	0	0	0	0	4	27	0	0	0	0
2	Dugumba	1	7	0	0	1	7	1	7	3	20	0	0
3	Dung	0	0	0	0	0	0	4	50	2	25	0	0
4	Gorsam	0	0	0	0	2	9	0	0	1	4	0	0
5	Hoongla	0	0	0	0	0	0	0	0	0	0	0	0
6	Kharman	2	5	0	0	0	0	1	2	13	30	0	0

7	Maio	1	4	0	0	0	0	0	0	1	4	0	0
8	Nam Tsering	1	2	1	2	1	2	0	0	1	2	0	0
9	Pharmey	0	0	0	0	0	0	0	0	7	21	0	0
10	Poito	1	5	0	0	0	0	0	0	4	18	0	0
11	Sazo	0	0	0	0	0	0	0	0	0	0	0	0
12	Yabab	2	14	0	0	0	0	0	0	2	14	0	0
13	Zimithang HQ	1	4	0	0	0	0	0	0	4	14	0	0
	Total	**13**	**3**	**1**	**0**	**4**	**1**	**10**	**3**	**38**	**10**	**0**	**0**

River Resources: In Table II. 3.665, data pertaining to the use of various river resources by the inhabitants of the thirteen surveyed villages is presented. All the river resources listed in Table II. 3.665 are being used across the studied villages. Water from river is used by a large number of HHs in the villages for drinking (n=258), domestic use (n=147), and for livestock (n=174). 86 HHs of four villages use aquatic flora. The villages are Dung, Gorsam, Kharman, and Maio. It is highly noteworthy that, 377 HHs in the surveyed villages use river for performing last rites of the dead. A majority of the HHs in most of the surveyed villages use sand (n=241) and stone (n=240) from the river bed for self consumption and selling.

Table II. 3.665: Dependence on water resources among surveyed HHs in the thirteen project villages

Sl. No.	Nature of dependence		Brokenthang	Dugumba	Dung	Gorsam	Hoongla	Kharman	Maio	Nam Tsering	Pharmey	Poito	Sazo	Yabab	Zimithang HQ	Total
1	Drinking water	n	5	13	8	23	46	44	22	52	0	0	45	0	0	**258**
		%	33	87	100	100	82	100	96	100	0	0	100	0	0	**68**
2	Water for domestic use	n	4	8	8	23	40	44	20	0	0	0	0	0	0	**147**
		%	27	53	100	100	71	100	87	0	0	0	0	0	0	**39**
3	Water for domestic animal	n	3	10	8	5	21	38	7	7	22	6	34	7	6	**174**
		%	20	67	100	22	38	86	30	13	67	27	76	50	21	**46**
4	Fishes	n	0	0	0	0	0	0	19	0	0	0	0	0	0	**19**
		%	0	0	0	0	0	0	83	0	0	0	0	0	0	**5**
5	Aquatic flora	n	0	0	8	23	0	44	11	0	0	0	0	0	0	**86**
		%	0	0	100	100	0	100	48	0	0	0	0	0	0	**23**
6	Religious	n	15	15	8	23	56	44	23	52	33	22	45	14	27	**377**
		%	100	100	100	100	100	100	100	100	100	100	100	100	96	**100**
7	Sand	n	0	0	8	23	0	44	19	52	0	22	45	0	28	**241**
		%	0	0	100	100	0	100	83	100	0	100	100	0	100	**64**
8	Stones (boulders)	n	0	1	8	23	0	44	17	52	0	22	45	0	28	**240**
		%	0	7	100	100	0	100	74	100	0	100	100	0	100	**63**
9	Any other	n	0	0	8	0	0	44	2	0	0	0	0	0	26	**80**
		%	0	0	100	0	0	100	9	0	0	0	0	0	93	**21**

Forest Resources: The inhabitants of all the thirteen villages are use varying degrees of forest resources (Table II. 3.666). Considerable variation is observed between uses of number of forest resources. It varies from 5 resources in two villages to 18 in Maio. There are four villages which use more than ten resources. All the thirteen villages gather fuel wood from the forest and graze their animals in the forest. Two resources, viz., water and stone, are used in ten and more villages. 177 HHs belonging to seven villages use forest resources for medicine. Aquatic fauna are also gathered by a small number of HHs. Forest also provides food, edible oils, spices, etc., to a substantial number of HHs. It is thus evident from above description that, for a majority of the inhabitants of the surveyed villages, forest resources play a very significant role to the livelihoods as well as the quality of life of the people.

Table II. 3.666: Dependence on forest resources among surveyed HHs in the thirteen project villages

Sl. No.	Forest resources		Brokenthang	Dugumba	Dung	Gorsam	Hoongla	Kharman	Maio	Nam Tsering	Pharmey	Poito	Sazo	Yabab	Zimithang HQ	Total
1	Fuel wood	n	15	15	8	23	56	44	15	52	19	22	45	14	28	**356**
		%	100	100	100	100	100	100	65	100	58	100	100	100	100	**94**
2	Timber	n	15	0	8	23	56	44	21	52	0	0	0	0	28	**247**
		%	100	0	100	100	100	100	91	100	0	0	0	0	100	**65**
3	Medicinal plants	n	15	0	8	23	0	44	14	0	0	0	45	0	28	**177**
		%	100	0	100	100	0	100	61	0	0	0	100	0	100	**47**
4	Honey	n	15	0	0	0	0	0	1	0	0	0	0	0	0	**16**
		%	100	0	0	0	0	0	4	0	0	0	0	0	0	**4**
5	Food	n	0	0	8	23	56	44	11	52	33	0	0	14	27	**268**
		%	0	0	100	100	100	100	48	100	100	0	0	100	96	**71**
6	Edible oil	n	0	0	0	0	0	0	2	0	0	0	0	0	0	**2**
		%	0	0	0	0	0	0	9	0	0	0	0	0	0	**1**
7	Ornamental	n	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
		%	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
8	Religious	n	0	0	8	23	56	44	8	0	33	22	45	14	27	**280**
		%	0	0	100	100	100	100	35	0	100	100	100	100	96	**74**
9	Fencing	n	0	0	8	0	0	44	19	0	0	0	0	0	27	**98**
		%	0	0	100	0	0	100	83	0	0	0	0	0	96	**26**
10	Handicrafts	n	0	0	0	0	0	0	7	0	0	0	0	0	0	**7**
		%	0	0	0	0	0	0	30	0	0	0	0	0	0	**2**
11	Thatching	n	0	0	0	0	0	0	6	0	0	0	0	0	27	**33**
		%	0	0	0	0	0	0	26	0	0	0	0	0	96	**9**
12	Spices	n	0	0	8	23	0	44	9	0	33	0	0	14	27	**158**
		%	0	0	100	100	0	100	39	0	100	0	0	100	96	**42**
13	Grazing	n	3	10	8	5	21	38	7	7	22	6	34	7	6	**174**
		%	20	67	100	22	38	86	30	13	67	27	76	50	21	**46**
14	Hunting of Wild animals	n	0	0	0	0	0	0	1	0	0	0	0	0	0	**1**
		%	0	0	0	0	0	0	4	0	0	0	0	0	0	**0**
15	Fishes	n	0	0	0	0	0	0	19	0	0	0	0	0	0	**19**
		%	0	0	0	0	0	0	83	0	0	0	0	0	0	**5**
16	Water	n	0	1	8	23	21	44	16	0	33	22	0	14	28	**210**
		%	0	7	100	100	38	100	70	0	100	100	0	100	100	**56**
17	Stones	n	0	3	8	23	56	44	17	52	33	22	45	14	28	**345**
		%	0	20	100	100	100	100	74	100	100	100	100	100	100	**91**
18	Sand	n	0	0	8	23	56	44	18	52	0	22	45	0	28	**296**
		%	0	0	100	100	100	100	78	100	0	100	100	0	100	**78**
19	Dyes	n	0	0	6	23	0	14	1	0	0	0	0	14	8	**66**
		%	0	0	75	100	0	32	4	0	0	0	0	100	29	**17**

Water Resources: All five types of water source, viz., river, hill stream/springs, wells, pond, and tap water are available across the studied villages (Table II. 3.667). Eight out of thirteen villages use river water. Water from hill stream/springs is used in seven villages. Tap water is used for various purposes in all surveyed villages. Pond water is also used only in Dung. Only in Yabab well water is used. In a majority of the villages three different sources of water are present.

Table II. 3.667: Dependence on water resources among surveyed HHs in the thirteen project villages

Sl. No.	Village	River		Hill stream/spring		Wells		Ponds		Tap water	
		n	%	n	%	n	%	n	%	n	%
1	Brokenthang	15	100	5	33	0	0	0	0	15	100
2	Dugumba	0	0	0	0	0	0	0	0	15	100
3	Dung	8	100	0	0	0	0	8	100	8	100
4	Gorsam	23	100	23	100	0	0	0	0	23	100
5	Hoongla	0	0	0	0	0	0	0	0	56	100
6	Kharman	44	100	5	0	0	0	0	0	44	100
7	Maio	21	91	14	61	0	0	0	0	0	0
8	Nam Tsering	52	100	52	100	0	0	0	0	52	100
9	Pharmey	0	0	33	100	0	0	0	0	33	100
10	Poito	0	0	0	0	0	0	0	0	22	100
11	Sazo	45	100	0	0	0	0	0	0	45	100
12	Yabab	0	0	0	0	14	100	0	0	14	100
13	Zimithang HQ	28	100	28	100	0	0	0	0	28	100
	Total	**236**	**62**	**160**	**42**	**14**	**4**	**8**	**2**	**355**	**94**

3.3.12 PAIKANGRONG

3.3.12.1 PHYSICAL ENVIRONMENT

Geology

The rock types exposed are calc. gneisses and pelitic schist. The area is also near to the main central thrust. Seismically it is active, so due precautions have to be taken during construction.

Landuse and Land Cover

The total area within 10 km radius of Paikangrong chu HEP site is 31442.41 ha (Figure II. 3.66). Majority of the area is covered by forest (54.92%) followed by scrubland (34.48%). Cropland covers only 0.11% of the total project area. Waterbody constitute around 7.93% of the total area, and grassland occupies only 0.93%. The total area occupied by snow and ice and other builtup area is 1.63% (Table II. 3.668).

Table II. 3.668: Landuse/land cover area of Paikangrong chu project site

Land category	Area (ha)	%
Forest	17268.7	54.92
Scrubland	10840.6	34.48
Waterbody	2494.37	7.93
Croplands	33.3225	0.11
Grasslands	292.298	0.93
Builtuparea	232.92	0.74
Snow and Ice	279.9	0.89
Total	**31442.11**	**100.00**

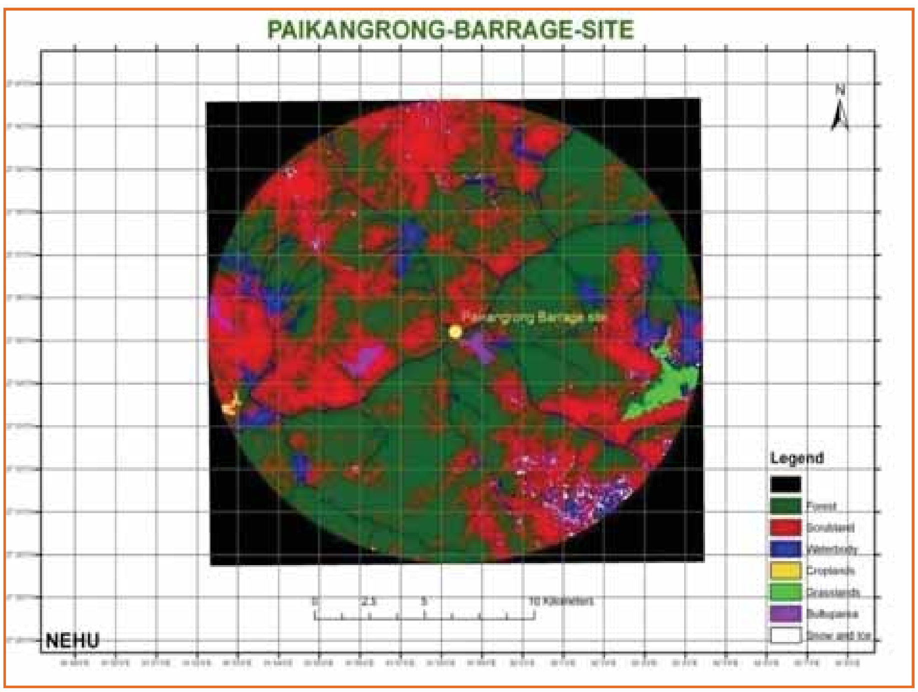


Figure II. 3.66: Landuse/land cover area of Paikangrong chu project site

Soil

The soil at this site was sandy clay but its water holding capacity was relatively lower (Table II. 3.669). It was slightly acidic with very low conductivity and exchangeable–K values. Like other sites, ammonium nitrogen concentration was high and the values of all other parameters including microbial biomass–C and–N were very low. They all varied in different seasons without exhibiting any consistent trend (Table II. 3.670).

Table II. 3.669: Soil physical properties at Paikangrong chu site

Site	Texture	WHC (%)	Bulk density (g/cm³)	Porosity (%)
Barrage	Sandy clay	44.59	1.55	41.51
Powerhouse	Sandy clay	43.34	1.57	40.75

Table II. 3.670: Seasonal variation in soil physico–chemical properties at Paikangrong chu site

Parameters	Post-monsoon		Monsoon		Winter		Mean	
	B	PH	B	PH	B	PH	B	PH
SMC (%)	31	26	35	31	20	15	29	24
pH	5.4	6.3	5.5	6.4	6.8	6.9	5.9	6.5
Conductivity (µS cm^{-1})	41	37	61	64	45	47	49	49
NH_4^+–N (µg g^{-1})	300	300	500	400	200	200	333	300
NO_3^-–N(µg g^{-1})	33	51	33	39	33	35	33	42
TKN (µg g^{-1}) x10^3	0.500	0.600	0.700	0.800	0.400	0.500	0.533	0.633
Av.P (µg g^{-1})	0.160	0.090	0.190	0.140	0.060	0.050	0.137	0.093
TP (%)	0.120	0.110	0.170	0.150	0.090	0.110	0.127	0.123
SOC (%)	0.001	0.004	0.007	0.008	0.002	0.004	0.003	0.005
Ex. K (µg g^{-1})	55	101	150	190	69	97	91	129
Ex. Mg (%)	0.012	0.041	0.019	0.009	0.015	0.012	0.015	0.021
Ex. Ca (%)	0.158	0.198	0.278	0.286	0.202	0.178	0.213	0.221
Soil microbial biomass–C (µg g^{-1})	15	0	11	2	20	25	15	9
Soil microbial biomass–N (µg g^{-1})	2.0	2.0	1.7	2.0	4.2	4.0	2.6	2.7

(Note: Post-monsoon–March, Monsoon–July, Winter–December); B = Barrage, PH = Powerhouse)

Water

The seasonal trend of physico–chemical parameter was similar to that observed at Jaswantgarh. Except for total alkalinity, DO, turbidity, NO_3–N and coliform count, all other parameters showed higher values during monsoon season. The former two parameters showed greater values in the winter seson, and the values of later three parameters were high in the post-monsoon season (Table II. 3.671).

Table II. 3.671: Seasonal variation in physico–chemical and biological properties of water and river primary productivity

Parameters	Post-monsoon			Monsoon			Winter		
	B	PH	Mean	B	PH	Mean	B	PH	Mean
Temperature (˚C)	7.40	7.60	7.50	13.40	14.50	13.95	4.20	4.90	4.55
Turbidity (NTU)	0.47	0.42	0.45	0.40	0.43	0.42	0.33	0.38	0.36
pH	6.70	6.83	6.77	7.75	7.82	7.79	7.38	7.44	7.41
Electrical conductivity (µS/cm)	34	38.00	36	59	65.00	62	46	38.00	42
Total dissolved solids (mg/l)	17	20.30	18.55	31	34.00	32.50	24	25.60	24.70
Practical salinity (ppt)	0.02	0.03	0.02	0.04	0.04	0.04	0.02	0.03	0.02
Total alkalinity (mg $CaCO_3$/l)	24	28.00	26.00	18	26.00	22.00	26	30.00	28.00
Total hardness (mg/l)	5	5.18	5.11	19	19.84	19.31	11	11.58	11.34
Chloride (mg Cl^-/l)	8.33	9.99	9.16	11.99	11.99	11.99	7.99	8.32	8.16
Ca^{2+} (mg/l)	1.27	1.32	1.30	5.29	5.52	5.41	2.73	2.76	2.75
Mg^{2+}(mg/l)	0.45	0.45	0.45	1.35	1.47	1.41	1.04	1.14	1.09
K^+ ppm	1.10	1.20	1.15	3.10	2.80	2.95	0.80	0.70	0.75
Na^+ ppm	3.20	3.20	3.20	9.00	9.40	9.20	2.80	2.80	2.80
TKN (mg/l)	0.35	0.37	0.36	0.51	0.55	0.53	0.25	0.26	0.26
NH_4^+ N (mg/l)	0.02	0.02	0.02	0.08	0.09	0.09	0.03	0.04	0.04
NO_3–N (mg/l)	0.30	0.28	0.29	0.14	0.15	0.15	0.19	0.19	0.19
Total phosphorus (mg/l)	0.10	0.01	0.06	0.07	0.07	0.07	0.08	0.08	0.08
GPP (mg C/cm^3/h)	0.31	0.31	0.31	0.47	0.47	0.47	0.23	0.23	0.23
NPP (mg C/cm^3/h)	0.10	0.10	0.10	0.23	0.23	0.23	0.08	0.08	0.08
Dissolved oxygen (mg/l)	11.70	11.70	11.70	10.60	10.20	10.40	12.50	12.50	12.50
Total coliforms (CFU/ml)	24	27.00	25.50	6	14.00	10.00	11	16.00	13.50

Ambient Air Quality

Concentration of PM_{10} and $PM_{2.5}$: PM_{10} concentration near proposed Paikangrong HEP ranged from a minimum of 11.7µg/m^3 at Jaswantgarh to a maximum of 49.7µg/m^3 at Nuranang Falls. Similarly, $PM_{2.5}$ concentration ranged from a minimum of 13.4µg/m^3 at Jaswantgarh and Rho to a maximum of 38.0 µg/m^3 at Nuranang Falls (Table II. 3.672). The concentration of sulphur–dioxide (SO_2), nitrogen–dioxide (NO_2), ammonia (NH_3), and ground level ozone (O_3) at all the monitored locations were below detectable limits.

Table II. 3.672: Concentration of PM_{10} and $PM_{2.5}$ in air at the proposed Paikangrong HEP

Sampling location	Nearest project site covered	PM_{10} (µg/m^3)	$PM_{2.5}$ (µg/m^3)
Nuranang falls	Paikangrong chu barrage site Paikangrong chu powerhouse site	49.7	38.0
Jang	Paikangrong chu barrage site Paikangrong chu powerhouse site	41.7	23.9
Jaswantgarh	Paikangrong chu barrage site Paikangrong chu powerhouse site	11.7	13.4
Rho	Paikangrong chu barrage site Paikangrong chu powerhouse site	23.5	13.4

Ambient air temperature at Paikangrong chu HEP ranged from a minimum of 4°C at Jang to a maximum of 10°C at Nuranang falls. Relative humidity ranged between 27% at Nuranang falls to 52% at Rho. Wind speed was 1.6 km/hr at Jang and 3.6 km/hr at Rho while wind direction NW to SE (Table II. 3.673).

Table II. 3.673: Meteorological condition at proposed Paikangrong HEP

Sampling location	Nearest project component covered	Ambient temperature (°C) Min Max	Relative humidity (%)	Wind speed (range in km/hr)	Wind direction
Nuranang falls	Paikangrong chu barrage site Paikangrong chu powerhouse site	06 10	27	2.4–3.2	SE
Jang	Paikangrong chu barrage site Paikangrong chu powerhouse site	04 08	39	1.6–2.3	SE
Jaswantgarh	Paikangrong chu barrage site Paikangrong chu powerhouse site	05 09	32	2.1–2.7	SE
Rho	Paikangrong chu barrage site Paikangrong chu powerhouse site	05 09	52	1.8–3.6	NW

Noise Level: Noise level near Paikangrong chu HEP was measured at four places. The values ranged from a minimum of 25.2 dBA at Jaswantgarh at 4.00 PM to a maximum of 64.2 dBA at Nuranang falls at 8.00 AM (Table II. 3.674).

Table II. 3.674: Noise level at proposed Paikangrong HEP

Sampling location	Nearest project component covered	Noise level (dBA) 8.00 AM	Noise level (dBA) 4.00 PM
Nuranang falls	Paikangrong chu barrage site Paikangrong chu powerhouse site	64.6	63.2
Jang	Paikangrong chu barrage site Paikangrong chu powerhouse site	38.2	29.7
Jaswantgarh	Paikangrong chu barrage site Paikangrong chu powerhouse site	27.1	25.2
Rho	Paikangrong chu barrage site Paikangrong chu powerhouse site	37.2	39.6

3.3.12.2 BIOLOGICAL ENVIRONMENT

Vegetation Types

The project components of Paikangrong chu HEP are located in montane sub-tropical forest and temperate forest area.

8/B/CI East Himalayan sub-tropical broad-leaved forest (1000-1800 m): These forests occur in and around 1000 m and extend up to 1800 m elevations. The canopy is comprised of: *Alnus nepalensis, Macaranga denticulata, Castanea sativa, Engelhardtia spicata, Erythrina arborescens, Quercus glauca, Rhus succedanea, Schima wallichii*, *Ficus auriculata, Myrica esculenta*, etc. Medium sized evergreen tree species such as: *Ficus semicordata, Lophopetalum wightianum, Lyonia ovalifolia, Rhus chinensis, Saurauia punduana, Tetracentron sinense, Phyllanthus emblica*, *Rhus javanica, Torricellia tiliifolia* etc., constituted the sub-canopy layer. Understory consisted of shrubs such as: *Artimisia nilagarica, Coriaria nepalensis, Elaeagnus parvifolia, Rubus ellipticus, Maesa indica* etc. and climbers. Epiphytes were abundant in the forest.

9/CI Eastern Himalayan sub-tropical pine forest (1200-1800 m): These forests occur in and around 1200 m and extend up to 1800 m elevations. The canopy is comprised of: *Pinus roxburghii*, *Mallotus philippensis, Pyrus pashia, Syzygium cumini, Albizzia arunachalensis, Prunus cerasoides, Purus* sp., etc. Shrubs were represented by: *Artimisia nilagirica, Coriaria nepalensis, Elaeagnus parvifolia, Rosa* sp., *Rubus ellipticus, Butea buteiformis* and *Viburnum erubescens*. The herbaceous layer constitutes of climber and epiphytes, but are not common.

11B/CI East Himalayan wet temperate forest (2000-3000 m): These are mixed evergreen forests with moderate size trees occurring between 1800 m and 3000 m altitude. In these forests important tree associates are: *Acer campbellii, Lithocarpus pachyphylla, Prunus cerasoides, Quercus serrata, Rhododendron arboreum, Schima wallichii* and *Tetracentron sinense*. Shrubs are represented by: *Berberis asiatica, Coriaria nepalensis, Elaeagnus parvifolia, Rosa brunonii, Rubus ellipticus* and *Viburnum erubescens*. Climber and epiphytes are not common.

12/ISI Alder forest (1800-2200 m): Typically seen as pure stand of *Alnus nepalensis, Populus ciliata*, 20-30 m high, as a strip of varying width along stream sides, spreading out to larger areas, more or less deciduous. In the lower course of the stream where the fringe of *Alnus* is the only remaining tree growth owing to cultivation, there is often an under growth of inedible or thorny shrubs comprising *Berberis, Rubus, Princepia* etc, whilst in the better wooded tracts progression starts early and other species, notably blue pine and other conifers, are usually present.

12/1S2 Riverine blue-pine forest (1800-3000 m): Irregular, often dense stands of blue pine with occasional *Picea*, *Tsuga, Populus* and *Alnus* with little or no undergrowth at first, but often becoming more open with inedible or thorny shrubs, if grazed.

Plant Diversity

A total of 76 plant species belonging to different groups at barrage and powerhouse sites, and catchment area were recorded. A complete list of plant species found in the study area representing different groups such as tree, shrub, herb, climber, orchid, pteridophyte, bryophyte, lichen and fungi along with their family name is given in Appendix II. 3.143. The number of plant species belonging to different groups is summarized in Table II. 3.675.

Table II. 3.675: Different groups of plant species present at Paikangrong chu project site

Plant groups		Barrage site	Powerhouse site	Catchment area
1	Tree	7	6	5
2	Shrub	8	7	7
3	Herb	16	16	14
4	Climbers	7		6
5	Orchids	8		6
6	Pteridophytes	9		8
7	Bryophytes	3		3
8	Lichens	7		5
9	Fungi	9	7	8

The trees were found laden with thick growth of mosses and epiphytes. Some flowering plants and ferns form this group. At the barrage site 7 tree, 8 shrub, and 16 herb species were recorded, and at the powerhouse site 6 tree, 7 shrub, and 16 herb species were observed. In the project catchment area, 5 tree, 7 shrub and 14 herb species were recorded. A total of 7 climber, 8 orchid, 9 pteridophyte,3 bryophyte, 7 lichen and 9 fungi species were recorded from barrage and powerhouse sites, whereas from the catchment area 6 climber, 6 orchid, 8 pteridophyte, 3 bryophyte, 5 lichen and 8 fungi species were recorded (Appendix II. 3.144).

Threatened and Endemic Species

During the floristic survey no threatened species was recorded at the HEP Site.

Economically Important Species/Plant Resources

The study area is rich in plant resources. A few of the important ones are listed below under different resource groups. (Table II. 3.676)

Table II. 3.676: Economically important species/plant resources recorded from Paikangrong chu project site

Sl. No.	Uses	Species name
1	Timber	*Pinus wallichiana, Schima wallichi*
2	Fuel	*Quercus griffithii, Quercus griffithi, Alnus nepalensis, Rhododendron* sp.
3	Ornamentals and orchids	*Rhododendron* sp.
4	Medicine and aromatics	*Centella asiatica*
5	Fodder	*Alnus nepalensis, Saurauia nepalensis, Ficus* sp., *Quercus griffithii*
6	Edible	*Rubus* sp., *Elaeagnus* sp., *Prasiola* sp.
7	Fibre and paper	*Daphne papyracea*
8	Bamboos	*Arundinaria* sp.
9	Resins and gums	*Pinus wallichiana*

Vegetation Analysis for Angiosperms and Gymnosperms

Species richness at this site was very low compared to other sites. Total number of species recorded at barrage and powerhouse sites, and the catchment area was 7 tree, 9 shrub and 15 herbaceous species (Table II. 3.677 and 3.678).

Table II. 3.677: Tree and shrub species recorded at the barrage and powerhouse sites, and in the catchment area of Paikangrong chu project site

Tree species	Shrub species
Alnus nepalensis	*Artemesia nilagarica*
Lindera sp.	*Berberis* sp.
Pinus Wallichiana	*Budlejia asiatica*
Quercus griffithii	*Coriaria nepalensis*
Quercus serrata	*Elaegnus*
Rhododendron arboreum	*Neilia thysifolia*
Schima wallichi	*Rubus ellipticus*
	Triumfetta rhomboidea
	Viburnum foetidum

Table II. 3.678: Herbaceous species at barrage and powerhouse sites, and in the catchment area of Paikangrong chu project site

Herb species		
Ageratum conyzoides	*Drymaria cordata*	*Galium rotundifolium*
Bidens pilosa	*Eupatorium adenophorum*	*Geranium* sp.
Centella asiatica	*Fragaria nubicola*	*Oxalis corniculata*
Crassocephalum crepidioides	*Galinsuga parviflora*	*Pepromia tetraphylla*
Cynoglossum sp.	*Rumex nepalensis*	*Plantago major*

At the three sites, number of tree species varied from 5 to 7, and shrub species from 6 to 8. Herbaceous species richness varied from 12 species at catchment area during winter season to 16 species at barrage site during monsoon season. Seasonal variation in all the three sites was indistinct. Among trees species, *Quercus serrata* at barrage and powerhouse sites, and *Rhododendron arboreum* in the catchment area, were dominants. *Artemisia nilagarica* was the dominant shrub species in all three sites. Unlike trees and shrubs, for a given site and season, different herbaceous species were dominant (Appendix II. 3.153).

Highest tree density was recorded at barrage site, and lowest in the catchment area. Contrary to this trend, shrub density was maximum in catchment areas and minimum at barrage site (Table II. 3.679). Highest density of herbaceous species was recorded during monsoon period at barrage site, and lowest during post monsoon period in catchment area. But at all three places, it was maximum during rainy season and minimum during post monsoon months (Appendix II.3.145-3.152). Shannon index of general diversity for tree species in the community was low in general. The highest value (H'= 1.87) was obtained for the barrage site, followed by powerhouse (H'= 1.72) and catchment area (H'= 1.31). For shrub species also, highest value (H'=1.89) was obtained for the barrage site, followed by catchment area (H'= 1.79) and powerhouse site (H'= 1.76) (Table II. 3.679). For herbaceous species, the highest value (H'= 2.59) was obtained for the powerhouse during monsoon season, and lowest (H'= 2.29) during winter season in the catchment area. In all the three sites, diversity of herbaceous species peaked during monsoon, and attained lowest value either during post-monsoon or winter season (Table II. 3.680). The plant community near barrage site had highest species diversity of tree, shrub and herb. In general, dominance index for trees was lower than those of herbs in all the three sites. Dominance index value for tree species ranged between 0.10 and 0.19, which was much lower than those obtained for shrubs 0.80-0.82.

Table II. 3.679: Species richness, diversity and dominance of trees and shrubs, and biomass and carbon stock of trees in Paikangrong chu project site

Parameters	Barrage		Powerhouse		Catchment area	
	Trees	**Shrubs**	**Trees**	**Shrubs**	**Trees**	**Shrubs**
Number of species	7	8	6	7	5	7
Density (ha^{-1})	500	2144	430	2160	330	2176
Simpson index of dominance	0.17	0.82	0.19	0.80	0.10	0.81
Shannon index of diversity (H')	1.87	1.89	1.72	1.76	1.31	1.79
Evenness index	0.96	0.83	0.96	0.83	0.81	0.85
Biomass (t/ha)	21.49		16.79			
Carbon (t/ha)	10.74		8.39		34.80	

Table II. 3.680: Species richness, diversity and dominance in herbaceous community in Paikangrong chu site

Parameters	Barrage			Powerhouse			Catchment area		
	PM	**M**	**W**	**PM**	**M**	**W**	**PM**	**M**	**W**
Number of species	13	16	16	14	16	15	13	13	12
Density (ha^{-1})$x10^3$	91	143	118	104	154	110	82	108	94
Simpson index of dominance	0.90	0.90	0.91	0.90	0.92	0.90	0.89	0.90	0.88
Shannon index of diversity (H')	2.44	2.54	2.55	2.41	2.59	2.51	2.36	2.43	2.29
Evenness index	0.88	0.79	0.80	0.80	0.83	0.82	0.81	0.88	0.82

PM: Post-monsoon; M: Monsoon; W: Winter

Phytoplankton/Periphyton

Five species of phytoplankton/periphyton were recorded from Paikangrong chu. The phytoplankton/periphyton community was represented by one species of Cyanophyceae and four species of Bacillariophyceae. Species richness was highest in the project affected area with four species, and lowest with three species in the catchment area. Phytoplankton/periphyton density was highest in the project affected area (30 individuals/l), and lowest in the catchment area (20 individuals/l). Similarly, species diversity index was maximum (H'= 1.32) in the project affected area, and minimum (H'= 1.03) in the catchment area (Table II. 3.681).

Table II. 3.681: Density (Individuals/l), species richness and Shannon index of diversity (H') of phytoplankton community in river water at project affected area and catchment area of Paikangrong chu

List of species	Project affected area	Catchment area
Cyanophyceae		
Lyngbya sp.	10	10
Bacillariophyceae		
Caloneis ventricosa	5	
Cocconeis placentula		5
Navicula cryptotenella	10	5
Opephora sp.	5	
Total density (Individuals/lit)	**30**	**20**
Species diversity index	**1.32**	**1.03**
Species richness	**4**	**3**

NB: Blank cells indicate absence of periphyton species

Zooplankton

The study on zooplankton diversity was conducted during monsoon and winter seasons in Paikangrong chu area. Five species were recorded during monsoon period, out of which 2 species i.e., *Alona affinis* and *Alonella (Nanalonella) nana* belongs to Cladocera and 3 species from Rotifera phylum (Table II. 3.682). *Keratella serrulata,* a rare zooplankton species was recorded from barrage site.

Table II. 3.682: Occurrence of species belonging to Cladocera and Rotifera during monsoon and winter seasons at Paikangrong chu site

Sl. No.	Taxa	Species	Season	
			Monsoon	Winter
1	Cladocera	*Alona affinis* (Leydig, 1860)	+	–
2	Cladocera	*Alonella (Nanalonella) nana* (Baird, 1850)	+	–
3	Rotifera	*Keratella serrulata* (Ehrenberg, 1838) *	+	–
4	Rotifera	*Lepadella acuminata* (Ehrenberg, 1834)	+	–
5	Rotifera	*Trichocerca weberi* (Jennings, 1903)	+	–
Total	**2**	**5**	**5**	**0**

*Rare

Fish Fauna

No fish species were documented from Paikangrong chu project sites.

Soil Fauna

The seasonal variation of soil faunal diversity (Collembola, Acarina and other arthropods) and equitability in litter and soil layer is shown in Table II. 3.683-3.685.

Table II. 3.683: Seasonal variation of soil faunal diversity (Collembola, Acarina and other arthropods) and equitability in litter and soil layer at Paikangrong chu site

Soil fungi	Diversity	Post-monsoon				Monsoon				Winter			
		Barrage		Powerhouse		Barrage		Powerhouse		Barrage		Powerhouse	
		Litter	Soil	Litter	Soil	Litter	Soil	Litter	Soil	Litter	Soil	Litter	Soil
Collembola	Dominance_D	0.19	0.16	0.16	0.17	0.13	0.16	0.14	0.15	0.19	0.21	0.18	0.18
	Shannon_H	1.73	1.89	1.97	1.84	2.05	1.86	2.01	1.93	1.73	1.68	1.75	1.75
	Evenness_e^H/S	0.94	0.95	0.90	0.90	0.97	0.92	0.94	0.98	0.94	0.89	0.96	0.96
Acarina	Dominance_D	0.16	0.21	0.19	0.13	0.23	0.21	0.16	0.11	0.19	0.36	0.19	0.20
	Shannon_H	1.89	1.58	1.73	2.05	1.51	1.67	1.90	2.25	1.74	1.06	1.73	1.61
	Evenness_e^H/S	0.94	0.97	0.94	0.97	0.91	0.89	0.95	0.95	0.94	0.96	0.94	1.00
Other Arthropods	Dominance_D	0.19	0.15	0.14	0.16	0.17	0.13	0.13	0.13	0.11	0.15	0.19	0.16
	Shannon_H	1.74	1.93	2.07	1.97	1.84	2.11	2.11	2.11	2.25	1.93	1.73	1.89
	Evenness_e^H/S	0.94	0.99	0.88	0.90	0.90	0.92	0.91	0.92	0.94	0.99	0.94	0.94

Table II. 3.684: Mean annual density (number/m^2) of soil fauna in litter and soil layer (0-5 cm) at Paikangrong chu site

Soil fauna	Site	Litter layer	Soil layer	Total
Collembola	Barrage	1600	1273	**2873**
	Powerhouse	1491	1382	**2873**
Acarina	Barrage	1029	771	**1800**
	Powerhouse	1114	1200	**2314**
Other arthropods	Barrage	1673	1855	**3527**
	Powerhouse	1964	1818	**3782**
Total fauna	Barrage	4302	3899	**8200**
	Powerhouse	4569	4400	**8969**

Table II. 3.685: Seasonal variation of soil fauna density (number/m^2) at barrage and powerhouse site of Paikangrong chu

Soil fauna	Site	Post-monsoon	Monsoon	Winter	Mean
Collembola	Barrage	7600	17200	6800	**10533**
	Powerhouse	12000	14000	5600	**10533**
Acarina	Barrage	7600	12000	5600	**8400**
	Powerhouse	12000	15200	5200	**10800**
Other arthropods	Barrage	9600	17200	12000	**12933**
	Powerhouse	13600	20800	7200	**13867**

Wildlife

Butterflies: Study on butterfly diversity in Nyamjang chu project area revealed the presence of 21 species belonging to 18 genera and five families. The family Pieridae was the dominant, represented by seven species. These 21 species did not include any of the threatened species (Tables II. 3.686-3.687).

Table II. 3.686: List of family belonging to butterflies species recorded from Paikangrong HEP area

Sl. No.	Family name
I.	Hesperiidae
II.	Papilionidae
III.	Pieridae
IV.	Lycaenidae
V.	Nymphalidae

Table II. 3.687: List of butterflies species recorded from Paikangrong HEP area

Sl. No.	Common name	Scientific name	Project area
1	Lucas Ace	*Sovia lucasii magna*	*
2	Common Peacock	*Papilio polyctor ganesa*	*
3	Paris Peacock	*Papilio paris paris*	*
4	Golden Birdwing	*Troides aeacus aeacus*	*
5	Dark Jezebel	*Delias berinda*	*
6	Small Grass Yellow	*Eurema brigitta rubella*	*
7	Indian Cabbage White	*Pieris canidia indica*	*
8	Green-veined White	*Pieris napi montana*	*
9	Green vein White	*Pieris melete*	*
10	Plain Sulphur	*Dercas lycorias*	*
11	Spotted Sawtooth	*Prioneris thestylis thestylis*	*
12	Peablue	*Lampides boeticus*	*
13	Green Sapphire	*Heliophorus moore*	*
14	Pale Hedgeblue	*Udara dilecta*	*
15	Large Hedgeblue	*Celastrina hugeli oreana*	*
16	Common Hedgeblue	*Acytolepis puspa gisca*	*
17	Chestnut Tiger	*Parantica sita*	*
18	Eastern Comma	*Polygonia egea*	*
19	Large Threering	*Ypthima nareda*	*
20	Large Silverstripe	*Argynnis children*	*
21	Banded Treebrown	*Lethe confusa*	*

Herpetofauna: The list of probable amphibians and reptiles for the project area was prepared following Ahmed *et al.* (2009), as the surveys carried out during three seasons did not result in reporting of any herpetofauna (Appendix II. 3.167).

Birds: The assessment of birds carried out in and around this project area during post-monsoon, monsoon, and winter season, revealed presence of 86 bird species belonging to 61 genera and 31 families. The Shannon diversity index of 3.9 show an even distribution of the species. When seasonal status was compared, it was found that richness was higher during monsoon season (49 species) than in winter. Low diversity during winter might have been due to snowfall and less availability of food resources in the area. The abundance of birds was high in monsoon (Table II. 3.688).

Table II. 3.688: Status of birds recorded from the Paikangrong project area

Details	Post monsoon	Monsoon	Winter	Overall
Family	18	17	15	31
Genera	25	37	23	61
Species	28	49	30	86
Abundance	232	389	166	787
Diversity H'	3.1	3.2	3.0	3.9

Migratory status: The migratory and resident status of these bird species showed that most of the birds were residents (62 species) followed by 11 breeding visitors and 13 winter visitors (Table II. 3.689).

Table II. 3.689: Status of migratory birds recorded from the Paikangrong HEP area

Migratory status	Post monsoon	Monsoon	Winter	Overall
Breeding visitor	5	7	3	11
Isolated record	0	0	0	0
Resident	19	35	23	62
Winter visitor	4	7	4	13

Abundance status: The abundance status of birds was derived by classifying the abundance of bird species into five abundance category (Very Low = 1-25 birds, Low = 26-50, Moderate = 51-75, High = 76-100 and Very High = > 100 birds). The details of abundance status are given in Table II. 3.690.

Table II. 3.690: Number of species and relative percent (%) of birds in different abundance classes

Abundance class	No. of species	Relative %
Very low -1 -25 birds	79	91.9
Low -26 -50 birds	5	5.8
Moderate -50 -75 birds	2	2.3
High -76-100 birds	0	0.0
Very high > 100 birds	0	0.0
Total	**86**	**100.0**

Status of foraging guilds: The recorded bird species in this project site belonged to six different foraging guilds. Among the six guilds, insectivores were dominant (60 species) followed by nine species each of granivores and omnivores. The high richness of insectivores show the presences of diverse habitat and niches available in this project site. Insectivores were dominant also in different seasons (Table II. 3.691 and Appendix II. 3.207).

Table II. 3.691: Status of foraging guild of birds recorded in Paikangrong HEP area

Foraging guild	Post monsoon	Monsoon	Winter	Overall
Aquatic feeder	0	0	0	0
Carnivore	0	1	1	2
Frugivore	1	0	0	1
Granivore	2	4	4	9
Insectivore	17	37	21	60
Nectarivore	3	1	1	4
Nucivore	0	1	1	1
Omnivore	5	5	2	9
Piscivore	0	0	0	0

Status of threatened species: Though a high species richness of birds was recorded (86 species) in the study area, none of them fall under threatened category (Appendix II. 3.207).

Mammals: Three surveys in and around the Paikangrong chu project site revealed the presence of seven mammalian fauna, each belonging to separate genus, and in seven families. This list consists of 1 primate, 3 ungulates, 1 rodent and 1 carnivore species (Appendix II. 3.208).

Abundance status: Among these seven species, presence of three species was confirmed based on direct sighting, and the remaining based on 18 indirect evidences. Further evaluation of species richness of the project area (7 species) with the possible species (29 species) of the Tawang district (Mishra *et al.* 2006) also revealed low species richness, as the species recorded in the project area formed only 24.13% (Appendix II. 3.208)

Status of threatened species: Except for the two animals, viz., Arunachal Macaque (*Macaca munzala*) and Himalayan goral (*Naemorhedus goral)* listed as Endangered(EN) and Near Threatened (NT) respectively in the IUCN Red List, the rest of the species of the project area fall under Least Concern (LC) of IUCN and Schedule II and III of WPA (1972) (Table II. 3.692).

Table II. 3.692: Status of mammalian fauna reported in the Paikangrong HEP area

Sl. No.	Common name	Scientific name	Seasons			Overall	Conservation status	
			PM	M	W		IUCN	WPA
I	**Cercopithecidae**							
1	Arunachal Macaque	*Macaca munzala*		IE 1	A 15	IE 1 A 15	EN	-
II	**Cervidae**							
2	Barking Deer	*Muntiacus muntjak*	IE 2			IE 2	LC	III
III	**Bovidae**							
3	Himalayan goral	*Naemorhedus goral*		IE 2		IE 2	NT	III

IV	**Suidae**							
4	Wild pig	*Sus scrofa*	IE 3	IE-3	IE 2	IE 8	LC	III
V	**Felidae**							
5	Jungle cat	*Felis chaus*	IE 2	IE 2	IE 1	IE 5	LC	II
VI	**Sciuridae**							
6	Orange-Bellied Himalayan Squirrel	*Dremomys lokriah*	A 1			A 1	LC	NE
7	Hoary-bellied Himalayan Squirrel	*Callosciurus pygerythrus*			A 1	A 1	LC	NE
	No of species		**4**	**4**	**4**	**7**		
	Total and types of records		**IE 7 A 1**	**IE 8**	**IE 3 A 16**	**IE 18 A 17**		

IE – Indirect Evidences A-animals sighted, W-Winter, PM-Post monsoon, M-Monsoon, IUCN-Red List, WPA-Indian Wildlife Protection act, EN-Endangered, NT-Near threatened, LC-Least Concern, NE-Not Evaluated

Faunal status within 500 m of project affected area: This section revealed species richness status of selected faunal groups such as avifauna and mammal species reported within 500 m up and down streams of the barrage and powerhouse sites of the proposed project area. The species richness reported in these specific sites was evaluated based on subjective rating through estimating percent contribution with the overall species list of the project area. If the species richness of barrage and powerhouse contributes 25% of overall list it was categorised as low, > 25-50% as medium, >50-75% as high and above 75% as high species richness.

Status of avifauna: At Powerhouse and barrage site of Paikangrong chu project, 55 species of birds were recorded. Thus, this area is designated as high species richness area. However, among these 55 species none of them fall under threatened category (Appendix II. 3.209).

Status of mammals: Site specific evaluation of mammalian fauna within 500 m of up and down streams showed occurrence of only three species in the barrage and powerhouse site, and showed very poor species richness and abundance. Among the species, only Hoary-bellied Himalayan Squirrel was recorded, based on direct sighting. Of all the species, only Arunachal Macaque fall under endangered category as per IUCN.

Table II. 3.693: Status of mammalian fauna at barrage and powerhouse sites of the proposed Paikangrong HEP area

Common name	Species name	Status	Conservation status	
		DS/PHS	IUCN	WPA
Arunachal Macaque	*Macaca munzala*	IE 1	**EN**	-
Wild pig	*Sus scrofa*	IE 1	LC	III
Hoary-bellied Himalayan Squirrel	*Callosciurus pygerythrus*	A 1	LC	-
Total no. of species		**3**		
Total no. of record		**2 IE, A1**		

IE – Indirect Evidences, A – No of Animals Sighted, BS –Barrage Site, PHS – Powerhouse Site, IUCN-Red List, WPA-Wildlife Protection Act, LC-Least Concern, EN – Endangered

3.3.12.3 SOCIO–ECONOMIC PROFILE

The results of socio–economic baseline survey for Paikangrong chu have been described separately for data gathered at the village level and at the HH level.

Village Level Survey

Profile of the Five Surveyed Villages: From Table II. 3.694, it is seen that Rho and Jangda are affected villages and the remaining three villages fall within impact zone of the Project. The five villages fall under four administrative circles. They are Thingbu, Lhau, Jang, and Mukto circle. The distance of the five villages from the river varies from 3 to 8 km. All villages are situated within 8 km from the river. The circle headquarters of the five villages are within 15 km. Except two villages i.e., Rho and Jangda, which are situated more than 90kms from the district headquarters, the remaining three are situated within 55kms.

Table II. 3.694: Profile of the ten surveyed villages

Sl. No.	Village	Circle	Distance of village (in km)			Category of village
			River/tributary	Circle HQ	District HQ	
1	Jangda	Lhau	7	15	90	Affected
2	Mirba	Mukto	3	10	55	Influenced
3	Rho	Thingbu	8	5	100	Affected
4	Shyro	Lhau	5	7	30	Influenced
5	Yuthembu	Jang	3	1	45	Influenced

Private Landuse Pattern: The details of private land holdings (in hectares) of the five villages are given in Table II. 3.695. The total private land holding in the studied villages is about 481.76 ha. Three villages, viz., Rho, Jangda and Yuthembu contribute 87% to the total land holdings in studied villages. In all the villages, the proportion of agricultural land exceeds that of the other land use types. Private forest land also contributes significantly (38%) to the total land holdings of the villages.

Table II. 3.695: Private land use pattern and their percentage to total private land

Sl. No.	Village	Total private land	Forest cover (ha)	%	Agriculture (ha)	%	Horticulture (ha)	%	Habitation and HG (ha)	%
1	Jangda	120.00	45	38	57	48	0	–	18	15
2	Mirba	30.50	12	39	18	59	0	–	0.5	2
3	Rho	160.00	58	36	66	41	0	–	36	23
4	Shyro	34.26	13	38	16.78	49	0	–	4.48	13
5	Yuthembu	137.00	53	39	62	45	0	–	22	16
	Total	**481.76**	**181**	**38**	**219.78**	**45**	**0**		**80.98**	**17**

Demography and Literacy Rate: The total number of HHs in the five villages is 378. The total population is 1651 (829 males; 822 females). In Jangda and Yuthembu, the number of females is greater than that of the males, and in three villages the males outnumber the females. The maximum literacy rate of 63.6% is found in Yuthembu. In the remaining four villages, the rate is less than 46 %. Jangda has the least number of literates (30%). Among males, the rate varies from 30% in Jangda to 70.8% in Yuthembu, and in females it varies from 23% in Rho to 52.5% in Yuthembu (Table II. 3.696).

Table II. 3.696: Demography and literacy rate

Sl. No.	Village	Demography					Literacy rate*		
		Total	Male	Female	Sex ratio (Per 1000 males)	No. of HH	Male	Female	Total
1	Jangda	525	249	276	1108	99	30	41	**30**
2	Mirba	166	89	77	865	40	43.7	33.3	**39.4**
3	Rho	286	150	136	907	85	58	23	**45**
4	Shyro	305	159	146	918	56	42.6	38.3	**41.4**
5	Yuthembu	369	182	187	1027	98	70.8	52.5	**63.6**
	Total	**1651**	**829**	**822**		**378**			

*After Census 2011

Number of Livestock: Altogether, 9 different types of animals are domesticated in five surveyed villages (Table II. 3.697). None of the villages owned all the nine animals. In total, 2858 animals are reared in the five villages. Considerable inter–village variation is observed in total number of animals reared. It varied from 182 in Mirba to 1021 in Jangda. Jangda alone accounts for 36% of all the animals found in the surveyed villages. Three animals, viz., cattle (53%), Yak (18%) and sheep (16%) account for 87% of the total animals (2858).

Table II. 3.697: Number of livestock

Sl. No.	Village	Mithun	Cattle	Yak	Goat	Sheep	Pig	Pony	Poultry	Others	Total
1	Jangda	0	395	114	37	364	72	10	28	1	**1021**
2	Mirba	0	103	67	5	0	0	7	0	0	**182**
3	Rho	0	255	49	68	85	14	6	7	3	**487**
4	Shyro	0	357	69	0	2	29	50	2	0	**509**
5	Yuthembu	10	413	224	2	10	0	0	0	0	**659**
	Total	**10**	**1523**	**523**	**112**	**461**	**115**	**73**	**37**	**4**	**2858**

Total Estimated value of Livestock: The monetary value of animals maintained by the inhabitants of the studied villages has been estimated separately for each animal, and for each village (Table II. 3.698). The detailed methodology used in estimating the monetary value of animals has been described in the methodology section of this document. As expected, there is considerable intra–inter village variation in this respect. The total value of animals numbering 2858 found in the five villages has been estimated as 595.09 lakhs. The value varied from 44.36 lakhs in Mirba to 171.53lakhs in Jangda. In terms of relative contribution made by different animals to the total value, cattle and Yak together contribute over 511.0 lakhs (86%).

Table II. 3.698: Total estimated value of livestock

Sl. No.	Village	Total estimated value (Rupees in lakh)									
		Mithun	Cattle	Yak	Goat	Sheep	Pig	Pony	Poultry	Others	Total
1	Jangda	0.00	98.75	28.50	1.85	21.84	18.00	2.30	0.14	0.15	**171.53**
2	Mirba	0.00	25.75	16.75	0.25	0.00	0.00	1.61	0.00	0.00	**44.36**
3	Rho	0.00	63.75	12.25	3.40	5.10	3.50	1.38	0.04	0.45	**89.87**
4	Shyro	0.00	89.25	17.25	0.00	0.12	7.25	11.50	0.01	0.00	**125.38**
5	Yuthembu	4.00	103.25	56.00	0.10	0.60	0.00	0.00	0.00	0.00	**163.95**
	Total	**4.00**	**380.75**	**130.75**	**5.6**	**27.66**	**28.75**	**16.79**	**0.19**	**0.6**	**595.09**

Average Annual Earnings of the Village: Average annual family income varies from 2.22 in lakhs in Mirba to 3.58 lakhs in Jangda (Table II. 3.699). The value of total earnings per year in the villages is estimated 1080.67 lakhs. The contribution made by animal husbandry compared to the other resources, and to the total earnings is maximum in all the villages. Of the total annual earnings, animal husbandry contributes 617.32 lakhs (57%). Traditional skills in particular weaving and daily wage labour together contribute over 25%. It is highly noteworthy that, agriculture contributes only 10% of the total annual village earnings.

Table II. 3.699: Average annual earning of the villages

Sl. No.	Village	Total earning/year (Rupees in lakh)								Average family income
		Agriculture	Animal husbandry	Horticulture	Traditional skills	Daily wages	GS	Others*	Total	
1	Jangda	28.50	220.54	0.00	39.75	40.10	14.94	10.46	**354.28**	3.58
2	Mirba	9.00	39.31	0.00	15.30	16.20	5.34	3.74	**88.89**	2.22
3	Rho	33.00	105.19	0.00	25.00	34.43	9.00	6.30	**212.92**	2.50
4	Shyro	8.39	109.94	0.00	30.00	22.68	9.54	6.68	**187.23**	3.34
5	Yuthembu	31.00	142.34	0.00	5.75	39.69	10.92	7.64	**237.35**	2.42
	Total	**109.89**	**617.32**	**0**	**115.8**	**153.1**	**49.74**	**34.82**	**1080.67**	

* Other includes artisans, monks, self–employed contractors etc; GS= Government Service

Average Annual Expenditure Pattern of a Family: Average annual family expenditure in the surveyed villages varies from 1.27 lakhs in Mirba to 1.58 lakhs in Rho. In all the villages, in general, the maximum expenditure is incurred on health and education, followed by transport and clothing. In general, expenditure incurred on food and drinks is less than other expenditures (Table II. 3.700).

Table II. 3.700: Average annual expenditure pattern of a family in the villages

Sl. No.	Village	Expenditure/year (Rupees in lakh)				
		Food and drinks	Clothing	Transport	Education and health	Total
1	Jangda	0.3	0.35	0.4	0.48	**1.53**
2	Mirba	0.35	0.35	0.27	0.3	**1.27**
3	Rho	0.35	0.35	0.4	0.48	**1.58**
4	Shyro	0.3	0.35	0.4	0.48	**1.53**
5	Yuthembu	0.3	0.3	0.4	0.45	**1.45**
	Total	**1.6**	**1.7**	**1.87**	**2.19**	

Water Sources: There are four types of water resources, viz., river, hill stream/springs, pond, and tap water available in the studied villages (Table II. 3.701). Except in Shyro, water from hill stream/spring(s) in studied villages is used for domestic purposes as well as for the domestic animals. Tap water is used for domestic purposes in all surveyed villages, and in addition in

Shyro, it is also used for domestic animals. In Shyro, pond water is also used for various purposes, and in Mirba river water is also used.

Table II. 3.701: Water sources in the villages

Sl. No.	Village	River				Hill stream/spring				Wells				Ponds				Tap Water			
		Drinking water	Domestic use	Livestock use	Agriculture	Drinking water	Domestic use	Livestock use	Agriculture	Drinking water	Domestic use	Livestock use	Agriculture	Drinking water	Domestic use	Livestock use	Agriculture	Drinking water	Domestic use	Livestock use	Agriculture
1	Jangda					1	1	1										1	1		
2	Mirba	1		1		1	1	1										1	1		
3	Rho					1	1	1										1	1		
4	Shyro													1	1	1		1	1	1	
5	Yuthembu					1	1	1										1	1		
	Total	**1**	**0**	**1**	**0**	**4**	**4**	**4**	**0**	**0**	**0**	**0**	**0**	**1**	**1**	**1**	**0**	**5**	**5**	**1**	**0**

Amenities in the Villages: In Yuthembu, except for traditional health healer, all the remaining 11 amenities listed in the Table II. 3.702 were present. In Jangda and Shyro, the least number of amenities (5/12) are observed. All the villages have motorable road, electricity, school, telephone and TV/radio. Traditional health healers are not found in any one of the studied villages.

Table II. 3.702: Amenities in the villages

Sl. No.	Village	Road connectivity	Health facility (PHC/sub–centre)	Traditional health healer	Veterinary services	Electricity	Fair price shop	Grocery shop	Post office	Bank	School	Telephone/Mobile	TV/Radios
1	Jangda	√				√					√	√	√
2	Mirba	√				√	√	√			√	√	√
3	Rho	√	√		√	√					√	√	√
4	Shyro	√				√					√	√	√
5	Yuthembu	√	√		√	√	√	√	√	√	√	√	√
	Total	**5**	**2**	**0**	**2**	**5**	**2**	**2**	**1**	**1**	**5**	**5**	**5**

NB: Blank indicates absent

Social Institutions: In none of the five villages all the four social institution listed in Table II. 3.703 are present. Four villages have community hall, three villages Anganwadi and all the villages have Gompa. SHGs are absent in all the villages.

Table II. 3.703: Social institutions in the village

Sl. No.	Village	SHGs	Anganwadis	Community hall	Gompa	Any other	Total
1	Jangda		√	√	√		**3**
2	Mirba			√	√		**2**
3	Rho			√	√	√	**3**
4	Shyro		√	√	√	√	**4**
5	Yuthembu		√		√	√	**3**
	Total	**0**	**3**	**4**	**5**	**3**	**–**

NB: Blank indicates absent

Occupation Profile: In Table II. 3.704, work force participation in four villages has been presented. The total working population in the studied villages comprises of 1440 (43%) of total population. Of the total workers, main workers are 86% while marginal workers are 14%.

Table II. 3.704: Occupation profile of the villages

Sl. No.	Village	Population			Workers			Main workers			Marginal workers			Non workers		
		T	M	F	T	M	F	T	M	F	T	M	F	T	M	F
1	Jangda	682	406	276	458	289	169	320	252	68	138	37	101	224	117	107
2	Rho	652	403	249	21	8	13	10	7	3	11	1	10	16	4	12
3	Shyro	636	448	188	62	35	27	35	20	15	27	15	12	61	25	36
4	Yuthembu	1363	828	535	899	629	270	867	605	262	32	24	8	693	310	383
	Total	**3333**	**2085**	**1248**	**1440**	**961**	**479**	**1232**	**884**	**348**	**208**	**77**	**131**	**994**	**456**	**538**

Household Level Survey

Age of the Head of the Household: The age of head of HHs across the five surveyed villages varied from 22 in Yuthembu to 98 years in Shyro. The age of 33% of heads is over 50 years and 11% of heads age was below 30 years. Considerable variation is observed in average age of heads of HH between villages. It varied from 43 to 53 (Tables II. 3.705 and 3.706).

Table II. 3.705: Distribution of head of the HHs by age across the five project villages

Sl. No.	Village	Jangda		Mirba		Rho		Shyro		Yuthembu		Total	
		n	%	n	%	n	%	n	%	n	%	n	%
1	Up to 30	7	7	4	10	8	9	1	2	20	20	**40**	**11**
2	31–40	19	19	13	33	36	42	17	30	27	28	**112**	**30**
3	41–50	31	31	13	33	24	28	11	20	21	21	**100**	**26**
4	> 50	42	42	10	25	17	20	27	48	30	31	**126**	**33**
	Total	**99**	**100**	**40**	**100**	**85**	**100**	**56**	**100**	**98**	**100**	**378**	**100**

Table II. 3.706: Minimum, maximum and average age of head of HHs across the five project villages

Sl. No.	Village	Age range		Average
		From	To	
1	Jangda	25	92	50
2	Mirba	24	88	45
3	Rho	24	78	43
4	Shyro	30	98	53
5	Yuthembu	22	86	46

Gender of the Head of Households: Data on gender of the HHs in the five surveyed project villages is given in Table II. 3.707. As expected, in all the five villages the number of males exceeds that of females as head of HHs. Across the surveyed villages, 74% of heads were males. Interestingly, in Jangda and Yuthembu, the female head of HHs also occur in substantial number being 34% each.

Table II. 3.707: Distribution of head of HHs by gender in the five project villages

Sl. No.	Village	Male		Female		Total
		n	%	n	%	n
1	Jangda	65	66	34	34	**99**
2	Mirba	34	85	6	15	**40**
3	Rho	72	85	13	15	**85**
4	Shyro	45	80	11	20	**56**
5	Yuthembu	65	66	33	34	**98**
	Total	**281**	**74**	**97**	**26**	**378**

Ethnicity: All the five villages are predominantly inhabited by Monpa tribals.

Household Size: From Tables II. 3.708 and 3.709, the HH size varies from 1–12 across the five villages. There is vast variation between the five villages in terms of distribution of HH size. The average HH size varies from three in Rho to five in Jangda and Shyro, the remaining three villages has average HH size of 4. The average HH size across the surveyed villages is four.

Table II. 3.708: Distribution of HH size in the five project villages

Sl. No.	Village	Jangda		Mirba		Rho		Shyro		Yuthembu		Total	
		n	%	n	%	n	%	n	%	n	%	n	%
1	1	5	5	2	5	9	11	4	7	9	9	**29**	**8**
2	2	11	11	3	8	8	9	2	4	14	14	**38**	**10**
3	3	6	6	8	20	22	26	9	16	18	18	**63**	**17**
4	4	13	13	10	25	39	46	7	13	27	28	**96**	**25**
5	5	14	14	10	25	4	5	8	14	16	16	**52**	**14**
6	6–8	39	39	7	18	3	4	19	34	14	14	**82**	**22**
7	9 and above	11	11	0	0	0	0	7	13	0	0	**18**	**5**
	Total	**99**	**100**	**40**	**100**	**85**	**100**	**56**	**100**	**98**	**100**	**378**	**100**

Table II. 3.709: Minimum, maximum and average HH size across the five project villages

Sl. No.	Village	HH size range		Average HH size
		From	To	
1	Jangda	1	9	5
2	Mirba	1	7	4
3	Rho	1	7	3
4	Shyro	1	12	5
5	Yuthembu	1	8	4
	Total	**1**	**12**	**4**

Education: Relevant data on the education of the head of the HHs in the five project villages is given in Table II. 3.710. It is highly noteworthy that, a majority of the heads in studied villages were illiterate (84%). It varied from 65% in Mirba to 93% in Yuthembu. There were six head of HHs (2%) in four villages who were Graduates.

Table II. 3.710: Distribution of education of head of HH in the five project villages

Sl. No.	Village	Jangda		Mirba		Rho		Shyro		Yuthembu		Total	
		n	%	n	%	n	%	n	%	n	%	n	%
1	Illiterate	84	85	26	65	74	87	41	73	91	93	**316**	**84**
2	Primary	3	3	1	3	0	0	1	2	0	0	**5**	**1**
3	Upper primary	5	5	6	15	2	2	8	14	2	2	**23**	**6**
4	Secondary	4	4	5	13	5	6	5	9	2	2	**21**	**6**
5	Higher secondary	2	2	0	0	3	4	1	2	1	1	**7**	**2**
6	Graduate or above	1	1	2	5	1	1	0	0	2	2	**6**	**2**
	Total	**99**	**100**	**40**	**100**	**85**	**100**	**56**	**100**	**98**	**100**	**378**	**100**

Main Occupation of Household Heads: The main occupations of the head of HHs across the five villages are agriculture, labour, pastoralism, and government service. Table II. 3.711 reveal the following:

Agriculture: It varies from 10% in Mirba to 78% in Rho. 57% of the surveyed head of HHs pursue agriculture.

Labour: Except in Rho, head of the HHs in several villages reported labour as one of the mode of occupation. Across the surveyed villages, 13% of 378 heads pursued labour as main occupation.

Pastoralist: Some of the heads of HHs in five surveyed villages practise pastoralism as the main occupation. It varied from 8% in Jangda to 28% in Mirba. In all the five villages, the animal associated with this occupation was Yak. Out of 378 heads, 37 (10%) were engaged in this activity.

Government service: Government servants were reported from all the five villages. The largest number is from Rho being 22% followed by Mirba (15%) and other villages. Government service constitutes 12% of the main occupations.

Any other occupation: 31 (8%) HHs was engaged in other occupation.

Table II. 3.711: Distribution of head of HHs by main occupation in the five project villages

Sl. No.	Village	Farmer		Labour		Pastoral		Govt. servant		Others		Total
		n	%	n	%	n	%	n	%	n	%	n
1	Jangda	51	52	15	15	8	8	10	10	15	15	**99**
2	Mirba	4	10	13	33	11	28	6	15	6	15	**40**
3	Rho	66	78	0	0	0	0	19	22	0	0	**85**
4	Shyro	32	57	7	13	7	13	1	2	9	16	**56**
5	Yuthembu	64	65	13	13	11	11	9	9	1	1	**98**
	Total	**217**	**57**	**48**	**13**	**37**	**10**	**45**	**12**	**31**	**8**	**378**

Private Land Holding Pattern: The private land holding pattern in the five villages comprises of agricultural land, horticulture land, habitation and home garden land, and forest land. It may be noted here that a majority of the inhabitants of the surveyed villages did not know actual area either in acres or hectares of all categories of land holdings. Therefore, the area reported here should be considered as very rough estimates. Data pertaining to this aspect have been described below.

Agricultural land: Except 15 HHs (4%), all the remaining HHs (96%) in five surveyed villages owned agricultural land in varying proportions (Table II. 3.712). A majority of the HHs (47%) owned agricultural land between 1 to 2 acres. Only 20% of HHs owned land which is greater than 2 acres. There exists a striking variation between the villages in terms of agricultural land holdings. For example, 97% of the HHs in Rho own more than one acre of land, while 58% of HHs in Mirba own less than one acre of land.

Table II. 3.712: Distribution of agricultural land holding among surveyed HHs in the five project villages

Sl. No.	Village	0.00 acre		< 1 acre		1–2 acre		> 2 acre	
		n	%	n	%	n	%	n	%
1	Jangda	6	6	22	22	54	55	17	17
2	Mirba	2	5	23	58	9	23	6	15
3	Rho	2	2	0	0	64	75	19	22
4	Shyro	1	2	27	48	28	50	0	0
5	Yuthembu	4	4	37	38	23	23	34	35
	Total	**15**	**4**	**109**	**29**	**178**	**47**	**76**	**20**

Horticultural land**:** None of the HHs in the five villages owned horticultural land (Table II. 3.713).

Table II. 3.713: Distribution of horticultural land among surveyed HHs in the five project villages

Sl. No.	Village	0.00 acre		< 1 acre		1–2 acre		> 2 acre	
		n	%	n	%	n	%	n	%
1	Jangda	99	100	0	0	0	0	0	0
2	Mirba	40	100	0	0	0	0	0	0
3	Rho	85	100	0	0	0	0	0	0
4	Shyro	56	100	0	0	0	0	0	0
5	Yuthembu	98	100	0	0	0	0	0	0
	Total	**378**	**100**	**0**	**0**	**0**	**0**	**0**	**0**

Habitation and home–garden land: Data presented in Table II. 3.714 revealed that only 2% of HHs in surveyed villages did not own any such land. A majority of HHs (83%) owned less than one acre of such land. 15% of the HHs owned land between 1–2 acre.

Table II. 3.714: Distribution of habitation and home garden land among surveyed HHs in the five project villages

Sl. No.	Village	0.00 acre		< 1 acre		1–2 acre		> 2 acre	
		n	%	n	%	n	%	n	%
1	Jangda	6	6	93	94	0	0	0	0
2	Mirba	0	0	40	100	0	0	0	0
3	Rho	0	0	32	38	53	62	0	0
4	Shyro	2	4	52	93	2	4	0	0
5	Yuthembu	0	0	98	100	0	0	0	0
	Total	**8**	**2**	**315**	**83**	**55**	**15**	**0**	**0**

Forest land: 68 HHs (18%) in surveyed villages do not owned private forest land (Table II. 3.715). A majority of HHs (58%) owned such land between 1 to 2 acres. It is noteworthy that, 41 (11%) HHs owned more than 2 acre of forest land (in Shyro under this category there were zero HHs).

Table II. 3.715: Distribution of forest land holding among surveyed HHs in the five project villages

Sl. No.	Village	0.0 acre		< 1 acre		1–2 acre		> 2 acre	
		n	%	n	%	n	%	n	%
1	Jangda	15	15	15	15	59	60	10	10
2	Mirba	9	23	23	58	4	10	4	10
3	Rho	14	16	0	0	54	64	17	20
4	Shyro	18	32	12	21	26	46	0	0
5	Yuthembu	12	12	0	0	76	78	10	10
	Total	**68**	**18**	**50**	**13**	**219**	**58**	**41**	**11**

Total land holdings: From Table II. 3.716–3.719, it is seen that there are only 7 HHs (2%) that do not own any type of private land. 70% of the HHs owned more than 2 acres of total land. There is striking variation between the HHs within a village, as well as between villages in ownership of total land. For example, in Rho inter–HH holdings vary from 1 acre to 26 acres, whereas in Shyro it varies from 0.0–4.5 acres. The proportion of agricultural land compared to other types of land to the total land holdings is greater in several villages, whereas in a few villages contribution of habitation and home garden land is greater than agricultural land. The 363 HHs in the five villages owned total private land totalling 1198 acres. Out of this, Jangda, Rho, and Yuthembu accounts for 87% of the total land. Agricultural land accounts for 46% and forest land 38% of total land holding in the five villages.

Table II. 3.716: Distribution of total land holding among surveyed HHs in the five project villages

Sl. No.	Village	0.00 acre		< 1 acre		1–2 acre		> 2 acre	
		n	%	n	%	n	%	n	%
1	Jangda	6	6	7	7	19	19	67	68
2	Mirba	0	0	14	35	18	45	8	20
3	Rho	0	0	0	0	10	12	75	88
4	Shyro	1	2	25	45	4	7	26	46
5	Yuthembu	0	0	5	5	5	5	88	90
	Total	**7**	**2**	**51**	**13**	**56**	**15**	**264**	**70**

Table II. 3.717: Number of HHs having land types in the five project villages

Sl. No.	Village	Agricultural land		Horticultural land		Habitation and home garden land		Forest land	
		n	%	n	%	n	%	n	%
1	Jangda	93	94	0	0	93	94	84	85
2	Mirba	38	95	0	0	40	100	31	78
3	Rho	83	98	0	0	85	100	71	84
4	Shyro	55	98	0	0	54	96	38	68
5	Yuthembu	94	96	0	0	98	100	86	88
	Total	**363**	**96**	**0**	**0**	**370**	**98**	**310**	**82**

Table II. 3.718: Minimum, maximum and average land holdings across the five project villages

Sl. No.	Village	Agricultural land			Horticultural land			Habitation and Homegarden land			Forest land			Total land		
		From	To	Avg.	From	To	Avg.	From	To	Avg.	From	To	Avg.	From	To	Avg.
1	Jangda	0.00	6.00	1.42	0.00	0.00	0.00	0.00	0.74	0.45	0.00	4.00	1.13	**0.00**	**10.74**	**3.00**
2	Mirba	0.00	9.88	1.11	0.00	0.00	0.00	0.02	0.07	0.03	0.00	4.94	0.74	**0.02**	**12.39**	**1.89**
3	Rho	0.00	12.00	1.94	0.00	0.00	0.00	0.46	2.00	1.04	0.00	12.00	1.69	**1.00**	**26.00**	**4.68**
4	Shyro	0.00	2.00	0.74	0.00	0.00	0.00	0.00	1.50	0.20	0.00	1.50	0.56	**0.00**	**4.50**	**1.50**
5	Yuthembu	0.00	3.75	1.57	0.00	0.00	0.00	0.20	0.74	0.58	0.00	4.00	1.36	**0.20**	**7.49**	**3.51**
	Total	**0.00**	**12.00**	**1.36**	**0.00**	**0.00**	**0.00**	**0.00**	**2.00**	**0.46**	**0.00**	**12.00**	**1.10**	**0.00**	**26.00**	**2.91**

Table II. 3.719: Distribution of area (in acres) of land holding among HHs in the five project villages

Sl. No.	Village	Agricultural land		Horticultural land		Habitation and Homegarden land		Forest land		Total land
		Area	%	Area	%	Area	%	Area	%	Area
1	Jangda	141	47	0	0	44	15	112	38	**297**
2	Mirba	45	59	0	0	1	2	30	39	**75**
3	Rho	165	41	0	0	89	22	144	36	**398**
4	Shyro	41	49	0	0	11	13	32	38	**84**
5	Yuthembu	154	45	0	0	57	17	133	39	**344**
	Total	**546**	**46**	**0**	**0**	**202**	**17**	**450**	**38**	**1198**

Livestock Holding: The data presented in Tables II. 3.720–3.722 in respect of distribution of livestock holding in the five surveyed villages reveals that, altogether 9 different types of animals are domesticated in the five surveyed villages. However, none of the villages owned all the nine animals. In total, 2857 animals are reared in the five villages. Considerable inter–village variation is observed in total number of animals reared. It varied from 181 in Mirba to 1021 in Jangda. Jangda alone accounts for 36% of all the animals found in the surveyed villages. Three animals, viz., cattle (53%), Yak (18%) and sheep (16%) account for 87% of the total animals (2857). 45% (170) of the HHs did not own any animals; whereas 24% HHs owned more than 10 animals.

Table II. 3.720: Livestock holding by HHs in the five project villages

Sl. No.	Livestock	Jangda		Mirba		Rho		Shyro		Yuthembu		Total HH of 10 villages	
		n	%	n	%	n	%	n	%	n	%	n	%
1	Mithun	0	0	0	0	0	0	0	0	2	2	**2**	**1**
2	Cattle	92	93	10	25	30	35	24	43	21	21	**177**	**47**
3	Yak	25	25	6	15	5	6	10	18	19	19	**65**	**17**
4	Goat	22	22	1	3	17	20	0	0	1	1	**41**	**11**
5	Sheep	71	72	0	0	20	24	2	4	1	1	**94**	**25**
6	Pig	63	64	0	0	6	7	29	52	0	0	**98**	**26**
7	Pony	2	2	1	3	1	1	16	29	0	0	**20**	**5**
8	Poultry	13	13	0	0	2	2	1	2	0	0	**16**	**4**
9	Others	1	1	0	0	1	1	0	0	0	0	**2**	**1**

Table II. 3.721: Number of livestock in surveyed HHs across the five project villages

Sl. No.	Village	Jangda		Mirba		Rho		Shyro		Yuthembu		Total	
		LS	%	LS	%	LS	%	LS	%	LS	%	LS	%
1	Mithun	0	0	0	0	0	0	0	0	10	2	**10**	**0.4**
2	Cattle	395	39	102	56	255	52	357	70	413	63	**1522**	**53**
3	Yak	114	11	67	37	49	10	69	14	224	34	**523**	**18**
4	Goat	37	4	5	3	68	14	0	0	2	0	**112**	**4**
5	Sheep	364	36	0	0	85	17	2	0	10	2	**461**	**16**
6	Pig	72	7	0	0	14	3	29	6	0	0	**115**	**4**
7	Pony	10	1	7	4	6	1	50	10	0	0	**73**	**3**
8	Poultry	28	3	0	0	7	1	2	0	0	0	**37**	**1**
9	Others	1	0	0	0	3	1	0	0	0	0	**4**	**0.1**
	Total livestock	**1021**	**100**	**181**	**100**	**487**	**100**	**509**	**100**	**659**	**100**	**2857**	**100**

Note: LS–Livestock

Table II. 3.722: Distribution of total number of livestock in HHs of the five project villages

Sl. No.	Village	0		1–5		6–10		> 10		Total
		n	%	n	%	n	%	n	%	n
1	Jangda	5	5	25	25	33	33	36	36	**99**
2	Mirba	27	68	3	8	3	8	7	18	**40**
3	Rho	48	56	9	11	11	13	17	20	**85**
4	Shyro	22	39	18	32	3	5	13	23	**56**
5	Yuthembu	68	69	7	7	4	4	19	19	**98**
	Total	**170**	**45**	**62**	**16**	**54**	**14**	**92**	**24**	**378**

Traditional Skills: Data pertaining to this aspect is presented in Table II. 3.723. It is highly noteworthy that, while in Tawang district at least 6 types of craft are practiced (see Table II.

3.723), in the surveyed village four types of crafts, viz., Wood Carving, Carpet Making, Bamboo Utensil, and Weaving are being practiced. 12 HH in surveyed villages are engage in wood carving, three HH make carpets, 15 HH make Bamboo utensils and weaving is practiced by 152 HH (40%).

Table II. 3.723: Distribution of various skills among surveyed HHs in the five project villages

Sl. No.	Village	Wood carving		Thanka painting		Carpet making		Bamboo utensil		Weaving		Paper making	
		n	%	n	%	n	%	n	%	n	%	n	%
1	Jangda	1	1	0	0	0	0	0	0	53	54	0	0
2	Mirba	2	5	0	0	2	5	0	0	8	20	0	0
3	Rho	0	0	0	0	0	0	2	2	40	47	0	0
4	Shyro	5	9	0	0	1	2	8	14	20	36	0	0
5	Yuthembu	4	4	0	0	0	0	5	5	31	32	0	0
	Total	**12**	**3**	**0**	**0**	**3**	**1**	**15**	**4**	**152**	**40**	**0**	**0**

River Resources: Six different river resources, viz., drinking water, water for domestic use, water for livestock, religious, sand and stone are used (Table II. 3.724). Atleast one river resource is used by all the five villages. There is vast inter–village variation in terms of number of river resources used. It varies from two in Rho to six resources used in Yuthembu. It is highly noteworthy that, all the 378 HHs in the surveyed villages use river for performing last rites of the dead. Although aquatic flora and fauna do occur in the river, none of the villages use these resources.

Table II. 3.724: Dependence on river resources among surveyed HHs in the five project villages

Sl. No.	River resources	Jangda		Mirba		Rho		Shyro		Yuthembu		Total	
		n	%	n	%	n	%	n	%	n	%	n	%
1	Drinking water	0	0	0	0	0	0	0	0	24	24	**24**	**6**
2	Water for domestic use	0	0	0	0	0	0	0	0	18	18	**18**	**5**
3	Water for livestock	94	95	13	33	37	44	35	63	30	31	**209**	**55**
4	Aquatic fauna	0	0	0	0	0	0	0	0	0	0	**0**	**0**
5	Aquatic flora	0	0	0	0	0	0	0	0	0	0	**0**	**0**
6	Religious	99	100	40	100	85	100	56	100	98	100	**378**	**100**
7	Sand	99	100	40	100	0	0	56	100	65	66	**260**	**69**
8	Stone	99	100	40	100	0	0	56	100	67	68	**262**	**69**

Forest Resources: The inhabitants of all the five villages are dependent on forest resources (Table II. 3.725). Out of the usage listed in the Table II. 3.725, 14 forest resources are used in varying degrees in the five surveyed villages. Five resources i.e., fuel wood, timber, grazing, stones, and sand, are used by atleast some HHs in all the surveyed villages. Over 50% of HH surveyed also use four forest resources, viz., food, fencing, religion, and water. A few HHs also use several other forest resources like spices, handicrafts, ornamentals, etc. It is thus evident from above description that, for a majority of the inhabitants of the surveyed villages, forest resources play very significant role to the livelihoods as well as the quality of life of the people.

Table II. 3.725: Dependence on forest resources among surveyed HHs in the five project villages

Sl. No.	Forest resources	Jangda		Mirba		Rho		Shyro		Yuthembu		Total	
		n	%	n	%	n	%	n	%	n	%	n	%
1	Fuel wood	99	100	40	100	85	100	56	100	90	92	370	**98**
2	Timber	99	100	40	100	85	100	56	100	90	92	370	**98**
3	Medicinal plants	0	0	40	100	0	0	0	0	0	0	40	**11**
4	Honey	0	0	0	0	0	0	0	0	0	0	0	**0**
5	Food	99	100	40	100	66	78	0	0	0	0	205	**54**
6	Edible oil	0	0	0	0	0	0	0	0	0	0	0	**0**
7	Ornamental	0	0	0	0	2	2	0	0	0	0	2	**1**
8	Religious	0	0	40	100	85	100	0	0	64	65	189	**50**
9	Fencing	99	100	0	0	19	22	0	0	84	86	202	**53**
10	Handicrafts	0	0	0	0	21	25	0	0	4	4	25	**7**
11	Thatching	0	0	0	0	0	0	0	0	1	1	1	**0**
12	Spices	0	0	40	100	0	0	0	0	2	2	42	**11**

13	Grazing	94	95	13	33	37	44	35	63	30	31	209	**55**
14	Hunting of wild animals	0	0	0	0	0	0	0	0	2	2	2	**1**
15	Fishes	0	0	0	0	0	0	0	0	1	1	1	**0**
16	Water	99	100	0	0	85	100	56	100	67	68	307	**81**
17	Stones	99	100	40	100	85	100	56	100	92	94	372	**98**
18	Sand	99	100	40	100	19	22	56	100	92	94	306	**81**
19	Dyes	0	0	0	0	0	0	0	0	0	0	0	**0**

Water Resources: The main source of water for various usages is hill stream/spring with the exception of Mirba and Shyro (Table II. 3.726). Out of 378 HHs in the study area, 275 HHs (73%) use hill stream/spring water. In Shyro village, all the HHs (56) uses both ponds and tap water for water requirements.

Table II. 3.726: Dependence on water resources among surveyed HHs in the five project villages

Sl. No.	Village	River		Hill stream/spring		Wells		Ponds		Hand pumps		Tap water	
		n	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**
1	Jangda	0	0	99	100	0	0	0	0	0	0	99	100
2	Mirba	0	0	0	0	0	0	0	0	0	0	40	100
3	Rho	85	100	85	100	0	0	0	0	0	0	85	100
4	Shyro	0	0	0	0	0	0	56	100	0	0	56	100
5	Yuthembu	26	27	91	93	0	0	0	0	0	0	0	0
	Total	**111**	**29**	**275**	**73**	**0**	**0**	**56**	**15**	**0**	**0**	**280**	**74**

3.3.13 JASWANTGARH STAGE-I

3.3.13.1 PHYSICAL ENVIRONMENT

Geomorphology

The geomorphological features at Jaswantgarh-I HEP have been depicted in the toposheet (Figure II. 3.67). The project is located at an elevation of 2456 m.

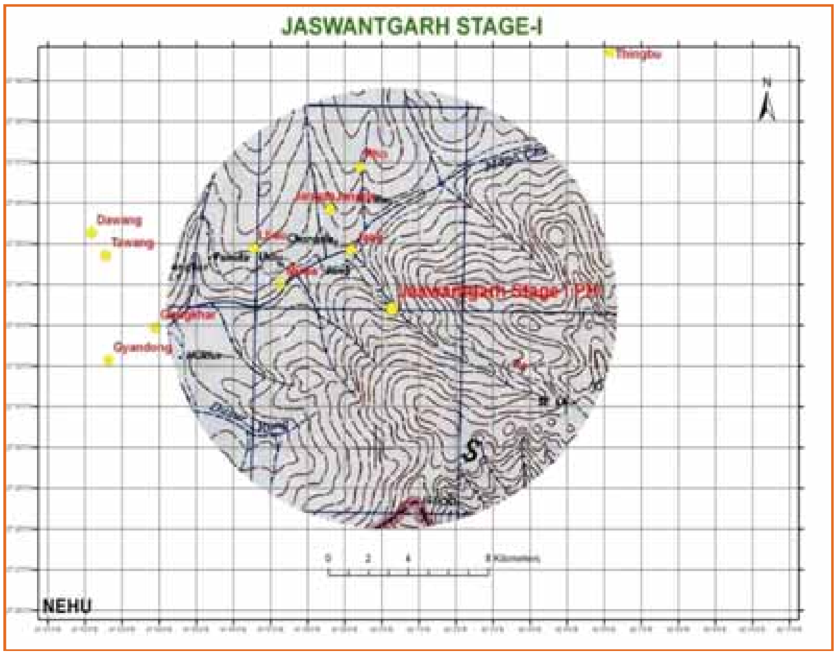


Figure II. 3.67: Contour map of Jaswantgarh Stage–I

Geology

The drainage is trellis type, and the rocks exposed are of schistose and gneissic group.

Soil

The soil was sandy clay with maximum water holding capacity, among all the 13 project sites (Table II. 3.727). The soil was fairly acidic (pH 4.7–5.5), conductivity values were lower than other sites, but concentration of ammonium nitrogen and exchangeable–K was high. Soil organic carbon and microbial biomass–C and–N was low. Seasonal variation in the physic–chemical properties is shown in Table II. 3.728.

Table II. 3.727: Soil physical properties at Jaswantgarh Stage–I site

Site	Texture	WHC (%)	Bulk density (g/cm³)	Porosity (%)
Barrage	Sandy clay	62.25	1.37	39.62
Powerhouse	Sandy clay	58.68	1.37	36.60

Table II. 3.728: Seasonal variation in soil physico–chemical properties at Jaswantgarh Stage–I site

Parameters	Post-monsoon		Monsoon		Winter		Mean	
	B	PH	B	PH	B	PH	B	PH
SMC (%)	20	25	30	26	20	15	23	22
pH	5.2	5.4	5.5	5.5	4.7	4.7	5.1	5.2
Conductivity ($\mu S\ cm^{-1}$)	112	113	204	196	117	87	144	132
NH_4^+–N ($\mu g\ g^{-1}$)	320	310	330	330	300	300	317	313
NO_3^-–N ($\mu g\ g^{-1}$)	40	51	53	54	31	32	41	46
TKN ($\mu g\ g^{-1}$) x10^3	0.900	0.890	1.200	1.170	0.760	0.770	0.953	0.943
Av. P ($\mu g\ g^{-1}$)	0.012	0.015	0.021	0.019	0.030	0.020	0.021	0.018
TP (%)	0.120	0.090	0.210	0.120	0.100	0.070	0.143	0.093
SOC (%)	0.008	0.007	0.009	0.008	0.006	0.005	0.008	0.007
Ex. K ($\mu g\ g^{-1}$)	401	553	539	602	398	489	446	548
Ex. Mg (%)	0.028	0.027	0.033	0.030	0.015	0.012	0.025	0.023
Ex. Ca (%)	0.269	0.268	0.290	0.285	0.176	0.172	0.245	0.242
Soil microbial biomass–C ($\mu g\ g^{-1}$)	20	17	17	14	23	23	20	18
Soil microbial biomass–N ($\mu g\ g^{-1}$)	10.0	13.0	8.5	11.7	15.2	16.5	11.2	13.7

(Note: Post-monsoon–March, Monsoon–July, Winter–December); B =Barrage, PH =Powerhouse

Water

Though seasonality in water chemistry was the hall mark of all investigated sites, Jaswantgarh Stage–I was unique in the sense that out of 20 parameters analysed, 14 showed peak values during monsoon season. Unlike other sites, water was slightly acidic and more turbid during post-monsoon season compared to monsoon and winter seasons. The total coliform count during this season was very high in comparison to other sites. Only two parameters viz., DO and alkalinity showed higher values during this season (Table II. 3.729).

Table II. 3.729: Seasonal variation in physico–chemical and biological properties of water and its primary productivity at Jaswantgarh Stage–I

Parameters	Post-monsoon			Monsoon			Winter		
	B	PH	Mean	B	PH	Mean	B	PH	Mean
Temperature (˚C)	16.90	16.10	16.50	14.60	15.10	14.85	1.20	1.30	1.25
Turbidity (NTU)	2.84	2.84	2.84	0.35	0.37	0.36	0.43	0.47	0.45
pH	6.59	6.63	6.61	7.46	7.62	7.54	7.13	7.25	7.19
Electrical conductivity (µS/cm)	29	33.00	31	36	42.00	39	34	37.00	36
Total dissolved solids (mg/l)	15	16.30	15.50	28	30.00	29.00	24	27.00	25.65
Practical salinity (ppt)	0.02	0.02	0.02	0.02	0.03	0.03	0.02	0.02	0.02
Total alkalinity (mg $CaCO_3$/l)	14	17.30	15.85	26	26.00	26.00	28	32.00	30.00
Total hardness (mg/l)	4	3.54	3.54	24	24.43	24.12	13	13.17	13.15
Chloride (mg Cl^-/l)	8.99	8.99	8.99	18.99	18.99	18.99	7.99	7.99	7.99
Ca^{2+} (mg/l)	0.86	0.86	0.86	7.79	7.92	7.86	3.65	3.65	3.65
Mg^{2+} (mg/l)	0.34	0.34	0.34	1.06	1.13	1.09	0.98	0.98	0.98
K^+ ppm	0.83	1.30	1.07	0.40	0.60	0.50	0.40	0.50	0.45
Na^+ ppm	2.70	2.80	2.75	5.20	5.60	5.40	2.20	2.30	2.25
TKN (mg/l)	0.28	0.34	0.31	0.46	0.50	0.48	0.19	0.20	0.19
NH_4^+ N (mg/l)	0.02	0.02	0.02	0.05	0.05	0.05	0.02	0.02	0.02
NO_3–N (mg/l)	0.15	0.15	0.15	0.17	0.18	0.18	0.13	0.13	0.13
Total phosphorus (mg/l)	0.11	0.11	0.11	0.05	0.05	0.05	0.06	0.06	0.06
GPP (mg C/cm^3/h)	0.21	0.21	0.21	0.39	0.39	0.39	0.21	0.21	0.21
NPP (mg C/cm^3/h)	0.10	0.10	0.10	0.16	0.15	0.15	0.08	0.08	0.08
Dissolved oxygen (mg/l)	11.30	10.20	10.75	10.40	10.00	10.20	12.60	12.60	12.60
Total coliforms (CFU/ml)	120	97.00	108.50	75	43.00	59.00	17	12.00	14.50

Ambient Air Quality

Concentration of PM_{10} and $PM_{2.5}$: PM_{10} concentration at proposed Jaswantgarh Stage–I HEP ranged from a minimum of 11.7µg/m^3 at Jaswantgarh Stage–I to a maximum of 49.7µg/m^3 at Nuranang Falls. Likewise, $PM_{2.5}$ concentration ranged from a minimum of 13.4µg/m^3 at Jaswantgarh Stage–I and Rho to a maximum of 38.7 µg/m^3 at New Melling (Table II. 3.730). The concentration of sulphur–dioxide (SO_2), nitrogen–dioxide (NO_2), ammonia (NH_3) and ground level ozone (O_3) at all the monitored locations were below detectable limits.

Table II. 3.730: Concentration of PM_{10} and $PM_{2.5}$ in air at proposed Jaswantgarh Stage–I HEP

Sampling location	Nearest project site covered	PM_{10} (µg/m^3)	$PM_{2.5}$ (µg/m^3)
Jaswantgarh Stage–I	Jaswantgarh Stage–I barrage site Jaswantgarh Stage–I powerhouse site	11.7	13.4
Nuranang falls	Jaswantgarh Stage–I barrage site Jaswantgarh Stage–I powerhouse site	49.7	38.0
Jang	Jaswantgarh Stage–I barrage site Jaswantgarh Stage–I powerhouse site	41.7	23.9
Rho	Jaswantgarh Stage–I barrage site Jaswantgarh Stage–I powerhouse site	23.5	13.4
New Melling	Jaswantgarh Stage–I barrage site Jaswantgarh Stage–I powerhouse site	39.4	38.7

HEP–Hydroelectric project

Ambient air temperature at Jaswantgarh Stage–I HEP was minimum (4°C) at the barrage site. The relative humidity varied between of 27% at Nuranang falls and 52% at Rho. Wind speed was found ranged between1.6 km/hr at Jang and 3.6 km/hr at Rho. The wind direction varied from NW to SE (Table II. 3.731).

Table II. 3.731: Meteorological condition at proposed Jaswantgarh Stage–I HEP

Sampling location	Nearest project component covered	Ambient temp. (°C) Min Max	Relative humidity (%)	Wind speed (range in km/hr)	Wind direction
Jaswantgarh Stage–I	Jaswantgarh Stage–I barrage site Jaswantgarh Stage–I powerhouse site	05 09	32	2.1–2.7	SE
Nuranang falls	Jaswantgarh Stage–I barrage site Jaswantgarh Stage–I powerhouse site	06 10	27	2.4–3.2	SE
Jang	Jaswantgarh Stage–I barrage site Jaswantgarh Stage–I powerhouse site	04 08	39	1.6–2.3	SE
Rho	Jaswantgarh Stage–I barrage site Jaswantgarh Stage–I powerhouse site	05 09	52	1.8–3.6	NW
New Melling	Jaswantgarh Stage–I barrage site Jaswantgarh Stage–I powerhouse site	04 09	37	1.7–2.5	SE

Noise Level: Noise level in the vicinity of proposed Jaswantgarh Stage–I HEP was 25.2 dBA at barrage site of Jaswantgarh Stage–I at 4.00 PM and 67.1 dBA at barrage site of New Melling at 4.00 PM (Table II. 3.732).

Table II. 3.732: Noise level at proposed Jaswantgarh Stage–I HEP

Sampling location	Nearest project areas covered	Noise level (dBA) 8.00 AM	Noise level (dBA) 4.00 PM
Jaswantgarh Stage–I	Jaswantgarh Stage–I barrage site Jaswantgarh Stage–I powerhouse site	27.1	25.2
Nuranang falls	Jaswantgarh Stage–I barrage site Jaswantgarh Stage–I powerhouse site	64.6	63.2
Jang	Jaswantgarh Stage–I barrage site Jaswantgarh Stage–I powerhouse site	38.2	29.7
Rho	Jaswantgarh Stage–I barrage site Jaswantgarh Stage–I powerhouse site	37.2	39.6
New Melling	Jaswantgarh Stage–I barrage site Jaswantgarh Stage–I powerhouse site	61.3	67.1

3.3.13.2 BIOLOGICAL ENVIRONMENT

Vegetation Types

The project components of Jaswantgarh Stage-I HEP are located in and temperate forest sub-alpine and alpine forest area.

12/C3b Abies forest (2750-3000 m): In this type of forest, the dominant tree species is *Abies densa* which occur in remarkable pure stand, and grows up to 20 m tall and attains girth of 2 m. However, in some places *Rhododendron, Lyonia,* and *Litsea* species are also seen. Dense and almost impenetrable brakes with one or more species of *Arundinaria* and related genera are also found, often practically with no other large woody plants. However, there are often few *Rhododendron* and *Berberis* species seen as shrub component in this forest type. In more damper regions, there may be epiphytic moss. The herbaceous flora covers the soil, wherever enough light penetrates. Transitions with scattered overwood are numerous.

14/C2 East Himalayan sub-alpine birch/fir forest (3500-4000 m): These are forests which occur in the Eastern part of the Himalaya between 3500 m and 4000 m. The forest comprise of trees such as *Abies densa, Juniperus, Larix griffithii, Betula utilis* etc., and small trees like those of *Rhododendron wightii, Salix*, etc., and shrubs such as *Rosa, Berberis, Spirea* etc. The herbaceous layer is comprised of *Polygonum* sp., *Potentilla* sp., *Primula* sp., *Fragaria* sp., etc.

15/C3 Alpine pasture (4000-5500): The alpine pasture medows are composed mostly of perennial mesophytic herbs, with very little grass. Conspicuous among the herbs are *Primula*, *Anemone, Fritillaria*, *Iris,* and *Gentiana*, with members of Ranunculaceae, Brassicaceae, Caryophyllaceae, and Asteraceae. This alpine pasture has a shorter snow free period.

Plant Diversity

A total of 29 plant species belonging to different groups at barrage and powerhouse sites, and catchment area were recorded during the survey. A complete list of plant species found in the study area representing different groups such as tree, shrub, herb, orchid, pteridophyte, and lichen along with their family name is given in Appendix II. 3.154. The number of plant species belonging to different groups is summarized in Table II. 3.733.

Table II. 3.733: Plants belonging to different groups recorded from Jaswantgarh Stage–I HEP site

Sl. No.	Groups	Number of species		
		Barrage site	**Powerhouse site**	**Catchment area**
1	Tree	5	5	5
2	Shrub	4	5	4
3	Herb	10	10	10
4	Orchids	1		1
5	Pteridophytes	3		2
6	Lichens	3		3

The trees were found laden with thick growth of mosses and epiphytes. Some flowering plants and ferns form this group. At the barrage site 5 tree, 4 shrub and 10 herb species were recorded, and at the powerhouse site 5 tree, 5 shrub, and 10 herb species were documente. In the catchment area, 5 tree, 4 shrub and 10 herb species were recorded. A total of 1 orchid, 3 pteridophyte and 3 lichen species were recorded from barrage and powerhouse site, whereas 1 orchid, 2 pteridophyte and 3 lichen species was recorded from the catchment area (Appendix II. 3.155 and 3.156).

Threatened and Endemic Species

No threatened species was recorded.

Economically Important Species/Plant Resources

The study area is rich in plant resources. A few of the important ones are listed below under different resource groups (Table II. 3.734).

Table II. 3.734: Economically important species/plant resources present at Jaswantgarh Stage–I HEP site

Sl. No.	Uses	Species name
1	Timber	*Abies densa*
2	Fuel	*Rhododendron* sp., *Abies densa*
3	Ornamentals and orchids	*Rhododendron* sp., *Primula* sp., *Aster* sp., *Satyrium* sp.

Vegetation Analysis for Angiosperms and Gymnosperms

The plant community around Jaswantgarh Stage-I including barrage and powerhouse sites, and the catchment area had very low species richness. It had 5 tree, 5 shrub and 12 herbaceous species (Table II. 3.735 and 3.736).

Table II. 3.735: Tree and shrub species at barrage and powerhouse sites, and in catchment area of Jaswantgarh Stage–I

Trees	Shrub
Abies densa	*Berberis* sp.
Acer sp.	*Periscaria chinensis*
Juniperus sp.	*Rhododendron nivale*
Rhododendron sp.	*Rhododendron* sp.
Salix sp.	*Rosa* sp.

Table II. 3.736: Herbaceous species at barrage and powerhouse sites, and in catchment area of Jaswantgarh Stage–I

Aconogonon alpinum	*Galium* sp.	*Primula* sp.
Elsholtzia strobilifera	*Meconopsis* sp.	*Rumex nepalensis*
Fragaria sp.	*Polygonum* sp.	*Swertia paniculata*
Galinsoga parviflora	*Primula denticulata*	*Swertia* sp.

In general, species richness was high during monsoon season and low during winter season. *Abies densa* was dominant in all the three sites i.e., barrage and powerhouse sites, and in the catchment area. Among shrubs, *Rhododendron nivale* was dominant in all the three sites. The hrbaceous species being mostly annual in nature, different species were dominant at a given site in the three seasons (Appendix II. 3.166).

Highest density of both trees and shrubs was recorded at barrage site. The lowest density was recorded at catchment area and powerhouse site, respectively (Table II. 3.737). Density of herbaceous species varied widely between barrage site, powerhouse site and catchment area, but at all places it was maximum during rainy season and minimum during winter season. Shannon index of diversity for tree species in the community was highest (H'= 1.39) at the barrage site followed by powerhouse site (H'= 1.37) and catchment area (H'= 1.24). For shrub species highest value was obtained at powerhouse site (H'= 1.48) followed by barrage sites (H'= 1.27) and catchment area (H'= 1.24) (Table II. 3.737).

Diversity index for herbs ranged between H'= 1.43 and 2.13. The highest value was recorded at powerhouse site during monsoon season, and the lowest during winter season in the catchment area. Overall, plant community near barrage and catchment area had higher species diversity. At all three sites species richness, density and diversity increased from pre-monsoon season to attain peak during monsoon, and attained lowest value during winter season (Table II. 3.738.) (Appendix II. 3.157-3.165). High diversity and low dominance was the characteristic feature of all three sites. Dominance index value for tree species ranged between 0.31 and 0.33, which was much lower than those obtained for shrubs 0.67-0.74.

Table II. 3.737: Species richness, diversity and dominance of tree and shrub community, and carbon stock of trees at Jaswantgarh Stage-I

Parameters	Barrage		Powerhouse		Catchment area	
	Tree	**Shrub**	**Tree**	**Shrub**	**Tree**	**Shrub**
Number of species	5	4	5	5	5	4
Density (ha-1)	240	1504	200	1200	170	976
Simpson index of dominance	0.31	0.69	0.32	0.74	0.33	0.67
Shannon index of diversity (H')	1.39	1.27	1.37	1.48	1.34	1.24
Evenness index	0.86	0.89	0.85	0.87	0.83	0.86
Carbon (t/ha)			-		5.6	

Table II. 3.738: Species richness, diversity and dominance in herbaceous community at Jaswantgarh Stage-I site

Parameters	Barrage			Powerhouse			Catchment area		
	PM	**M**	**W**	**PM**	**M**	**W**	**PM**	**M**	**W**
Number of species	6	10	6	5	9	5	5	9	6
Density (ha-1)x103	54	82	42	34.4	60.8	40.8	43.2	76	45.2
Simpson index of dominance	0.81	0.86	0.82	0.76	0.87	0.72	0.77	0.82	0.76
Shannon index of diversity (H')	1.74	2.12	1.75	1.52	2.13	1.43	1.55	1.93	1.61
Evenness index	0.94	0.83	0.95	0.92	0.94	0.84	0.94	0.77	0.84

PM: Post monsoon; M: Monsoon; W: Winter

Phytoplankton/Periphyton

A total of about 8 species of phytoplankton/periphyton were recorded from Jaswantgarh Stage-1. The phytoplankton/periphyton community was represented by three species of Cyanophyceae and five species of Bacillariophyceae. Maximum species richness in the community was recorded at the catchment area with 6 species and minimum with 4 species from the project affected areas. Phytoplankton/periphyton density at the project affected areas (90 individuals/l) was higher than that of catchment area (40 individuals/l). Similarly, species diversity index was maximum (H'= 2.13) at the catchment area and minimum (H'=1.25) at the project affected areas (Table II. 3.739).

Table II. 3.739: Density (Individuals/l), species richness and Shannon index of diversity (H') of phytoplankton community in river water at project affected area and catchment area of Jaswantgarh Stage-I

List of species	Project affected area	Catchment area
Cyanophyceae		
Lyngbya sp.		15
Oscillatoria sp.		25
Phormidium sp.		10
Bacillariophyceae		
Achnanthidium pyrenaicium	**5**	
Cocconeis placentula	**5**	
Didymosphenia germinata		10
Encyonema minutum	15	10
Eunotia bilunaris	15	20
Total density (Individuals/lit)	**40**	**90**
Species diversity index	**1.25**	**1.72**
Species richness	**4**	**6**

NB: Blank cells indicate absence of periphyton species

Zooplankton

Zooplankton survey was conducted during monsoon and winter seasons in Jaswantgarh Stage-I area. Seven species were recorded during monsoon and post-monsoon periods, out of which only 2 species belong to Cladocera i.e., *Bosmina (Bosmina) longirostris* and *Moina micrura*, and 5 species belong to Rotifera (Table II. 3.740). Only 1 species *Lecane leontina* of Rotifera occurred during monsoon period, while the remaining 6 species occurred during winter season.

Table II. 3.740: Occurrence of species belonging to Cladocera and Rotifera during monsoon and winter seasons at Jaswantgarh Stage-I site

Sl. No.	Taxa	Species	Season	
			Monsoon	Winter
1	Cladocera	*Bosmina* (Bosmina) *longirostris* (O.F. Muller, 1776)	–	+
2	Rotifera	*Epiphanes brachionus spinosa* (Rousselet, 1901)	–	+
3	Rotifera	*Lecane bulla* (Gosse, 1851)	–	+
4	Rotifera	*Lecane closterocerca* (Schmarda, 1859)	–	+
5	Rotifera	*Lecane leontina* (Turner, 1892)	+	
6	Rotifera	*Lecane closterocerca* (Schmarda, 1859)	–	+
7	Cladocera	*Moina micrura* (Kurz, 1874)	–	+
Total	**2**	**7**	**1**	**6**

Fish Fauna

No fish fauna was recorded from the study site.

Soil Fauna

The seasonal variation of soil faunal diversity (Collembola, Acarina and other arthropods) and equitability in litter and soil layer is shown in Table II. 3.741-3.743.

Table II. 3.741: Seasonal variation of soil faunal diversity (Collembola, Acarina and other arthropods) and equitability in litter and soil layer at Jaswantgarh Stage-I site

Soil fungi	Diversity	Post monsoon				Monsoon				Winter			
		Barrage		Powerhouse		Barrage		Powerhouse		Barrage		Powerhouse	
		Litter	Soil	Litter	Soil	Litter	Soil	Litter	Soil	Litter	Soil	Litter	Soil
Collembola	Dominance_D	0.18	0.16	0.15	0.20	0.14	0.17	0.16	0.19	0.33	0.28	0.33	1.00
	Shannon_H	1.75	1.87	1.97	1.71	2.00	1.86	1.86	1.72	1.10	1.33	1.10	0.00
	Evenness_e^H/S	0.96	0.93	0.89	0.92	0.93	0.92	0.92	0.93	1.00	0.95	1.00	1.00
Acarina	Dominance_D	0.19	0.21	0.25	0.22	0.12	0.19	0.21	0.17	0.28	0.63	1.00	1.00
	Shannon_H	1.74	1.68	1.39	1.56	2.17	1.79	1.67	1.77	1.33	0.56	0.00	0.00
	Evenness_e^H/S	0.94	0.89	1.00	0.95	0.97	0.86	0.89	0.98	0.94	0.88	1.00	1.00
Other Arthropods	Dominance_D	0.13	0.13	0.20	0.16	0.16	0.13	0.13	0.20	0.50	1.00	1.00	1.00
	Shannon_H	2.14	2.05	1.70	1.95	1.86	2.05	2.11	1.71	0.69	0.00	0.00	0.00
	Evenness_e^H/S	0.94	0.97	0.91	0.88	0.92	0.97	0.92	0.92	1.00	1.00	1.00	1.00

Table II. 3.742: Mean annual density (number/m^2) of soil fauna in litter and soil layer (0-5 cm) at Jaswantgarh Stage-I site

Soil fauna	Site	Litter layer	Soil layer	Total
Collembola	Barrage	1564	1200	**2764**
	Powerhouse	1309	909	**2218**
Acarina	Barrage	1400	800	**2200**
	Powerhouse	629	686	**1314**
Other Arthropods	Barrage	1636	1055	**2691**
	Powerhouse	1236	1091	**2327**
Total fauna	Barrage	4600	3055	**7655**
	Powerhouse	3174	2686	**5859**

Table II. 3.743: Seasonal variation of soil fauna density (number/m2) at barrage and powerhouse site of Jaswantgarh Stage-I

Soil fauna	Site	Post monsoon	Monsoon	Winter	Mean
Collembola	Barrage	14000	13200	3200	10133
	Powerhouse	12400	10400	1600	8133
Acarina	Barrage	12000	14800	4000	10267
	Powerhouse	8000	9600	800	6133
Other arthropods	Barrage	13600	14800	1200	9867
	Powerhouse	12000	12800	800	8533

Wildlife

Butterflies: Survey of butterfly in Jaswantgarh Stage-I HEP area, revealed the presence of 15 species belonging to 12 genera and four families. The family Pieridae was the dominant, represented by seven species. These 15 species however are not included in the list of threatened species (Table II. 3.744).

Table II. 3.744: Butterflies recorded in Jaswantgarh Stage-I HEP site

Sl. No.	Family common name	Scientific name	PA
I.	**Papilionidae**		
	Common Bluebottle	*Graphium sarpedon sarpedon*	*
II.	**Pieridae**		
2	Dark Jezebel	*Delias berinda*	*
3	Plain Sulphur	*Dercas lycorias*	*
4	Spotless Grass Yellow	*Eurema laeta*	*
5	Small Grass Yellow	*Eurema brigitta rubella*	*
6	Indian Cabbage White	*Pieris canidia indica*	*
7	Green-veined White	*Pieris napi montana*	*
8	Green vein White	*Pieris melete*	*
III.	**Lycaenidae**		
9	Peablue	*Lampides boeticus*	*
10	Green Sapphire	*Heliophorus moore*	*
11	Pale Hedgeblue	*Udara dilecta*	*
12	Common Hedgeblue	*Acytolepis puspa gisca*	*
IV.	**Nymphalidae**		
13	Chestnut Tiger	*Parantica sita*	*
14	Eastern Comma	*Polygonia egea*	*
15	Large Threering	*Ypthima nareda*	*

Herpetofauna: The probable list of amphibians and reptiles was prepared following Ahmed *et al.* (2009), as surveys carried out during the three seasons did not result in reporting of any herpetofauna (Appendix II. 3.167).

Birds: The assessment of birds carried out in and around this project area during post monsoon, monsoon, and winter seasons, revealed presence of 73 species belonging to 50 genera and 25 families. The Shannon diversity value of 3.9 revealed a evenly distributed diversity of species. When the status was compared between different seasons, it was found that richness was higher during monsoon (52 species) than in winter season. The low richness during winter season might be due to snowfall and less availability of food resources in the area. The abundance of birds was high in monsoon (Table II. 3.745).

Migratory status: The migratory and resident status of these bird species showed that most of the birds were residents (51 species) followed by 11 breeding visitors and 11 winter visitors (Table II. 3.745).

Table II. 3.745: Status of birds recorded in Jaswantgarh Stage-I HEP site

Details	Post monsoon	Monsoon	Winter	Overall
Family	17	16	11	25
Genera	19	35	18	50
Species	22	52	22	73
Abundance	143	354	109	606
Diversity H'	2.8	3.5	2.7	3.9
Migratory status				
Breeding visitor	3	9	3	11
Isolated record	0	0	0	0
Resident	15	36	17	51
Winter visitor	4	7	2	11

Abundance status: The abundance status of birds was derived by classifying the abundance of bird species into five abundance category (Very Low = 1-25 birds, Low = 26-50, Moderate = 51-75, High = 76-100 and Very High = > 100birds). The details of abundance status are given in the Table II. 3.746.

Table II. 3.746: Number of species and relative % of birds in different abundance classes

Abundance class	No. of species	Relative %
Very low -1 -25 birds	71	97.3
Low -26 -50 birds	2	2.7
Moderate -50 -75 birds	0	-
High -76-100 birds	0	-
Very high > 100 birds	0	-
Total	**73**	**100**

Status of foraging guilds: In this project area, the birds were represented by eight different foraging guilds, of which maximum species were insectivores with 49 species followed by nine species of omnivores and seven species of granivores. Among the remaining that were represented by less species, nectarivore was with four species. The high richness of insectivores was reported across the seasons and it showed the presences of diverse habitat and niches in this project site (Table II. 3.747 and Appendix II. 3.210).

Table II. 3.747: Status of foraging guild of birds recorded in the Jaswantgarh Stage-I HEP site

Foraging guild	Post monsoon	Monsoon	Winter	Overall
Aquatic feeder	0	0	0	0
Carnivore	0	1	0	1
Frugivore	1	0	0	1
Granivore	2	5	2	7
Insectivore	10	36	17	49
Nectarivore	3	3	1	4
Nucivore	0	1	1	1
Omnivore	5	6	1	9
Piscivore	1	0	0	1

Status of threatened species: No threatened bird species was encountered within the project site during the field study (Appendix II. 3.210).

Mammals: Surveys in and around the Jaswantgarh Stage-I project site revealed the presence of four mammalian fauna under seven families, and each species belonging to a separate genus. This list consists of primate, ungulates, rodent and carnivore species represented by one species each (Appendix II. 3.211).

Abundance status: Record of one indirect evidence (IE) of Arunachal Macaque (*M. munzala*), six of Wild pig (*Sus scrofa*), three of Jungle cat (*Felis chaus)*, and one direct sighting of one Hoary-bellied Himalayan Squirrel (*Callosciurus pygerythrus)* showed that, overall the project area supports very low species richness (four species) and abundance (10 IE and A 1). Seasonal surveys revealed the presence of only two species during winter and monsoon season, whereas four species in post-monsoon season (Table II. 3.). Further evaluation of species richness of the project area (four species) with the possible species (28 species) of the Tawang district (Mishra *et al.* 2006) also revealed the low species richness, as the species recorded in the project area formed only 14.2 % (Appendix II. 3.211)

Status of threatened species: Except for Arunachal Macaque (*Macaca munzala*) which is Endangered(EN) according to IUCN Red List, the rest of the species of the project area fall under Least Concern (LC) of IUCN and Schedule II and III of WPA (1972) (Table II. 3.748).

Table II. 3.748: Status of mammalian fauna recorded in the Jaswantgarh Stage-I HEP area

Sl. No.	Name	Scientific name	Seasons			Overall	Conservation Status	
			S	M	W		IUCN	WPA
I.	**Cercopithecidae**							
1	Arunachal Macaque	*Macaca munzala*	IE-1			IE 1	EN	-
II.	**Suidae**							
2	Wild pig	*Sus scrofa*	IE-2	IE-3	IE 1	IE 6	LC	III
III	**Felidae**							
3	Jungle cat	*Felis chaus*	IE-1	IE1	IE 1	IE 3	LC	II
IV	**Sciuridae**							
4	Hoary-bellied Himalayan Squirrel	*Callosciurus pygerythrus*	A 1			A 1	LC	NE
	No of species		**4**	**2**	**2**	**4**		
	Total and types of records		**IE 4 A 1**	**IE 4**	**IE 2**	**IE 10 A 1**		

IE – Indirect Evidences A-animals sighted, W-Winter, S-Summer, M-Monsoon, IUCN-Red List, WPA-Wildlife Protection Act, EN-Endangered, LC-Least Concern, NE – Not Evaluated

Faunal status within 500 m of project affected area: This section revealed species richness status of selected faunal groups such as avifauna and mammal species reported within 500 m up and down streams of the barrage and powerhouse site of the proposed project area. The species richness reported in those specific sites was evaluated based on subjective rating through estimating percent contribution with the overall species list of the project area. The species richness of barrage and powerhouse contributes 25% of overall list. Further it was categorised as low, > 25-50% as medium, >50-75% as high and above 75% as high species richness.

Status of avifauna: At Jaswantgarh Stage-I area, 55 species were recorded at Powerhouse and barrage site. However, none of them were identified as threatened species (Appendix II. 3.212).

Status of mammals: Site specific evaluation of mammalian fauna within 500 m of up and down streams showed occurrence of only two species at barrage and powerhouse site with three indirect evidences which include Wild pig (IE2) and Jungle cat (IE1). None of these species were categorized under IUCN and WPA (1972) (Table II. 3.). Overall, the powerhouse and barrage site of Jaswantgarh Stage-I project area did not have any mammalian fauna of high conservation significance.

Table II. 3.749: Status of mammalian fauna at barrage and powerhouse sites of the proposed Jaswantgarh Stage-I HEP area

Common name	Species name	Status		Conservation status	
		BS	PHS	IUCN	WPA
Wild pig	*Sus scrofa*		IE 2	LC	III
Jungle cat	*Felis chaus*		IE 1	LC	II
Total no. of species			**2**		
Total no. of record			**3 IE**		

IE – Indirect Evidences, A – No of Animals Sighted, BS –Barrage Site, PHS – Powerhouse Site, IUCN-Red List, WPA-Wildlife Protection Act, LC-Least Concern, EN – Endangered

4.1 INTRODUCTION

Impact identification and prediction are two key processes in environmental impact assessment of any development project. The baseline data are collected to predict the potential impact of the proposed project on different environmental and socio-economic components. Based on the predictions, mitigation measures are undertaken as a part of the project design itself. In the present study, impacts of individual proposed hydel power projects on physical, biological, social and economic environmental components of TRB have been predicted using diverse tools such as mathematical and statistical modelling, geospatial modelling, expert consultations and stakeholder discussions. However, earthquake impacts, dam break modelling and air pollution modelling have not been undertaken because of the following reasons: i) The components have been studied thoroughly in the individual project reports and the findings are more or less applicable to the entire basin (e.g., earthquake impacts), ii) the components are not too much relevant to TRB (e.g., dam break analysis and air pollution modelling).

4.2 METHODS

4.2.1 Impact Identification and prediction

After collection of baseline data, it is important to identify the impacts of developmental activities on the environment. There are various methods of impact identification ranging from simple checklist, matrices to complex computerized model and network. Simple checklist method was used to identify the impacts of individual projects. The impacts were identified on the basis of their nature, magnitude and potential.

Prediction is essentially a process to forecast the future environmental conditions of the project area that might be expected to occur because of implementation of the project. An attempt was generally made to forecast future environmental conditions quantitatively to the extent possible. But for certain parameters, which cannot be quantified, general approach has been to discuss such intangible impacts in qualitative terms so that planners and decision-makers are aware of their existence as well as their possible implications. Impact of project activities has been predicted using mathematical models and overlay technique (super-imposition of activity on environmental parameter). For intangible impacts qualitative assessment has been done.
Using the baseline information the adverse and beneficial impacts on the various environmental components will be evaluated under the following categories:

- Positive impacts
- Negative impacts
- Reversible impacts
- Irreversible impacts
- Short run impacts
- Long run impacts
- Quantitative description of impacts
- Qualitative description of impacts
- Cumulative impacts (Described in detail in Section V)

4.2.2 Mitigation Measures

Based on the nature, intensity and magnitude of the impacts, mitigation measures were developed through expert opinion and expert group consultation. Mitigation measures being highly subject specific, the consultation process was confined to relevant subject experts.

4.3 IMPACTS OF THE PROJECTS AND MITIGATION MEASURES

All the projects being on the same river basin and along the same river system, many of the impacts for each of the proposed project will be the same. However, due to differential location particularly along a wide elevation gradient, the magnitude of these impacts would vary. Nevertheless, the mitigation measure for a particular impact irrespective of the magnitude would be more or less same. Therefore, in this report, such similar impacts common to all the individual projects have been listed and discussed in the beginning. In the subsequent paragraph, project specific impacts and respective mitigation measures have been presented.

4.3.1 Impacts Common to all the Individual Projects and Mitigation Measures

The impacts may be as follows:

- ***Major impacts:*** land use changes such as barrage structure, powerhouse, submergence, habitat destruction, downstream impacts, local area development, increased population during construction phase.
- ***Minor impacts:*** acquisition of private land, cultural conflicts, threats of new disease in the area, increased concentration of air pollutants and increased noise levels, water quality deterioration, wildlife disturbance due to blasting.
- ***Positive impacts:*** infrastructure development, job opportunity for local, fisheries development, infrastructural facilities for education, health, communication, transport, developmental schemes like merit scholarships, training programmes, rehabilitation of weaker sections,
- ***Negative/direct impacts:*** landuse changes due to construction activities, construction of permanent colony, barrage structure, muck disposal, diversion of water from downstream, powerhouse complex, construction of roads, increased population, emission of toxic gases, and dust in the air, deterioration of water and air quality, cultural conflicts, submergence of a large number of plants, obstacles in the way of fish migration, local economy etc.
- ***Indirect impacts:*** cultural and social resources, forest resources,
- ***Short run:*** construction of roads, tunnels, adits, bridges, colonies
- ***Long run:*** permanent acquisition of land, downstream and upstream activities

The common environmental impacts predicted and their respective mitigation measures applicable to all the individual projects are listed below. The details of the evaluation pertaining to the impacts on biodiversity and ecosystems are described in Section-VII.

4.3.1.1 Possible Impacts on Ecosystems

Impact on river ecosystem and associated faunal diversity

- Regulating the normal water flow in the downstream may affect habitat and food regime of faunal species in the concerned river.
- Polluting the river system during the construction phase through disposing solid wastes and other concrete materials into the river.
- Pollution may cause reduction in abundance of several faunal species of river ecosystem.
- Increase in air pollution level during project construction phase
- Impacts on terrestrial and aquatic ecosystems due to increased human interferences during project construction and operation phases.

Mitigation: Adopting strict management and regulatory options for pollution. E–flow needs to be adjusted to minimize the impact on faunal species.

Impact of muck generated through the construction of tunnels and the impact of muck disposal on land and water resources

- Loss of habitats along the river systems including the alteration of hydraulics and hydrology of the river.
- Construction of very long retaining wall to store the muck dumps along the river system will restrict the normal movement of mammal species, as well as access to the river water resources.

- Runoff from the muck dumps will contaminate the land and water resources of the river system.
- Creation of muck dumping yards and disposal sites would damage the existing plant species.

Mitigation: In view of the above impacts, appropriate technical and structural interventions are needed. While constructing the disposal and storing structures, the factors described above should be kept in mind. While using the muck dumps, it has to be made mandatory to keep the disposal limit within the capacity of the site so that the muck does not spill into the river bed.

Impacts of noise due to drilling, tunnelling, blasting and vehicular movements on the faunal groups

- Changes in the normal behavior due to restrictions in normal movement, feeding and resting activities of major faunal groups of the project area.
- Possible permanent exodus of some affected larger territorial faunal species from the project area.
- The noise and associated ground vibration would impact the lower vertebrates mainly ground dwelling, specifically burrowing and reptilian species.

Mitigation: The use of high–tech equipments would minimize noise levels. Adoption of suitable managerial, ecological and technical interventions would minimize the impact of noise pollution.

Unregulated vehicular movement in the forest areas, and its impacts on faunal groups i.e. mortality due to accidents on the road, pollution load on the roadside plants, and soil compaction

- *Road killings:* Mostly herpetofauna (amphibians and reptiles) and smaller mammals are vulnerable to get killed by the vehicles while crossing the roads.
- Frequent movement of vehicles leading to collision of bird species may reduce species richness and abundance in the habitats along the road side.
- *Compaction of soil:* Movement of heavy vehicles would lead to soil compaction in the project areas leading to alteration of soil physico–chemical properties.
- Movement of vehicles for construction works would increase the pollution load on roadside plants leading to the loss of plant diversity and productivity.

Mitigation: The appropriate measures to minimize this impact would include, strict management decisions on regulated vehicular movement.

Influx of population and pressure on the local natural resources

- Clearing of land and vegetation cover for labour settlements.
- Cutting of wooden poles from the forest area for the construction of temporary sheds.
- Cutting of trees from the forest area to meet their fuel wood needs, and risk of their involvement in illegal activities like poaching/ hunting of animals.

Mitigation: Very strict managerial role is suggested to minimize the above impacts on forest and associated floral and faunal species of TRB.

Invasion of alien plant species

- Reduced flow in the downstream areas would increase the areas under IAS.

Mitigation: The existing identified IAS should be weeded out and adequate measures should be taken to avoid import of new IAS through appropriate quarantine measures. An appropriate policy to regulate the introduction of IAS needs to be formulated by the Government of Arunachal Pradesh.

4.3.1.2 Possible impacts on flora and fauna

Acquisition of forest land and changing the land use for the proposed development activities and associated impacts of loss of habitats

- *Loss of habitat:* Due to diversion of forest land for the project activities including the construction of approach road, habitat conditions are altered resulting in deforestation, soil erosion and land degradation.
- *Changes in floral composition:* Following removal of the forests for construction of various structures, the species composition of the altered habitat would change due to modified micro–environmental conditions. The pioneer species are likely to dominate the regenerating forests replacing the primary forest species.
- *Changes in faunal composition:* The smaller groups of faunal species, which are potent indicators of habitat changes (e.g. butterflies, amphibians and reptiles), are likely to be more impacted than the larger faunal groups.

Mitigation: It is suggested that afforestation programmes using dominant native tree species and woody shrubs should be undertaken to compensate the floral and faunal losses in the project areas.

Impact: Construction activities would impact the terrestrial and aquatic plant and animal species having commercial importance and would have important livelihood implications.
Mitigation: The biodiversity management plan has described in detail the development of these resources to mitigate the impact.

Impact: Acquisition of forest land for the proposed project activities is expected to increase the resource dependency (timber, fire wood, fodder and grazing) on other adjoining forest lands, thereby impacting the overall floral and faunal diversity.
Mitigation: The activities planned under compensatory afforestation and catchment area treatment components should be adequate to mitigate this impact.

4.3.1.3 Possible impacts on threatened floral and faunal species

Impact

- Loss of specific habitats of the threatened floral and faunal species of the project area.
- Habitat degradation and fragmentation will have significant impact on threatened floral and faunal populations.

Mitigation: It is important to follow specific management strategies suggested in the Biodiversity management plan which should minimise the impact on the identified floral and faunal species of TRB Landscape.

4.3.1.4 Possible impacts due to seismicity

Impact: Impacts due to seismicity
Mitigation: Safety criteria have been suggested to be followed in design of the barrage.

4.3.1.5 Possible impacts on hydrology and water quality

Impact

- Impacts on hydrologic regime.
- Impacts on water quality.
- Increase in incidence of water–related diseases including water–borne and vector–borne diseases.
- Effect on riverine fisheries including migratory fish species.
- Impacts due to sewage generation from labour camps.

Mitigation: For fish migration, fish ladder at all the project sites should be a part of barrage design. Adequate E–flow must be ensured at all project sites, and regulatory steps to minimise the pollution close to zero discharge should be taken.

4.3.2 Individual Project-Specific Impacts and Mitigation Measures

4.3.2.1 Tsa Chu-I

Impact: *Being situated at very high elevation, the ecosystems are extremely fragile and difficult to recover and susceptible to hazards such as, high intensity landslides, soil erosion and GLoF.*
Mitigation: Impacts being from natural origin, it is difficult to mitigate.

Impact: *Close to hotspring and temple - a place of worship. Also close to Chumbi Gyatser with high religious importance among the Monpa Buddhists.*
Mitigation: Impacts cannot be mitigated. The project should not be undertaken.

4.3.2.2 Tsa Chu-I Lower and Tsa Chu-II

Impact: *High elevation ecosystems with high fragility, difficult to regenerate and reverse the degradation.*
Mitigation: Specific sites for different project components should be selected in such a manner that no damage to forest and biodiversity is caused. No additional road construction should be permitted and the existing roads should be used without widening, and the transportation of machineries should be regulated with load limit. A sanctuary of at least 40 ha area should be established in the degraded areas surrounding the projects to conserve the biodiversity.

4.3.2.3 Thingbu Chu

Impact: *The proposed dam project would destroy substantial areas of land under forest and alter the river and adjoining ecosystems substantially. The identified site for the dam is highly unstable and landslide prone.*
Mitigation: Barrage construction must be avoided.

4.3.2.4 Nykcharong Chu and Rho

Impact: *The terrestrial ecosystems close to the barrage sites of both the projects have old growth broadleaved forests with high plant (Cymbidium spp.) and animal diversity (Arunachal Macaque). The construction activities may adversely impact the biodiversity and forest cover.*
Mitigation: The construction activities should be planned in such a way that no existing forests and habitats of the biodiversity are destroyed. If required, the ancillary construction activities may be relocated to save the old growth forests (e.g., colony site of Rho project).

4.3.2.5 New Melling

Impact: *The right bank of the project site at New Melling is unstable and landslide prone.*
Mitigation: Adequate measures to prevent landslide hazards should be taken.

Impact: *Substantial areas near the proposed barrage site are the habitat for the edible algae (Presiola crispa). The project would impact the survival and productivity of the species.*
Mitigation: Adequate care must be taken to minimise the disturbance to the species' habitats and E-flow should be adjusted accordingly.

4.3.2.6 Mago Chu

Impact: *Substantial areas near the proposed barrage site are the habitat for the edible algae (Prasiola crispa). The project would impact the survival and productivity of the species.*
Mitigation: Adequate care must be taken to minimise the disturbance to the species' habitats and E-flow should be adjusted accordingly.

4.3.2.7 Tawang-I

Impact: *The proposed barrage might affect the existing tourist spot Nuranang falls, particularly during construction phase.*

Mitigation: Adequate care must be taken to save this tourist place from the adverse impacts of barrage construction. The tourism interest should also be ensured during operational phase as well.

Impact: *The villagers near the powerhouse site of Tawang–I project are afraid of losing their water sources due to tunnelling and underground powerhouse construction.*

Mitigation: Drinking water sources for all the influenced villages must be ensured.

4.3.2.8 Tawang-II

Impact: *Due to high abundance of birds in this project sites, the project activities will adversely impact the bird populations.*

Mitigation: The habitats for birds must be protected. The host plant species should be planted under various afforestation programmes, and artificial nest boxes must be installed in sufficient number as described in Section–VII. Although these measures are common to all the projects, Tawang–II project must make extra efforts in this regard in view of high abundance of birds.

4.3.2.9 Nyamjang Chu

Impact: *Possible submergence of pastureland near the barrage site might threaten the livelihood of pastoralist community.*

Mitigation: The design of the barrage should be so adjusted that the pastureland does not come in the submergence zone. If it is unavoidable, an appropriate land must be procured in consultation with the pastoral communities of Zimithang village and provided to them. In addition, adequate compensation must be paid to them to neutralise this impact.

Impact: *A Hippophae stand which is rare in distribution in Arunachal Pradesh would be destroyed at the barrage site.*

Mitigation: At least 10 ha of *Hippophae rhamnoides* must be planted to compensate this loss.

Impact: *The catchment area of Taksang chu in Panchen valley is rich in biodiversity/wildlife. If water from this tributary of Nyamjang chu is diverted, the availability of water for the wildlife could be crucial. Any disturbance to the catchment could affect the wildlife populations adversely.*

Mitigation: Taksang chu should be allowed to flow freely.

Impact: *Disturbing the lateral flow could affect the aquatic biodiversity in the downstream region which is critical for the livelihood of the people.*

Mitigation: A number of villages in the downstream region of proposed Nyamjang chu barrage are dependent on river for fish. Therefore, adequate waterflow must be ensured for this downstream region. The lateral flow from 18 stream/streamlets must be allowed naturally. This would also help in maintaining the biodiversity in the downstream areas.

Impact: *The proposed barrage site is close to the wintering habitat of the threatened black–necked crane. Therefore, it is very important to strictly adopt some mitigation measures for the protection of its wintering ground to ensure the long term survival of this endangered species.*

Mitigation: The project proponent should take several mitigation measures to protect the habitat of the threatened bird. This should include a wide range of measures ranging from maintaining prescribed E–flow, restricting the construction activities during winter months and minimising the noise pollution. A detailed study on black-necked crane habitat requirement vis-a-vis E-flow at Nyamjang Chu project barrage site should be undertaken by a competent national level institution such as WII, SACON or BNHS.

SECTION–III

CUMULATIVE IMPACT ASSESSMENT

SUMMARY

The analysis of cumulative impacts at river basin level is important. In addition to the direct major impacts, significant environmental changes occur owing to accumulation of seemingly minor impacts over time and space. The cumulative impact could be linear, additive and synergistic depending upon the nature of the proposed project activities, future and past actions, and their interactions. External environmental drivers and risk factors have additional aggravating impacts on the river basin.

In the process of assessing the cumulative impacts of the proposed 13 hydel power projects and related developmental activities on TRB, a holistic analysis approach was undertaken to characterize the potential impacts on ecosystems, and Valued Environmental and Social Components (VECs). Subject-specific expertise, past experiences and examples from case studies, available literature and tools on the subject, extensive consultations with the stakeholders, and intensive field works were used to prepare this report, and arrive at an acceptable conclusion.

Two approaches viz., basin and project level approaches, were used to achieve strategic assessment of the cumulative impacts on TRB. Basin level cumulative impact analysis resulted in identification of the resources/attributes of the VECs most severely impacted and the corresponding impacts. This should be useful to address the impacts/issues at appropriate strategic level of implementation.
CIA index for each project was developed using 33 identified aspects under 6 selected VECs. The index was used to assess the relative contribution of the individual project to the cumulative impacts at basin level (Table III. 0.1).

Table III. 0.1: Environmental effects of different projects

	Projects	Thingbu chu	New Melling	Mago chu	Nykcharong chu	Rho	Tsa chu-I	Tsa chu-I Lower	Tsa chu-II	Tawang-I	Tawang-II	Nyamjang chu	Jaswantgarh	Paikangrong chu
	Aspects/Projects	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
1	Ecosystem structure, function and services	1.21	1	0.8	0.93	0.66	0.86	0.63	0.63	0.74	0.64	0.74	0.62	0.56
2	Biodiversity	0.96	0.68	1.02	0.48	1.04	0.85	1.24	0.67	0.91	0.53	0.77	0.62	0.24
3	Ecosystem vulnerability	0.94	0.93	0.86	0.94	1.06	0.8	0.8	0.91	1.06	0.91	0.4	0.2	0.2
4	Hydrology	1.62	1.19	1.27	0.65	0.62	1.2	0.75	0.59	0.77	0.59	0.75	0	0
5	Culture and livelihood	0.47	0.41	0.41	0.5	1.17	1.47	0.47	0.47	1.14	1.14	1.41	0.47	0.47
6	Dependency on natural resources	1.01	0.73	0.73	0.73	0.87	1.16	0.58	0.58	1.02	0.87	0.87	0	0.87
	SCIA	**1.03**	**0.82**	**0.85**	**0.71**	**0.9**	**1.06**	**0.74**	**0.64**	**0.94**	**0.78**	**0.82**	**0.32**	**0.39**

At the end, indicators for effective monitoring have been developed, and mitigation measures for minimizing and potentially eliminating the cumulative impacts have been suggested. The stakeholders were engaged at each level of the CIA process and the details of engagement have been presented.

1.1 INTRODUCTION

Environmental impact of a project or cumulative impact of a group of projects refers to any change that the project(s) may cause in the environment. This includes the change(s) on health and socio–economic conditions, on physical, biological and cultural heritage, on the current use of lands and resources for traditional purposes by local inhabitants, or any structure, site or thing that is of historical, archaeological, paleontological or architectural significance (European Commission, 1999). Cumulative impacts are the product of combined, incremental or sub-sequential effect of actions associated with planned/unplanned developmental activities in combination with existing, past or future conditions/activity in a spatially defined area which allows the effects to interact/multiply and affect the ecosystem structural and functional balance. The impact assessment also includes the trans–boundary concerns if applicable.

Thus, CIA is done to understand the incremental effects resulting from the combined influences of various projects, and to ensure their mitigation. These incremental effects may be significant even the effects of each project when independently assessed are insignificant. Thus, cumulative impacts occur when the individual effects of many projects are combined over time and/or space. Most often they have a combined impact greater than the individual projects added together i.e., synergetic impact is greater than the additive impact. Cumulative impacts involve relationships between discrete actions. Because many of these relationships are complex and hard to identify and visualize, they are often over–looked.

1.2 NEED FOR THE CIA STUDY

The CIA study is a prime requirement in assessment of effect of a development activity that may imbalance the environment, and as such is expected to answer the following questions:

- Baseline studies–What are the relevant aspects of the environment and the environmental characteristics of areas likely to be significantly affected, and any existing environmental problems?
- Effect on ecosystems, biodiversity, population, human health, flora, fauna, soil, water, air, climatic factors, material assets, cultural heritage, and landscape -How significant it will be at a cumulative level?
- Mitigation measures-What mitigation measures can be envisaged to prevent and reduce the environmental effects?

1.3 TYPES OF CUMULATIVE IMPACT

Impact evaluation may be divided into three types' viz., indirect impacts, cumulative impacts and impact interactions (Box III. 1.1). Most of the literature available on the subject classifies indirect impacts and impact interactions as components of cumulative impacts (European Commission, 1999).

Box III 1.1: Components of cumulative impacts

Indirect impacts:
Impacts on the environment which are not a direct result of the project, often produced away from or as a result of a complex pathway, sometimes referred to as second or third level impacts or secondary impacts. For example, a development activity that changes the water Table and thus affects a nearby wetland.

Impact interactions:
The reactions between the impacts that include (i) between the impacts of just one project, (ii) between the impacts of other projects in the area e.g., two major developments being constructed adjacent to one another and during the overlapping time periods will have many interactive impacts, from land use issues to construction and operational noise.

Cumulative impacts:
Impacts that result from incremental changes caused by other past, present or reasonably foreseeable actions together with the project. For example, (i) incremental noise from a number of separate developments, (ii) combined effect of individual impacts e.g., noise, dust and visual from one development on a particular receptor, (iii) several developments with insignificant impacts individually but which together have a cumulative effect.

Cumulative impact can be studied at two levels. The first is the cumulative impact of the impacts arising from multiple project activities (Figure III. 1.1a). The second level is the impacts arising out of multiple impacts from a single project (Figure III. 1.1b).

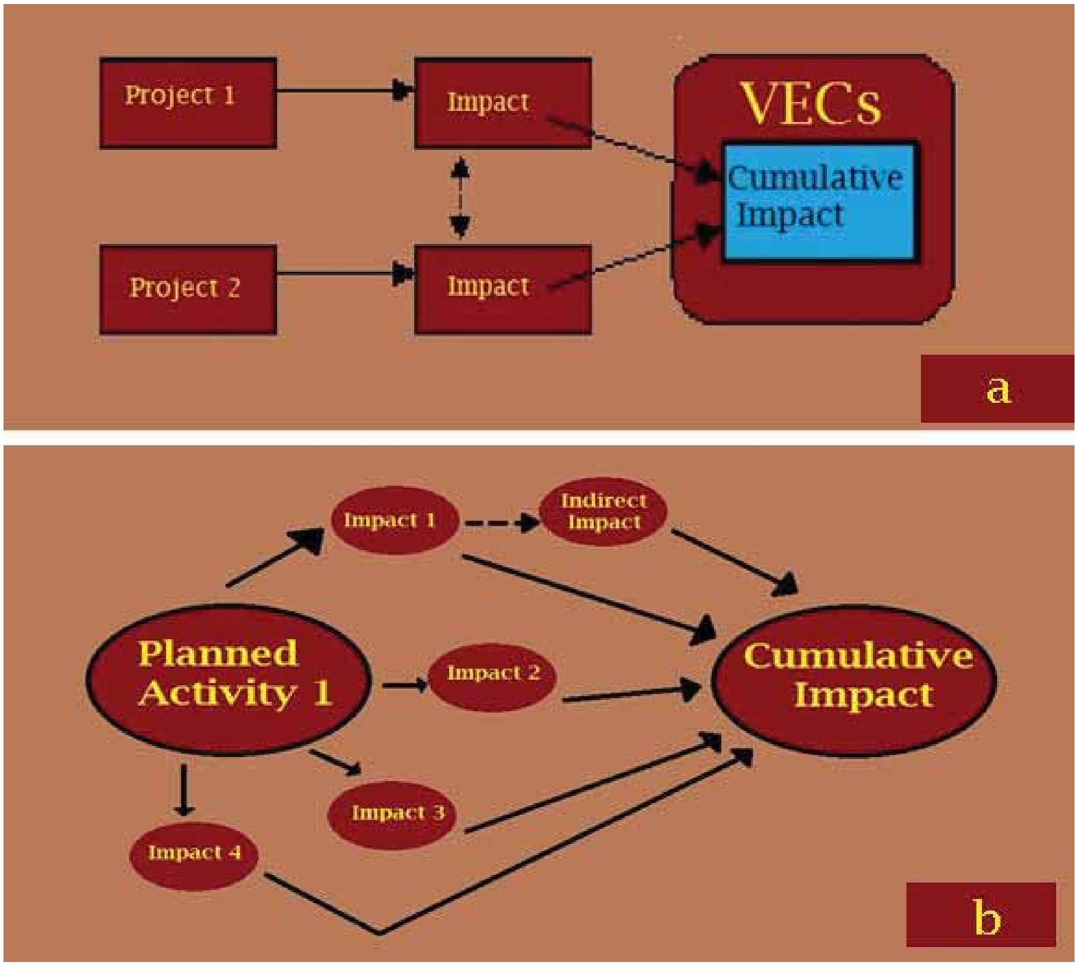


Figure III 1.1: Demonstration of cumulative impact due to multiple projects and multiple impacts

Cumulative impacts can occur in various ways. The cumulative impacts could be positive as well as negative. Table III 1.1 summarizes the types and characteristics of cumulative environmental impacts (Adapted from Council on Environmental Quality, 1997 of the US).

Table III. 1.1: Type of cumulative impact and main characteristics with examples in TRB

Type	Main characteristics	Example in TRB
Time crowding	Frequent and repetitive effects on an environmental system	Repeated Coliform introduction through waste disposal and sewage owing to increased population pressure and activities.
Time lags	Delayed effects	Sediment trapping at successive barrages leading to impairment of river system in long run
Space crowding	High spatial density of effects on environmental system	Pollution and sewage discharges into streams from more than one source on same river system
Cross-boundary	Effects occur beyond the influence zone of individual project	Loss in ecosystem services in basin area viz., water table lowering and reduced capacity of carbon sequestration
Cross-border	Effect of the projects on the river stretch beyond international boundary	Dam break and flash floods in TRB would impact the downstream region in Bhutan. Such events in the upstream region of the basin i.e., in China would impact the downstream regions i.e., Tawang Basin in India
Fragmentation	Change in landscape and waterscape pattern	Forest fragmentation due to deforestation and river fragmentation due to barrage construction
Compounding effects	Effects arising from multiple sources or pathways	Decrease in river primary productivity due to synergy in altered biogeochemical cycle and species composition in river ecosystem
Indirect effects	Secondary effects	Social infrastructure development
Triggers and thresholds	Fundamental changes in system behaviour or structure	Global warming owing to increase in carbon pool due to deforestation

1.4 FRAMEWORK FOR ASSESSMENT APPROACH

A framework for assessing cumulative impacts identifies the major issues that require consideration in a CIA process. In order to effectively assess cumulative impacts, each component of the framework must be populated with the relevant data or information. An ecosystem can respond to stressors in different ways at varying levels of intensity, depending on what has happened in the past, what is happening now, and what will happen in the future. These interactions occur within an ecological setting that has its own natural bio–physical attributes, and the impacts need to be considered within that context.

1.5 TECHNICAL CHALLENGES IN CARRYING OUT CIA

There are several technical challenges associated with CIA both as applied to project level assessments and plan/programme level assessments. These challenges have been listed in Table III 1.2 (adapted from ODPM, 2002 and Environment Agency, 2003b**)**.

Table III 1.2: Technical challenges faced at different stages during CIA (adapted from ODPM, 2002 and Environment Agency, 2003b)

CIA Stage	Challenges
Screening (does the plan/programme require CIA)	Will the plan/programme require CIA? The cumulative nature of the impacts of a plan or programme may help to define whether an impact is considered significant. Therefore, when assessing the significance of the plan or programme, CIA may become important.
Identify other plans/programmes, objectives and problems	How far can analysts go in looking at the combined effect of their plan/programme with other plans/programmes?
Select the baseline including forward and back casting (data on trends)	How can trends in the baseline environment be identified? How can the effects of future issues such as climate change be built into the assessment? What will the environment be like in 20-30 years time if the plan/programme is not implemented?
Scoping	To what extent should cumulative effects inform the setting of objectives? How should the temporal and spatial boundaries of the assessment be chosen? Which aspects of the environment need to be looked at? If cumulative effects are likely to be important, more aspects of the environment may need to be analysed than is first apparent.
Option and policy identification and assessment	How can analysts ensure that indicators are sufficiently focused to be able to identify and assess cumulative effects? Outcome focused indicators are likely to identify more impacts than action focused indicators. How can the relative contribution made by particular actions be judged, recognising that the last action although small may be sufficient to breach an environmental threshold?
Impact assessment	What tools can be used to judge the magnitude and significance of cumulative and synergistic impacts and hence the significance of multiple impacts?
Mitigation	How can the different parties' responsibility for mitigation be identified? Should mitigation aim to offset the effects of the plan/programme or aim to seek environmental enhancement?
Consultation	How can input from other interested parties be assured?
Monitoring	How practical is it to define monitoring programmes to address cumulative effects? Is state of the environment reporting adequate?

1.6 CIA IN INDIAN CONTEXT

In India, till date the clearance to the projects was mostly single project approach. When environmental, social and economic impacts of developmental projects are evaluated, the effects are typically examined individually and in response to a specific proposed action. Unfortunately, this approach to evaluation – one action at a time – can overlook important cumulative impacts. Both informed decision making and adequate protection of people, communities, and the environment are undermined when cumulative impacts are ignored. Actions may also be linked when they are seemingly small and independent of each other but have an impact on the same resource or linked set of resources (for example, when fish habitat silts up due to runoff from many small, unrelated upstream construction sites or logging operations). While individual impacts may appear modest or inconsequential, over time and in combination with other impacts, they can significantly degrade the natural and human environment. Total impact is often greater than the sum of the parts. This realization has led to the introduction of the practice of CIA in India very recently, although it is yet to be a part of the mandatory policy framework such as EIA notification, 2006.

1.7 CIA STUDY IN TAWANG RIVER BASIN

The need of a comprehensive study to assess the cumulative impact of proposed 13 HEPs in TRB was felt by the Forest Clearance Committee of Ministry of Environment and Forests, Government of India, while considering the forest clearance for Tawang-I and Tawang-II HEPs. The Government of Arunachal Pradesh was asked to conduct the study. The Government of Arunachal Pradesh assigned the study to North-Eastern Hill University, Shillong. The study was started on 1st June, 2013 and took a holistic approach to assess the CIA. In recognition that there is not one single prescriptive method to conduct a CIA, the present study used a combination of tools and techniques for different steps of CIA. The objectives of the present CIA are:

1. To determine if the combined impacts of the projects, other projects and activities, and natural environmental drivers in TRB will result in VEC condition that may put the sustainability of VEC at risk i.e., might exceed the threshold for VEC conditions.

2. To determine the management measures to be implemented in TRB to prevent unacceptable VEC conditions. This may include additional mitigation of the project(s) being assessed or other regional management strategies that could maintain VEC conditions within acceptable limits.

2.1 INTRODUCTION

The present assessment of cumulative impacts intends to have a broadened perspective on the nature of human-environment interactions. This perspective acknowledges that:

- Environmental change originates not only from single projects but also from interactions of all the 13 proposed and existing 6 micro-hydel projects. These interactions need to be considered in planning to ensure that environmental limits are not breached.
- Environmental change accumulates through additive or interactive processes. The impact of two actions on the environment can be complex and may result in environmental degradation that is worse than originally thought because of interactions between projects. These can be chemical, biological or physical interactions (Wood *et al*., 1997).

2.2 APPROACH TO CIA

The present CIA process involved (a) analysis and quantification of potential impact and risks essentially inherent with social, anthropogenic and economic drivers associated with proposed developmental activities due to upcoming HEPs *vis-a-vis* the sustenance/sustainability of the ecosystem structure and function, and (b) providing measures to mitigate, substantially reduce or completely avoid the impacts and risks involved with developmental activities.

2.3 CIA FRAMEWORK

The study adapted the CIA framework described in European Commission (1999) and Canadian Environmental Assessment Agency (1998) and combined the framework which is listed in Table 1.

Table III 2.1: CIA frameworks

Steps	Tasks
Scoping	• Identify regional issues of concern • Select appropriate regional VECs • Identify spatial and temporal boundaries • Identify other actions that may affect the same VECs • Identify potential impacts due to actions and possible effects • Consideration of alternatives
Collection of baseline and assessment of impacts	• Complete the collection of regional baseline data • Assess effects of proposed action on selected VECs • Assess effects of all selected actions on selected VECs
Identification and development of mitigation measures	• Recommend mitigation measures • Impact shifts
Evaluation of Significance	• Evaluate the significance of residual effects • Compare results against thresholds or land use objectives and trends
Monitoring and evaluation	• Monitoring of cumulative impact using identified indicators

2.4 STEPS IN CIA

In the present study, seven steps as described below were followed:

Step I	**Scoping Phase I** *Tasks* 1. Identification of VECs, 2. Identification of the spatial boundaries of the CIA 3. Identification of temporal extent of the CIA
Step II	**Scoping Phase II** *Tasks* 1. Identification of other existing and predictable/potential projects and human activities that would affect the VECs 2. Identification of natural environmental drivers that also impact the conditions of VECs
Step III	**Establishment of baseline status of VECs** *Tasks* 1. Generation of baseline data for VECs and assessment of impacts of other activities and natural drivers on the condition of the VECs 2. Establishment/estimation of trends in VEC condition 3. Establishment/estimation of thresholds for VEC conditions

Step IV	**Assessment of cumulative impacts on VECs** *Tasks* 1. Establishment of indicators for expression of VEC condition 2. Estimation of future baseline for condition of the VECs 3. Estimation of the project impact on VEC condition (after including the planned mitigation). 4. Estimation of the cumulative impact on VECs
Step V	**Assessment of significance of anticipated cumulative impact** *Tasks* 1. Assessment of the significance of the foreseen impact on the VECs
Step VI	**Management of cumulative impacts -design and implementation** *Tasks* 2. Identification of additional project mitigation for individual projects (beyond those identified in the respective EIA reports) 3. Identification of additional mitigation measures for other existing or future projects. 4. Identification of other strategies and activities that could maintain VECs at acceptable conditions. 5. Contributing to a multi-stakeholder collaborative approach for the implementation of management actions that are beyond the capacity of a single project proponent.
Step VII	**Stakeholder engagement** *Tasks* 1. Engagement of all the stakeholders early in the process i.e., in scoping and continue throughout the CIA process. 2. Engagement of stakeholders to clarify their roles and responsibilities in CIA process. CIA being essentially a multiparty involvement process, a collective responsibility and maintaining a constructive relationship with all the stakeholders was essential.

2.5 DESCRIPTION OF THE TASKS

2.5.1 Screening

Screening involves determining whether there is a requirement to undertake CIA of a plan or programme and whether CIA is required as a part of this. Where certain plans or programmes are likely to give rise to significant effects then they are subjected to a CIA. Such effects should include consideration of their cumulative effects.

The cumulative nature of impacts becomes important in the screening process itself. The cumulative nature of the impacts is one criterion that can be used to judge their significance and whether the plan or programme should be subject to the CIA. The projects in TRB have already been screened for CIA by the Forest Clearance Committee of Ministry of Environment and Forests, Government of India.

2.5.2 Scoping

Scoping has two purposes. Firstly it helps identify appropriate boundaries and issues of concern on which to focus an assessment. Secondly it ensures that data collection and assessment is limited to only those issues required to address the impacts (Kingsley, 1997). There is further complexity when assessing cumulative effects because it is important to avoid assessing more than necessary. This can be difficult because the scope of a CIA can be very wide.

2.5.2.1 Identification of VECs

Cumulative impacts as such are practically immeasurable and thus need to be broken up in components which are discrete and indicate the general health of the ecosystem. For this purpose, cumulative impacts are measured as potential impact to VECs. VECs are the attributes of an environment and encompass the bio-physical-social components forming the backbone of an environment. Thus, their assessment and management go a long way in Impact assessment apart from being an indicator of environmental health.

An examination of cumulative impacts requires the considerations of impacts on both valued environment and community resources. It is not possible to assess the plan or programme's impact on every receptor. Therefore, it is necessary to define those resources that are particularly valued by the community or vital to the healthy functioning of the environment.

The characterization and attributes of VECs in the present study were:

- physical features, habitats, wildlife populations (e.g., biodiversity),
- ecosystem services,
- natural processes (e.g., water and nutrient cycles, microclimate),

- social conditions (e.g., health, economics), or
- Cultural aspects (e.g., traditional spiritual ceremonies).

2.5.2.2 Identification of Potential Issues and Problems
Identifying potential cumulative impacts of plans and programmes requires taking account of natural dynamics and the current state of a natural system. Several mechanisms for undertaking an initial review are in practice. In this study, a questionnaire and checklist approach was followed that involved identifying which issues are important and documenting how they are selected for further technical analysis. It is important within CIA to identify problems in terms of those environmental components that are in decline and are near to their threshold. These environmental components may not be able to cope with the multiple stresses of the cumulative effects of different plans and programmes.

2.5.2.3 Establish Spatial Boundaries
The setting of spatial boundaries involves finding a balance between the constraints of time, budget and data availability, and the need to adequately address environmental effects that could extend for considerable distances away and into the future. Establishing spatial boundaries includes both an examination of the effects resulting from the plan or programme and spatial boundaries of the valued resources.

2.5.2.4 Establish Temporal Boundaries
Cumulative effects need to be considered in terms of a specified time period. *How far back in time* and *how far ahead in time* the assessment considers is dependent upon the environmental and community resource. It is also dependent upon the time frames of the effects any individual actions/policies within a plan or programme. Different actions and policies within a plan/programme may be implemented over different time scales or the effects may become apparent over different time scales. This needs to be addressed within scoping whilst recognizing that uncertainties increase with projections further into the future.

2.5.2.5 Identification of Past, Present and Reasonably Foreseeable Future Actions
To identify cumulative effects, there is a need to consider the state of the environment, past and likely future environmental trends, and the valued qualities that are being actively managed. Identifying past, present and future activities can often be difficult, as empirical evidences are scarce. However, the assessment should only concentrate on those impacts that have had a major influence on future quality of the resource.

2.5.3 Evaluating significance
The assessment of the significance of the interaction impacts was based on the significance criteria used when considering the direct impacts. The significance was based on the degree of change (intensity of impact), duration of the impact, and the spatial extension of the impact. The study considered the cumulative impact as significant when the impact on VEC condition approaches or exceeds a threshold.

2.5.4 Mitigation and enhancement
Mitigation of environmental impacts is vital to meet the objective of providing for a high level of protection of the environment. The CIA should provide information on the measures envisaged to prevent, reduce and as fully as possible offset any significant adverse effects on the environment of implementing the projects.

2.5.5 Monitoring of Cumulative Impacts
Monitoring helps to ensure that impact predictions were accurate and that mitigation methods are implemented as required. Monitoring should be carried out using the indicators that the plan or programme was measured against and that this should take account of cumulative effects as well as direct effects. A n in depth knowledge of cause and effect pathways is required in order to

determine the elements of the plan/programme that are having an undesirable effect. The plan or programme may also be operating against a background of general environmental degradation/improvement or may be producing unforeseen interactions with other plans and programmes (both key issues in CIA). Therefore, it is difficult to separate out the effects of one plan/programme with another and the effects of plans/programmes against general environmental trends.

2.6 DESCRIPTION OF TOOLS AND METHODS (AFTER COUNCIL OF ENVIRONMENTAL QUALITY, 1997)

2.6.1 Checklists

Checklists help to identify the potential environmental effects by providing a list of common or likely effects. Checklists are especially valuable for analysing cumulative effects because they provide a format for juxtaposing multiple actions and resources in a way that highlights potential and cumulative effects. Checklists are potentially dangerous for the analyst who uses them as a shortcut to thorough scoping.

The strength of checklists is that they structure the analysis and reduce the likelihood that major effects will be overlooked; however, checklists are incomplete, they may cause important effects to be omitted. Because of the standard checklist format, checklists are more repeatable than ad hoc methods. They also provide a means of concisely presenting effects. At the same time, the simplicity of the checklist format has disadvantages. A checklist may be either an incomplete compilation of effects or a huge unwieldy list with many irrelevant effects. In an attempt to be comprehensive, the checklist may also lead to 'double counting' the same effect under different headings.

Many of these disadvantages are avoided by developing checklists for specific kinds of projects. Checklists can also be simplified by organizing potential effects into separate lists or hierarchical categories for each resource, ecosystem, and human community of concern. To address cumulative effects, checklists need to incorporate all of the activities associated with the proposed action, and other past, present, and future actions affecting the resources. A promising approach is to use project-specific checklists (for each relevant past, present, and future action) to identify and quantify effects on resources and then transfer these effects to a cumulative checklist or interaction matrix. Two or more effects on a single resource indicate a potential cumulative effect; weighted effects can be summed to indicate the magnitude of the effect.

2.6.2 Matrices

Matrices are two-dimensional checklists that attempt to quantify the interactions between human activities and resources or ecosystems of concern. They were designed to assess the magnitude and importance of individual interactions between activities and resources, but have been extended to consider the cumulative effects of multiple actions on resources.

Matrices alone cannot quantify effects, but they are a useful means of presenting and manipulating quantitative results of modelling, mapping, and subjective techniques. Once even relatively complex numerical data are obtained, matrices are well-suited to combining the values in individual cells in the matrix (through matrix algebra) to evaluate the cumulative effects of multiple actions on individual resources, ecosystems, and human communities. Matrices have the advantage of being mathematically straightforward and readily amenable to interpretation because of their familiar tabular format.

The values entered in a matrix can take one of several forms. The analyst may elect to simply note the presence or absence of an effect (i.e., a binary entry). This has the benefit of being straightforward and readily understandable; however, it fails to note of the magnitude of effects on various resources, and does not allow the user to value resources differentially (e.g., through the use of numeric weights). Thus, a binary approach does not facilitate analysing the cumulative effects on a resource, where the activities have consequences of varying degrees.

Analysts may instead choose to score effects based on factors such as magnitude, importance, duration, probability of occurrence, or feasibility of mitigation. The value entered may reflect some measurable value (e.g., soil loss may be expressed in tons/acre/year), or it may reflect some relative ranking of the effect. Although complex weighting schemes allow the user to rank resource effects, the results may be difficult for others to understand, and the weighting schemes can be highly subjective. When using weighting schemes, analysts should enunciate the ranking criteria and consider whether it is scientifically reasonable to attempt a numeric comparison of cumulative effects on different resources.

The matrix concept can be extended to include stepped matrices that display resources against other resources. Stepped matrices address secondary and tertiary effects of initiating actions and facilitate tracing effects through the environment.

2.6.3 Networks and system diagrams

Networks and system diagrams relate the components of an environment or social system in a chain (network) or web (loop or system diagram) of causality and allow the user to trace cause and effect through a series of potential links. They allow the user to analyse the multiple, subsidiary effects of various actions and trace indirect effects on resources stemming from direct effects on other resources. In this way, the accumulation of multiple effects on individual resources, ecosystems, and human communities can be determined. Networks and system diagrams are often the analyst's best method for identifying the cause-and-effect relationships that result in cumulative effects.

Networks, loops, and system diagrams improve on the stepped matrix approach to illustrating the relationship among actions, effects, and environmental or socioeconomic conditions by using component boxes (or symbols) and linkage arrows (denoting processes). Networks and system diagrams concisely illustrate interactions among variables and secondary effects. Cumulative effects are identified whenever multiple sources affect the same resource, or when multiple effects of the same source affect a resource (via indirect pathways through other resource components). When quantitative measures are included, effects and their interactions can be evaluated using a common unit of measurement (usually energy flow). The use of a common scale distinguishes networks and system diagrams from other cumulative effects analysis methods but requires evaluating different classes of effects separately (e.g., ecological versus social impacts).

By definition, network analysis proceeds in only one direction (forward), whereas loops or system diagrams allow feedback of information output by one part of the system to any other part of the system. Networks also assume a strict hierarchical linkage among system variables and are thus not capable of showing all relationships among variables. In contrast, system diagrams are specifically designed to illustrate the interrelationships (and process pathways) among all components and thus are more realistic. The lack of an appropriate unit of measure for all system compartments can limit the analyst's ability to quantify system diagrams, but some success has been obtained by using the flow of water or energy flow as common units of measure.

Expert systems can be used to implement network analysis. Expert systems are simply sets of logical rules that mirror the analysis process of an expert in some field. To identify cumulative effects, an expert system would (1) query the analyst about additional activities that might affect the resource in question and (2) carry the predicted effects through known causal links to reveal additional secondary effects on each resource. The line of questioning will take different courses, depending on the user's answers to question along the way. The program used to work its way through the questions and answers is called an inference engine.

2.7 TOOLS AND METHODS USED IN CIA OF TAWANG RIVER BASIN

A combination of tools and methods such as checklists, matrices, network and system analysis, consultations, modelling, GIS spatial and overlaying analysis, and expert opinion were used to complete the CIA. The framework/task-specific tools and methods used in the present study are listed in Table III 2.2.

Table III. 2.2: Tools used in CIA of TRB

Assessment framework	Events	Tools used
Scoping	Identification of VECs, determination of spatial and temporal boundaries,	Expert opinion, matrices, network and systems analysis, consultations, questionnaires, checklists, spatial analysis
Collection of baseline and assessment of Impacts	Baseline/current status of VECs, identification of all developmental activities affecting VECs, assessing cumulative impacts on VECs future	Checklists, consultations, mapping overlay (GIS), network and systems analysis, expert opinion, modelling
Identification of mitigation	Mitigation measures and monitoring mechanism	Expert opinion
Evaluation of significance	Evaluate the significance of residual effects and compare results against threshold	Expert opinion, matrices, modelling, carrying capacity analysis

Some of the tools and methods used to assess the CIA for specific tasks are listed in Table III 2.3.

Table III. 2.3: Tools and methods used to assess cumulative impact pertaining to certain VECs/attributes/indicators

Tool	Examples of tasks/VECs/attributes/indicators
Impact models	Detailed assessment of cause-effect relationships between reduced flow due to project implementation and valued resources.
Spatial analysis using GIS and geospatial modelling	Quantifying land use changes, and invasiveness due to implementation of the project
Landscape level indicators of change	Providing numerical values that represent large-scale disturbances or change
Numerical modelling	Quantifying physical-chemical constituents (e.g., water quality) to determine the minimum threshold

2.8 FORECASTING CIA

A wide variety of methods are used for CIA analysis. Methods are chosen based on the information available for the analysis. In the present study, quantitative estimates of cumulative impact were undertaken through developing a social development index (SDI) for each affected/impacted village and a CIA index to assess the relative contribution of each proposed project to the cumulative impact (additive) on the river basin.

2.8.1 Socio-Economic Development Index (SDI)

Index of Socio-Economic Status of Sample Villages in the Influence Zone

Data have been collected/compiled on the socio-economic characteristics of 46 villages in the influence zone of various projects. These villages form a sample for assessment of the envisaged effects of the projects that would affect the socio-economic conditions of the people. From these villages the following data have been collected/compiled.

1. Land-use at the village level: (i) Area under forest cover, (ii) Area under agriculture, (ii) Area under horticulture, (iv) Habitation & HG
2. Use of private land for different purposes: Information on different uses of private land in the villages, viz. (i) Total private land holding, (ii) Private land under forest cover, (iii) Private land under agriculture, (iv) Private land under horticulture, (v) Private land under habitation & HG have been collected.
3. No. of households (HHs), sex ratio and literacy in the village: Information on (i) No. of HHs, (ii) sex ratio and (iii) male/female/total literacy rate in the village have been collected.
4. Livestock and value of livestock: Information on various types of livestock, viz. (i) Mithun, (ii) Cattle, (iii) Goat, (iv) sheep, (v) Poultry, (vi) Yak, (vii) Pig, (viii) Pony, and (ix) other livestock, and value of the livestock for each particular have been collected.

5. Average annual earning (at the village level, in Rs. lakh): (i) Animal husbandry, (ii) Horticulture, (iii) Traditional skills, (iv) Daily wages, (v) GS, (vi) Other sources, (vii) Average family income
6. Average annual expenditure at the family level (at the village level): (i) Expenditure on food and drinks, (ii) clothing, (iii) Transport, (iv) Education and health, (v) Total expenditure
7. Use of water, purpose-wise and source wise. Five sources of water viz. river, hill stream/spring, well, pond and tap, each for four purposes, viz. drinking, domestic, livestock and agriculture have been collected.
8. Amenities in the village: Information on availability of twelve amenities in the villages have been collected. Those twelve amenities are: (i) Road connectivity, (ii) Health facility (PHC/sub-centre), (iii) Traditional health healer, (iv) Veterinary services, (v) Electricity, (vi) Fair price shop, (vii) Grocery shop, (viii) Post office, (ix) Bank branch, (x) School, (xi) Telephone/Mobile, and (xii) TV/Radios.
9. Social institutions in the village: Information on presence of social institutions in the village such as (i) Self Help Groups (SHGs), (ii) Aanganwadis, (iii) Community hall, (iv) Gompa, and (v) Any other have been collected.
10. Occupation profile of the people in the village: Information on (i) Population size, (ii) No. of workers, (iii) No. of main workers, (iv) No. of marginal workers, and (v) No. of non-workers each according to gender (male female and total) have been collected.

Construction of Composite Index of Socio-economic Status

At the first stage, from the (village level) information as detailed out above, the following indicator variables have been constructed:

(i) Percentage area under forest, (ii) Percentage area under agriculture, (iii) Percentage area under horticulture, (iv) Percentage area under habitation, (v) Private land holding per HH, (vi) Male literacy, (vii) Female literacy, (viii) Value of livestock, (ix) Earning from agriculture, (x) Earning from livestock, (xi) Earning from wages (xii) Earning traditional skills, (xii) Earning from GS, (xiv) Earning from other sources, (xv) Expenditure on food, drinks and clothing, (xvi) Expenditure on transport, (xvii) Expenditure on education, (xviii) Expenditure on health, (xix) Ratio of expenditure to income, (xx) Index of availability of water for different uses, (xxi) Index of amenities available in the village, (xxii) Index of presence of social institutions in the village, and (xxiii) Weighted economic dependency ratio. Of these indicators, the first nineteen are self-explanatory. However, the subsequent ones need some elaboration.

The index of availability of water from different uses is a weighted sum of 20 (five different sources and four different uses of water, explained in 7 above) variables available for the sample villages. The weights have been obtained by the principal component analysis. It is well known that such an index obtained by weighted sum of individual variables provides the factor score for individual cases (villages) that has the highest possible correlation with the constituent variables (or alternatively highest explanatory power for the observed variance). Similarly, the index of amenities available in the village is a weighted sum of 12 variables explained in 8 above, and the weights are based on the principal component analysis. In the same vein, the index of presence of social institutions in the village is a weighted sum of variables in 9 above obtained by the principal component analysis. Lastly, the weighted economic dependency ratio is a product of two different ratios: (total non-workers)/total main workers) x (main female workers/main male workers). This index summarizes the dependency ratio of no-workers on the workers weighted by the ratio of female workers to male workers.

At the second stage, the indicators (twenty three in all, as detailed out above) were subjected to the principal component analysis for the purpose of data reduction and eight leading component score thereof were retained (Table-1: PC_1 through PC_8). Together, they explain 77.1 percent of variation in the indicator variables. Subsequently, those eight principal component scores were fused into a single composite index (Table-1: Socio-Econ Index or IS) according to the formula given below:

$$IS_i = \left[\sum_{j=1}^{8} (w_j PC_j)^2\right]^{0.5} \quad ;/$$

Moreover,/

The weights assigned to different PC_j is normed to unity in proportion to the variance they explain in the indicator variables. The index values have been standardized to lie between zero and unity. Thus, the eights PCs (for 56 villages) are considered as 56 points or vectors in 8-dimensional space, with weights in proportion to the variance they explain. Then, the values of socio-economic index is the length of the vectors those points signify. For illustration, Nam-Tsering has the highest length (1.00) and Kelenteng has zero length. For the sake of interpretation, Nam-Tsering obtains the largest score and Kelenteng is at the bottom.

2.8.2 CIA Index

Project: There are 13 projects that have several effects on the environment as well as economy of the villages in the study area. In all, 33 possible effects of the projects have been taken into consideration. The effects are categorized into six types, which we would call the 'aspects' of the project effects:

1. **Ecosystem Structure, Function and Services:** Under this category of effects, the following have been considered: (i) Forest area loss/MW (Ha), (ii) Carbon stock loss/MW, (iii) Ambient air quality, (iv) Periphyton and zooplankton density, (v) NPP, (vi) Change in turbidity (NTU), (vii) Total coliforms (CFU/ml), (viii) IAS invasibility, (ix) Dependency of villagers on hill stream/spring water. In total, 9 (m_1) effects.

2. **Biodiversity:** In this category, the following effects have been considered: (i) Proportion of total plant diversity to be affected, (ii) Proportion of total bird diversity to be affected, (iii) Proportion of total mammal diversity to be affected, (iv) No. of butterfly species to be affected, (v) No. of fish species, (vi) Periphyton richness, (vii) Endemic and/or threatened plants, (viii) Endemic and/or threatened mammals, (ix) Endemic and/or threatened birds, (x) Endemic and/or threatened fish, (xi) Endemic periphyton and zooplankton. In total, 11 (m_2) effects.

3. **Ecosystem vulnerability:** Under this, three effects have been taken into consideration: (i) Soil and landslide vulnerability of impact area (%), (ii) Vulnerability of core area and (iii) Glacial lake outburst discharge. In total, 3 (m_3) effects.

4. **Hydrology:** Under this category, two aspects have been considered: (i) Ecological flow percentage, (ii) Intermediate river length per megawatt, (iii) Ecological flow (lean season in cumec). In total, 3 (m_4) effects.

5. **Cultural and Livelihood:** Under this category the following five aspects have been taken into consideration: (i) Dead body last rites, (ii) Totem worship (iii) Employment opportunities, (iv) Health risks, (v) Quality of life. In total, 5 (m_5) effects.

6. **Dependency on Natural Resources:** Under this category, the following gave been taken into consideration: (i) Forest dependency (%), (ii) Water dependency (%). In total, 2 (m_6) effects.

To compute the aspect-wise effects of the projects the following steps have been taken:

1. **Assignment of weights to the project effects:** It is considered desirable to assign weights to the project effects (E) according to the altitude of the site where the project activities will be carried out. Accordingly, the effects on ecosystem structure, functions and services (aspect-1) and biodiversity (aspect-2) have been multiplied by the exponential value of altitude (A) so that higher the altitude exponentially larger is the severity of effects. The weighted effects

may be called as $e_{ij}^{(p)} = E_{ij}^{(p)} A^{(p)}$. Here $E_{ij}^{(p)}$ is the j^{th} effect in i^{th} category/aspect expected of the p^{th} project. $A^{(p)}$ is the altitude at which the p^{th} project is located.

2. **Standardization of aspect-wise (category-wise) effects:** As it is observed, in certain categories/aspects a large no. of effects (such as 11 or 9) have been considered whereas in some others only two effects are there. It is required therefore that they are summarized so as to provide a single vector of standardized effects for each aspect category. This has been done such that $\varepsilon_{ij}^{(p)} = (e_{ij}^{(p)} / \sum_{j=1}^{m_i} e_{ij}^{(p)}) * 10$, where $e_{ij}^{(p)}$ is the jth effect (already weighted by the altitude factor) in the ith category/aspect pertaining to the p^{th} project. It may be noted that the values of m_i are different for different categories and $\varepsilon_{ij}^{(p)}$ is the standardized effect in the scale (0, 10). Following this standardization, the aspect-wise effect indices are obtained as $AWE_i^{(p)} = (1/m_i) \sum_{j=1}^{m_i} \varepsilon_{ij}^{(p)}$. This gives us the expected effects of the projects in each category (aspect).

3. **Cumulated Project Effect Index (CIA):** A weighted aggregation of all aspect-wise effects for each project provides the cumulated project effect index. That is $CIA^{(p)} = \sum_{i=1}^{M} (w_i)(AWE_i^{(p)})$; where w_i is the weight assigned to different aspects of the project effects. In our case, we have used equal weight of unity to every aspect. Moreover, $M = 6$ as we have considered six aspects of the project effects.

4. **Standardized Cumulated Project Effect Index (SCIA):** For convenience of perception the cumulated project effect index may be standardized as $SCIA^{(p)} = k(CIA^{(p)} / \sum_{p=1}^{NP} CIA^{(p)})$ where NP is the total number of projects (13 in this case) and k is a suitable non-zero constant (such as 10 or 100). On account of this standardization, the value of every cumulated project effect lies between $(0,\ k)$ and renders itself convenient for comparison and visualization.

5. **Cumulated Project Effect Index at the Sample Village Level:** Different villages in the sample are likely to be differently affected by different projects. A particular village may or may not be under the effect zone of a project, but some villages may be in the effect zone of several projects. Accordingly, the likely effects of the projects on the sample villages may be obtained as $VSCIA_i = \sum_{p=1}^{NP} \alpha_i^{(p)} SCIA^{(p)}; i = 1, 2. \ldots,\ 56$ (no. of villages) and $\alpha_i^{(p)} = 1$ if the i^{th} sample village is under the effect zone of the p^{th} project, else $\alpha_i^{(p)} = 0$ (Table III 5.13). This index may also be standardized to lie between (0,100) to facilitate comparison and visualization.

3.1 SCOPING

The scoping exercise for CIA in TRB involved the following steps:

- Identification of potential issues and problems
- Identification of VECs
- Establish spatial boundaries
- Establish temporal boundaries
- Identification of past, present and reasonably foreseeable future actions

3.1.1 Identification of Issues and Problems

1. Elevation: High elevation mountain ecosystems are extremely fragile and highly vulnerable to disasters such as earthquake, landslides, soil erosion, glacial lake outburst floods, flash floods and avalanches. Both the resistance and resilience of these ecosystems are weak because of slow decomposition rate owing to low precipitation and critically low temperature, less diverse microbial community, and poor rate of forest regeneration following deforestation. Extremely slow rate of succession takes a long time for (re)establishment as well as recovery of vegetal cover in such extreme climatic conditions.
2. Being in the higher Himalayas, the biodiversity elements are unique and diverse. The ecosystems also contain several threatened and endemic species not found elsewhere, whose conservation has become a challenge.
3. Mitigation measures for ecosystem and biodiversity conservation are often not achievable because of prevailing environmental, institutional and social constraints.
4. The rivers in TRB though perennial, the discharge volume is limited. Therefore, any use of water resource threatens the minimum level of flow required to maintain the ecosystem structure, function, services and dynamics.
5. The population of TRB is 49,977 persons. Any influx would imbalance the social, political and demographic character of the ethnic population.
6. Most of the forest cover in TRB is primary old growth forests contributing as a major carbon sink, and the forest cover contributes substantially to the national forest cover. Loss of forest cover owing to various developmental activities has become a major issue of concern during the recent times.
7. Himalayas being the regulator of the global climatic conditions and given the current level of multifarious stresses originating from various developmental activities could severely handicap or potentially degrade it.
8. Because of the remoteness, mountainous terrain, resource scarcity (particularly availability of arable lands), and lack of livelihood opportunities, the socio-economic conditions of the people of TRB continues to deteriorate.
9. There are several threatened and endemic floral and faunal elements, having global importance for which species-specific conservation measures need to be ensured.

3.1.2 Identification of VECs

The scoping of VECs was undertaken by selecting a few VECs/components out of a list of several possible components. The process involved the following steps:

1. In the first step, a list of all the potentially impacted components/VECs impacted by HEPs was prepared (Box III 3.1).
2. In the second step, the effects of proposed actions and possible mitigation measures were evaluated and ranked after several steps of discussions and consultations.
3. In the next step, the effects of other (besides proposed project activities) past, present and reasonably foreseeable future actions on the VECs/components were added and ranked.

4. Finally, the severity of cumulative impacts on identified components was generated through combined ranking, and accordingly the VECs were prioritized for assessment of cumulative impacts (Table III 3.1).

Box III 3.1: List of potentially impacted physical, biological and social environmental parameters considered for scoping.	
Physical Environment	
Air	• Changes in ambient levels and ground level concentrations due to emission from point, line and area sources. • Effect on soils, materials, vegetation, and human health. • Impact of emissions from DG sets used for power generation during construction phase, on the vegetation and air environment
Noise	• Changes in ambient noise levels due to different sources. • Effect on fauna and human health.
Geomorphology	• Slope destabilization due to construction of barrage, powerhouse and ancilliary infrastructure.
Soil	• WHC, Bulk density, Porosity, SMC, pH, Conductivity, NH_{4+}–N, NO_3–N, TKN, Available phosphorous, Total phosphorous, SOC, Ex. K, Ex. Mg, Ex. Ca, Soil microbial biomass–C, Soil microbial biomass–N, Fish diversity, Periphyton richness, Soil faunal density, Soil erosion
Water	• Changes in water quality: Temperature, Turbidity, pH, Electrical Conductivity, Total dissolved solids, Practical salinity, Total alkalinity, Total hardness, Chloride, Ca_2^+, Mg_2^+, K^+, Na^+, TKN, NH_4^+ N, NO_3–N, Total phosphorus, Dissolved oxygen, Total Coliforms • Impact on fish fauna • Impact of sewage disposal • NPP
Land use/land cover	• Changes in land use and drainage pattern. • Changes in land quality including effects of waste disposal. • River banks and their stability. • Impact due to submergence • Impact due to construction during construction phase: Forest area loss, Carbon stock loss
Biological Environment	
Ecosystem Diversity	• Habitat fragmentation and destruction due to construction activities. • Deforestation and loss of plant species. • Impact on flora due to decreased flow of water. • IAS invasion
Plants	• Impact on threatened species, endemic species, if any.
Animals	• Impact on animal species due to deforestation and land clearing • Impact on animal distribution, migration routes, if any, • Impact on fauna (including aquatic species, fish) due to decreased flow of water. • Impact on breeding and nesting grounds, if any. • Periphyton and Zooplankton density
Human Environment	
Existing development infrastructure	• Impact of increased traffic. • Downstream impact on water, land and human environment due to drying up of the river at least 10 km downstream of the barrage(s).
Socio–economic profile	• Impact on the local community including demographic changes. • Impact on economic status. • Impact on human health. • Positive as well as negative impacts likely to be accrued due to the proposed HEPs and ancillary activities are to be listed.
Culture/religious profile	• Impact on holy places and tourism.
Resource use	• Dependency of villagers on spring water
Traditional Knowledge System	• Impact on the traditional knowledge system

Table III. 3.1: Checklist for identifying potential cumulative effects of HEPs and effect of past present and future activities on cumulative impacts along with impact of mitigation measures

VECs	Potential impact area	Proposed action			Past actions	Present actions	Future actions	Cumulative impacts
		Construction	Operation	Mitigation				
Ecosystems	Terrestrial ecosystems	***	**	++	--	--	*	***
	Riverine ecosystems	***	**	++	--	*	*	***
	River ecosystem	***	***	+	--	--	**	***
Ecosystem structure and functions	Habitat	***	**	++	--	*	*	***
	Productivity	***	*	++	--	--	*	***
	Temperature	*	*	-	--	--	*	*
	Biogeochemical cycle	**	*	+	--	*	*	***
	Food web	**	*	+	--	--	--	**
	Hydrology							
Soil ecosystem	Soil microbial diversity	**	*	+	--	--	--	**
	Soil physico-chemistry	**	*	++	--	--	--	**
	Soil temperature	*	*	--	--	--	--	*
Ecosystem services	Water table	**	**	+	--	*	*	***
	Water quality	***	**	+	*	*	*	***
	Air quality	*	--	+	*	*	*	*
Social conditions	Demography	**	**	+	--	--	*	***
	Social infrastructure	**	*	++	--	--	--	**
	Disease, crime, alcohol, drug	**	*	++	--	--	--	*
Cultural aspects	Religious areas	**	**	--	--	--	--	***
	Tradition	**	**	--	--	--	--	**
	Ethnicity	**	*	--	--	--	--	*
Livelihood	Farmland loss	***	*	--	--	--	*	***
	Forest dependency	***	**	+	--	--	*	***
	Pastures loss	***	**	+	--	--	*	***
Ecosystem vulnerability	Seismicity	***	**	+	--	--	*	***
	GLoF	***	**	+	--	--	*	***
	Erosion	***	**	+	--	--	*	***
KEY: * low adverse effect ** moderate adverse effect * high adverse effect + beneficial effect _ no effect**								

Thus, the prioritized VECs which were predicted to be most adversely affected were identified. In the next step components were identified under each VECs, and the impact of different developmental activities on each of them were enumerated (Table III 3.2).Since the number of VECs were too large to conduct an analysis, 6 VECs were prioritized for analysis having basin level concern as reflected in the baseline data (Figure III 3.1).

Table III. 3.2:.Matrix showing impact of developmental activities on selected valued VECs used for finalizing the VECs to be used for CIA in TRB

VECs	Components	Developmental activities	Impact
Ecosystem structure	Aquatic habitat	Barrage, road construction, tunnelling	Destruction, fragmentation, displacement
	Terrestrial habitat	Construction, deforestation, transmission lines, access road	Destruction, fragmentation, displacement, barrier effect, dewatered segments
	Vegetation	Construction, deforestation, transmission lines, access road, anthropogenic	Deforestation, erosion, Invasion
	Water Quality/quantity	Anthropogenic, construction	Pollution, reduced time to recuperate, Downstream water availability
	Air quality/pollution	Construction activities impact	Pollution load though insignificant
	Edaphic	Construction, deforestation, transmission lines, access road, land use change	Erosion, landslide,
Ecosystem function	Food web/Trophic changes	Disturbances due to developmental activity	Nutrient cycling

	Productivity	Deforestation, nutrient cycle disturbance	Increase in carbon stock, global warming
Livelihood	Livelihood	Grazing grounds loss, NTFB loss, land alienation, loss of land	Loss of livelihood, cultural and medicinal product loss, asset loss, land holding loss, agro product loss, subsistence use
Cultural	Cultural aspects	Construction activities	Traditional ceremonies and spiritual areas loss
Social	Social conditions disease, crime, alcohol, drug	Construction workers	Social unrest
	Population influx	Work force from outside	Imbalance in human demography
Landscape vulnerability	Geology, seismicity, landslide, Soil erosion and GLoF	Construction on land prone to hazard	Increased intensity and instances of natural hazard

Figure III 3.1: Identification of VECs for CIA analysis in TRB

3.1.3. Identification of the spatial and temporal boundaries of the CIA

The spatial and temporal boundaries for the CIA of TRB is presented in Figure III 3.2. The spatial boundary was delimited to TRB and the temporal boundary was limited to past 20 years and stretched to 20 years in future.

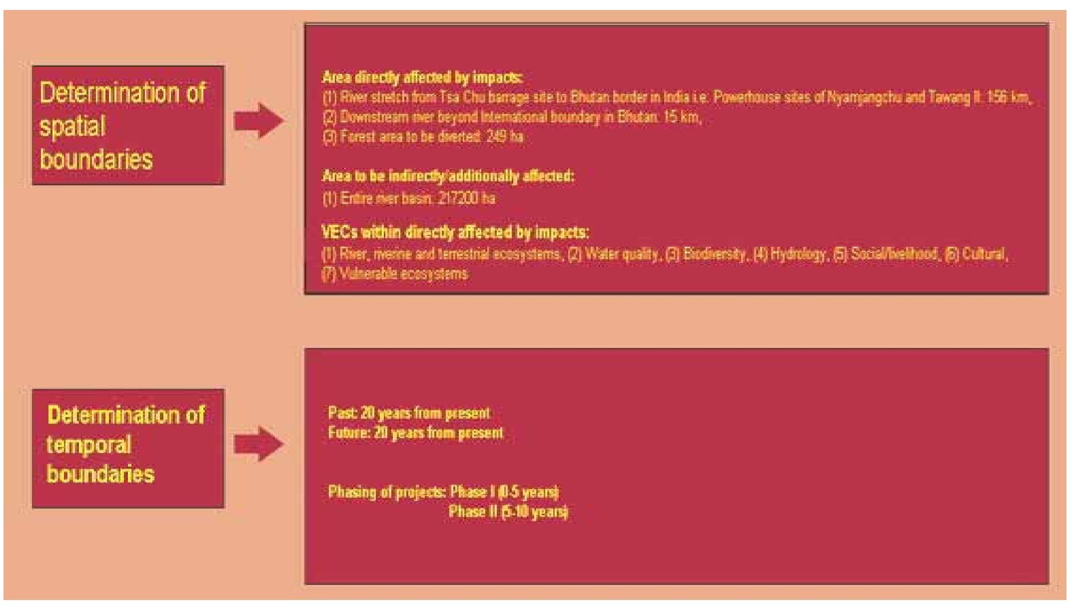


Figure III 3.2: Identification of the spatial and temporal boundaries of the CIA for TRB

3.1.4. Identification of other existing and predictable/potential projects, human activities and natural environmental drivers impacting VECs

The classification of future actions in TRB were considered in the following ways:

- Hypothetical (there is a considerable uncertainty whether the action will ever proceed): All the infrastructure proposed in the developmental plan such as roads, educational institutions, and hospitals
- Reasonably foreseeable (the action may proceed but there is some uncertainty): All the hydel projects including micro-hydels proposed
- Certain (the action will proceed or there is a high probability the action will proceed): Some of the hydel projects

The identified developmental activities and environmental drivers are presented in Figure III 3.3.

3.1.5 Parameters/indicators selected after scoping

The parameters/indicators selected for CIA analysis through generating primary data are presented in Table III 3.3. The selection of VECs/indicators was finalized through several rounds of consultation and expert meetings after carefully considering the availability of data in the existing EIA/EMP reports and other secondary sources. The parameters having similar impact on all the projects e.g., seismicity, were not considered.

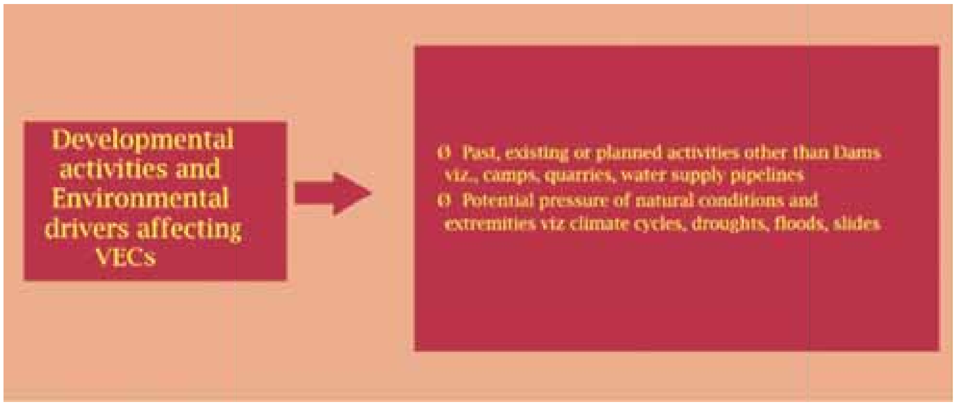


Figure III 3.3: Identified developmental activities and environmental drivers

Table III 3.3: Parameters/indicators selected after scoping for TRB

Parameters/Indicators
Ecosystem Structure, Function and Services
• Forest area loss/MW power production (ha) • Carbon stock loss/MW power production (tonnes) • Ambient air quality • Periphyton and zooplankton density • NPP • Change in turbidity (NTU) • Total coliforms (CFU/ml) • IAS invasibility • Dependency of villagers on hill stream/spring water
Biodiversity
• Proportion of total plant diversity to be affected • Proportion of total bird diversity to be affected • Proportion of total mammal diversity to be affected • No. of butterfly species to be affected • No. of fish species • Periphyton richness • Endemic and/or threatened plants • Endemic and/or threatened mammals • Endemic and/or threatened birds • Endemic and/or threatened fish • Endemic periphyton and zooplankton
Ecosystem vulnerability
• Soil and landslide vulnerability (%) • Disaster vulnerability of core area of project site • Glacial lake outburst discharge (cumecs)
Hydrology
• Ecological flow recommended (lean season flow in cumec) • Ecological flow percentage • Intermediate river length per MW (dry portion)
Culture and livelihood
• Dead body last rites • Totem/Worship • Employment opportunities • Health risks • Quality of life
Dependency on natural resources
• Forest dependency (% of Villages) • Water dependency (% of Villages)

4.1 INTRODUCTION

The impact study area was identified based on a combination of ecological characteristics, and the locations in the main river systems. The study area was divided into upstream, downstream and catchment area as the main impact zones. The cumulative impacts of construction and operation phases of the projects were assessed separately. The impacts that contribute to the cumulative effect were separately assessed for physical, biological and socio-economic environment. Based on analysis of the site-specific impacts for the proposed projects, the key impacts contributing to the cumulative effect were identified. The baseline data or the current status of the scoped VECs were generated with reference to identified indicators and wherever possible trends were analysed (Figure III. 4.1).

Figure III 4.1: Parameters for determination of baseline/current status of VECs

4.2 BASELINE DATA FOR SELECTED VECs/INDICATORS

The detailed data pertaining to the selected parameters are provided and discussed in Section II and IX. The data based on which the CIA index has been computed are provided in this chapter.

4.2.1 Ecosystem vulnerability assessment

Vulnerability was assessed based on geological features, seismicity, and potential soil erosion and landslide hazards.

4.2.1.1 Geology

Most of the project sites fall within 0.5-1 km of the fault lines in TRB. Therefore, the geological vulnerability is quite high for all the projects (Figure III 4.2 and Figure III 4.3).

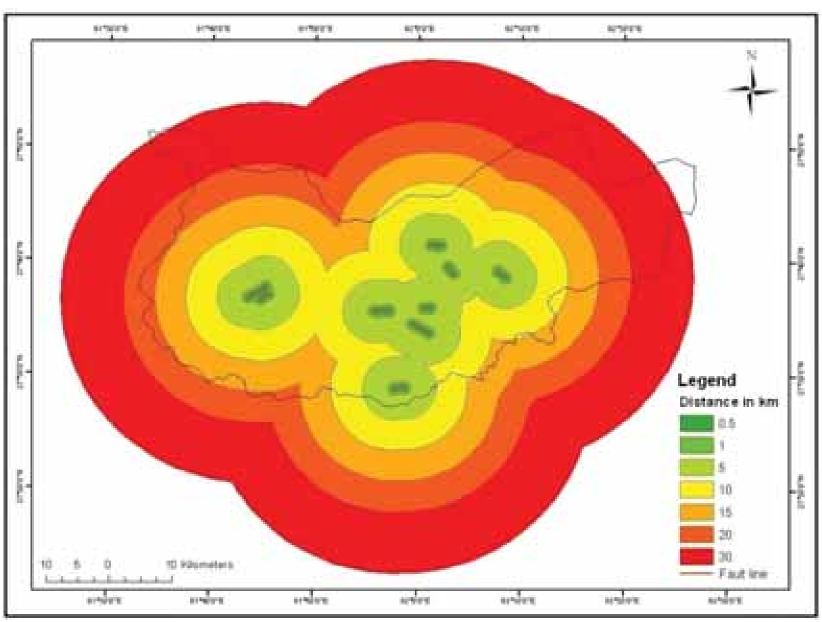


Figure III 4.2: Accessibility of fault lines in Tawang district

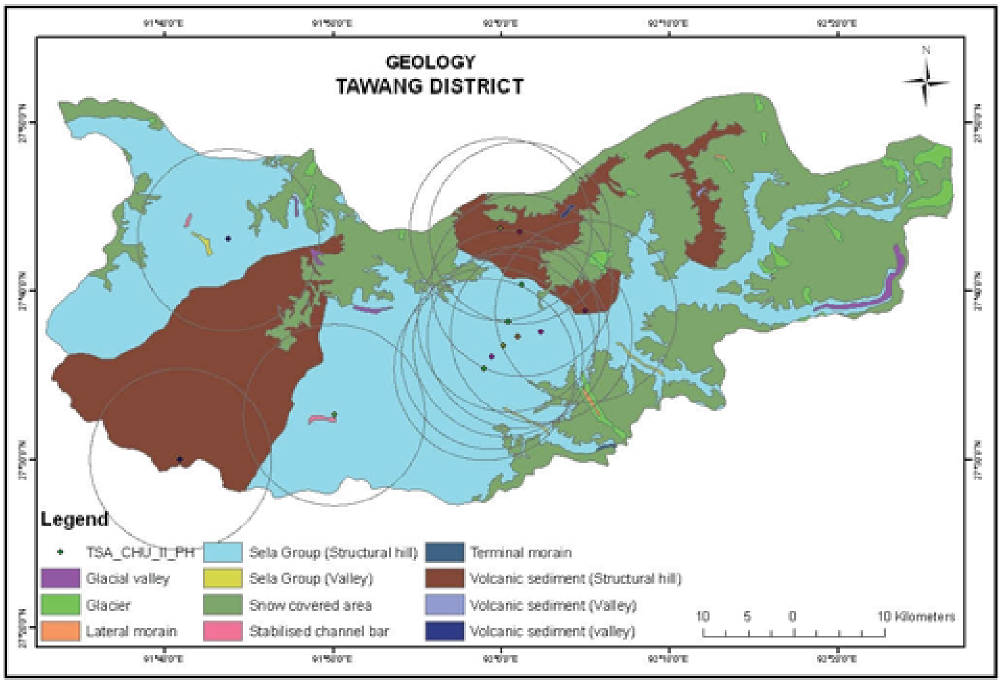


Figure III 4.3: Geological Map of entire TRB and Impact zones of all HEPs to be constructed in TRB

4.2.1.2 Glacial Lake out-burst Flood (GLoF)

GLoF can possess threat to the barrage stability if the design flood value is less than the GLoF value. This is particularly important with increasing climate uncertainties. The potential GLoF values calculated at each project site are presented in Table III.4.1.

Table III 4.1: The calculated GLoF values (cumecs) at each proposed project barrage site in TRB based on HEC-RAS model output.

Lake	HEP	Distance from Lake	Peak Q	
ID-20			**2125**	**Inflow**
	Thingbu chu	29.57	1516.066	
	New Melling	31.89	1469.28	
	Mago chu	37.48	1354.35	
	Rho	42.09	1260.81	
	Tawang-I	45.78	1183.68	
	Tawang-II	63.86	823.5	
ID-7			**2453**	**Inflow**
	Tsa chu-I	19.55	2408	
	Tsa chu-II	23.943	2397	
	Nykcharong chu	33.463	2376.59	
	Rho	37.423	2366.89	
	Tawang-I	41.193	2358.21	
	Tawang-II	59.273	2316.61	

4.2.1.3 Basin level land use and land cover classes

In TRB, forest is the dominated land-use form followed by the scrubland (Figure III 4.4, Figure III 4.5, and Table III 4.2).

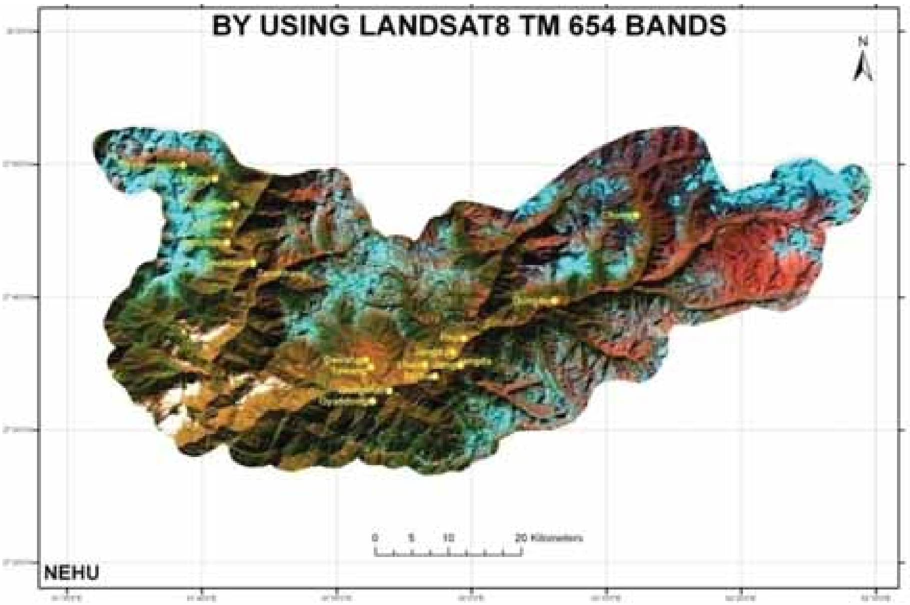


Figure III 4.4: Landsat 8TM with band combination of 654 for RGB for identifying natural vegetation landscapes. The greenish tone is helpful in possible identification of remaining vegetation areas with suitable ground truth. It is evident that despite the low population densities in the Tawang district, a substantial areas are without forest cover and or with scrub/degraded vegetation. Blue is snow.

Table III 4.2: Statistics of land use/land cover of TRB obtained from supervised classification of Landsat 8 data (December, 2013)

Landuse/land cover	Area (ha)
Forest	95840.78
Scrubland	103325.4
Water body	29934.56
Croplands	735.12
Grasslands	1658.228
Built-up area	799.92
Snow and ice	11622.53

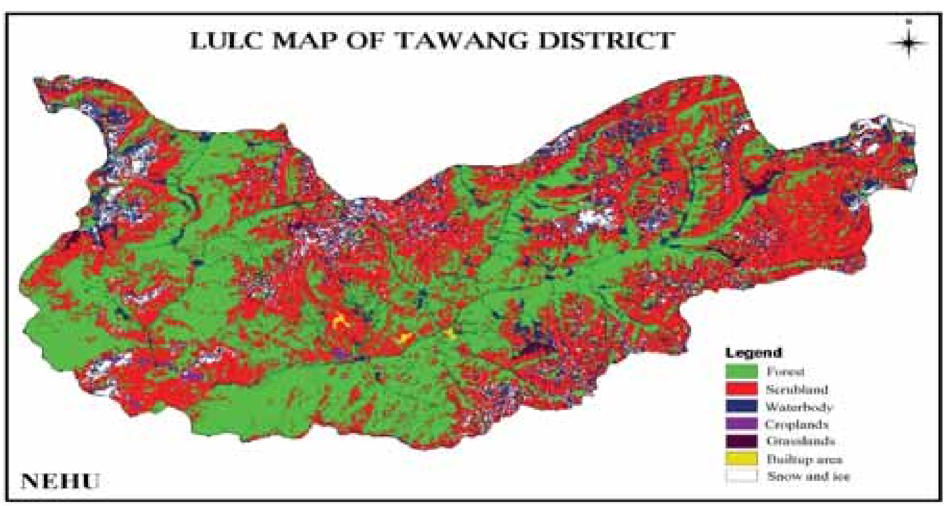


Figure III 4.5: Supervised classification of Landsat 8 data of 18th December, 2013. The results obtained in this were extensively used for individual project and CIA.

4.2.1.4 Forest area and carbon stock

The land use map and land acquisition data in respect of each project was used to derive the total forest area perceived to be degraded or deforested owing to the proposed project activities. Mean carbon stock value per hectare was calculated to derive potential carbon stock loss as a result of project activities (Table III 4.3). The values obtained were used to derive forest cover and carbon stock loss per MW electricity generation.

Table III 4.3: Perceived loss in forest cover and carbon in different proposed project areas in TRB

Project sites	Capacity (MW)	Forest area (ha)	Forest area loss per MW	Calculated carbon stock (tonnes/ha)	Carbon loss	Carbon loss per MW
Jaswantgarh	4.5	0.50	0.11	1.20	0.60	0.13
Mago chu	96.0	5.00	0.26	40.70	662.40	6.90
New Melling	90.0	15.30	0.17	78.19	658.80	7.32
Nyamjang chu	780.0	54.60	0.07	18.77	959.40	1.23
Nyukcharong chu	96.0	5.00	0.26	53.66	1341.50	13.97
Paikangrong chu	2.4	0.50	0.21	0.15	0.19	0.08
Rho	93.0	4	0.14	32.16	411.99	4.43
Tawang-I	600	30.96	0.05	48.38	1254.00	2.09
Tawang-II	800	32.93	0.04	21.93	984.00	1.23
Thingbu	60.0	22.80	0.38	23.29	523.80	8.73
Tsa chu-I	43	4.73	0.11	19.73	97.18	2.26
Tsa chu-I Lower	77.2	1.54	0.02	50.86	37.06	0.48
Tsa chu-II	67	4.69	0.07	35.73	63.65	0.95

4.2.1.5 Hydrology/hydraulics

The basic hydrological baseline data pertaining to 13 proposed projects are presented in Table III 4.4. From flow dataset, 90% dependable year for each project site has been identified and the average lean flow of respective project have been used for CIA.

Table III 4.4: Observed hydraulic/hydrology conditions at 13 HEP sites in TRB.

Sl. No.	Name of HEP	Hydrology/Hydraulic characteristics			Average flow during lean season
		Velocity (m/s)	Depth (m)	Flow width (m)	
1	Tawang–II	2.6	1.23	23.62	39
2	Tawang–I	2.39	1.04	22.38	28
3	Rho	2.4	1.07	23	28
4	Nykcharong chu	2.9	0.98	14	20
5	Mago chu	1.4	0.6	13.16	7
6	New Melling	1.3	0.68	14.09	6
7	Paikangrong chu	1.02	0.39	14.15	2
8	Tsa chu–1	2.13	0.92	16	19
9	Tsa chu-I Lower	2.13	0.92	16	19
10	Tsa chu–II	1.72	1.10	17.7	20
11	Nyamjang chu	1.88	0.64	25.72	14
12	Jaswantgarh Stage–I	1.7	0.4	5.62	1.65
13	Thingbu chu	0.9	0.55	7	1

4.2.1.6 Water quality

The baseline data pertaining to water quality at 13 HEP sites are presented in Table III 4.5. All the parameters were within the permissible limit as notified by CPCB.

Table III 4.5: Water quality during three seasons at 13 project sites in TRB analysed during 2013-14

Season	Tawang-I	Tawang-II	Rho	Mago chu	New Melling	Nykcharong chu	Tsa chu-I	Tsa chu-II	Tsa chu-I Lower	Nyamjang chu	Thingbu chu	Jaswantgarh Stage-I	Paikangrong chu
Turbidity (NTU)													
Post-monsoon	0.38	0.51	0.46	0.34	0.24	0.38	0.6	0.59	0.63	0.0	0.19	2.84	0.45
Monsoon	1.21	1.2	1.55	1.67	1.52	1.15	0.53	0.71	0.53	1.41	1.19	0.36	0.42
Winter	0.72	0.85	1.2	1.36	1.28	0.97	0.57	0.88	0.57	0.0	1.19	0.45	0.36
Gross Primary Productivity (mg C/cm^3/h)													
Post-monsoon	36.46	36.46	36.5	32.55	31.25	41.67	39.07	35.16	36.46	0.0	27.34	20.83	31.25
Monsoon	50.78	54.69	46.9	46.88	46.88	46.88	41.02	46.88	42.97	46.88	46.88	39.06	46.88
Winter	31.25	31.25	26	26.04	26.04	20.83	20.83	20.83	20.83	0.0	23.44	20.83	23.44
Net Primary Productivity (mg C/cm^3/h)													
Post-monsoon	15.63	15.63	11.7	11.4	17.58	10.42	10.42	10.42	10.42	0.0	12.7	10.42	10.42
Monsoon	31.25	31.25	31.3	25.39	23.44	31.25	25.39	31.25	27.34	23.44	31.25	15.63	23.44
Winter	10.42	10.42	10.4	10.42	10.42	10.42	10.42	10.42	10.42	0.0	7.81	7.81	7.81
Total Coliforms (CFU/ml)													
Post-monsoon	72.0	68.5	44.0	42.0	33.5	18.5	17.5	23.0	16.5	0.0	25.0	108.5	25.5
Monsoon	40.0	51.5	33.5	13.5	25.5	22.5	20.5	25.0	15.0	23.0	33.5	59.0	10.0
Winter	43.0	54.0	19.0	26.0	26.0	14.0	8.5	13.5	12.0	0.0	17.5	14.5	13.5

4.2.1.7 Air Quality

The ambient air quality data for 13 projects in TRB are provided in Table III 4.6. It may be noted that the gaseous pollutants such as SOx, NOx, NH_3, and ozone were all below detectable limit in the basin. The remaining parameters were far below the limit notified by CPCB. Since air pollution was not identified as a major impact, future pollution level was not predicted using air pollution models.

Table III 4.6: Concentration of suspended particulate matter (SPM) and gaseous pollutants in air at various project sites in Tawang district during pre–monsoon and post–monsoon seasons

Name of HEP	Sampling site	Date of sampling	Duration of sampling	SPM10 conc. (µg/m^3)	SPM 2.5 conc. (µg/m^3)
Tawang–I	Nuranang falls	06/03/14	09:45 am –06:25 pm	49.6524	37.919
Tawang–II	Khet bridge	12/12/13	09:40 am –06:00pm	33.7636	25.7851
Rho	Rho	13/12/13	08:50 am –04:50 pm	23.447	13.43
Mago chu	Rho	13/12/13	08:50 am –04:50 pm	23.447	13.43
New Melling	New Melling	04/03/14	09:30 am –06:10 pm	39.3909	38.6777
Nykcharong chu	Rho	13/12/13	08:50 am –04:50 pm	23.447	13.43
Tsa chu–I	Tsa chu	08/03/14	10: 48 am –07:48 pm	10.4209	0.0
Tsa chu–II	Tsa chu	08/03/14	10: 48 am –07:48 pm	10.4209	0.0
Tsa chu–I Lower	Tsa chu	08/03/14	10: 48 am –07:48 pm	10.4209	0.0
Nyamjang chu (powerhouse site)	Lumla	11/3/14	10:00 am –06:00 pm	23.4469	26.86
Thingbu chu	Thingbu chu	05/03/14	10:00 am –06:00 pm	41.0321	26.86
Jaswantgarh Stage–I	Jaswantgarh	12/3/14	09:30 am –05:30 pm	11.6991	13.4019
Paikangrong chu	Nuranang falls	06/03/14	09:45 am –06:25 pm	49.6524	37.919

NB: The gaseous pollutants such as SOx, NOx, NH_3, and Ozone were not depicted in the Table since all the values were recorded at below detectable level. Abbreviations used: SPM: Suspended Particulates Matter; SO_x: Oxides of Sulphur; NO_x: Oxides of Nitrogen

4.2.1.8 Intermediate river length with reduced flow

The stretch of river between barrage and powerhouse site where the flow is reduced owing to water diversion through head race tunnel is referred to as intermediate river length. Table III 4.7 presents the intermediate river length per unit of power output for different proposed HEPs.

Table III 4.7: Intermediate river length per unit of power output for different proposed HEPs in TRB.

Name of HEP	Intermediate dry river length (km)	Capacity (MW)	Affected intermediate stretch per MW
Jaswantgarh	0	4.5	0.00
Mago chu	2.5	96	0.03
New Melling	3.56	90	0.04
Nyamjang chu	23	780	0.03
Nykcharong chu	2	96	0.02
Paikangrong chu	0	2.4	0.000
Rho	1.8	93	0.02
Tawang-I	15	600	0.03
Tawang-II	16	800	0.02
Thingbu chu	2	60	0.03
Tsa chu-I	2.5	24	0.06
Tsa chu-II	1.98	67	0.03
Tsa chu-I Lower	1.67	77.2	0.02

4.2.1.9 Biodiversity

A summary of the basin level baseline biodiversity data used for developing CIA index is provided in Table III 4.8.

Table III 4.8: Baseline biodiversity data for selected aspects for 13 HEP areas in TRB

Sl. No.	Parameters	Thingbu chu	New Melling	Mago chu	Nykcharong chu	Rho	Tsa chu-I	Tsa chu-I Lower	Tsa chu-II	Tawang-I	Tawang-II	Nyamjang chu	Jaswantgarh	Paikangrong chu
1	No. of plant species at barrage site	64	67	72	69	76	42	41	44	71	60	53	20	35
2	Total number of plant species in influence zone	180	177	178	267	253	46	46	46	188	144	92	21	237
3	Proportion of plant diversity affected (values at Sl. No. 1/values at Sl. No. 2)	0.36	0.38	0.40	0.26	0.30	0.91	0.98	0.96	0.38	0.42	0.50	0.95	0.15
4	No. of bird species seen at barrage sites	55	27	27	31	39	21	28	18	34	25	38	34	35
5	Total number of bird species in influence zone	67	67	95	106	110	46	43	43	114	136	86	73	86
6	Proportion of bird species diversity affected (values at Sl. No. 4/values at Sl. No. 5)	0.82	0.40	0.28	0.29	0.35	0.46	0.65	0.42	0.30	0.18	0.44	0.47	0.41
7	No. of mammal species directly seen at barrage sites	10	3	6	6	5	2	2	2	3	5	3	1	3
8	Total number of mammal species in influence zone	29	29	29	29	29	29	29	29	29	29	29	29	29
9	Proportion of mammalian diversity affected (values at Sl. No. 7/values at Sl. No. 8)	0.10	0.10	0.21	0.21	0.17	0.07	0.07	0.07	0.10	0.17	0.10	0.03	0.10
10	No. of affected butterfly species	19	19	19	18	20	15	20	20	28	22	20	15	21
11	No of fish species at barrage site	0	0	0	0	3	0	0	0	10	10	3	0	0
12	Periphyton species richness	13	6	5	11	29	9	19	6	8	10	5	4	4
13	No. of endemic and/or threatened angiosperms/gymnosperm plant species	6	3	5	2	1	0	4	3	2	2	0	0	0
14	No. o endemic and/or threatened mammal species	2	2	1	4	1	1	1	1	1	1	4	1	2
15	No. of endemic and/or threatened birds	0	0	1	0	0	0	0	0	0	0	1	0	0
16	No. of endemic fish species	0	0	0	0	2	0	0	0	1	1	0	0	0
17	No. of endemic periphyton and zooplankton species	3	3	1	0	0	1	2	1	1	1	0	0	1

4.2.1.10 Socio-economic parameters

Forty six villages situated within 10 km radius of the proposed barrage/powerhouse sites of 13 proposed HEPs were surveyed both at village and HH levels. These villages fall under nine administrative circles. The distance of these villages from the river varies from 0 km in BTK, Dung, Gorsam, Kelenteng and Nam Tsering villages to 20 km in Thingbu village. The distance of circle headquarters from these villages ranges from 0 km in Zimithang village to 28 km in Kudung village. The distance of district headquarters town i.e., Tawang from these villages varies from 12 km in case of Gyankhar village to 151 km in case of Thingbu village (Table III 4.9).

Table III 4.9: Distance of surveyed villages from river, Circle HQ and district HQs in Tawang district/river basin

Sl. No.	Name of village	Circle	Dist. from River/ Tributary (km)	Dist. from Circle HQ (km)	Dist. from District HQ (km)
1	Baghar	Lumla	6	13	61
2	Brokenthang	Zimithang	0.5	3	70
3	BTK	Zimithang	0	10	66
4	Dugumba	Lumla	5	5.7	52
5	Dung	Zimithang	0	3	76
6	Dungse	Jang	2	1	45
7	Gemreteng	Lhau	2	4	24
8	Gomkang	Tawang	1	19	19
9	Gomkelleng	Mukto	4	13	100
10	Gorsam	Zimithang	0	8	68
11	Gyada	Tawang	3	18	18
12	Gyankhar	Tawang	1	12	12
13	Hoongla	Lumla	4	4	49
14	Jangda	Lhau	7	15	90
15	Kelenteng	Zimithang	0	3	76
16	Khamba	Lhau	3.5	4	20
17	Kharman	Zimithang	0.5	2	75
18	Kharsa	Jang	2	1	45
19	Kharteng	Lumla	7	14	62
20	Kharthut	Tawang	1	13	13
21	Kregyang	Lhau	2	2	22
22	Kudung	Tawang	2.5	28	28
23	Lumla	Lumla	10	4	50
24	Lumpo	Zimithang	2	22	96
25	Maio	Lumla	2	4	46
26	Menteng	Lhau	2	4	24
27	Mirba	Mukto	3	10	55

28	Muchut	Zimithang	1	15	88
29	Nam Tsering	Dudunghar	0	20	66
30	Pharmey	Lumla	7	5	51
31	Phomang	Lumla	5	12	61
32	Poito	Lumla	7	8	53
33	Regyang	Lhau	2	3	23
34	Rho	Thingbu	8	5	100
35	Sazo	Lumla	7	7	52
36	Seru	Tawang	8	16	16
37	Sherbang	Lumla	4	11	55
38	Shyro	Lhau	5	7	30
39	Teli	Tawang	2	14	14
40	Thingbu	Thingbu	20	1	151
41	Thrillam	Lumla	4	17	30
42	Tsaikhar	Tawang	3	18	18
43	Yabab	Lumla	5	12	57
44	Yusum	Tawang	3	21	21
45	Yuthembu	Jang	2.5	1	45
46	Zimithang	Zimithang	1	0	73

Hill stream/springs and tap water originating from hill stream/springs are the dominant sources of potable water for the villagers of 46 villages in TRB (Table III 4.10).

Table III 4.10: Availability of water sources in surveyed villages in the proposed 13 HEP areas in TRB

Sl. No.	Project	Type	No. of villages	No. of HHs	N	River	Hill stream/spring	Wells	Ponds	Hand pumps	Tap water
1	Tawang–I	A	13	742	n	112	496	3	56	39	395
					%	15	67	0	8	5	53
		I	12	429	n	132	201	2	56	0	364
					%	31	47	0	13	0	85
2	Tawang–II	A	7	263	n	47	35	0	0	0	293
					%	16	12	0	0	0	100
		I	15	633	n	345	454	56	120	4	397
					%	55	72	9	19	1	63
3	Rho	A+I	10	601	n	183	419	0	100	0	360
					%	30	70	0	17	0	60
4	Mago	A+I	10	590	n	111	480	0	109	0	333
					%	19	81	0	18	0	56
5	New Melling	A+I	7	537	n	111	427	0	56	0	280
					%	21	80	0	10	0	52
6	Nykcharong chu	A+I	10	590	n	111	480	0	109	0	333
					%	19	81	0	18	0	56
7	Tsa chu–I	A	2	184	n	85	184	0	0	0	184
					%	46	100	0	0	0	100
8	Tsa chu–II	A+I	3	236	n	85	236	0	0	0	184
					%	36	100	0	0	0	78
9	Tsa chu–I Lower	A	2	184	n	85	184	0	0	0	184
					%	46	100	0	0	0	100
10	Nyamjang chu	A	9	453	n	345	197	40	143	0	345
					%	76	43	9	32	0	76
		I	13	378	n	236	160	14	8	0	355
					%	62	42	4	2	0	94
11	Thingbu chu	A	3	236	n	85	236	0	0	0	184
					%	36	100	0	0	0	78
12	Paikangrong chu	A+I	5	378	n	111	275	0	56	0	280
					%	29	73	0	15	0	74
	Total	**A+I**	**121**	**6434**	**n**	**2184**	**4464**	**115**	**813**	**43**	**4471**
					%	**34**	**69**	**2**	**13**	**1**	**69**

NOTE: A = Directly Affected villages -from where lands would be acquired; I = Influenced villages-villages within 10 km radius of the project barrage/powerhouse site

Dependency on river and forest resources: The nature of dependency on river and forest resources in surveyed villages in proposed HEP areas in TRB is given in Table III 4.11 and Table III 4.12, respectively. The data reveals that six different river resources, namely, religion, sand, stone, water for domestic animal, drinking water and water for domestic use are used. Almost all HHs (95%) in the surveyed villages use river for performing last rites of the dead (cultural aspect). 52% of the total HHs use river resources for sand and stone collection for self use as well as for selling, and 50% of the inhabitants use river water for domestic animals. Only few HHs use aquatic flora (8%) and fauna (2%) from the river resources. The villagers depend on forest resources for different uses.

Table III 4.11: Nature of dependency on forest resources in surveyed villages across the proposed HEPs in TRB

Sl. No.	Project		Tawang–I		Tawang–II		Rho	Mago	New Melling	Nykcharong chu	Tsa chu–I	Tsa chu–II	Tsa chu–I Lower	Nyamjang chu		Thingbu chu	Paikangrong chu	Total
	Type		A	I	A	I	A+I	A+I	A+I	A+I	A	A+I	A	A	I	A	A+I	**A+I**
	No. of villages		13	12	7	15	10	10	7	10	2	3	2	9	13	3	5	**121**
	No. of HHs		742	429	263	633	601	590	537	590	184	236	184	453	378	236	378	**6434**
1	Fuel wood	n	724	427	261	600	486	582	529	582	184	236	184	450	356	236	370	**6207**
		%	98	99.5	89	95	99	99	99	99	100	100	100	99	94	100	98	**96**
2	Timber	n	582	386	174	417	460	449	422	449	184	236	184	298	247	236	370	**5094**
		%	78	90	59	66	77	76	79	76	100	100	100	66	65	100	98	**79**
3	Medicinal plants	n	170	151	96	300	130	97	76	97	0	36	0	345	177	36	40	**1751**
		%	23	35	33	47	22	16	14	16	0	15	0	76	47	15	11	**27**
4	Honey	n	39	18	0	71	38	4	0	4	0	0	0	51	16	0	0	**241**
		%	5	4	0	11	6	1	0	1	0	0	0	11	4	0	0	**4**
5	Food	n	332	269	127	485	285	299	246	299	165	206	165	381	268	206	205	**3938**
		%	45	63	43	77	47	51	46	51	90	87	90	84	71	87	54	**61**
6	Edible oil	n	37	12	3	13	36	0	0	0	0	0	0	4	2	0	0	**107**
		%	5	3	1	2	6	0	0	0	0	0	0	1	1	0	0	**2**
7	Ornamental	n	1	4	0	2	2	2	2	2	2	2	2	0	0	2	2	**25**
		%	0	1	0	0	0	0	0	0	1	1	1	0	0	1	1	**0.4**
8	Religious	n	267	356	189	418	305	294	241	294	85	137	85	392	280	137	189	**3669**
		%	36	83	65	66	51	50	45	50	46	58	46	87	74	58	50	**57**
9	Fencing	n	255	111	34	158	274	202	202	202	118	118	118	227	98	118	202	**2437**
		%	34	26	12	25	46	34	38	34	64	50	64	50	26	50	53	**38**
10	Handicrafts	n	52	31	0	29	61	25	25	25	21	21	21	0	7	21	25	**364**
		%	7	7	0	5	10	4	5	4	11	9	11	0	2	9	7	**6**
11	Thatching	n	88	10	1	65	37	1	1	1	0	0	0	1	33	0	1	**239**
		%	12	2	0	10	6	0	0	0	0	0	0	0	9	0	0	**4**
12	Spices	n	255	74	13	237	78	46	42	46	0	0	0	172	158	0	42	**1163**
		%	34	17	4	37	13	8	8	8	0	0	0	38	42	0	11	**18**
13	Grazing	n	281	143	109	261	225	272	261	272	131	183	131	219	174	183	209	**3054**
		%	38	33	37	41	37	46	49	46	71	78	71	48	46	78	55	**47**
14	Hunting of	n	3	1	0	2	3	2	2	2	0	0	0	0	1	0	2	**18**
		%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	**0.3**
15	Fishes	n	34	24	0	43	34	1	1	1	0	0	0	0	19	0	1	**158**
		%	5	6	0	7	6	0	0	0	0	0	0	0	5	0	0	**2**
16	Water	n	458	225	109	373	381	364	359	364	184	236	184	324	210	236	307	**4314**
		%	62	52	37	59	63	62	67	62	100	100	100	72	56	100	81	**67**
17	Stones	n	572	405	241	475	487	477	424	477	184	236	184	354	345	236	372	**5469**
		%	77	94	82	75	81	81	79	81	100	100	100	78	91	100	98	**85**
18	Sand	n	537	298	201	259	421	411	358	411	118	170	118	202	296	170	306	**4276**
		%	72	69	69	41	70	70	67	70	64	72	64	45	78	72	81	**66**
19	Dyes	n	98	10	0	121	35	0	0	0	0	0	0	69	66	0	0	**399**
		%	13	2	0	19	6	0	0	0	0	0	0	15	17	0	0	**6**

NOTE: A = Directly Affected villages; I = Influenced villages within 10 km radius of the projects

Table III 4.12: Nature of dependency on river resources in surveyed villages across the proposed HEPs in TRB

Sl. No.	Project		Tawang–I		Tawang–II		Rho	Mago	New Melling	Nykcharong chu	Tsa chu–I	Tsa chu–II	Tsa chu–I Lower	Nyamjang chu		Thingbu chu	Paikangrong chu	Total
	Type		A	I	A	I	A+I	A+I	A+I	A+I	A	A+I	A	A	I	A	A+I	A+I
	No. of villages		13	12	7	15	10	10	7	10	2	3	2	9	13	3	5	**121**
	No. of HHs		742	429	263	633	601	590	537	590	184	236	184	453	378	236	378	**6434**
1	Drinking water	n	178	114	155	321	163	0	131	131	0	0	0	383	258	0	24	**1858**
		%	24	27	53	51	27	0	24	22	0	0	0	85	68	0	6	**29**
2	Water for domestic use	n	159	98	93	112	157	0	125	125	0	0	0	186	147	0	18	**1220**
		%	21	23	32	18	26	0	23	21	0	0	0	41	39	0	5	**19**
3	Water for domestic animal	n	281	143	107	261	225	261	261	272	131	261	131	219	174	261	209	**3197**
		%	38	33	37	41	37	78	49	46	71	78	71	48	46	78	55	**50**
4	Fishes	n	35	21	0	40	35	0	0	0	0	0	0	1	19	0	0	**151**
		%	5	5	0	6	6	0	0	0	0	0	0	0.2	5	0	0	**2**
5	Aquatic flora	n	35	5	0	122	37	0	0	2	0	0	0	225	86	0	0	**512**
		%	5	1	0	19	6	0	0	0.34	0	0	0	50	23	0	0	**8**
6	Religious	n	742	429	293	633	601	236	537	590	184	236	184	453	377	236	378	**6109**
		%	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	**95**
7	Sand	n	462	152	145	380	330	99	260	260	99	99	99	387	241	99	260	**3372**
		%	62	35	49	60	55	42	48	44	54	42	54	85	64	42	69	**52**
8	Stones (Boulders)	n	464	151	146	374	332	99	262	262	99	99	99	384	240	99	262	**3372**
		%	63	35	50	59	55	42	49	44	54	42	54	85	63	42	69	**52**

NOTE: A = Directly Affected villages; I = Influenced villages within 10 km radius of the projects

5.1 BASIN LEVEL CUMULATIVE IMPACT OF THE PROPOSED DEVELOPMENTAL ACTIVITIES IN TAWANG RIVER BASIN

There was a need to analyse the cumulative impact of all the activities proposed by all the 13 proposed and six existing HEPs in the river basin in addition to the cumulative impact arising from activities of the individual project as analysed in the preceding section. This was primarily important to assess the future conditions of TRB in context of the environmental degradation caused by additive and synergistic effects of all the developmental activities considered together. This would help in prediction of impacts in temporal as well as spatial scale. Based on these, the impacts and their severity were assessed at the following two levels of concern:

1. Temporal scale: This represented the time period of effect, and was limited to short term, long term and permanent effect.
2. Spatial scale: It dealt with area of concern i.e., at project level (local scale), or at basin level (regional scale).

For quantifying the cumulative impacts, both direct as well as indirect impacts (Figure III 5.1) of the proposed developmental activities irrespective of the size of the individual projects were considered. All the components of ecosystems were critically analysed for possible futuristic change in their condition. In quantifying the impacts, the effects of planned actions were considered in combination with the reasonably foreseeable future actions, past and present conditions/actions, and environmental drivers (Figure III 5.2).

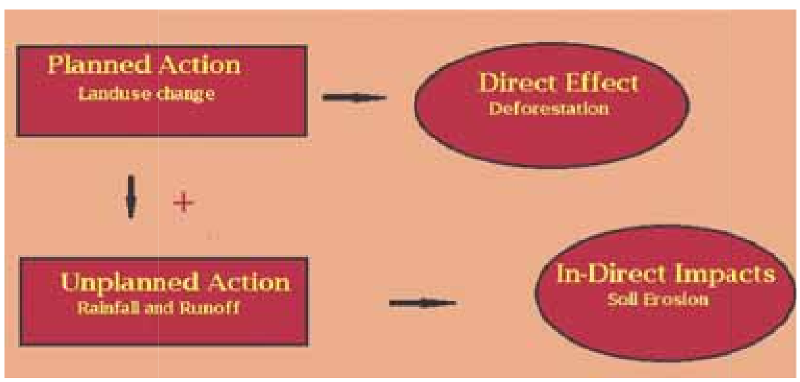


Figure III 5.1: Direct and indirect impact in TRB

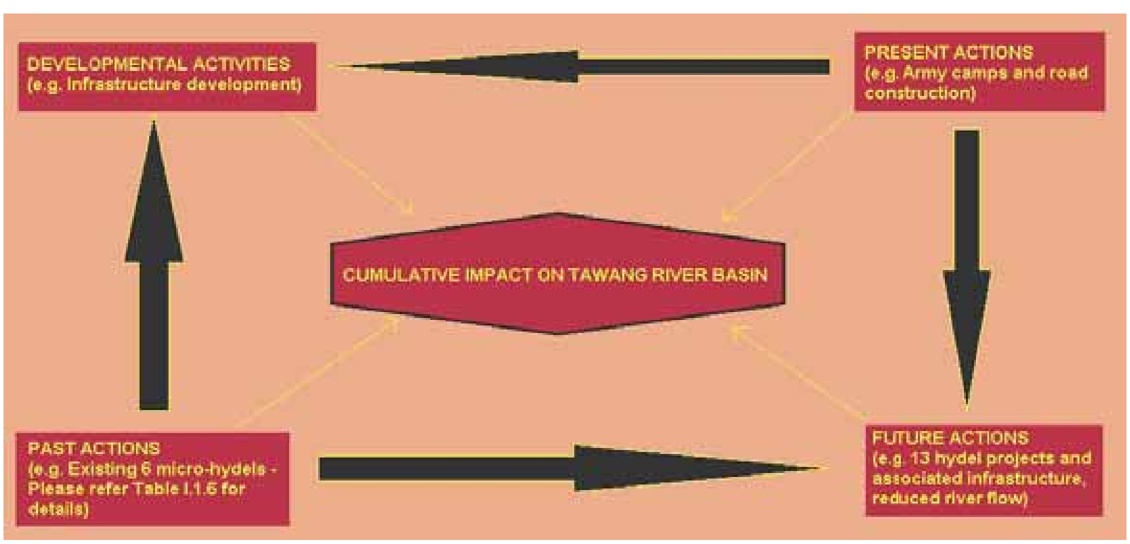


Figure III 5.2: Cumulative impacts on TRB analysed based on the combined effects of past, present, future and planned development activities

5.1.1 CIA Matrix

The cumulative impact analysis is presented in the form of an interaction matrix where rows represent major ecosystems/components and the columns spatial and temporal effects. In order to avoid overstating the impacts, these have been classified on the basis of effects during construction and operation phases.

For visualising the severity of impacts, numerical values were assigned to each level of concern (Table III 5.1). Finally, a significance value for each derived impact was added to the total numerical value and cumulative value of each impact was obtained. For the impact not having cumulative potential no value was assigned and for having cumulative potential a significance value of 3 was chosen. The figure 3 was chosen to: a) indicate severity of cumulative potential in comparison to having no cumulative potential, b) proper demarcation and classification into four classes of cumulative impact viz., critical, high, moderate and low.

Table III 5.1: Numerical values assigned to impacts with different levels of concern

Level of concern	Numerical value
Duration of impacts (Temporal)	
Negligible	0
Short term	1
Long term	2
Permanent	3
Type of impact	
Negligible impact	0
Indirect impact	1
Direct impact	2
Area of impacts (spatial)	
Project area	1
Basin area	2
Significance value of impact	
Cumulative potential	3
No cumulative potential	0

On the basis of the cumulative score that each affected component/attribute of the respective natural resource obtained in CIA matrix, affected components/attributes were classified into four classes of significance. Those having a score of above 15 were classified as critically impacted, 11-15 as highly impacted, 6-10 as low impact, and below 6 score as very low impact class.

The CIA Matrix, i.e., the interaction matrix represents potential impacts and extent of impact during construction and operation phases at different spatial and temporal scales on identified attributes of different ecosystems/components (Table III 5.2 to Table III 5.10)

5.1.1.1 Cumulative impacts on stream/river ecosystem

As evident from Table III 5.2, all the attributes of stream/river ecosystem are severely impacted as a result of HEPs. All the impacts have long term potential except bed morphology, flow volume/speed which would be permanently impacted by the HEPs.

Table III 5.2: Interaction matrix representing potential impacts and extent of impact during construction and operation phases at different spatial and temporal scales on identified attributes of Stream/River ecosystem

Attributes	Potential impacts and extent				Cumulative impact	
	Construction phase		Operation phase			
	Spatial	**Temporal**	**Spatial**	**Temporal**	**Potential (yes/no)**	**Cum. value**
Net primary productivity	Direct impact-basin area	Long term	Direct impact-basin area	Long term	Yes	17
Periphyton density	Direct impact-basin area	Long term	Direct impact-basin area	Long term	Yes	17
Bio-geo-chemical cycling	Direct impact-basin area	Long term	Direct impact-basin area	Long term	Yes	17
Increased turbidity	Direct impact-basin area	Long term	Direct impact-basin area	Long term	Yes	17
Increased total dissolved solids	Direct impact-basin area	Long term	Direct impact-basin area	Long term	Yes	17
Increased coliforms	Direct impact-basin area	Long term	Direct impact-basin area	Long term	Yes	17
River bed morphology	Direct impact-project area	Permanent	Direct impact-project area	Permanent	Yes	15
Flow speed reduction	Direct impact-project area	Permanent	Direct impact-project area	Permanent	Yes	15
Flow volume reduction	Direct impact-project area	Permanent	Direct impact-project area	Permanent	Yes	15
Total						**147**

5.1.1.2 Cumulative impacts on riverine ecosystem

HEP construction and operation will lead to bank instability, high soil erosion and enhance vulnerability to invasion by Invasive Alien Species (IAS). Flow regime alteration is expected to enhance the aforementioned impacts and thus this needs to be monitored carefully (Table III 5.3).

Table III 5.3: Interaction matrix representing potential impacts and extent of impact during construction and operation phases at different spatial and temporal scales on identified attributes of Riverine ecosystem

Attributes	Activities and potential impacts and extent				Cumulative impact	
	Construction phase (impact)		Operation phase (impact)			
Riverine ecosystem	Spatial	Temporal	Spatial	Temporal	Potential (yes/no)	Cum. value
Net primary productivity	Direct impact-project area	Long term	Negligible	Negligible	No	5
Flow regime alteration	Direct impact-basin area	Permanent	Direct impact-basin area	Permanent	Yes	15
Inundation	Direct impact-project area	Permanent	Negligible	Negligible	No	6
Erosion	Direct impact-project area	Long term	Direct impact-project area	Short term	No	9
Bank stability	Direct impact-project area	Long term	Direct impact-project area	Long term	No	10
Vulnerability to invasion by IAS	Indirect impact-basin area	Permanent	Indirect impact-project area	Permanent	Yes	15
Total						**60**

5.1.1.3 Cumulative impacts on terrestrial ecosystem

Terrestrial ecosystems as such are not affected severely by the HEPs. But the invasion by IAS can lead to much drastic changes in ecosystem structure and function. The remaining attributes are low to moderately affected by HEP (Table III 5.4).

Table III 5.4: Interaction matrix representing potential impacts and extent of impact during construction and operation phases at different spatial and temporal scales on identified attributes of Terrestrial ecosystem

Attributes	Activities and potential impacts and extent				Cumulative impact	
	Construction phase (impact)		Operation phase (impact)			
	Spatial	Temporal	Spatial	Temporal	Potential (yes/no)	Cum. value
Net primary productivity	Direct impact-project area	Long term	Negligible	Negligible	No	5
Deforestation	Direct impact-project area	Long term	Negligible	Negligible	No	5
Plant diversity	Direct impact-project area	Long term	Negligible	Negligible	No	5
Birds diversity	Direct impact-project area	Long term	Negligible	Negligible	No	5
Animal diversity	Direct impact-project area	Long term	Negligible	Negligible	No	5
Endemic species	Direct impact-project area	Permanent	Negligible	Negligible	No	6
Vulnerability to invasion by IAS	Direct impact-basin area	Permanent	Direct impact-basin area	Permanent	Yes	17
Soil erosion Soil compaction	Direct impact-project area	Short term	Indirect impact-project area	Short term	No	7
Loss of topsoil/topsoil degradation	Indirect impact-basin area	Long-term	Negligible	Negligible	No	5
Agricultural, range, pasture land soil degradation	Indirect impact-project area	Long-term	Negligible	Negligible	No	4
Total						**64**

5.1.1.4 Cumulative impacts on identified attributes of plant and animal communities

The major effect of HEP on animal and plant communities is creation of barrier to movement. This is a serious issue especially in the case of animal communities. Human intrusion is also a major reason for concern. The remaining attributes are moderately affected/impacted by HEPs (Table III 5.5).

Table III 5.5: Interaction matrix representing potential impacts and extent of impact during construction and operation phases at different spatial and temporal scales on identified attributes of plant and animal communities

Attributes	Activities and potential impacts and extent				Cumulative impact	
	Construction phase (impact)		Operation phase (impact)			
	Spatial	Temporal	Spatial	Temporal	Potential (yes/no)	Cum. value
Habitat loss, alteration	Direct impact-basin area	Permanent	Negligible	Negligible	No	7
Fragmentation	Direct impact-basin area	Long term	Negligible	Negligible	Yes	9
Creation of barriers to movement	Direct impact-basin area	Permanent	Direct impact-basin area	Permanent	Yes	17
Edge effects	Direct impact-project area	Long term	Negligible	Negligible	No	5
Intrusion of humans	Direct impact-basin area	Long term	Direct impact-basin area	Permanent	Yes	16
Total						**54**

5.1.1.5 Cumulative impacts on identified socio-economic attributes

HEP activity would have a pronounced impact on the socio-economic conditions in the basin area. Most of the socio-economic attributes are critically impacted by HEPs (Table III 5.6). All the parameters of human development index needs to be monitored effectively in the basin.

Table III 5.6: Interaction matrix representing potential impacts and extent of impact during construction and operation phases at different spatial and temporal scales on identified socio-economic attributes

Attributes	Activities and potential impacts and extent				Cumulative impact	
	Construction phase (impact)		Operation phase (impact)			
	Spatial	Temporal	Spatial	Temporal	Potential (yes/no)	Cum. value
Availability of edible algae	Direct impact-project area	Long term	Direct impact-project area	Long term	No	10
Livestock dependency on pastoral/forest land	Direct impact-project area	Long term	Direct impact-project area	Long term	No	10
Community forest loss	Direct impact-project area	Permanent	Negligible	Negligible	No	6
Agricultural land loss	Direct impact-project area	Permanent	Negligible	Negligible	No	6
River and stream based resources	Direct impact-basin area	Short term	Direct impact-basin area	Negligible	No	9
Demographic change	Direct impact-basin area	Permanent	Direct impact-basin area	Permanent	Yes	17
Total						**58**

5.1.1.6 Cumulative impacts on cultural attributes

The project activities will result in loss of cremation/last ritual areas and impact the cultural and ethnic practices of the indigenous people (Table III 5.7). A balance is needed to be maintained between HEP and cultural aspects.

Table III 5.7: Interaction matrix representing potential impacts and extent of impact during construction and operation phases at different spatial and temporal scales on identified cultural attributes

Attributes	Activities and potential impacts and extent				Cumulative impact	
	Construction phase (impact)		Operation phase (impact)			
	Spatial	Temporal	Spatial	Temporal	Potential (yes/no)	Cum. value
Loss in area of religious importance	Direct impact-project area	Permanent	Direct impact-project area	Permanent	No	12
Loss in area for last rituals	Direct impact-project area	Long term	Direct impact-project area	Long term	No	10
Total						**22**

5.1.1.7 Cumulative impacts on identified species of endemic and threatened species

The proposed HEPs in Tawang during construction phase have a severe impact on threatened and endemic species. But with proper management and mitigation the impact will be minimized during operational phase. In the case of fish, phytoplankton, periphyton and zooplankton species the impacts will be severe due to altered volume and flow regime (Table III 5.8)

Table III 5.8: Interaction matrix representing potential impacts and extent of impact during construction and operation phases at different spatial and temporal scales on identified attributes of endemic and threatened species of TRB

Species	Activities and potential impacts and extent				Cumulative impact	
	Construction phase (impact)		Operation phase (impact)			
	Spatial	Temporal	Spatial	Temporal	Potential (yes/no)	Cum. value
Endemic and/or threatened plants						
Acer hookeri	Direct impact-project area	Long term	In-direct impact-project area	Short term	No	8
Acer sikkimensis	Direct impact-project area	Long term	In-direct impact-project area	Short term	No	8
Aconitum spp.	Direct impact-project area	Long term	In-direct impact-project area	Short term	No	8
Panax bipinnatifidus	Direct impact-project area	Long term	In-direct impact-project area	Short term	No	8
Paris polyphylla	Direct impact-project area	Long term	In-direct impact-project area	Short term	No	8
Swertia chirayita	Direct impact-project area	Long term	In-direct impact-project area	Short term	No	8
Taxus wallchiana	Direct impact-project area	Long term	In-direct impact-project area	Short term	No	8
Endemic and/or threatened mammals						
Macaca munzala	Direct impact-basin area	Long term	Direct impact-project area	Long term	No	12
Nemorhaedus goral	Direct impact-basin area	Long term	Direct impact-project area	Long term	No	12
Panthera pardus	Direct impact-basin area	Long term	Direct impact-project area	Long term	No	12
Cuon alpinus	Direct impact-basin area	Long term	Direct impact-project area	Long term	No	12
Trachypithecus pileatus	Direct impact-basin area	Long term	Direct impact-project area	Long term	No	12
Ailurus fulgens	Direct impact-basin area	Long term	Direct impact-project area	Long term	No	12
Endemic and/or threatened birds						
Aceros nipalensis	Direct impact-basin area	Long term	Direct impact-project area	Long term	No	12
Grus nigricollis	Direct impact-basin area	Long term	Direct impact-project area	Long term	No	12

Endemic and/or threatened fish						
Schizothorax richardsonii	Direct impact-basin area	Permanent	Direct impact-basin area	Permanent	Yes	17
Schizothorax progastus	Direct impact-basin area	Permanent	Direct impact-basin area	Permanent	Yes	17
Endemic periphyton and zooplankton						
Keratella serrulata	Direct impact-basin area	Permanent	Direct impact-basin area	Permanent	Yes	17
Notholca squamula	Direct impact-basin area	Permanent	Direct impact-basin area	Permanent	Yes	17
Total						**220**

5.1.1.8 Cumulative impacts on identified attributes of Noise and Air quality

HEPs have a low and very low impact on noise and air quality in TRB (Table III 5.9). As no gaseous emissions are expected during operational phase of the HEPs, the air quality will not be significantly impacted.

Noise on the other hand is expected to increase during construction phase and stabilize at moderate levels during operational phase. Thus, this effect need to be monitored and mitigated to the extent suggested in mitigation measures.

Table III 5.9: Interaction matrix representing potential impacts and extent of impact during construction and operation phases at different spatial and temporal scales on identified attributes of air quality and noise

Attributes	**Activities and potential impacts and extent**				**Cumulative impact**	
	Construction phase (impact)		**Operation phase (impact)**			
	Spatial	**Temporal**	**Spatial**	**Temporal**	**Potential (yes/no)**	**Cum. value**
Combustion emissions	Direct impact-basin area	Short term	Negligible	Negligible	Yes	8
Fugitive dust emissions (pm10 and pm 2.5)	Direct impact-basin area	Short term	Negligible	Negligible	Yes	8
Noise from heavy construction equipment and vehicles	Direct impact-project area	Short term	Negligible	Negligible	No	4
Noise from blasting	Direct impact-project area	Short term	Negligible	Negligible	No	4
Noise from pump stations	Direct impact-project area	Short term	Direct impact-project area	Permanent	No	10
Noise from substations	Direct impact-project area	Short term	Direct impact-project area	Permanent	No	10
Total						**44**

5.1.1.9 Cumulative beneficial impacts on identified socio-economic attributes

The HEPs will lead to improvement in social and economic infrastructure and will lead to rise in standard of living in the TRB. Only beneficial cumulative impacts of the proposed developmental activities are analyzed in the Table III 5.10.

Table III 5.10: Interaction matrix representing potential impacts and extent of impact during construction and operation phases at different spatial and temporal scales on identified socio-economic attributes

Attributes	**Activities and potential impacts and extent**				**Cumulative impact**	
	Construction phase (impact)		**Operation phase (impact)**			
	Spatial	**Temporal**	**Spatial**	**Temporal**	**Potential (yes/no)**	**Cum. value**
Impact on tourism	Direct impact-basin area	Short term	Direct impact-basin area	Permanent	Yes	12
Housing	Direct impact-basin area	Permanent	Direct impact-basin area	Permanent	Yes	17
Economic activity	Direct impact-basin area	Permanent	Direct impact-basin area	Permanent	Yes	17
Public services (education and health)	Direct impact-basin area	Permanent	Direct impact-basin area	Permanent	Yes	17
Tax revenues, property values	Direct impact-basin area	Permanent	Direct impact-basin area	Permanent	Yes	17
Traffic and transportation	Direct impact-basin area	Permanent	Direct impact-basin area	Permanent	Yes	17
Total						**97**

5.1.2 Cumulative impacts on identified attributes of ecosystems/components in TRB

Based on the CIA matrix of potentially impacted attributes, four classes of cumulative impacts were identified (Table III 5.11). This was done with a view to identify critically and highly impacted ecosystems/resource attributes. This would help in prioritization of the areas which need policy intervention and help in developing mitigation measures.

Table III 5.11: Environmental attributes classified on basis of critical, high, low and very low impact

Critical Impact	High Impact	Low Impact	Very Low Impact
Net primary productivity	River bed morphology	Bank stability	Net primary productivity (terrestrial)
Periphyton density	Flow speed reduction	Availability of edible algae	Net primary productivity (aquatic)
Bio-geo-chemical cycling	Flow volume reduction	Livestock dependency on pastoral and forest land	Deforestation
Increased turbidity	Flow regime alteration	Loss in area of last rituals conduction.	Plant diversity
Increased total dissolved solids	Vulnerability to invasion by IAS	Noise from pump stations	Birds diversity
Increased coliform	Loss in area of religious importance	Noise from substations	Animal diversity
Vulnerability to invasion by IAS		Erosion	Loss of topsoil/topsoil degradation
Creation of barriers to movement		Fragmentation	Edge effects
Demographic change		Combustion emissions	Agricultural, range, pasture land , soil degradation
Intrusion of humans		Fugitive dust emissions (PM10 and PM2.5)	Visual impacts to cultural resources
		Soil erosion	Noise from heavy construction equipment and vehicles
		Habitat loss, alteration, and	Noise from blasting
		Inundation	
		Endemic species	
		Community forest loss	
		Agricultural land loss	
		River and stream based resources	

5.2 INDIVIDUAL PROJECT LEVEL CUMULATIVE IMPACTS

In order to assess the relative contribution of the individual project to the cumulative impacts at basin level, a CIA index was developed as discussed in the following section.

5.2.1 Effect of Developmental activities on future conditions of VECs

This has been evaluated by assigning numerical value to measurable/predictable change in future condition of VECs. Determining the future conditions of VECs is a necessity for assessing the cumulative impact. More precisely, it is the effect of developmental activities on the future of VECs that needs to be determined e.g., transmission line after construction phase. Therefore, cumulative impacts in this study are the potential changes in the conditions of VECs, which were arrived at after using the tools viz., impact models, network analysis, GIS, and experts opinion.

For the purpose of understanding the changes or effect of developmental activities on VECs, the impacts can be categorised into the following:

1. Immediate visible impacts (e.g., deforestation, land diversion)
2. Gradual and steady change in VECs condition (e.g., poor air/water quality, increase in SPM concentration, loss in ecosystem services etc.)
3. Accumulation and delayed additive effects causing complete transformation (e.g., ecosystem degradation, species loss, extinction)

The major issue of concern being the 3rd category of impact, it had been tried to visualize, quantify and enumerate these as the major cumulative impacts. Since all these fall under the futuristic condition assessment, care has been taken to keep the prediction at the normal level of reference and not arrive at over estimations.
The future conditions of VECs or the potential changes in VECs were arrived at through expert opinion based on their previous experiences and knowledge as well as outputs from network analysis and models. This process had 4 steps which are, described in the following paragraphs.

In the first step, the impacts were understood as the sub-sequential effect on temporal as well as spatial scale. The basic idea being how a small activity can interact and transform into primary, secondary and tertiary effects culminating in large spatial and temporal impacts on the environmental components. This is explained in Figure III 5.3.

In the second step, several simple impact models were created to understand how different activities related to hydropower development activities can have additive, synergistic or individual effect on ecosystem structure and function. One such example of impact model is demonstrated in Figure III 5.4.

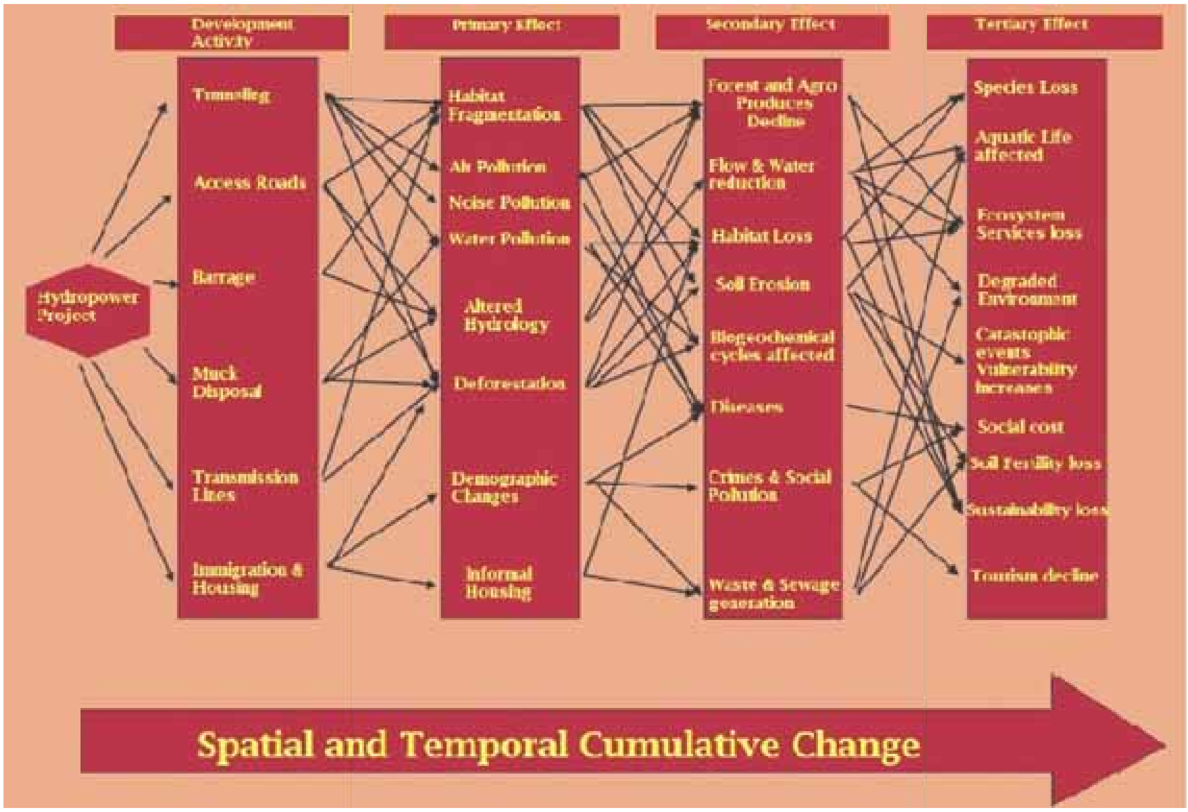


Figure III 5.3: Network diagram showing the perceived primary, secondary and tertiary impacts of the proposed HEPs in TRB

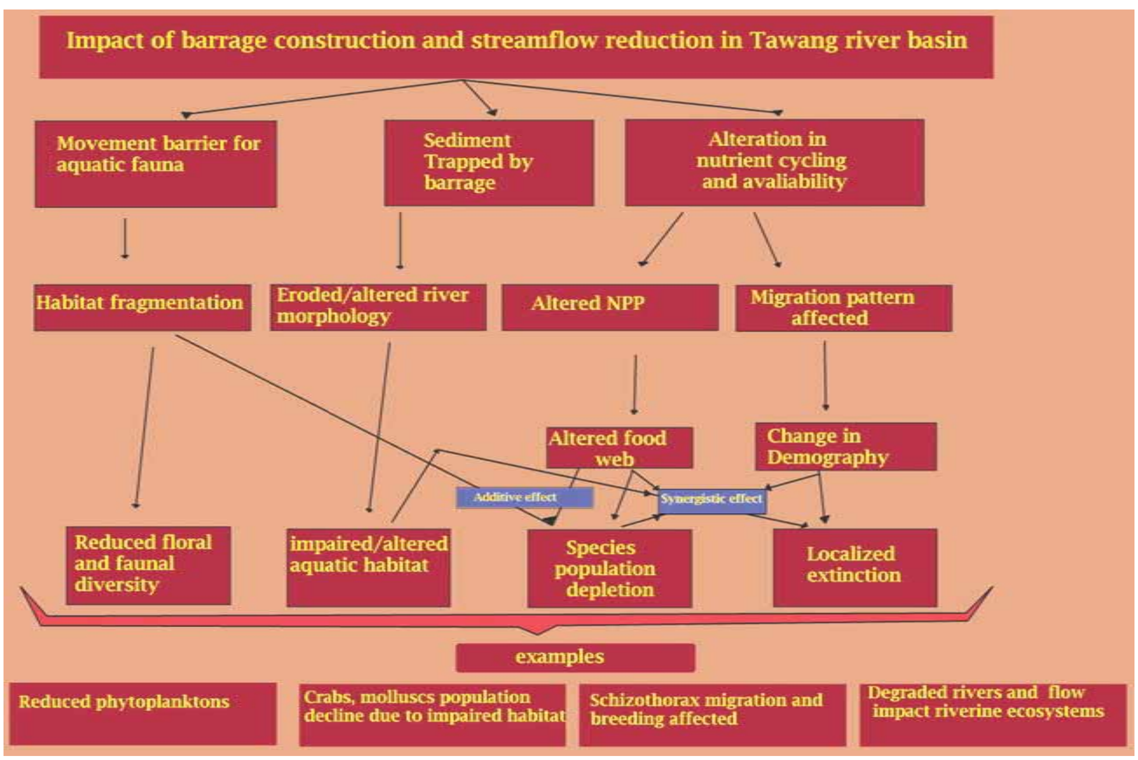


Figure III 5.4: A simplified impact model presenting the impacts of barrage construction on river ecosystems of TRB

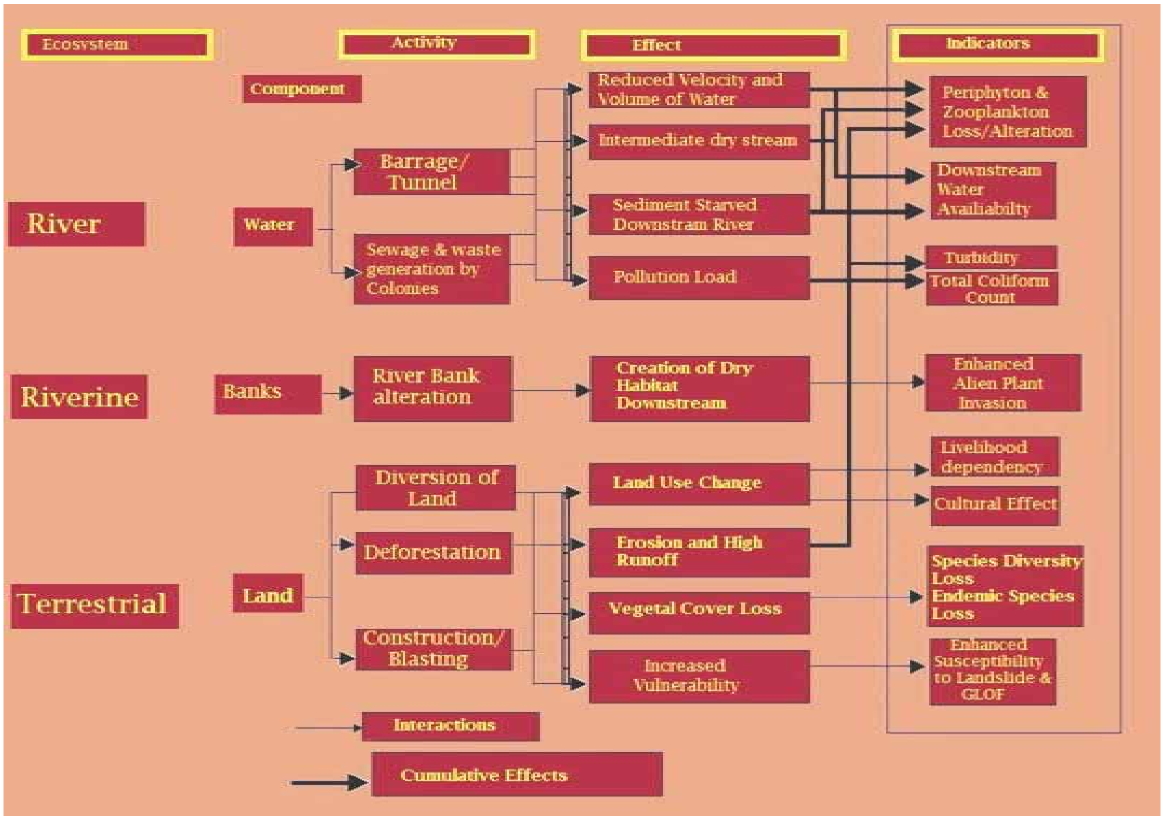


Figure III 5.5: Steps involved in identification of indicators under each VECs present in three different ecosystems in TRB

In the third step, it was necessary to identify suitable indicators for each VECs to quantitatively describe the cumulative impacts and their subsequent monitoring. For this, the landscape was divided into three major ecosystem types viz., river, riverine and terrestrial ecosystems. The associated VECs, proposed development activities and their effects on each ecosystem type were determined. Once the effects were clearly understood, suitable indicators were developed. These steps are explained in Figure III 5.5.

In the fourth step, the Indicators were given numerical values based on: 1) true measured value of impact, when the change was well-characterized and measureable. For example, in case of forest cover loss, or carbon stock loss, the quantities of loss were well established and the values were directly used, 2) the potential change in the condition of the indicators: this was done by categorising the potential impacts into 3 categories viz., i) significant impact with value1, ii) high impact with value 2, and iii) critical impact with value 3. This value was assigned after considering the quantum and magnitude of the activity as well as the temporal and spatial effect of the impact. In essence, the values correspond to the degree of change in relation to the baseline condition with 1 being the least and 3 being the most. A long process of discussions, consultations and deductions from the related case studies in northeast India was done before arriving at the numerical value representing the potential future condition of the concerned indicators of the respective VECs. The consolidated matrix containing the numerical values for each indicator with respect to each proposed HEP is presented in Table III 5.12.

Table III 5.12: Values of indicators selected during scoping exercise used in developing CIA index for TRB

Parameters	Thingbu chu	New Melling	Mago chu	Nykcharong chu	Rho	Tsa chu-I	Tsa chu-I Lower	Tsa chu-II	Tawang-I	Tawang-II	Nyamjang chu	Jaswantgarh Stage-I	Paikangrong chu
Ecosystem Structure, Function and Services													
Forest area loss/MW (ha)	0.38	0.17	0.05	0.05	0.04	0.11	0.02	0.07	0.05	0.04	0.07	0.11	0.21
Carbon stock loss/MW	8.73	7.32	6.90	13.97	4.43	2.26	0.48	0.95	2.09	1.23	1.23	0.13	0.08
Ambient air quality	2	2	2	2	2	2	2	2	2	2	2	2	2
Periphyton and zooplankton density	3	2	2	2	3	1	1	1	3	3	3	1	1
NPP	2	2	1	1	1	1	1	1	2	2	2	1	1
Change in turbidity (NTU)	2	2	2	2	2	3	3	3	1	1	1	1	2
Total coliforms (CFU/ml)	1	1	1	1	1	1	1	1	2	2	2	1	1
IAS invasibility	1	2	1	1	1	1	1	1	2	2	2	1	2
Dependency of villagers on hill stream/spring water	2	2	2	2	2	1	1	1	3	3	3	0	1
Biodiversity													
Proportion of total plant diversity to be affected	0.36	0.38	0.40	0.26	0.30	0.91	0.98	0.96	0.38	0.42	0.50	0.95	0.15
Proportion of total bird diversity to be affected	0.82	0.40	0.28	0.29	0.35	0.46	0.65	0.42	0.30	0.18	0.44	0.47	0.41
Proportion of total mammal diversity to be affected	0.10	0.10	0.21	0.21	0.17	0.07	0.07	0.07	0.10	0.17	0.10	0.03	0.10
No. of butterfly species to be affected	19	19	19	18	20	15	20	20	28	22	20	15	21
No. of fish species	0	0	0	0	3	0	0	0	10	10	3	0	0
Periphyton richness	13	6	5	11	29	9	19	6	8	10	5	4	4
Endemic and/or threatened plants	6	3	5	2	1	0	4	3	2	2	0	0	0
Endemic and/or threatened mammals	2	2	1	4	1	1	1	1	1	1	4	1	2
Endemic and/or threatened birds	0	0	1	0	0	0	0	0	0	0	1	0	0
Endemic and/or threatened fish	0	0	0	0	2	0	0	0	1	1	0	0	0
Endemic periphyton and zooplankton	3	3	1	0	0	1	2	1	1	1	0	0	1
Vulnerability													
Soil and landslide vulnerability (%)	60	60	70	75	78	45	45	45	80	70	40	20	20
Disaster vulnerability of core area of project site	4	4	3	2	3	2	2	3	3	2	2	1	1
Glacial lake outburst discharge	1516	1469	1354	2368	2367	2408	2408	2397	2358	2316	0	0	0
Hydrology													
Ecological flow (lean season in cumec)	1	3	5	6	7.6	5	5	5	7.6	10	3.5	0	0
Ecological flow (percentage)	100	50	70	30	27	25	25	25	27	25	25	0	0
Intermediate river length per Megawatt (dry portion)	0.03	0.04	0.03	0.02	0.02	0.06	0.03	0.02	0.03	0.02	0.03	0	0
Culture and livelihood													
Dead body last rites	0	0	0	0	1	0	0	0	1	1	0	0	0
Totem worship	0	0	0	0	0	1	0	0	0	0	1	0	0
Employment opportunities	1	1	1	2	2	1	1	1	3	3	3	1	1
Health risks	1	1	1	2	2	1	1	1	3	3	3	1	1
Quality of life	1	2	2	1	1	1	1	1	2	2	3	1	1
Dependency on natural resources													
Forest dependency (% of villages)	3	2	2	2	3	3	3	3	3	3	3	0	3
Water dependency (% of villages)	2	2	2	2	2	2	2	2	2	3	3	0	2

5.2.2 Development of Cumulated Project Impact Assessment Index (CIA) and Standardized Cumulated Project Impact Assessment Index (SCIA)

The matrix thus obtained was used to develop CIA index and SCIA index following the methods as described below:

1. **Assignment of weights to the project effects:** It is considered desirable to assign weights to the project effects (E) according to the altitude of the site where the project activities will be carried out. Accordingly, the effects on ecosystem structure, functions and services (aspect-1) and biodiversity (aspect-2) have been multiplied by the altitude (A) so that higher the altitude more is the severity of effects due to potential project development. The weighted effects may be called as $e_{ij}^{(p)} = E_{ij}^{(p)} A^{(p)}$. here $E_{ij}^{(p)}$ is the j^{th} effect in i^{th} category/aspect expected of the p^{th} project. $A^{(p)}$ is the altitude at which the p^{th} project is located.
2. **Standardization of aspect-wise (category-wise) effects:** As it is observed, in certain categories/aspects a large no. of effects (such as 11 or 9) have been considered whereas in some others only data on two effects are used. It is required therefore that they are standardised so as to provide a single vector of (comparable) effects for each aspect category. This has been done such that $\varepsilon_{ij}^{(p)} = (e_{ij}^{(p)} / \sum_{j=1}^{m_i} e_{ij}^{(p)})*10$, where $e_{ij}^{(p)}$ is the jth effect

(already weighted by the altitude factor) in the ith category/aspect pertaining to the p^{th} project. It may be noted that the values of m_i are different for different categories and $\varepsilon_{ij}^{(p)}$ is the standardized effect in the scale (0, 10). Following this standardization, the aspect-wise effect indices are obtained as $AWE_i^{(p)} = (1/m_i)\sum_{j=1}^{m_i}\varepsilon_{ij}^{(p)}$. This gives us the expected effects of the projects in each category (aspect).

3. **Cumulated Project Effect Index (CIA):** A weighted aggregation of all aspect-wise effects for each project provides the cumulated project effect index. That is $CIA^{(p)} = \sum_{i=1}^{M}(w_i)(AWE_i^{(p)})$; where w_i is the weight assigned to different aspects of the project effects. In our case, we have used equal weight of unity to every aspect. Moreover, $M = 6$ as we have considered six aspects of the project effects.
4. **Standardized Cumulated Project Effect Index (SCIA):** For convenience of perception the cumulated project effect index may be standardized as $SCIA^{(p)} = k(CIA^{(p)} / \sum_{p=1}^{NP} CIA^{(p)})$ where NP is the total number of projects (13 in our case) and k is a suitable non-zero constant (such as 10 or 100). On account of this standardization, the value of every cumulated project effect lies between $(0,\ k)$ and renders itself convenient for comparison and visualization.

The indices thus obtained are presented in the Table III 5.13.

Table III 5.13: Environmental impacts of 13 HEPs in TRB

Sl. No.	Projects	Thingbu chu	New Melling	Mago chu	Nykcharong chu	Rho	Tsa chu-I	Tsa chu-I Lower	Tsa chu-II	Tawang-I	Tawang-II	Nyamjang chu	Jaswantgarh	Paikangrong chu
	Aspects/Projects	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
1	Ecosystem structure, function and services	1.21	1	0.8	0.93	0.66	0.86	0.63	0.63	0.74	0.64	0.74	0.62	0.56
2	Biodiversity	0.96	0.68	1.02	0.48	1.04	0.85	1.24	0.67	0.91	0.53	0.77	0.62	0.24
3	Vulnerability	0.94	0.93	0.86	0.94	1.06	0.8	0.8	0.91	1.06	0.91	0.4	0.2	0.2
4	Hydrology	1.62	1.19	1.27	0.65	0.62	1.2	0.75	0.59	0.77	0.59	0.75	0	0
5	Culture and livelihood	0.47	0.41	0.41	0.5	1.17	1.47	0.47	0.47	1.14	1.14	1.41	0.47	0.47
6	Dependency on natural resources	1.01	0.73	0.73	0.73	0.87	1.16	0.58	0.58	1.02	0.87	0.87	0	0.87
SCIA		**1.03**	**0.82**	**0.85**	**0.71**	**0.9**	**1.06**	**0.74**	**0.64**	**0.94**	**0.78**	**0.82**	**0.32**	**0.39**

Thingbu chu project has the highest cumulative impact on the ecosystem aspect followed by New Melling. Biodiversity aspect is impacted most by Tsa chu-I Lower, Mago chu, and Rho. The projects highly vulnerable to hazards are Rho and Tawang-I. Tsa chu-I, Thingbu chu, New Melling, and Mago chu are having high impact on hydrological aspects. The projects having high impact on culture and livelihood are Tsa chu-I, Rho, Tawang-I, Tawang-II and Nyamjang chu. The projects having high impact on dependency on natural resources are Tsa chu-I, Thingbu chu and Tawang-I. Cumulatively, Tsa chu-I is having the highest Standardized Cumulated Project Effect Index (SCIA) value of 1.06 followed by Thingbu chu (1.03).

5.3 CUMULATIVE IMPACT OF OTHER ENVIRONMENTAL DRIVERS

The contribution of other environmental drivers to cumulative impact is important. For instance, vulnerability to natural hazards is an important factor in risk assessment and its interaction with the cumulative impacts in the river basin. In this section, some of these environmental drivers has been described.

5.3.1. Seismicity

Keeping in view the overall seismicity and seismo-tectonic set up, the entire TRB has been kept in seismic zone-V as per map of India showing seismic zones (IS: 1893, Part-I-2002). The project/site specific earthquake vulnerability analysis has been made in the respective DPRs by the 7 projects. The range mentioned for MCE and DBE for these seven projects may represent all the proposed projects in TRB (Table III 5.14).

Table III 5.14: Peak ground acceleration (PGA) values for maximum credible earthquake (MCE) and design based earthquake (DBE) conditions

Sl. No.	HEP	maximum credible earthquake (g)	Design based earthquake conditions (g)
1	Mago chu	0.35	0.18
2	New Melling	0.35	0.18
3	Nyamjang chu	0.36	0.18
4	Nykcharong chu	0.24	0.16
5	Rho	0.38	0.19
6	Tawang-I	0.39	0.19
7	Tawang-II	0.39	0.19

5.3.2 Glacial lake outburst

Being most of the rivers are glacial origin, and the threat of global warming is looming large, glacial lake outburst modelling was undertaken to predict the peak flow in case such events happen in future. The projected flood data is presented in Table III 5.15.

Table III 5.15: Glacial lake outburst projected flood data for TRB

Lake	HEP	Distance from Lake (km)	Peak Q (cumecs)	
ID-20			**2125**	**Inflow**
	Thingbu chu	29.57	1516.066	
	New Melling	31.89	1469.28	
	Mago chu	37.48	1354.35	
	Rho	42.09	1260.81	
	Tawang-I	45.78	1183.68	
	Tawang-II	63.86	823.5	
ID-7			**2453**	**Inflow**
	Tsa chu-I	19.55	2408	
	Tsa chu-I	23.943	2397	
	Nyukcharong chu	33.463	2376.59	
	Rho	37.423	2366.89	
	Tawang-I	41.193	2358.21	
	Tawang-II	59.273	2316.61	

5.3.3 Landslide and Erosion Vulnerability of Tawang District

The areas under various landslide and erosion vulnerability classes of Tawang district is given in Table III 5.16. Out of the total area of Tawang district, which is 2,172 sq.km, only 0.28% (6 sq.km) falls under highly vulnerable zone whereas, 6.38% (138 sq.km) area falls under moderately-high vulnerable zone. About 25.23% (548 sq.km) of the total area falls under low risk zone, while 40.31% (876 sq.km) falls under moderately-low vulnerable zone. The moderately vulnerable area is about 27.8% (604 sq.km). The spatial distribution of landslide and erosion vulnerability areas under Tawang district is given in Figure III 5.6.

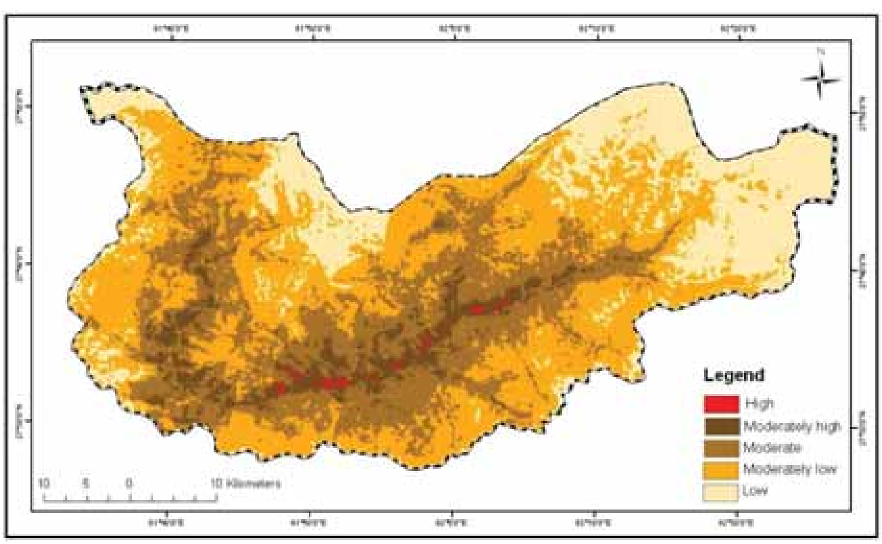


Figure III 5.6: Spatial distribution of vulnerability in Tawang district

5.3.4 Soil Erosion Vulnerability of Tawang District

Out of the total area of Tawang district, which is 2,172 sq.km, a considerable portion areas with more than 10 percent fall under high soil erosion vulnerable areas. The area under low soil erosion vulnerability is about 25 percent (Figure III 5.7) (Table III 5.16).

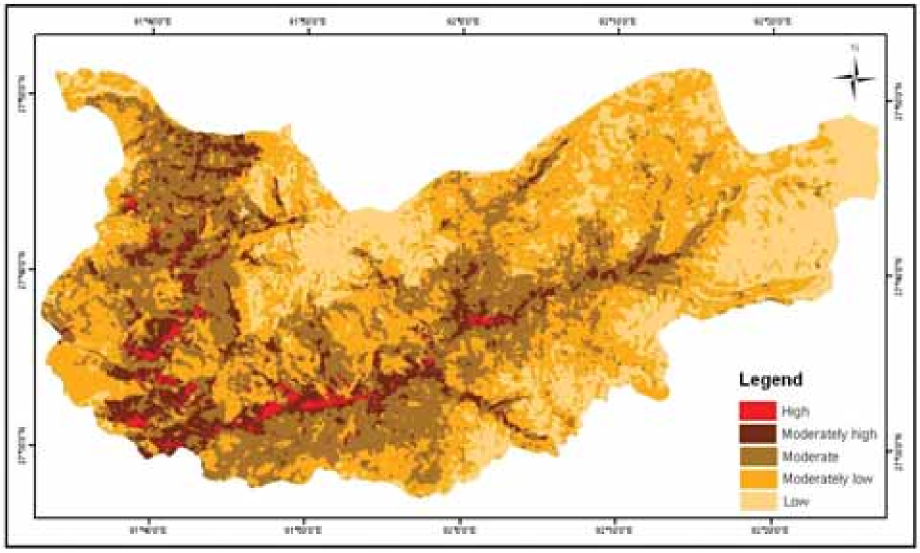


Figure III 5.7: Spatial distribution of soil erosion vulnerability in Tawang district

Table III 5.16: Soil erosion vulnerable areas of Tawang district

Soil erosion vulnerability	Area (sq.km)	%
High	30.03	1.38
Moderately high	201.23	9.26
Moderate	610.66	28.12
Moderately low	785.27	36.15
Low	544.81	25.08
Total	**2172.00**	**100.00**

5.4 CUMULATIVE INDEX OF SOCIO-ECONOMIC IMPACTS

Consequent upon the implementation of the proposed projects, land use change, deforestation, and construction activities would impact economic conditions of dependent population as well as affect ecosystem services. The influx of migrant population change the demography, affect the social equations and have profound impact on indigenous population. Thus, assessing the cumulative impact on socio-economics of the region is a prime requirement. Keeping this in mind socio-economic impact index has been developed for the affected as well as impacted population in the 10 km influence zone of the proposed activities.

5.4.1 Index of Socio-Economic Status of Sample Villages in the Influence Zone

Data have been collected/compiled on the socio-economic characteristics of 46 villages in the influence zone of various projects. These villages form a sample for assessment of the envisaged effects of the projects that would affect the socio-economic conditions of the people. From these villages the following data have been collected/compiled.

1. Land-use at the village level: (i) Area under forest cover, (ii) Area under agriculture, (ii) Area under horticulture, (iv) Habitation & HG.
2. Use of private land for different purposes: Information on different uses of private land in the villages, viz. (i) Total private land holding, (ii) Private land under forest cover, (iii) Private land under agriculture, (iv) Private land under horticulture, (v) Private land under habitation & HG have been collected.
3. No. of HHs, sex ratio and literacy in the village: Information on (i) No. of HHs, (ii) sex ratio and (iii) male/female/total literacy rate in the village have been collected.
4. Livestock and value of livestock: Information on various types of livestock, viz. (i) Mithun, (ii) Cattle, (iii) Goat, (iv) sheep, (v) Poultry, (vi) Yak, (vii) Pig, (viii) Pony, and (ix) other livestock and value of the livestock for each particular have been collected.

5. Average annual earning (at the village level, in Rs. lakh): (i) Animal husbandry, (ii) Horticulture, (iii) Traditional skills, (iv) Daily wages, (v) GS, (vi) Other sources, (vii) Average family income.
6. Average annual expenditure at the family level (at the village level): (i) Expenditure on food and drinks, (ii) clothing, (iii) Transport, (iv) Education and health, (v) Total expenditure.
7. Use of water, purpose-wise and source wise. Five sources of water viz. river, hill stream/spring, well, pond and tap, each for four purposes, viz. drinking, domestic, livestock and agriculture have been collected.
8. Amenities in the village: Information on availability of twelve amenities in the villages have been collected. Those twelve amenities are: (i) Road connectivity, (ii) Health facility (PHC/sub-centre), (iii) Traditional health healer, (iv) Veterinary services, (v) Electricity, (vi) Fair price shop, (vii) Grocery shop, (viii) Post office, (ix) Bank branch, (x) School, (xi) Telephone/Mobile, and (xii) TV/Radios.
9. Social institutions in the village: Information on presence of social institutions in the village such as (i) SHGs, (ii) Aanganwadis, (iii) Community hall, (iv) Gompa, and (v) Any other have been collected.
10. Occupation profile of the people in the village: Information on (i) Population size, (ii) No. of workers, (iii) No. of main workers, (iv) No. of marginal workers, and (v) No. of non-workers each according to gender (male female and total) have been collected.

5.4.2 Construction of Composite Index of Socio-economic Status

At the first stage, from the (village level) information as detailed out above, the following indicator variables have been constructed:

(i) Percentage area under forest, (ii) Percentage area under agriculture, (iii) Percentage area under horticulture, (iv) Percentage area under habitation, (v) Private land holding per HH, (vi) Male literacy, (vii) Female literacy, (viii) Value of livestock, (ix) Earning from agriculture, (x) Earning from livestock, (xi) Earning from wages (xii) Earning traditional skills, (xii) Earning from GS, (xiv) Earning from other sources, (xv) Expenditure on food, drinks and clothing, (xvi) Expenditure on transport, (xvii) Expenditure on education, (xviii) Expenditure on health, (xix) Ratio of expenditure to income, (xx) Index of availability of water for different uses, (xxi) Index of amenities available in the village, (xxii) Index of presence of social institutions in the village, and (xxiii) Weighted economic dependency ratio. Of these indicators, the first nineteen are self-explanatory. However, the subsequent ones need some elaboration.

The index of availability of water from different uses is a weighted sum of 20 (five different sources and four different uses of water, explained in 7 above) variables available for the sample villages. The weights have been obtained by the principal component analysis. It is well known that such an index obtained by weighted sum of individual variables provides the factor score for individual cases (villages) that has the highest possible correlation with the constituent variables (or alternatively highest explanatory power for the observed variance). Similarly, the index of amenities available in the village is a weighted sum of 12 variables explained in 8 above, and the weights are based on the principal component analysis. In the same vein, the index of presence of social institutions in the village is a weighted sum of variables in 9 above obtained by the principal component analysis. Lastly, the weighted economic dependency ratio is a product of two different ratios: (Total Non-workers)/Total Main workers) x (Main female workers/Main male workers). This index summarizes the dependency ratio of no-workers on the workers weighted by the ratio of female workers to male workers.

At the second stage, the indicators (twenty three in all, as detailed out above) were subjected to the principal component analysis for the purpose of data reduction and eight leading component score thereof were retained (Table III 5.17). Together, they explain 77.1 percent of variation in the indicator variables. Subsequently, those eight principal component scores were fused into a single composite index (Table III 5.17) according to the formula given below:

$$IS_i = \left[\sum_{j=1}^{8}(w_j PC_j)^2\right]^{0.5};\ i = 1, 2, \ldots, 56 \text{ (no. of villages)}.$$ Moreover, $\sum_{j=1}^{8} w_j = 1$.

The weights assigned to different PC_j is normed to unity in proportion to the variance they explain in the indicator variables. The index values have been standardized to lie between zero and unity. Thus, the eights PCs (for 56 villages) are considered as 56 points or vectors in 8-dimensional space, with weights in proportion to the variance they explain. Then, the values of socio-economic index is the length of the vectors those points signify. For illustration, Nam Tsering has the highest length (1.00) and Kelenteng has zero length. For the sake of interpretation, Nam Tsering obtains the largest score and Kelenteng is at the bottom.

5.4.2.1 Socio-Economic Index of Sample Villages in the Projects Influence Zone

Using the method described above the socio-economic index of sample villages in the influence zone of 13 proposed HEPs was developed (Table III 5.17).

Table III 5.17: Socio-economic index of sample villages in the projects influence zone

Sl. No.	Sample villages	Eight leading principal components obtained from 23 indicators								Socio-Econ Index (IS)
		PC_1	PC_2	PC_3	PC_4	PC_5	PC_6	PC_7	PC_8	
1	Baghar	0.5624	0.3073	0.3006	0.5591	0.8762	0.7957	0.3582	0.3185	0.460791
2	Dugumba	0.5028	0.2979	0.3001	0.6341	0.6343	0.3783	0.5052	0.2685	0.338412
3	Hoongla	0.66	0.4078	0.3849	0.665	0.7565	0.5327	0.5031	0.4648	0.586718
4	Kharteng	0.5978	0.5214	0.5682	0.8428	0.5747	0.4173	0.7775	1	0.618666
5	Lumla	0.505	0.7641	0.4744	0.7548	0.7161	0.7371	0.4405	0.3947	0.551042
6	Maio	0.5879	0.7848	0.4285	0.5127	1	0.5589	0.4285	0.3757	0.612197
7	Pharmey	0.429	0.4856	0.3603	0.5581	0.898	0.5483	0.7192	0.3118	0.361171
8	Phomang	0.5717	0.4766	0.346	0.4486	0.877	0.3942	0.1807	0.5825	0.459359
9	Poito	0.7343	0.3882	0.2142	0.7972	0.5248	0.6015	0.2946	0.3582	0.656088
10	Sazo	0.5923	0.4182	0.4382	0.5798	0.8778	0.6314	0.6387	0.4967	0.535481
11	Sherbang	0.482	0.4499	0.36	0.5226	0.8447	0.6765	0.5918	0.1921	0.392367
12	Thrillam	0.8535	0.1193	0.4365	0.5893	0.4104	0.954	0.6157	0.6021	0.815229
13	Yabab	0.6166	0.2856	0.3412	0.4563	0.8021	0.4779	0.5523	0.3739	0.480401
14	Kelenteng	0.0406	0.0954	0.4753	0.6252	0.5991	0.7298	0.5009	0.3365	0.039661
15	Dung	0.0223	0	0.4593	0.5287	0.856	0.3065	0.5252	0.3982	0
16	Gorsam	0.5136	0.3269	0.507	0.3717	0.821	0.7435	0.6649	0.4708	0.42185
17	BTK	0.6345	0.8203	0.0157	0	0.5076	0.3348	0.7727	0.4031	0.566609
18	Brokenthang	0.5189	0.4919	0.0613	0.7006	0.7093	0.1952	0.2478	0.5804	0.394471
19	Muchut	0.2881	0.5461	0.4399	0.5913	0.5537	0.8531	0.3716	0.3484	0.248268
20	Zimithang_HQ	0.7294	0.7254	0.2303	0.6988	0.4475	0.5713	0	0.1756	0.6946
21	Kharman	0	0.4471	0.2027	0.5324	0.937	0.3026	0.3355	0.3555	0.035219
22	Lumpo	0.3194	0.7049	0.3238	0.5076	0.6488	0.9373	0.511	0.3719	0.328279
23	Rho	0.2945	0.7491	0.5101	0.6281	0.752	0.439	0.8137	0.2762	0.354307
24	Thingbu	0.1038	0.6448	0.4515	0.8193	0.4239	0.4298	0.375	0.164	0.178223
25	Shyro	0.2536	0.7391	0.3605	0.5511	0.4233	0.6014	0.4766	0.3164	0.233286
26	Jangda	0.197	0.7158	0.4746	0.6167	0.5897	0.4576	0.5803	0.3227	0.23483
27	Khamba	0.5187	0.8083	0.4634	1	0.5324	0	0.6916	0.5239	0.594761
28	Yuthembu	0.2996	0.992	0.6463	0.7159	0.7914	0.7143	0.623	0.2549	0.522071
29	Kharsa	0.3842	0.9178	0.3199	0.7894	0.8135	0.8762	0.4354	0.4372	0.524271
30	Dungse	0.8469	0.8234	0.2408	0.6495	0.7412	0.7563	0.6345	0.5206	0.914823
31	Nam Tsering	1	0.1564	0.5343	0.7771	0.7073	0.3428	0.2984	0	1
32	Gomkelleng	0.2937	0.6363	0.1749	0.4342	0	0.6233	0.4652	0.544	0.165383
33	Mirba	0.3985	0.5517	0.1908	0.9091	0.6966	1	0.6819	0.3148	0.43989
34	Gomkang	0.5389	0.6473	0.0708	0.5801	0.8091	0.6252	0.7107	0.4092	0.495235
35	Kharthut	0.6661	0.1994	0.5299	0.6718	0.5062	0.8493	0.943	0.1991	0.61996
36	Kudung	0.4661	0.8729	0.3106	0.4218	0.8175	0.7307	0.625	0.3908	0.503173
37	Gyankhar	0.6158	0.3805	0.5611	0.5689	0.6821	0.7021	0.7802	0.2775	0.561041
38	Seru	0.572	1	0.4164	0.7008	0.8362	0.7411	0.5257	0.4599	0.701999
39	Teli	0.6112	0.6311	1	0.3015	0.4986	0.3252	0.2038	0.4996	0.62368
40	Yusum	0.2096	0.116	0	0.771	0.6435	0.6966	0.5873	0.4783	0.108304
41	Tsaikhar	0.601	0.5661	0.2233	0.6339	0.4461	0.2174	1	0.03	0.514765
42	Gyada	0.6781	0.4266	0.1908	0.5928	0.8632	0.4025	0.5538	0.532	0.591735
43	Menteng	0.3411	0.4424	0.5087	0.28	0.4771	0.7116	0.5914	0.4427	0.21247
44	Gemreteng	0.6876	0.5396	0.3048	0.5226	0.5085	0.9385	0.2137	0.2802	0.62123
45	Regyang	0.7447	0.6808	0.3311	0.5305	0.6321	0.3052	0.7292	0.0933	0.705262
46	Kregyang	0.5025	0.6881	0.3866	0.4519	0.8571	0.6366	0.3791	0.1746	0.460302
Weights (w)		**0.3058**	**0.1497**	**0.1272**	**0.1148**	**0.0867**	**0.0855**	**0.07013**	**0.0602**	**1.0000**

5.4.2.2 Cumulated Project Effect Index at the Sample Village Level

Different villages in the sample are likely to be differently affected by different projects. A particular village may or may not be under the effect zone of a project, but some villages may be in the effect zone of several projects. Accordingly, the likely effects of the projects on the sample villages may be obtained as/and $\alpha_i^{(p)}=1$ if the i^{th} sample village is under the effect zone of the p^{th} project, else $\alpha_i^{(p)}=0$ (Table III 5.18). This index may also be standardized to lie between (0,100) to facilitate comparison and visualization.

Table III 5.18: Cumulated project effect index at the sample village level

Sl.. No.	Sample Villages	Projects													VSCIA
		Thingbu chu	New Melling	Mago chu	Nykcharong chu	Rho	Tsa chu-I	Tsa chu-I Lower	Tsa chu-II	Tawang-I	Tawang-II	Nyamjang chu	Jaswantgarh	Paikangrong chu	
		1	2	3	4	5	6	7	8	9	10	11	12	13	
1	Baghar	N	N	N	N	N	N	N	N	N	I	A	N	N	0.113207
2	Dugumba	N	N	N	N	N	N	N	N	N	A	I	N	N	0.107519
3	Hoongla	N	N	N	N	N	N	N	N	I	A	I	N	N	0.107519
4	Kharteng	N	N	N	N	N	N	N	N	N	I	A	N	N	0.113207
5	Lumla	N	N	N	N	N	N	N	N	I	A	A	N	N	0.220726
6	Maio	N	N	N	N	N	N	N	N	N	I	I	N	N	0
7	Pharmey	N	N	N	N	N	N	N	N	N	I	I	N	N	0
8	Phomang	N	N	N	N	N	N	N	N	N	I	A	N	N	0.113207
9	Poito	N	N	N	N	N	N	N	N	N	A	I	N	N	0.107519
10	Sazo	N	N	N	N	N	N	N	N	N	A	I	N	N	0.107519
11	Sherbang	N	N	N	N	N	N	N	N	N	I	A	N	N	0.113207
12	Thrillam	N	N	N	N	N	N	N	N	I	A	N	N	N	0.107519
13	Yabab	N	N	N	N	N	N	N	N	N	I	I	N	N	0
14	Kelenteng	N	N	N	N	N	N	N	N	N	N	A	N	N	0.113207
15	Dung	N	N	N	N	N	N	N	N	N	N	I	N	N	0
16	Gorsam	N	N	N	N	N	N	N	N	N	N	I	N	N	0
17	BTK	N	N	N	N	N	N	N	N	N	N	A	N	N	0.113207
18	Brokenthang	N	N	N	N	N	N	N	N	N	N	I	N	N	0
19	Muchut	N	N	N	N	N	N	N	N	N	N	A	N	N	0.113207
20	Zimithang_HQ	N	N	N	N	N	N	N	N	N	N	I	N	N	0
21	Kharman	N	N	N	N	N	N	N	N	N	N	I	N	N	0
22	Lumpo	N	N	N	N	N	N	N	N	N	N	A	N	N	0.113207
23	Rho	A	A	A	A	A	A	A	A	I	N	N	N	A	0.983902
24	Thingbu	I	I	I	I	N	N	N	I	N	N	N	N	N	0
25	Shyro	N	I	I	I	I	N	N	N	A	N	N	N	I	0.129362
26	Jangda	A	I	A	A	A	A	A	A	A	N	N	N	A	1
27	Khamba	N	N	N	N	N	N	N	N	A	N	N	N	N	0.129362
28	Yuthembu	N	A	I	I	I	N	N	N	A	N	N	N	I	0.242625
29	Kharsa	N	I	I	I	I	N	N	N	A	N	N	N	N	0.129362
30	Dungse	N	N	N	N	I	N	N	N	I	N	N	N	N	0
31	Namtsering	N	N	N	N	N	N	N	N	N	I	I	N	N	0
32	Gomkelleng	N	N	N	N	I	N	N	N	A	N	N	N	N	0.129362
33	Mirba	N	I	I	I	I	N	N	N	A	N	N	N	I	0.129362
34	Gomkang	N	N	N	N	N	N	N	N	A	I	N	N	N	0.129362
35	Kharthut	N	N	N	N	N	N	N	N	I	N	N	N	N	0
36	Kudung	N	N	N	N	N	N	N	N	A	A	N	N	N	0.23688
37	Gyankhar	N	N	N	N	N	N	N	N	I	I	N	N	N	0
38	Seru	N	N	N	N	N	N	N	N	A	I	N	N	N	0.129362
39	Teli	N	N	N	N	N	N	N	N	A	N	N	N	N	0.129362
40	Yusum	N	N	N	N	N	N	N	N	A	I	N	N	N	0.129362
41	Tsaikhar	N	N	N	N	N	N	N	N	A	N	N	N	N	0.129362
42	Gyada	N	N	N	N	N	N	N	N	I	I	N	N	N	0
43	Menteng	N	N	N	N	N	N	N	N	I	I	N	N	N	0
44	Gemreteng	N	N	I	I	N	N	N	N	I	I	N	N	N	0
45	Regyang	N	N	I	I	I	N	N	N	I	N	N	N	N	0
46	Kregyang	N	N	I	I	I	N	N	N	I	N	N	N	N	0

Note: A=Under effect zone; I=Under influence zone; N=Neither A nor I.

5.4.2.3 Cumulated Environmental Effect of Projects (VSCIA) and Socio-Economic Index (IS)

Considering three levels of cumulated environmental effect of projects on the sample villages (low=1; medium=2 and high=3) and three levels of socio-economic status of villages (low=1, medium=2; high=3) a cross classification of sample villages has been presented in Table III 5.19. The indices (VSCIA as well as IS) have been grouped into 3-quantiles (terciles) scheme and the code for the villages in the lowest tercile is 1, in the mid tercile is 2 and the upper tercile is 3. The classification (based on lexicographic ordering) has been presented in Figure III 5.8.

Alternatively, the vector length based classification may also be done. For this, the vector length/is computed with standardized VSCIA in (0,1) and standardized IS in (0,1). Then, L may be coded for the three terciles (low=1; mid=2 and high=3) as given in Table III 5.20.

Table III 5.19: Classification of sample villages according to environmental effect of projects (VSCIA) and socio-economic index (IS)

Sl. No.	Sample villages/ projects	VSCIA	Socio-econ index (IS)	Median-based lexicographic class code (VSCIA & IS)	Tercile-based lexicographic class code (VSCIA & IS)	Length measure code (L)
1	Baghar	0.113207	0.460791	12	22	2
2	Dugumba	0.107519	0.338412	11	22	1
3	Hoongla	0.107519	0.586718	21	22	2
4	Kharteng	0.113207	0.618666	22	32	3
5	Lumla	0.220726	0.551042	22	23	2
6	Maio	0	0.612197	21	22	2
7	Pharmey	0	0.361171	11	22	2
8	Phomang	0.113207	0.459359	12	22	2
9	Poito	0.107519	0.656088	21	32	3
10	Sazo	0.107519	0.535481	21	22	2
11	Sherbang	0.113207	0.392367	12	22	2
12	Thrillam	0.107519	0.815229	21	32	3
13	Yabab	0	0.480401	11	22	2
14	Kelenteng	0.113207	0.039661	12	12	1
15	Dung	0	0	11	12	1
16	Gorsam	0	0.42185	11	22	2
17	BTK	0.113207	0.566609	22	22	2
18	Brokenthang	0	0.394471	11	22	2
19	Muchut	0.113207	0.248268	12	12	1
20	Zimithang_HQ	0	0.6946	21	32	3
21	Kharman	0	0.035219	11	12	1
22	Lumpo	0.113207	0.328279	12	12	1
23	Rho	0.983902	0.354307	12	23	3
24	Thingbu	0	0.178223	11	12	1
25	Shyro	0.129362	0.233286	12	12	1
26	Jangda	1	0.23483	12	13	3
27	Khamba	0.129362	0.594761	22	22	2
28	Yuthembu	0.242625	0.522071	22	23	2
29	Kharsa	0.129362	0.524271	22	22	2
30	Dungse	0	0.914823	21	32	3
31	Namtsering	0	1	21	32	3
32	Gomkelleng	0.129362	0.165383	12	12	1
33	Mirba	0.129362	0.43989	12	22	2
34	Gomkang	0.129362	0.495235	12	22	2
35	Kharthut	0	0.61996	21	32	2
36	Kudung	0.23688	0.503173	22	23	2
37	Gyankhar	0	0.561041	21	22	2
38	Seru	0.129362	0.701999	22	32	3
39	Teli	0.129362	0.62368	22	32	3
40	Yusum	0.129362	0.108304	12	12	1
41	Tsaikhar	0.129362	0.514765	22	22	2
42	Gyada	0	0.591735	21	22	2
43	Menteng	0	0.21247	11	12	1
44	Gemreteng	0	0.621231	21	32	2
45	Regyang	0	0.705262	21	32	3
46	Kregyang	0	0.460302	11	22	2

Table III 5.20: Interpretation for Length measure Code (L)

Median		
Environmental	**Social**	**Environmental , social**
1	1	Low ,low
1	2	Low, high
2	1	High, low
2	2	High, high
Tricile		
1	1	Low, low
1	2	Low, mid
1	3	Low, high
2	1	Mid. low
2	2	Mid. mid
2	3	Mid. high
3	1	High. low
3	2	High. mid
3	3	High. high
Euclidean distance		
1		Low socio-environmental
2		Med socio-environmental
3		High socio-environmental

Based on the Cumulated Environmental Effect of Projects (VSCIA) and Socio-Economic Index (IS) analysis, 11 villages would be highly impacted, 24 villages belong to the medium impact class and 11 villages would be under the low impact class.

6.1 NEED FOR EFFECTIVE MONITORING OF IMPACTS

Development of indicators for monitoring of impacts is an integral part of CIA and management. For timely intervention and mid-term correction, it is imperative that impacts are monitored periodically. In this section the indicators are provided for monitoring purpose.

6.2 INDICATORS FOR EFFECTIVE MONITORING

Described VECs are the candidate for effective monitoring of cumulative impacts. Table III 6.1 outlines the major VECs and the indicators for monitoring.

Table III 6.1: Selected VECs and the suitable indicators for effective monitoring of cumulative impacts

VECs	Indicators
Ecosystem Structure, Function and Services	• Ambient air quality • Periphyton and Zooplankton density • NPP • Change in Turbidity (NTU) • Total Coliforms (CFU/ml)
Biodiversity	• Plant species diversity • Mammal species diversity • Bird species diversity • Fish species diversity • Soil arthropods diversity • Periphyton diversity
Ecosystem vulnerability	• Soil erosion • Riverbank instability • Invasion by alien species • Siltation
Hydrology and hydraulics	• Downstream water availability • River sediment analysis
Livelihood	• Human development parameters

7.1 NEED FOR MITIGATION

Many significant cumulative environmental impact could be potentially reduced and possibly eliminated with technically sound and practical mitigation measures. The potential impacts and respective mitigation measures have been discussed in detail in Section II & VII. In this chapter, cumulative impact-specific mitigation measures have been suggested for effective management and significant reduction of impacts.

7.1.1 Project Level Mitigation Measures

- Critically impacted attributes (basin level CIA) of ecosystem/components to be properly monitored and addressed.
- Hazardous non-toxic waste treated before disposal.
- Installing “fish-friendly” horizontal bulb type turbines instead of the preferred vertical Kaplan type which are easier to maintain. Alternately, conventional fish ladders must be provided in the projects where threatened and endemic fish species are present.
- Creation of green zones and wildlife corridors in biodiversity rich regions of specific projects as detailed in section VII.
- Strict adherence to CAT plan for watershed management as discussed in section VI
- Strict adherence to calculated E-Flow value for sustenance of river and riverine ecosystems as discussed in section IV.

All the 13 projects in TRB are run-of-the-river scheme and thus water storage is limited to peaking purpose only for a few hours. As such, most projects are barrage based projects and the villages are situated much above the river bed, thus reducing the impact of any possible dam break. Therefore, the dam-break analysis has not been undertaken for the proposed power projects in TRB. But, keeping in mind the possible loss of social and economic infrastructure from dam break, disaster management measures have been suggested in section VI.

7.1.2 Basin Level Mitigation Measures

- Steps must be taken to ensure reduction of socio-economic impacts on the indigenous population due to implementation of the proposed projects. This has been described in section VI.
- Phasing of construction work to limit migrant influx to 33% of the present indigenous population.
- Electric crematorium to be constructed in identified places

8.1 FIELD LEVEL CONSULTATIONS

Several stakeholder consultation meetings including the villagers to be directly affected/benefited, hydel-power developing agencies, officers of the district administration, other heads of the department at district level, and important personalities in the project areas were organized. Meetings at village level in 61 impacted/affected villages were conducted (Table III.8.1) and opinion/suggestions of each of the village on various aspects of the study were collected. Since, the view and vision of the public leaders are keys to any development planning, the former and present members of Arunachal Pradesh State Legislative Assembly from Lumla and Tawang, and Shri Jambey Tsering, Chairman, Tawang Zila Parishad, and religious leaders of Tawang district were individually consulted and their view points were included in the report.

Table III 8.1 compiles the list of the villages in which meetings were held at Panchayat and HH level for stakeholder engagement.

Table III 8.1: List of villages with date of stakeholder's engagement for population affected/influenced proposed HEPs

Sl. No.	Name of the village	Circle HQ	Date of meeting
1	Nam Tsering	Dudunghar	11-07-2014
2	Dungse	Jang	22-04-2014
3	Jang Yuthembu	Jang	22-04-2014
4	Kharsa	Jang	22-04-2014
5	Khirmu	Kitpi	19-06-2014
6	Gemreteng	Lhau	01-04-2014
7	Grelleng	Lhau	24-06-2014
8	Jangda	Lhau	15-03-2014
9	Jobrang	Lhau	01-04-2014
10	Khamba	Lhau	21-06-2014
11	Kregyang	Lhau	01-04-2014
12	Lhau	Lhau	01-04-2014
13	Menteng	Lhau	01-04-2014
14	Regyang	Lhau	01-04-2014
15	Shyro	Lhau	21-06-2014
16	Baghar	Lumla	20-07-2014
17	Buikyong	Lumla	14-07-2014
18	Dugumba	Lumla	07-07-2014
19	Hoongla	Lumla	27-04-2014
20	Kharteng	Lumla	21-07-2014
21	Kungba	Lumla	27-04-2014
22	Lumla	Lumla	27-02-2014
23	Mangnam	Lumla	25-02-2014 , 27-02-2014, 14-03-2014
24	Pharmey	Lumla	07-07-2014
25	Phomang	Lumla	20-07-2014
26	Poito	Lumla	27-04-2014
27	Sakyur	Lumla	25-02-2014, 14-03-2014 , 27-06-2014
28	Sazo	Lumla	27-04-2014
29	Sherbang	Lumla	21-07-2014
30	Yabab	Lumla	21-07-2014
31	Gispu	Lumla	14-07-2014
32	Thrillam	Lumla	26-02-2014
33	Gomkelleng	Mukto	24-04-2014
34	Mirba	Mukto	08-06-2014
35	Khet	Mukto	22-06-2014
36	Bumteng	Tawang	03-06-2014
37	Gomkang	Tawang	09-06-2014
38	Gyada	Tawang	21-02-2014
39	Gyangkhar	Tawang	04-06-2014
40	Kharthut	Tawang	04-06-2014
41	Kudung	Tawang	29-06-2014
42	Paidhar	Tawang	03-06-2014
43	Sakpret	Tawang	14-03-2014, 29-06-2014
44	Seru	Tawang	01-06-2014
45	Teli	Tawang	09-06-2014

46	Tsaikhar	Tawang	21-02-2014
47	Yusum	Tawang	28-04-2014
48	Thingbu	Thingbu	16-03-2014
49	Rho	Thingbu	15-03-2014
50	Dung	Zimithang	12-06-2014
51	Gorsam	Zimithang	16-07-2014
52	Kharman	Zimithang	16-07-2014
53	Kelenteng	Zimithang	16-07-2014
54	Lumpo	Zimithang	15-07-2014
55	Muchut	Zimithang	15-07-2014
56	Shoksten	Zimithang	12-06-2014
57	Zimithang	Zimithang	12-06-2014
58	Brokenthang	Zimithang	12-06-2014
59	BTK	Zimithang	14-07-2014
60	Shakti	Zimithang	14-07-2014
61	Mago *	Thingbu	16-03-2014

Table III 8.2: Stakeholder's response and developmental concerns recorded during stakeholders' engagement.

Sl. No.	Name of the village	View about HEP	Developmental needs
1.	Mirba	• Mini Hydel has been proposed • No clear idea about the NHPC projects • If Jung Hydel cannot provide for such a small population, why spoil the land • Ensure that the existing one functions effectively	• Drinking Water supply: 2-3km away in winter • 8-9 km road to agricultural land required • Sanction of subsidised Zom would help • A spot for cremation
2.	Khet	• Against the project • Not willing for any discussion	• Overall development required • Feel ignored by departments
3.	Gomkang, Gyankhar , Kharthut	• No opinion in particular • Feel they should not be cheated	• Roads, Water supply, CC steps, needs development in general
4.	Teli	• No interactions or survey done • Villagers need to be made aware • Religious site, Agriculture may be affected • Road may be cut through agricultural Land	• Water connection • Up gradation of primary school
5.	Seru	• Not sure about compensation • Land has always been given without returns • If all go well, it will benefit as electricity is a must, job opportunities will increase • To avoid loss, initially the land may be given on lease. • Fear of migrants, may influence safety, culture, votes. • Govt should rather try to improve micro-hydels.	• Fodder development • Improved seed supply • Solution for menace of wild boar and monkeys, street dogs/fencing
6.	Bomba, Bumteng, Paidhar , Kitghar	• Project is not wanted • No villager will cooperate • Improve Mini-hydels	• Education • (shortage of Teachers, quarters, Assembly/play ground) • Sub health centre • FPS – stock insufficient • Agriculture suffers • NREGA work required
7.	Kharthut	• Strongly fear safety of women due to migrants • If their number is controlled, other aspects are beneficial	• Agriculture schemes
8.	Khirmu	• Chaksam-holy place is affected • Not willing for project • Markings done in agricultural land by developers without permission	• Health sub-center in Kitpi, but no staff • Water insufficient • Agriculture suffers • School requires benches
9.	Lhau	• Public hearing done, all are aware • Not much agriculture • People are convinced and support the projects	• Pharmacy • Cattle upgrading centre • Quarters for veterinary staff • Indoor facility in medical Centre • Monyul Development centre • Transportation is a problem, fruits spoil before reaching markets

10.	Khamba	• Not willing for project • Markings done w/o permissions, in agricultural land • Have given a letter to DC • Place is geologically unstable	• Water insufficient • No water, in case of fire • Drainage system
11.	Shyro	• Land asked for is an old agriculture land , • Now used as grazing ground • In future, agriculture may be practised • NHPC contributed to the school	• Fair Price Shop, license has been granted, yet they have to go to Jung
12.	Grelleng	• Not willing for project • Loss of agriculture and Forest land • Lowest house is 500 m above project area • No faith in compensation • In case of Landslide, no place to shift • Local people do not get jobs in government schemes	• Poverty • Overall dev elopement • PMGSY
13.	Kudung	• Orange plantations, Puja site will be affected • Landslide prone, hence very risky	• Old age pension scheme to be made effective • School exists , but closed since 2 years , no teachers, benches , boards • Pharmacy • Gompa • Community Hall maintenance
14.	Tsaikhar/Gyada	• Displeasure/Unawareness about project effects	• School is required nearby • Road connectivity required
15.	Gormang, Sahajing, Dungri, Nodo	• Let there be a joint meeting to clear doubts	• Education needs improvement
16.	Surbhi/Teli	• Map issue on project location • Public hearing video provides wrong information	• Pipeline • CC steps 60% required • Play ground • Hro ang site, 1 lama should be caretaker, no chowkidar required • VFMC
17.	Yusum	• PMGSY-no quality, damaged but not repaired • Landslide prone-near Gompa • Tunnel made for testing is drawing water into it. • Yusum has very limited community land • No guarantee of Electricity, Jobs, Compensation • No compensation for mud dug out in tunnel • The village is against the project • Opinion: first complete Bhilwaras 7.5 MW project which has destroyed forest, tail race pipe must be elongated upto river bed, Water storage chamber must be underground, • Ground vibration should be minimum • No invitation for public hearing	• Water supply insufficient • No KG School • Anganwadi staff illiterate • Required Bamboo, Pine Plantation • Road needs repairs. • Computer trainer, Computers required in Middle school
18.	Gomkelleng	• Survey without the villagers consent and help would create boundary disputes • Land may be given on lease • Debate on pros and cons should take place • Interaction is a must • All resources of Sand, stone will be used up • Deforestation will be excessive • C, D group jobs must be given to locals • Migrants should not influence votes • Atta chakki needs water flow • Edible algae are collected	• Community Hall insufficient • Sports must be encouraged • VFMC to be implemented • NREGA-100 days not even in 5 years • No savings, economically poor • Paper unit • Medicinal plant programmes • Computer training Institute
19.	Gyankhar	• No information about the project • Totally ignorant and apprehensive	• Retention wall in landslide points • Agriculture fencing • Drainage system • CC steps
20.	Yuthembu	• Barrage complex near Nuranang falls will destroy the beauty-It is a tourist destination • Depends on Sand, Stone for sale • Grazing ground and agriculture land is asked for by the project • Height of village is 500m – 600m above the river bed • Should guarantee compensations	• Community hall, Children's park • Free medicines, Pathology • BSNL towers present, but no network • Water, Electricity, Ration supply need attention • Craft centre, Packaging unit • Electric cremation

		• No free electricity from Jung hydel	
21.	Kharsa, Namazing	• Barrage complex near Nuranang falls will destroy the tourist place i.e., fall • Sand, stone are extracted from the project site for sale • Grazing ground and agriculture land will be lost • Height of village is 500m above the river bed • Should guarantee compensation • No free electricity from Jung hydel	• College • Electric cremation site
22.	Kungba	• Survey done with Panchayat members • Not clear about project • 2 tunnels of two projects • Damaged due to landslide • Should be assured compensation • Landslide in tunnel site is scary • Electricity-only 1 hour • Toilet blocked	• Extra teachers required in school • CC step • Drainage system
23.	Sazo/Poito	• NHPC guest house in Poito, but no interactions • NHPC refused joint meetings • Markings through agriculture land • Company gave furniture to school • Cremation point near the project site	• NREGA – 1-2 weeks only • Hostel beds • CC steps • Gompa • Sanction of animals • Agriculture affected
24.	Hoongla Khuminteng	• Survey without notification • Markings through agriculture land • Nagdevta is worshipped there, digging of the mud is prohibited • NHPC assured infrastructure in school	• Water supply pipeline required • Community hall is too small • Only one Chorten is provided • Poverty • Higher education is a problem • NREGA only for few days • VFMC, Plantations • Foot track-Khuminteng to Pharmey • CC steps
25.	Nam Tsering	• Will be most affected • TB due to impure water	• Medical centre • Hygiene
26.	Maio	• Can not stop the project • But , expect honesty	• Community hall • School • Anganwadi • Gompa (maintenance) • Water supply tank • NREGA work • Mobile tower –Lumla
27.	Pharmey	• No strong opinion , mostly ignorant	• Gompa • Water supply • CC step • Anganwadi • NREGA • River water flood affects agriculture
28.	Dugumba	• Contracts given politically, hence quality suffers • Loss of land not comparable to the compensation • Kungba landslide due to tunnel activity	• Agriculture affected
29.	Sherbang/Yabab	• Bhilwara company has surveyed • People are willing as land asked for is community land • Graduates being jobless is sending wrong message amongst younger generation	• Many vegetables can be grown – provided there is water supply • In case of fire, no remedy , as there is no water • 40 mm 1 pipe for – Baghar, Phomang, Kharteng-absolutely insufficient • Employment
30.	Kharteng	• Project should be ok.	• Electricity issue-as micro-hydel is affected in winters • Around 75 days of labour work • GREF 117 RCC provides 80 labour works since past 15 years • Habit of drinking should be discouraged
31.	Mangnam	• NHPC promised computers, • Benches and safety wall for school	
32.	Sakyur	• Against project	• Rhododendron juice

		• No discussions entertained.	• Mushroom cultivation
33.	Sakpret	• No opinion in particular • Feel they should not be cheated	• 90% BPL • Youth are interested in sports
34.	Mago	• Ignorant about project	
35.	Buikyong	• Divided opinion on project • Apprehension for project effects	• Roads, medical centre • Drainage and hygiene • Water supply
36.	Lumla, Phomang, Baghar, Thrillam	• Anxious about projects repercussions • Loss of agricultural land • Indifference to projects	• Health hygiene and education • Awareness programmes
37.	Rho, Jangda, Jang	• Extremely supportive for • HEPs • Excited over the possible development avenues and job opportunities • Having large chunk of forest and land resources, ready to provide land for • development	• Roads, medical centre • Drainage and hygiene • Water supply • Employment • College in Tawang
38.	Thingbu	• Indifference towards project • Proper compensation	• Roads, medical centre • Water supply lines • Sports training centre • Fair price shop
39.	Zimithang, Lumpo, Gorsam	• Apprehension towards loss of tourism and wildlife • especially revered Black-necked crane habitat • Proper compensation • Apprehensive of dam break flood • Loss of pasture land • Drying of hill streams/springs owing to tunnel and barrages	• Teachers required. • Computer training center. • Fixed days/village – for visiting doctors. • Career counselling center. • Polytechnic college. • Free books, medicine, long term scholarships. • Sports training.

8.2 CONSULTATIONS ON DRAFT REPORT

The draft report was submitted to Government of Arunachal Pradesh on 25th September, 2014. The Government of Arunachal Pradesh organized two rounds of consultation at Itanagar involving the developers, Senior officials of Forests and Environment department, Power department, Planning department, Ministers and MLA, and Chief Secretary. The views of each of the above stakeholders were considered, and the draft report was revised. The revision was undertaken taking the following into consideration:

- Many developers have redesigned the project, and also have changed the location of the project sites. When the study was started, these developers did not finalize their DPR. The data were collected from the sites as shown by the developers at the beginning of the study. The new sites/changed location of the project components were revisited and the data were modified accordingly.
- The data on dead body disposal, and dependency on natural resources including river were verified. Necessary corrections were made. Minor reorganization of VECs was done to give adequate emphasis on human dependency on natural resources.
- The developer of Nyamjang chu joined the study late. The sites could be visited only for one season i.e., pre-monsoon. In absence of three season data, it was not possible to conclude and recommend on all the aspects of the project. This was particularly important in determination of E-Flow. The expert team felt that the protection of the wintering habitat of the threatened black-neck crane could be a major deciding factor in determining the E-Flow. However, during the present study the team could not directly observe or camera-trap the bird because of late joining of the developer in the study, E-Flow could not be recommended. The E-flow recommended by the EIA committee of MoEF & CC for Nyamjang chu project was therefore used for calculating cumulative index at basin level.
- Because of latitudinal difference between Eastern and Western Himalayas, the climatic and vegetation features at 2,500 m in the Western Himalaya are similar to those found at about 3,200 m elevation in the Eastern Himalayan mountains.

- Based on the available imagery evidences duly supported by adequate ground truthing, it was concluded that paraglacial deposits (Ballantyne, 2002) are present in Tawang district above the elevation of 3,500 m a.s.l. Although winter snowline is at about 2,700-2,800 m a.s.l., the Himalaya in Tawang harbors considerable vegetation cover at this elevation and is relatively stable. Therefore, the snow cover at this elevation should not cause any disaster like paraglacial sediment outburst. Current glacial line in Tawang district is at an elevation of 5,000 m and above. A recent study in Sikkim Himalaya i.e., the glacial study available for the nearest area shows that the retreat rate of glaciers during 1976-2005 period was on an average 13.02 m per year (Raina, 2010). Thus, the glacial retreat in the last century should not be more than 1300 m. Since no glacier retreat data for Eastern Himalaya in Tawang is available, we considered the above mentioned rate of glacier retreat in Tawang district, and concluded that the glaciers were at least 3,700 m a.s.l. before 100 years. Therefore, the paraglacial deposit in no case was visible at or below3,200 m asl.

- Based on the above facts, it is recommended that no hydel electric project should be constructed above 3,200 m. However, project-specific strict environmental safeguards/mitigation measures must be undertaken for the projects above 2,500 m elevation.

- Considering the agreed mitigation measures as stated by the developers and public leaders, such as electric crematorium instead of dead body disposal in the river, creation of riverine green belt to reduce IAS invasion, reassessment of ecosystem structure and function vis-a-vis flow dynamics in different seasons, E-Flows for three seasons were recalculated.

SECTION–IV

ASSESSMENT OF E–FLOW

SUMMARY

Environmental flow of a river refers to the quantity, quality and timing of water needed to sustain aquatic and terrestrial ecosystems, and the related ecosystem services on which people depend on. Environmental flow assessment for TRB was done following building block method taking a holistic assessment approach. It comprises the following steps: (1) using a stakeholder consultation process to set objectives (thresholds) for the environmental conditions of the river, (2) assessing a modified flow regime that will meet those objectives, (3) using flow–dependent indicators and non-consumptive human requirements, as well as water quality metrics to identify water depths, velocities, river widths, and substrate types that will provide the required habitats and conditions. Such hydraulic requirements can be then converted to flow characteristics, and (4) identifying the critical components known as building blocks of the flow regime that govern environmental conditions. The Building Block Method followed in this study has identified six building blocks based on baseline data and expert opinion. The components are: (i) ecosystem structure, function, and services, (ii) river biodiversity, (iii) river hydraulics, (iv) cultural requirements, and (v) livelihood requirements. For river hydraulics, bed composition was considered as an indicator. Dead body disposal, and habitat requirement of the threatened bird - black-necked crane, also attached with religious belief in Buddhism, were two critical attributes for deciding the minimum flow depth width under the culture building block. Similarly water use, river resources, and edible algae were considered as major indicators for livelihood building block. The indicators for the ecosystem structure and function building block were: periphyton density, water quality, NPP, invasibility by invasive alien species (IAS).

Analysis of hydrological parameters is a pre-requisite for E-Flow determination. The hydrological analysis of TRB included the following: (1) 90% dependable flow analysis, (2) lateral flow contribution analysis, (3) analysis of river cross sections, and (4) hydrodynamic modelling using HEC-RAS model. 90% dependable flow analysis showed that average lean flow at different project sites varied from 39 cumec to 1 cumec, whereas the variation in monsoon season ranged from 141 cumec to 4 cumec. Lateral flow contribution in the intermediate length during lean season for most of the projects was not significant, except the intermediate length in Tawang-I and Tawang-II. Hence, the contribution from lateral flow was not included in environmental flow assessment for any HEP. River cross section analysis showed that Tawang chu is a very shallow river with gravel, cobbles, few boulders as bed material. Flow depth and velocity measured at some of the project sites shows that flow depth ranges from 0.39 m to 1.23 m, and flow velocity ranges from 0.9 to 2.59 m/s. The flow width varies from 7 m to 26 m. The E-Flow requirement for each project site was assessed after extracting the average value of calculated flow depth, velocity, top width for each seasons through hydrodynamic modelling using HEC-RAS model. The recommended seasonal E-Flow requirements for all the studied HEPs are summarized in Table IV. 0.1

Table IV. 0.1: Seasonal E–Flows requirements for all the studied HEPs

Sl. No.	Name of HEP	Recommended environmental flow in discharge (cumecs)			Recommended environmental flow in percentage of 90% dependable flow		
		Lean	Monsoon	Non–Monsoon	Lean	Monsoon	Non–Monsoon
1	Tawang–II	10	26	13	25	18	20
2	Tawang–I	7.6	20	10	27	18	20
3	Rho	7.6	20	10	27	18	20
4	Nykcharong chu	6	13	10	30	30	27
5	Mago chu	5	10	8	70	20	53
6	New Melling	3	10	7	50	20	50
7	Tsa chu–I	5	10	6	25	25	17
8	Tsa chu–I Lower	5	10	6	25	25	17
9	Thingbu chu	1	2	1	100	30	100
10	Tsa chu–II	5	10	6	25	25	15
11	Nyamjang chu						

1.1 ENVIRONMENTAL FLOW

In the development of HEPs, release of environmental flow (E-Flow) is ensured to the downstream of the diversion structure to sustain ecology and environment in the project area. Many approaches for estimation of quantity and quality of environmental flow have been followed in different parts of the world. Because of that, definition of environmental flow has undergone a number of refinements in the last one decade by considering different aspects of the river system. Some of the E-Flow definition are given below indicating the importance of the E-Flow:

- As per the IUCN (2003), E-Flow is defined as, 'the water regime provided within a river, wetland or coastal zone to maintain ecosystems and their benefits where there are competing distinction water uses and where flows are regulated'.

- Brisbane Declaration (2007) defines E-Flows as, 'the quantity, timing, and quality of water flows required to sustain fresh water and estuarine ecosystems and the human livelihoods and wellbeing that depend on these ecosystems'.

- After critical study of various definitions of E-Flows, Ganga River Basin Management Plan (GRBMP) 2011 defines E-Flow as, 'Environmental flows are a regime of flow in a river or stream that describes the temporal and spatial variation in quantity and quality of water required for fresh water as well as estuarine systems to perform their natural ecological functions (including sediment transport), and support the spiritual, cultural and livelihood activities that depend on these ecosystems'.

1.2 CURRENT NORMS BEING FOLLOWED FOR ENVIRONMENTAL FLOW IN INDIA

There are no set specific norms for the E-Flow to be released. This is due to the fact that environmental conditions vary widely among the rivers, even it is heterogeneous at different points along the course of the same river. Besides the heterogeneity in river ecology, the issues concerning livelihood dependence on river, river biodiversity, river hydraulics, river bank ecosystem properties, sensitive issues relating to socio–cultural rites and practices, vary extensively among ecosystems and human societies. Therefore, a universal norm for E–Flow cannot be set.

In India, Expert Appraisal Committee (EAC) for river valley and HEP of Ministry of Environment, Forest & Climate Change (MoEF & CC) recommends 20% of average lean flow of 90% dependable year for lean season, 30% for monsoon, and 20-30% of average non-monsoon 90% dependable year flow as minimum releases for sustaining the river ecosystem.

1.3 ESTIMATION OF E-FLOW FOR THE PROPOSED HEPs IN TAWANG BASIN

A number of HEPs are being planned in the TRB, and their design features are listed in Table IV. 1.1. Three HEPs of more than 500 MW power generation are being planned along with other HEPs lesser than 100 MW. Two small HEPs less than 25 MW are included in this study. Most of these projects are at present either in survey stage or in preparation of detailed project report stage. It may be noted that, of the total 13 projects, Detailed Project Reports (DPR) for 7 projects have been prepared. In those projects for which DPRs are not available, the locations of barrage and power house sites, given by the department of power were considered for E-Flow assessment. One project is located in 1500-2000 m range, six projects are between 2000 and 2500 m, and six HEPs are located at altitude of above 2500 m asl. Intermediate river length which is the distance from barrage/dam site to the tail water discharge point for all the projects are also tabulated (Table IV. 1.1).

Table IV. 1.1: HEPs covered for hydrodynamic modeling

Sl. No.	Name of HEP	Proposal Power generation (MW)	River/ Tributary	Main River	Status of the DPR (Yes/No)	Altitude of the Project (m)	Intermediate River length (km)
1	Tawang-I	600	Tawang chu	Tawang chu	Yes	2092	15
2	Tawang-II	800	Tawang chu	Tawang chu	Yes	1536	16
3	Paikangrong chu	2.4	Tawang chu	Tawang chu	No	2150	0
4	Rho	98	Tawang chu	Tawang chu	Yes	2240	1.8
5	Mago chu	96	Mago chu	Tawang chu	Yes	2456	2.5
6	New Melling	96	Mago chu	Tawang chu	Yes	2786	3.56
7	Thingbu chu	60	Mago chu	Tawang chu	No	2800	2
8	Nykcharong chu	96	Nykcharong chu	Tawang chu	Yes	2460	2
9	Tsa chu-I	24	Tsa chu	Nykcharong chu	No	3350	2.5
10	Tsa chu-I Lower	77.2	Tsa chu	Nykcharong chu	No	3245	1.98
11	Tsa chu-II	67	Tsa chu	Nykcharong chu	No	3170	1.67
12	Jaswantgarh Stage-I	4.5	-	Tawang chu	No	3357	0
13	Nyamjang chu	780	Nyamjang chu	Tawang chu	Yes	2115	23

2.1 INTRODUCTION

In order to carry out hydrological analysis, daily discharge data from Central Water Commission (CWC) and CWC approved 10-day discharge series were used. Daily discharge data obtained from CWC gauging station sites along Tawang chu River and its tributaries like Mago chu and Nykcharong chu have been used for flow analysis of six projects. These projects are, Tawang-I, Tawang-II, Rho, Nykcharong chu, Mago chu and New Melling. In the case of Nyamjang chu project, design discharge series from the detailed project report have been considered. For the remaining projects, 10-day discharge series have been generated by area proportionate approach. This approach has been applied on discharge data of the nearest upstream HEPs in which CWC approved design discharge series is available.

For the long term flow series analysis, 90% dependable year component for HEPs is used as the baseline hydrological condition year for environmental flow assessment. Figure IV. 2.1 shows 10 days discharge variation of river Tawang chu at Yusum village. From this Figure it may be noted that three different hydrological response seasons as given below

1) Lean season (January-March): Ground water contribution dominated
2) Monsoon season (May-September): Monsoon (rain) mainly dominated
3) Non-monsoon season (April & October-December): snow-melting and ground water dominated.

Therefore, we shall henceforth use these three season average concept for environmental flow assessment.

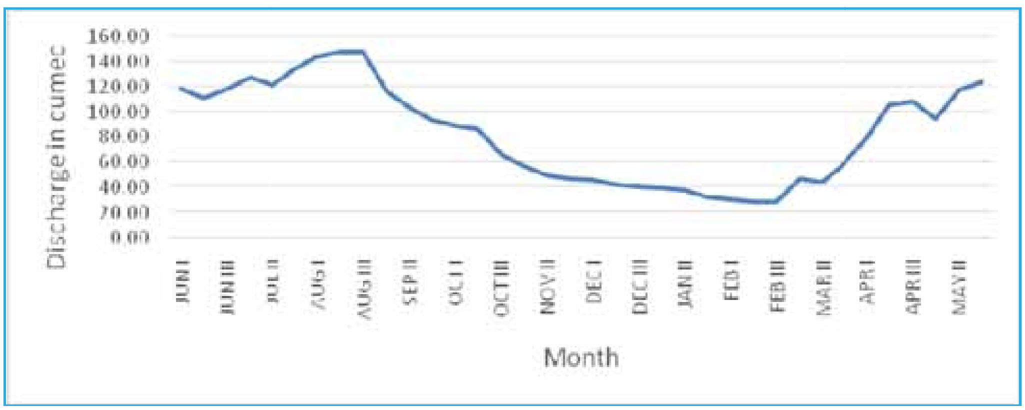


Figure IV. 2.1: 10 daily average discharge for a 90% dependable year at Yusum village gauging station

2.2 90% DEPENDABLE FLOW ANALYSIS

From flow dataset, 90% dependable year for each project site has been identified. The 10-day discharge series of the dependable year have been used to compute average of the three selected seasons. Table IV. 2.2 to 2.14 summarizes flow variations of all the project sites for the three seasons for 90% dependable year. From this Table, it can be observed that average lean flow at project varies from 39 cumecs to 1 cumecs whereas the variation in monsoon season ranges from 141 cumecs to 4 cumecs.

Table IV. 2.1: 90% Dependable year average discharge data for Tawang–I HEP

90% Dependable Year	2011–12		
	Discharge in cumecs		
	Lean	Monsoon	Non–monsoon
Average	28	114	51
10%	2.8	11.4	5.1
20%	5.6	22.8	10.2
30%	8.4	34.2	15.3
50%	14	57	25.5
70%	19.6	79.8	35.7

Table IV. 2.2: 90% Dependable year average discharge data for Tawang–II HEP

90% Dependable Year	2009–10		
	Discharge in cumecs		
	Lean	Monsoon	Non–monsoon
Average	39	141	67
10%	3.9	14.1	6.7
20%	7.8	28.2	13.4
30%	11.7	42.3	20.1
50%	19.5	70.5	33.5
70%	27.3	98.7	47

Table IV. 2.3: 90% Dependable year average discharge data for Rho HEP

90% Dependable Year	2011–12		
	Discharge in cumecs		
	Lean	Monsoon	Non–monsoon
Average	28	114	51
10%	2.8	11.4	5.1
20%	5.6	22.8	10.2
30%	8.4	34.2	15.3
50%	14	57	25.5
70%	19.6	79.8	35.7

Table IV. 2.4: 90% Dependable year average discharge data for Nykcharong chu HEP

90% Dependable Year	2006–07		
	Discharge in cumecs		
	Lean	Monsoon	Non–monsoon
Average	20	42	37
10%	2	4.2	3.7
20%	4	8.4	7.4
30%	6	12.6	11
50%	10	21	18.5
70%	14	29	26

Table IV. 2.5: 90% Dependable year average discharge data for Mago chu HEP

90% Dependable Year	2011–12		
	Discharge in cumecs		
	Lean	Monsoon	Non–monsoon
Average	7	51	15
10%	0.7	5.1	1.5
20%	1.4	10.2	3
30%	2.1	15.3	4.5
50%	3.5	25.5	7.5
70%	4.9	35.7	10.5

Table IV. 2.6: 90% Dependable year average discharge data for New Melling HEP

90% Dependable Year	2011–12		
	Discharge in cumecs		
	Lean	Monsoon	Non–monsoon
Average	6	48	13
10%	0.6	4.8	1.3
20%	1.2	9.6	2.6
30%	1.8	14.4	3.9
50%	3	24	6.5
70%	4.2	33.6	9.1

Table IV. 2.7: 90% Dependable year average discharge data for Paikangrong chu HEP

90% Dependable Year	Area Proportionate Method		
	Discharge in cumecs		
	Lean	Monsoon	Non–monsoon
Average	2	5	3
10%	0.2	0.5	0.3
20%	0.4	1.0	0.6
30%	0.6	1.5	0.9
50%	1.0	2.5	1.5
70%	1.4	3.5	2.1

Table IV. 2.8: 90% Dependable year average discharge data for Jaswantgarh Stage-I HEP

90% Dependable Year	Area Proportionate Method		
		Discharge in cumecs	
	Lean	Monsoon	Non-monsoon
Average	1.65	4	2.4
10%	0.17	0.4	0.24
20%	0.33	0.8	0.48
30%	0.50	1.2	0.72
50%	0.83	2	1.2
70%	1.16	2.8	1.68

Table IV. 2.9: 90% Dependable year average discharge data for Tsa chu–I HEP

90% Dependable Year	Area Proportionate Method		
		Discharge in cumecs	
	Lean	Monsoon	Non–monsoon
Average	19	41	35
10%	1.9	4.1	3.5
20%	3.8	8.2	7
30%	5.7	12.3	10.5
50%	9.5	20.5	17.5
70%	13.3	28.7	24.5

Table IV. 2.10: 90% Dependable year average discharge data for Tsa chu–I Lower HEP

90% Dependable Year	Area Proportionate Method		
		Discharge in cumecs	
	Lean	Monsoon	Non–monsoon
Average	19	41	35
10%	1.9	4.1	3.5
20%	3.8	8.2	7
30%	5.7	12.3	10.5
50%	9.5	20.5	17.5
70%	13.3	28.7	24.5

Table IV. 2.11: 90% Dependable year average discharge data for Tsa chu–II HEP

90% Dependable Year	Area Proportionate Method		
		Discharge in cumecs	
	Lean	Monsoon	Non–monsoon
Average	20	42	37
10%	2	4.2	3.7
20%	4	8.4	7.4
30%	6	12.6	11.1
50%	10	21	18.5
70%	14	29.4	25.9

Table IV. 2.12: 90% Dependable year average discharge data for Thingbu chu HEP

90% Dependable Year	Area Proportionate Method		
		Discharge in cumecs	
	Lean	Monsoon	Non–monsoon
Average	1	7	2
10%	0.1	0.7	0.2
20%	0.2	1.4	0.4
30%	0.3	2.1	0.6
50%	0.5	3.5	1
70%	0.7	4.9	1.4

Table IV. 2.13: 90% Dependable year average discharge data for Nyamjang chu HEP

90% Dependable Year	1994–95		
		Discharge in cumecs	
	Lean	Monsoon	Non–monsoon
Average	14	77	31
10%	1.4	7.7	3.1
20%	2.8	15.4	6.2
30%	4.2	23.1	9.3
50%	7	38.5	15.5
70%	9.8	53.9	21.7

2.3 LATERAL FLOW CONTRIBUTION ANALYSIS

Intermediate river length which is the distance between barrage site to tail water discharge point for all the projects are listed in Table IV. 1.1. Three projects viz. Tawang-I, Tawang-II, Nyamjang chu, have intermediate river length more than 10 km distance. As a part of flow analysis, it is necessary to quantify lateral flow contribution in these intermediate lengths of the rivers. Figure IV. 2.2 shows season average flows of three seasons for all the projects with river network. By following the flow budgeting, the flow contribution from the tributaries and ground water contribution in the intermediate reaches has been estimated. For lean season, Table IV. 2.15 shows the lateral contribution of the Tawang chu, Mago chu and Nykcharong chu rivers. It can be observed from the Table that expect the intermediate length between Tawang-I and Tawang-II the lateral flow contribution for other reaches is found to be negligible. Similarly, Table IV. 2.16 shows the estimated lateral flow contributions for Tawang, Nykcharong chu, Mago chu in monsoon season. The estimate indicates that lateral flow contributions for the Tawang chu during monsoon season is about 20%. However other two tributaries have less significant contribution in lateral flow in their intermediate length. In non–monsoon season similar estimates have seen carried out for lateral flow contribution (Table IV. 2.17). The trend of lateral flow contributions is more or less same as in the case of lean season (Table IV. 2.15). In summary, we can conclude that as the lateral flow contribution in the intermediate length during lean season is not significant except the intermediate length in Tawang-I and Tawang-II. Lateral flow contribution cannot be included in environmental flow assessment for any HEP.

Table IV. 2.14: Lateral flow contribution in the intermediate reaches during lean season

Sl. No.	Name of river	From	To	U/S flow (cumecs)	D/S flow (cumecs)	Contribution in cumecs (final)	% of U/S flow
1	Tawang	Tawang–I	Tawang–II	28	39	11	39.29
2	Tawang	Rho	Tawang–I	28	28	0	0.00
3	Tawang	Confluence of Mago chu & Nykcharong chu	Rho	27	28	1	3.70
4	Mago chu	New Melling	Mago chu	6	7	1	16.67
5	Nykcharong chu	Tsa chu Project	Nykcharong chu	19	20	1	5.26

Table IV. 2.15: Lateral flow contribution in monsoon season

Sl. No.	Name of river	From	To	U/S flow (cumecs)	D/S flow (cumecs)	Contribution in cumecs (final)	% of U/S flow
1	Tawang	Tawang–I	Tawang–II	114	141	27	23.68
2	Tawang	Rho	Tawang–I	114	114	0	0.00
3	Tawang	Confluence of Mago chu & Nykcharong chu	Rho	94	114	20	21.28
4	Mago chu	New Melling	Mago chu	48	51	3	6.25
5	Nykcharong chu	Tsa chu Project	Nykcharong chu	41	43	2	4.88

Table IV. 2.16: Lateral flow contribution in non–monsoon season

Sl. No.	Name of river	From	To	U/S flow (cumecs)	D/S flow (cumecs)	Contribution in cumecs (final)	% of U/S flow
1	Tawang	Tawang–I	Tawang–II	51	67	16	31.37
2	Tawang	Rho	Tawang–I	51	51	0	0.00
3	Tawang	Confluence of Mago chu & Nykcharong chu	Rho	51	51	0	0.00
4	Mago chu	New Melling	Mago chu	13	15	2	15.38
5	Nykcharong chu	Tsa chu Project	Nykcharong chu	35	37	2	5.71

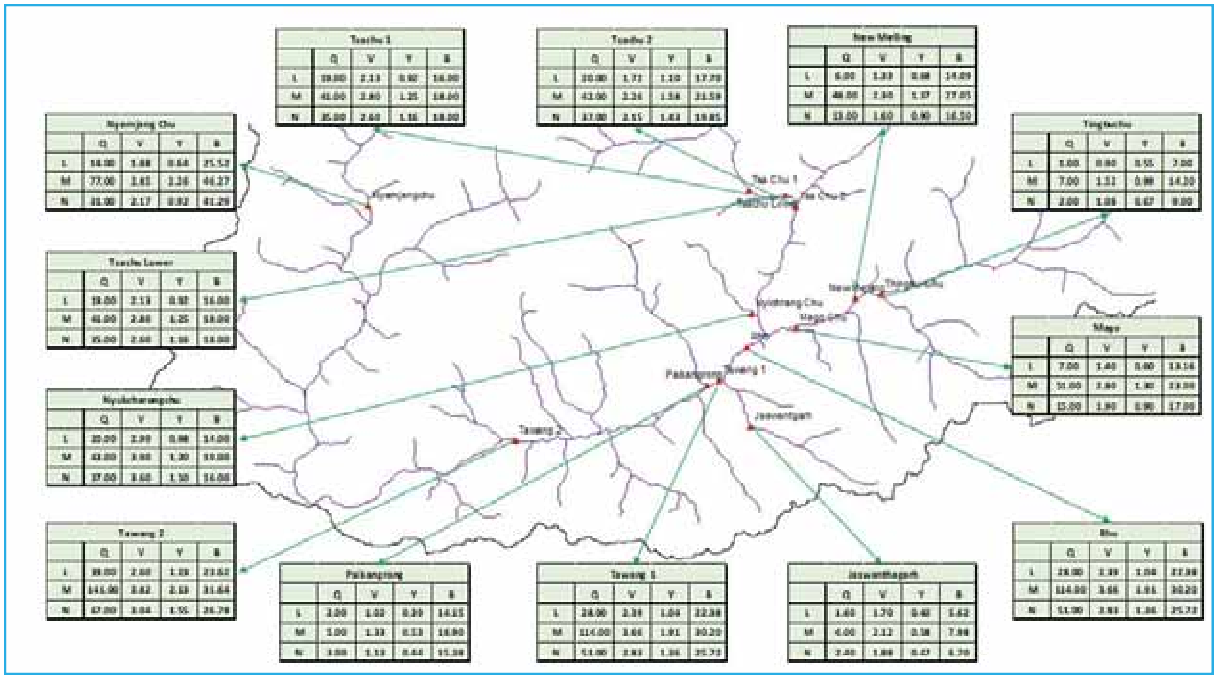


Figure IV. 2.2: Summarizing 90% dependable year season average flows and simulated conditions for all projects with river network

2.4 RIVER CROSS SECTIONS

River cross sections data is critical dataset for river hydrodynamic modeling, which is set up for obtaining hydraulic characteristics. The hydraulic characteristics such as depth, velocity, and top width are used in the assessment of environmental flow. In this study, river cross sections data provided by HEP developers have been used for Tawang and its tributaries Mago chu and Nykcharong chu. Note that there are 15 cross sections available at Mago chu, 29 cross sections available at Nykcharong chu, 69 cross sections at Rho, and 16 cross sections available at new Melling with an interval of 100-200 m range. For the remaining project sites 8-10 cross sections were surveyed using total station survey instrument at the downstream of the diversion structures. The surveyed reaches are about 1-2 km and considered as critical stretches for which hydrodynamic modeling conducted instead of taking total effected length for the modeling work. The assumption of considering only critical stretch indicates that if a river flow health condition is good at that critical location then river health condition of the remaining reaches seems to be good condition. Some typical cross sections with field photographs are show in Figure IV. 2.4 to 2.16.

The cross sections show that the Tawang chu River is very shallow river with gravel, cobbles, few boulders bed. Flow depth and velocity measured at some of the project sites are given in Table IV. 2.18. These measurements were conducted in December 2013 and May 2014. It is observed that flow depth ranges from 0.39 m to 1.23 m and flow velocity ranges from 0.9 to 2.59 m/s. The flow width varies from 7 m to 26 m. Table IV. 2.18 shows observed hydraulic characteristics (flow depth, velocity and width) at the project sites during December, 2013 or May 2014.

Sieve analysis is conducted for the bed samples collected at accessible locations of the project sites. For the results obtained the particle size distribution curves are plotted. Figure IV. 2.3 shows the particle size distribution curves at Tawang-I and Tawang-II HEP sites.

Table IV. 2.17: Observed hydraulic conditions at all HEP sites

Sl. No.	Name of HEP	Hydraulic characteristics		
		Velocity (m/s)	Depth (m)	Flow width (m)
1	Tawang–II	2.6	1.23	23.62
2	Tawang–I	2.39	1.04	22.38
3	Rho	2.4	1.07	23
4	Nykcharong chu	2.9	0.98	14
5	Mago chu	1.4	0.6	13.16
6	New Melling	1.3	0.68	14.09
7	Paikangrong chu	1.02	0.39	14.15
8	Tsa chu–1	2.13	0.92	16
9	Tsa chu–I Lower	2.13	0.92	16
10	Tsa chu–II	1.72	1.10	17.7
11	Nyamjang chu	1.88	0.64	25.72
12	Jaswantgarh Stage–I	1.7	0.4	5.62
13	Thingbu chu	0.9	0.55	7

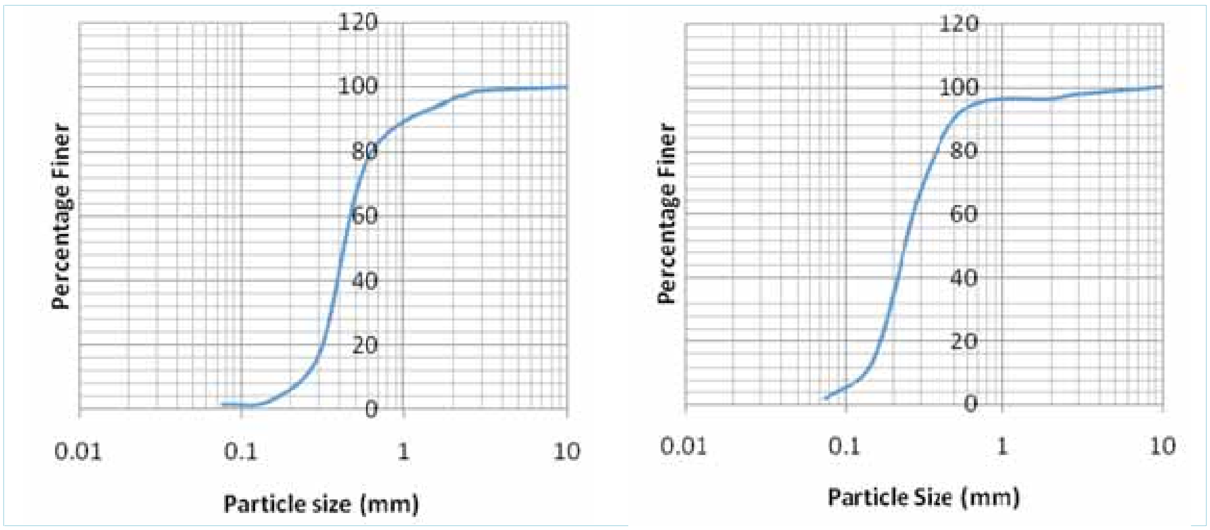
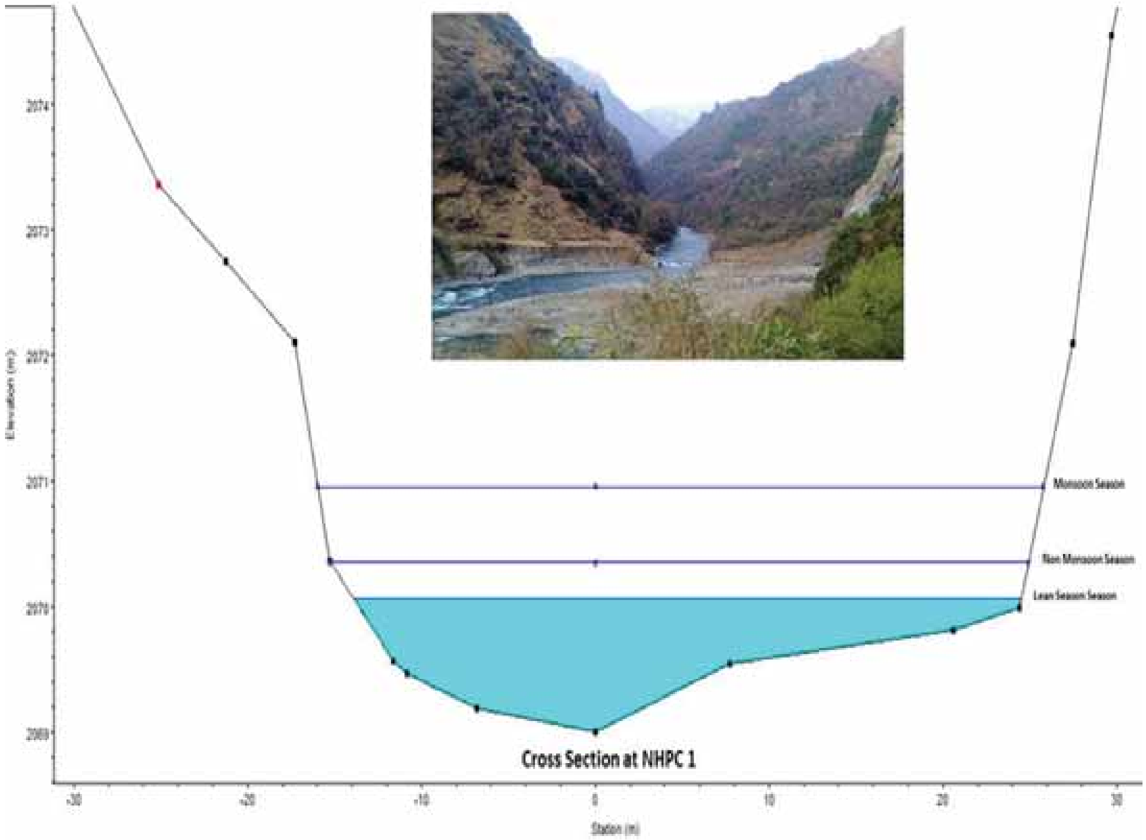


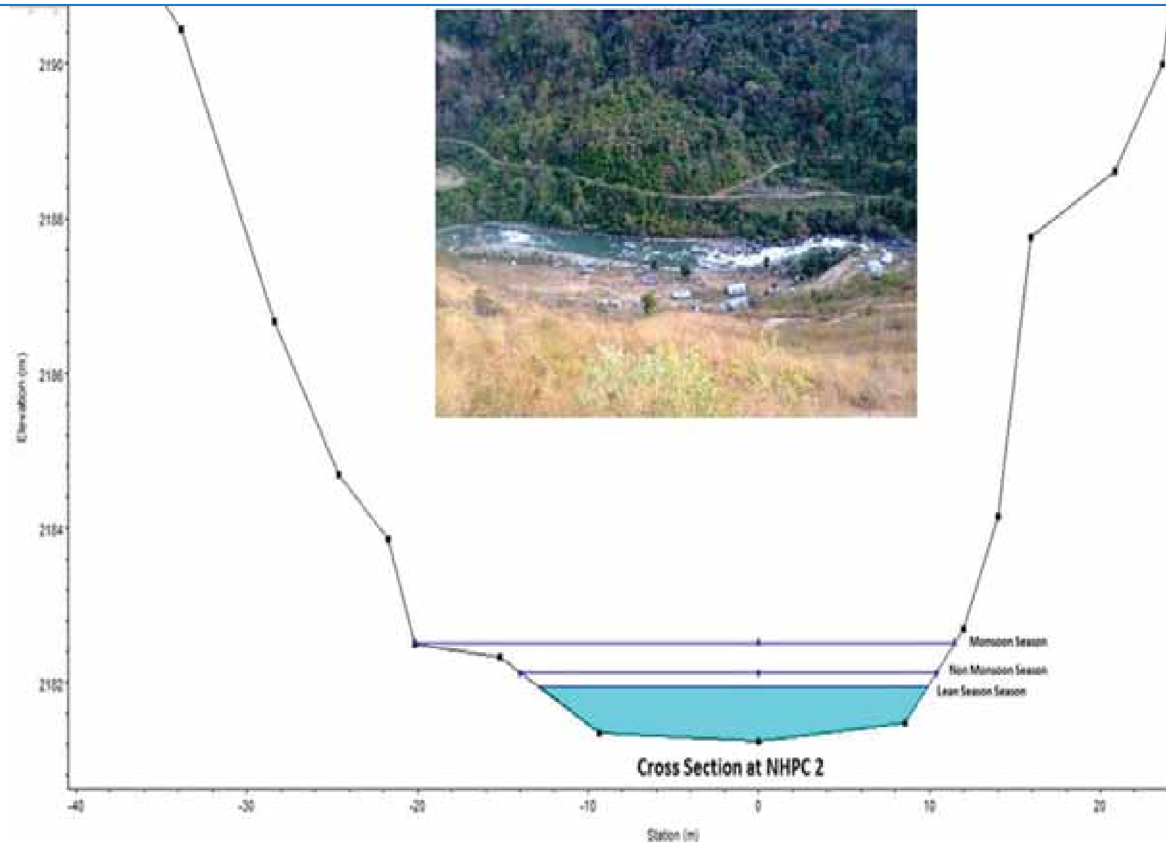
Figure IV. 2.3: Particle size distribution curve for bed material at (a) Tawang–I and (b) Tawang–II sites



Location	Tawang–I
Observed hydraulic conditions	
Latitude	27°35'24.35"N
Longitude	91°58'54.42"E
Velocity	2.39 m/s
Flow depth	1.04 m
Flow width	22.38 m

Bed material: Fine sediment, small pebbles along with few boulders were observed on either side of the banks.

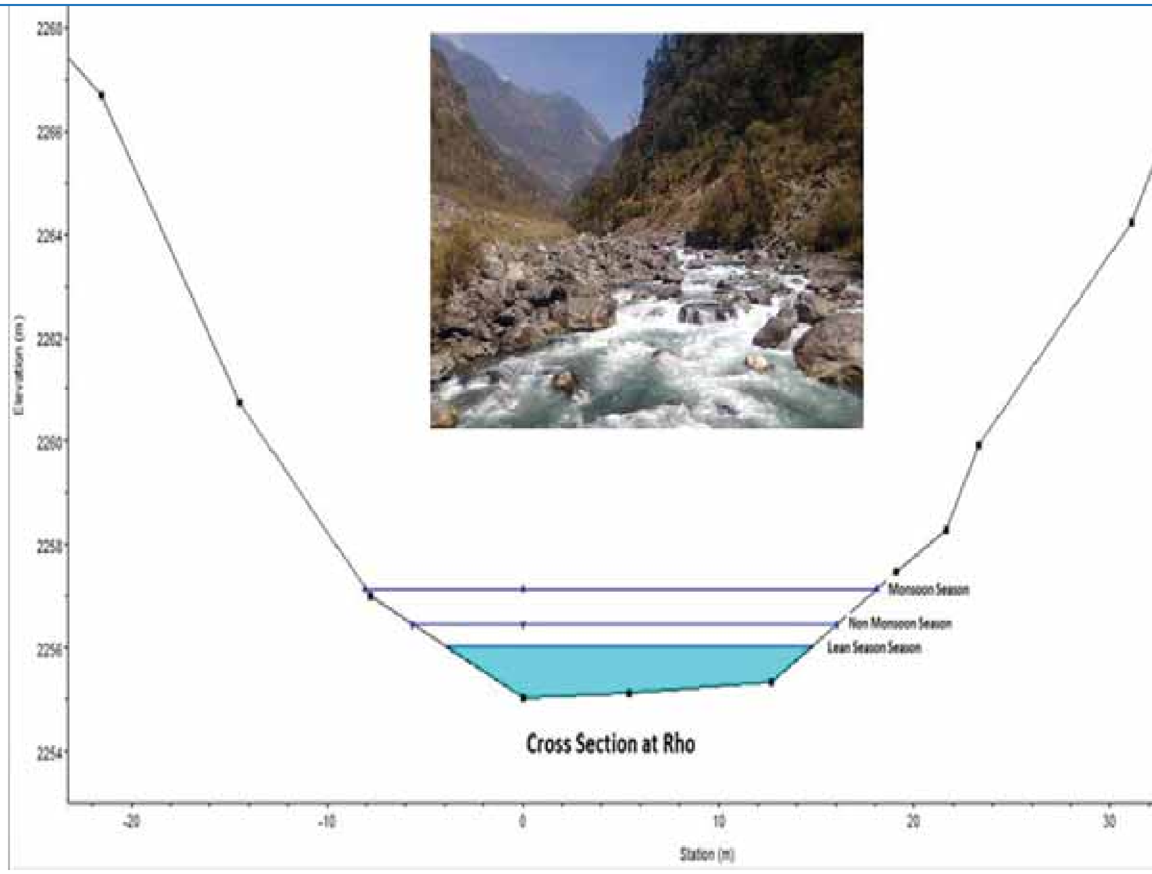
Figure IV. 2.4: River cross section at Tawang–I



Location	Tawang–II
Observed hydraulic conditions	
Latitude	27°32'47.66"N
Longitude	91°49'58.42"E
Velocity	2.60 m/s
Flow depth	1.25 m
Flow width	23 m

Bed material: Fine sediment, small pebbles along with few boulders were observed on either side of the banks.

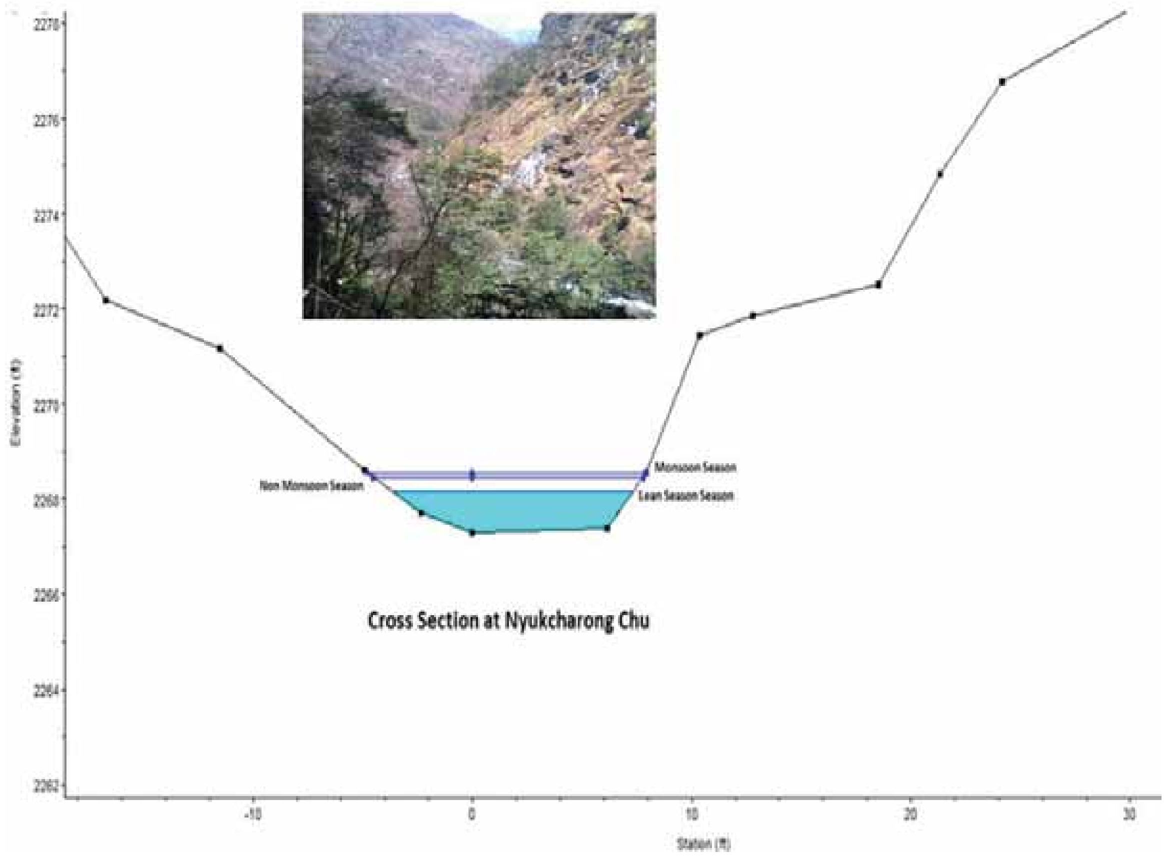
Figure IV. 2.5: River cross section at Tawang–II



Location	Rho
Observed hydraulic conditions	
Latitude	27°36'52.48"N
Longitude	92° 00'07.52"E
Velocity	2.39 m/s
Flow depth	1.05 m
Flow width	22 m

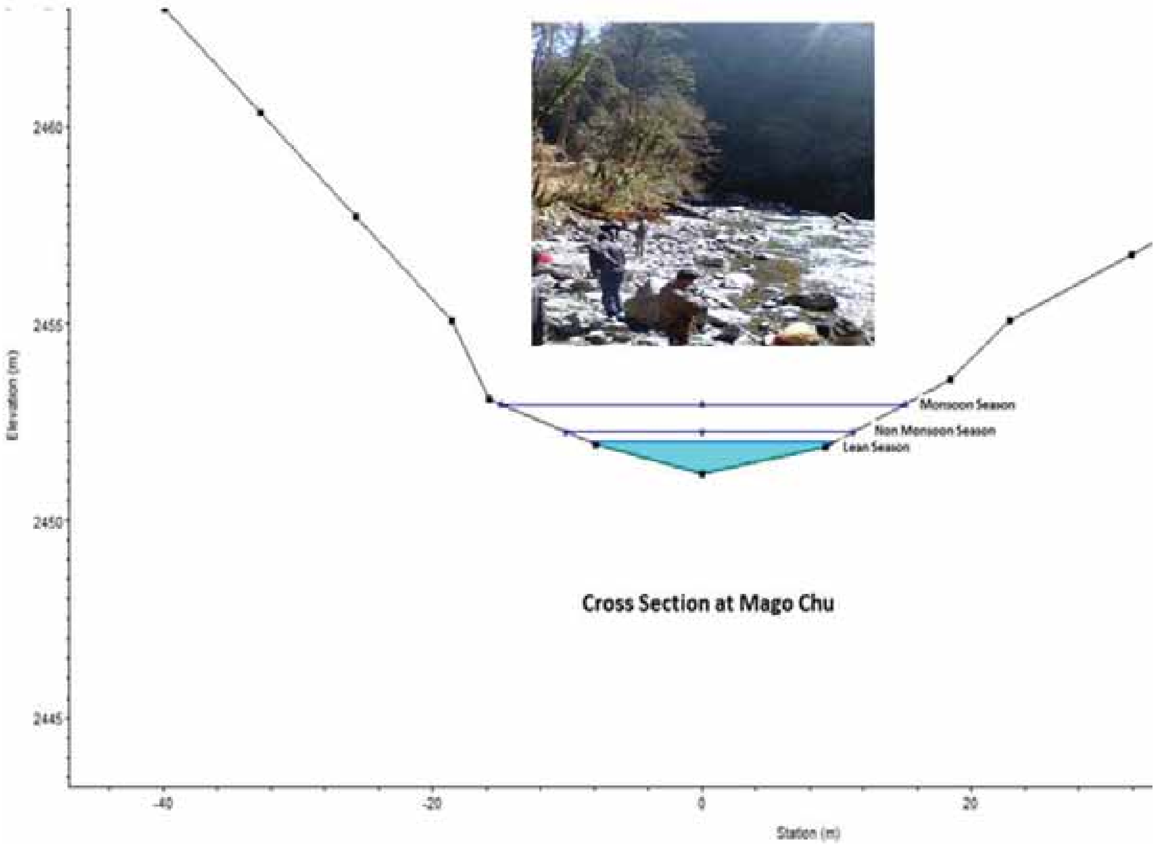
Bed material: Fine sediment, cobbles, boulders were observed along the channel and banks

Figure IV. 2.6: River cross section at Rho



Location Nykcharong chu
Observed hydraulic conditions
Latitude 27°38'20.23"N
Longitude 92° 0'20.21"E
Velocity 2.9 m/s
Flow depth 0.98m
Flow width 14 m
Bed material: Cobbles, boulders, trees, branch were observed on either side of banks

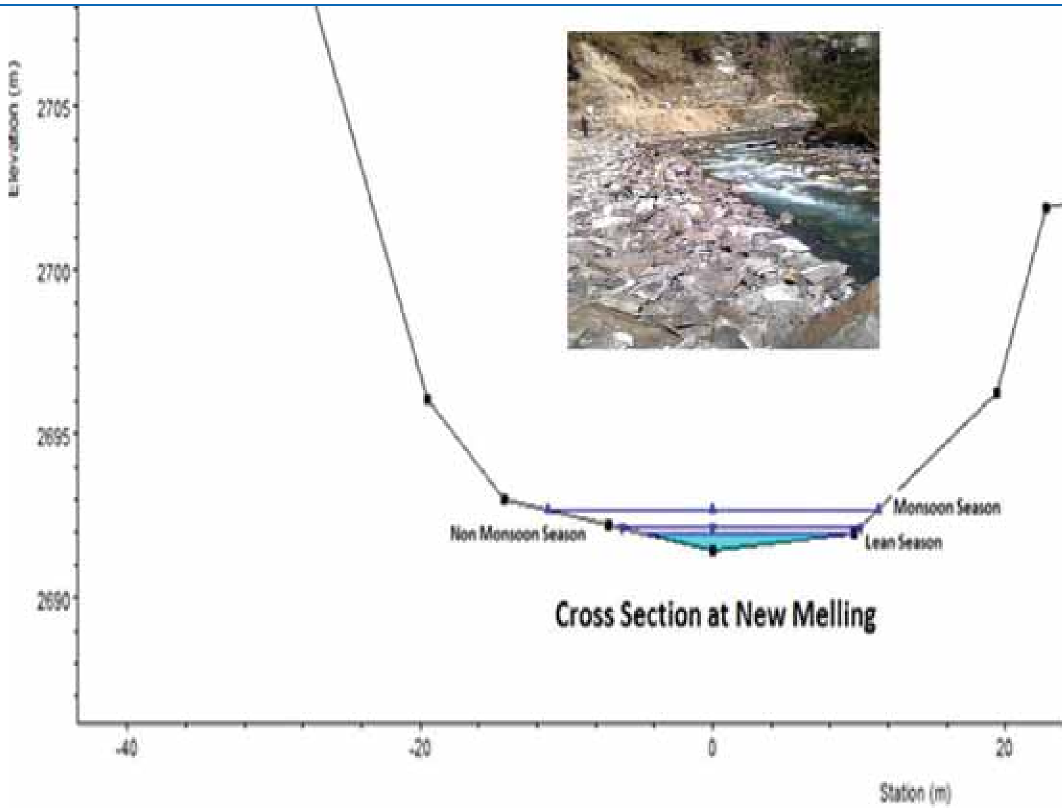
Figure IV. 2.7: River cross section at Nykcharong chu



Location	Mago chu
Observed hydraulic conditions	
Latitude	27°37'43.62"N
Longitude	92° 2'17.55"E
Velocity	1.4 m/s
Flow depth	0.6 m
Flow width	13.16 m

Bed material: Fine sediment, cobbles boulders were observed on either side of the banks and boulders within the channel.

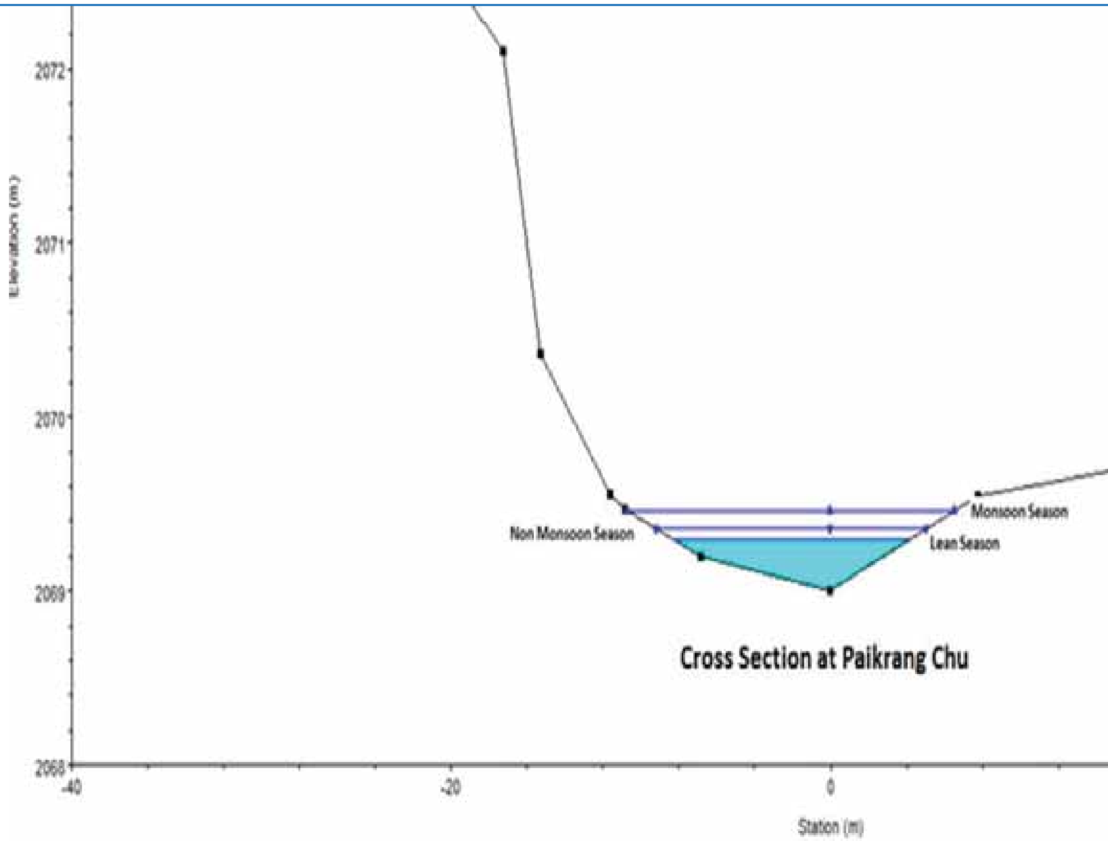
Figure IV. 2.8: River cross section at Mago chu



Location	New Melling
Observed hydraulic conditions	
Latitude	27°39'1.22"N
Longitude	92° 4'53.94"E
Velocity	1.33 m/s
Flow depth	0.68 m
Flow width	14.09 m

Bed material: Fine sediment, cobbles, boulders were observed at banks and boulders with in channel.

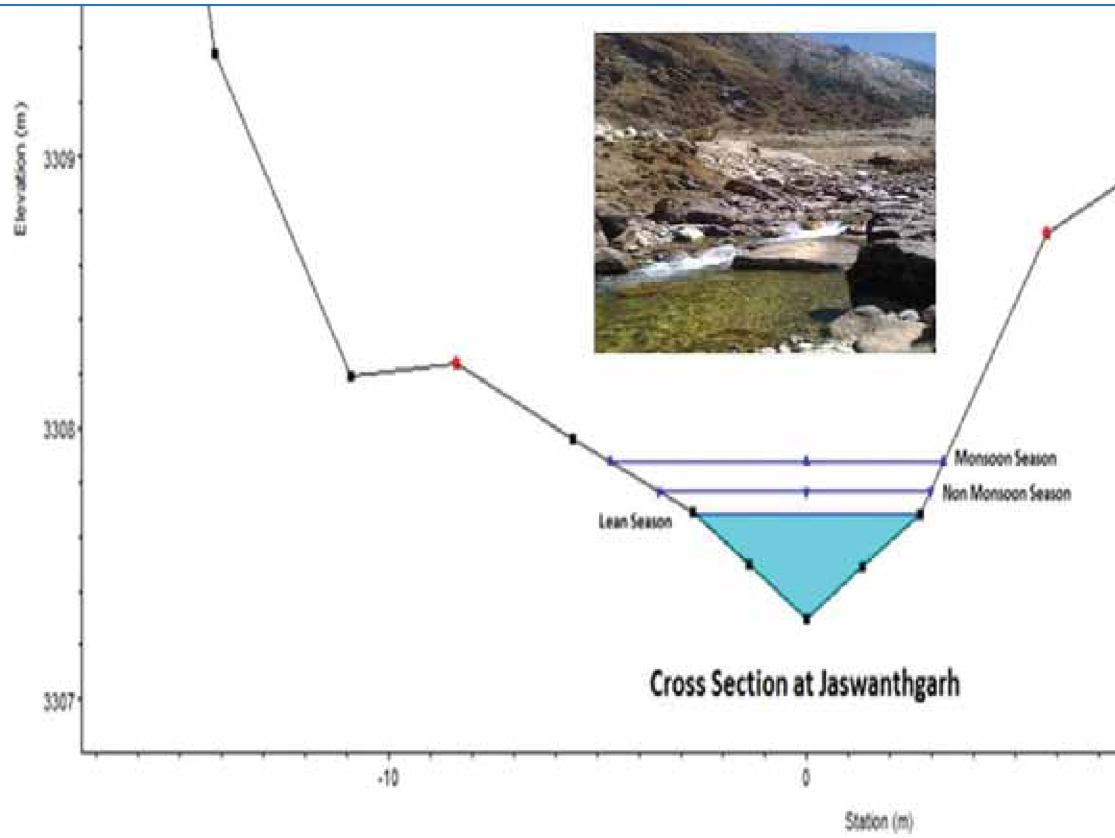
Figure IV. 2.9: River cross section at New Melling



Location	Paikangrong chu
Observed hydraulic conditions	
Latitude	27°35'12.00"N
Longitude	91°58'21.00"E
Velocity	1.02 m/s
Flow depth	0.39 m
Flow width	14.15 m

Bed material: Fine sediment, small pebbles along with the few boulders were observed on either side of the banks.

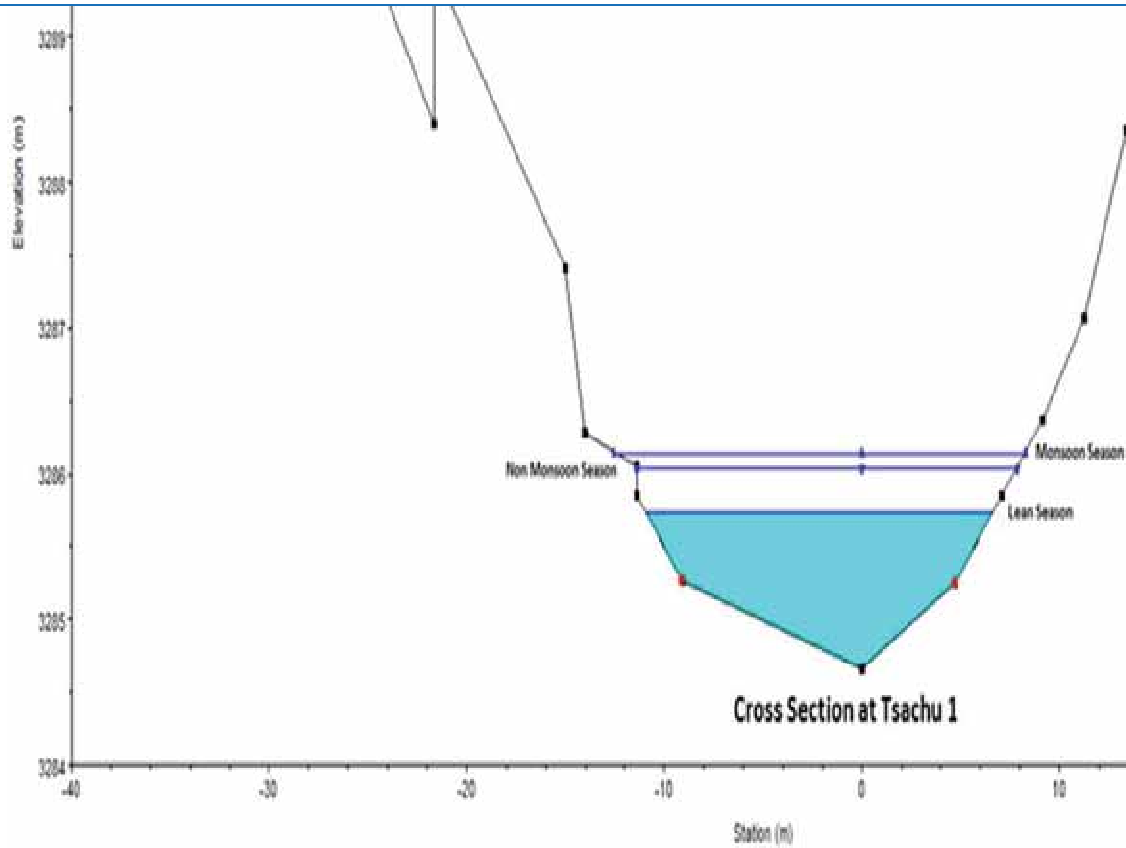
Figure IV. 2.10: River cross section at Paikangrong chu



Location	Jaswantgarh Stage–I
Observed hydraulic conditions	
Latitude	27°33'24.00"N
Longitude	92° 0'17.00"E
Velocity	1.79 m/s
Flow depth	0.4 m
Flow width	5.6 m

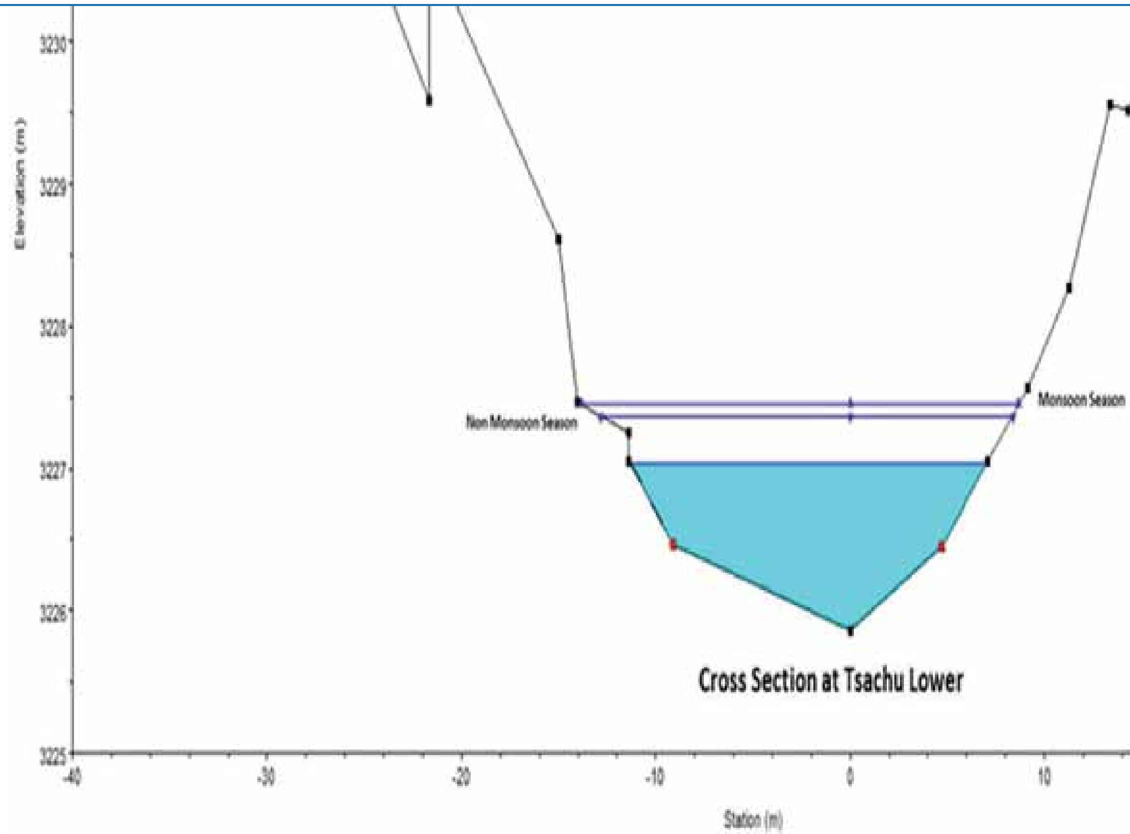
Bed material: Pebbles, cobbles, boulders, gravel were observed within the channels and along the banks

Figure IV. 2.11: River cross section at Jaswantgarh Stage-I



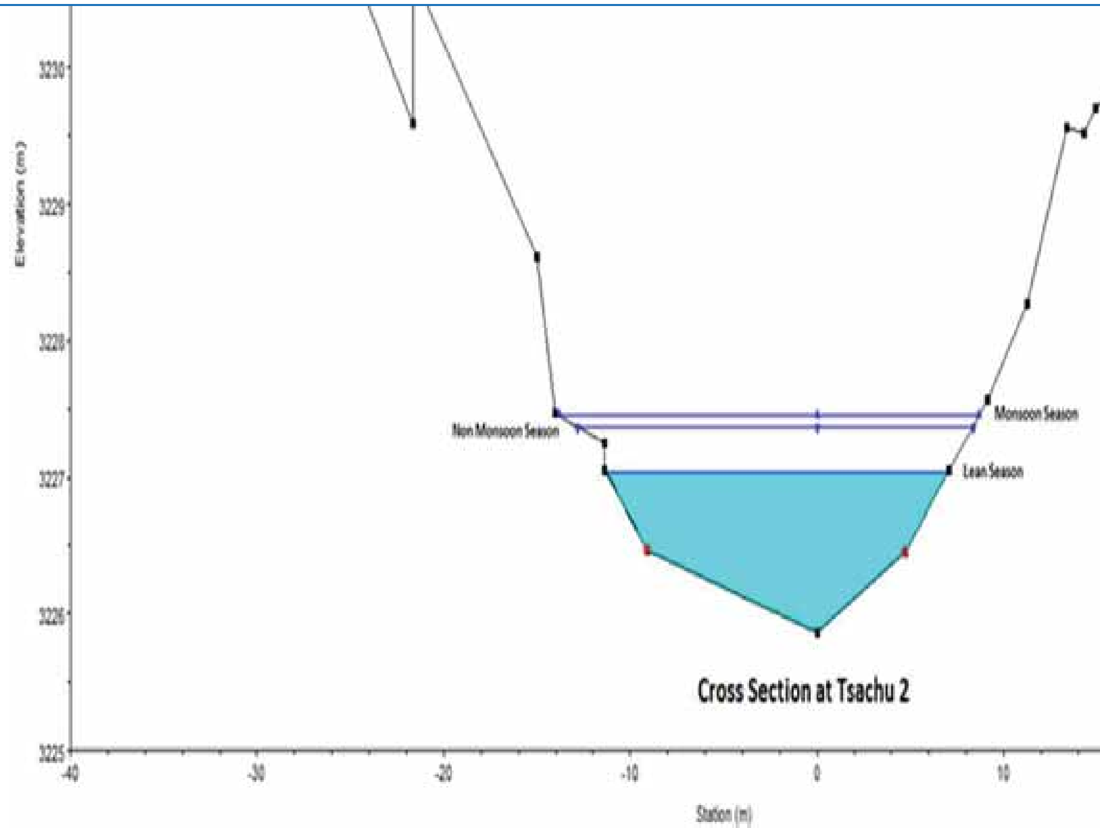
Location	Tsa chu–1
Observed hydraulic conditions	
Latitude	27°43'46.09"N
Longitude	92° 0'10.93"E
Velocity	2.13 m/s
Flow depth	0.92 m
Flow width	16 m
Bed material	Fine sediment, small pebbles along with the few boulders were observed on either side of the banks.

Figure IV. 2.12: River cross section at Tsa chu–I



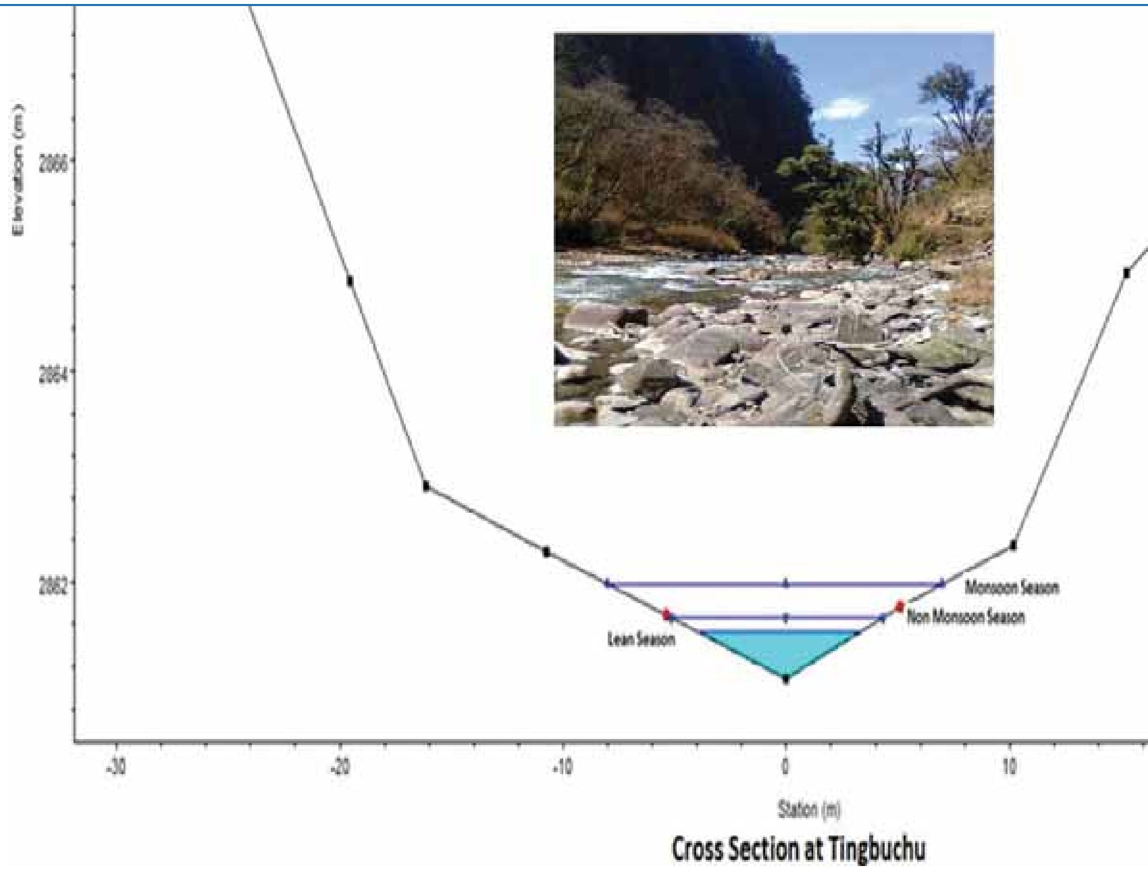
Location	Tsa chu–I Lower
Observed hydraulic conditions	
Latitude	27°43'32.39"N
Longitude	92° 1'50.36"E
Velocity	2.13m/s
Flow depth	0.92 m
Flow width	16 m
Bed material	Fine sediment, small pebbles along with the few boulders were observed on either side of the banks.

Figure IV. 2.13: River cross section at Tsa chu–I Lower



Location	Tsa chu–II
Observed hydraulic conditions	
Latitude	27°43'1.50"N
Longitude	92° 2'15.54"E
Velocity	1.72 m/s
Flow depth	1.10 m
Flow width	17.70 m
Bed material	Fine sediment, small pebbles along with the few boulders were observed on either side of the banks

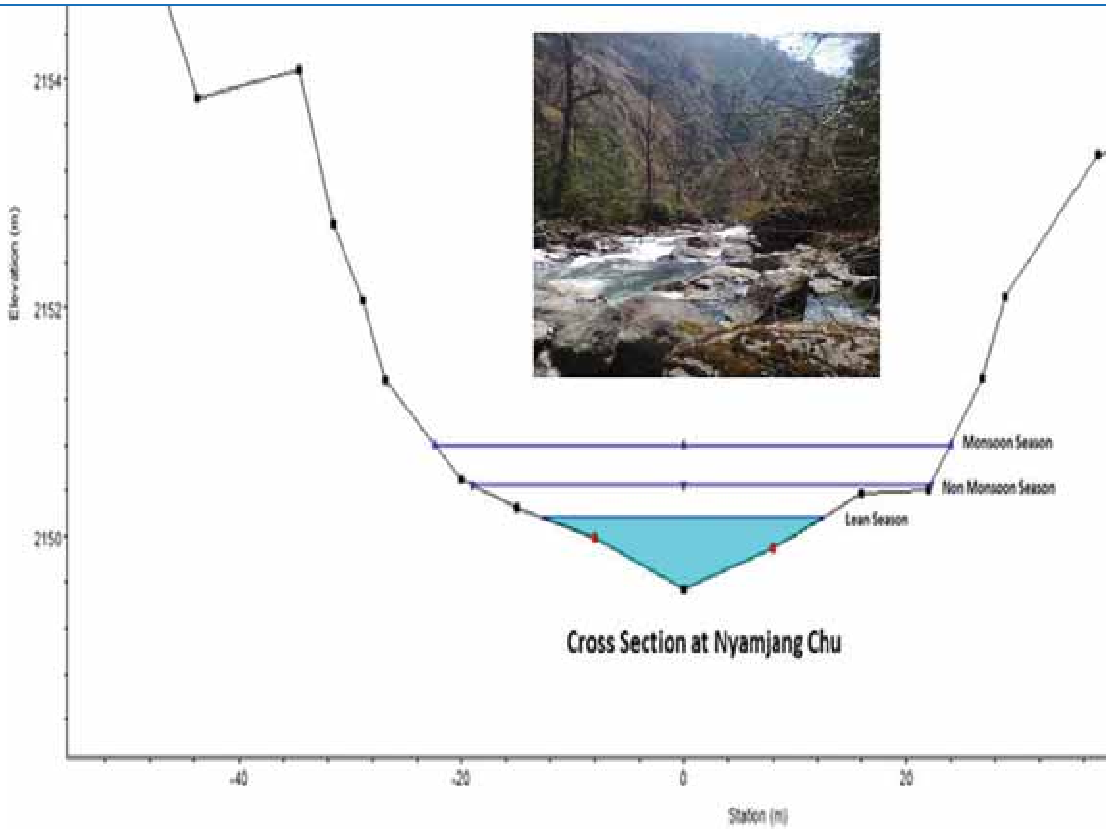
Figure IV. 2.14: River cross section at Tsa chu–II



Location	Thingbu chu
Observed hydraulic conditions	
Latitude	27°39'12.00"N
Longitude	92° 5'60.00"E
Velocity	0.9 m/s
Flow depth	0.55 m
Flow width	7 m

Bed material: Consist of gravels, cobbles and boulders on either side of the bank and small trees and brush on the right side of the bank.

Figure IV. 2.15: River cross section at Thingbu chu



Location	Nyamjang chu
Observed hydraulic conditions	
Latitude	27°43'26.58"N
Longitude	91°43'28.92"E
Velocity	1.88 m/s
Flow depth	0.64 m
Flow width	25.52 m

Bed material: Consist of gravels, cobbles and boulders, small trees and branch on either side of the bank and boulders within the channel.

Figure IV. 2.16: River cross section at Nyamjang chu

3.1 INTRODUCTION

The hydrodynamic modeling tool used in this study was HEC-River Analysis Software (RAS), developed at the Hydrologic Engineering Centre (HEC), which is a division of the Institute for Water Resources (IWR), U.S. Army Corps of Engineers. This hydrodynamic software allows one-dimensional steady and unsteady flow river hydraulic calculations. It contains four modules, namely steady flow water surface profile computations, unsteady flow simulation, movable boundary sediment transport computations, and water quality analysis.

In this study steady flow analysis is carried out which is capable of performing one dimensional water surface profile calculations in the channels. HEC–RAS enable us to simulate sub critical, super critical and mixed flow regime profiles. The important hydraulic parameters for e flow analysis like velocity, flow depth, flow width are obtained at each cross section along the reach. The basic equation for computation of water surface profiles is the energy equation with iterative procedure called standard step method and the equation is:

$$Z_2 + Y_2 + \frac{\alpha_2 V_2^2}{2g} = Z_1 + Y_1 + \frac{\alpha_1 V_1^2}{2g} + h_l$$

$$Z_{1,}Z_2 = elevation\ of\ main\ channel\ inverts$$

$$Y_1 Y_2 = Depth\ of\ water\ at\ cross\ sections$$

$$V_1^2 V_2^2 = average\ velocities\ at\ cross\ sections$$

$$h_l = energy\ head\ loss$$

$$\alpha_1 \alpha_2 = weighted\ velocity\ ceefficients$$

Hydrodynamic modeling setup for flow simulation needs cross sections data, Manning's roughness coefficients, upstream stream boundary condition and downstream boundary conditions. A typical setup of Tawang chu and its tributaries is shown in Figure IV. 3.1 and 3.2. The longitudinal profiles obtained from HEC–RAS simulations for Mago chu, Nykcharong chu and Tawang chu are shown in Figure IV. 3.3, 3.4 and 3.5. The average discharge given in Table IV. 2.1 to 2.13 for 90% dependable flow have been used as upstream boundary condition and normal depth is used as downstream boundary condition for all the model setups. The model setup for all the project sites has been carried out in the same manner.

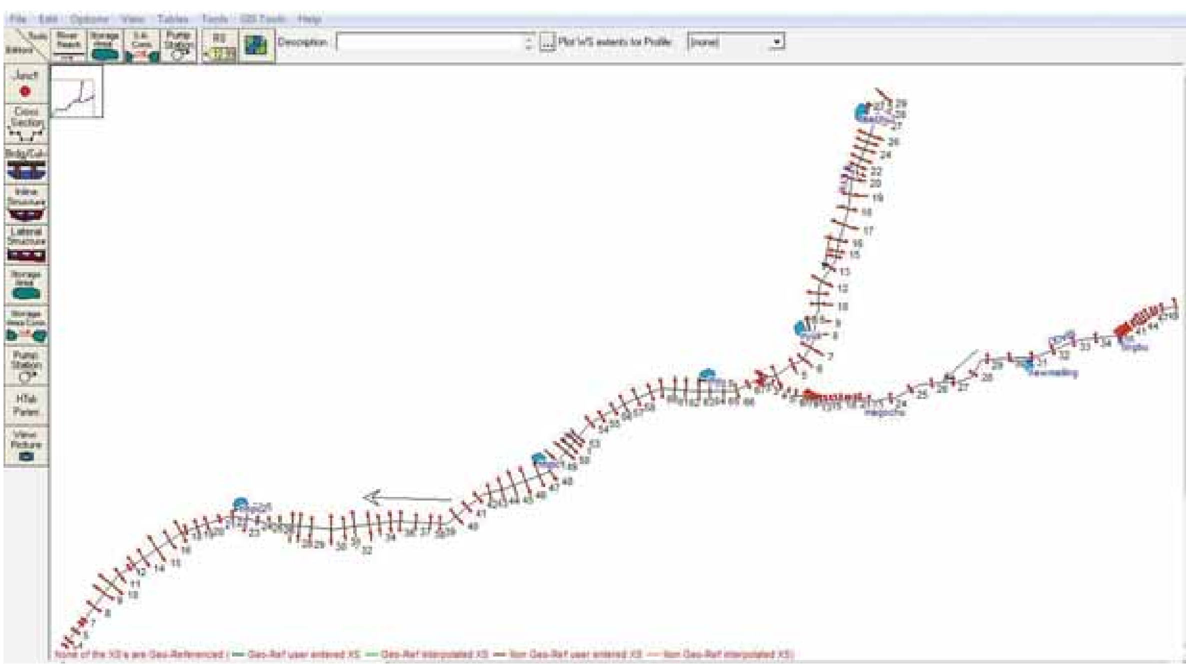


Figure IV. 3.1: HEC–RAS model setup for various surveyed river cross sections

Figure IV. 3.2: HEC–RAS model setup for Google Earth cross sections

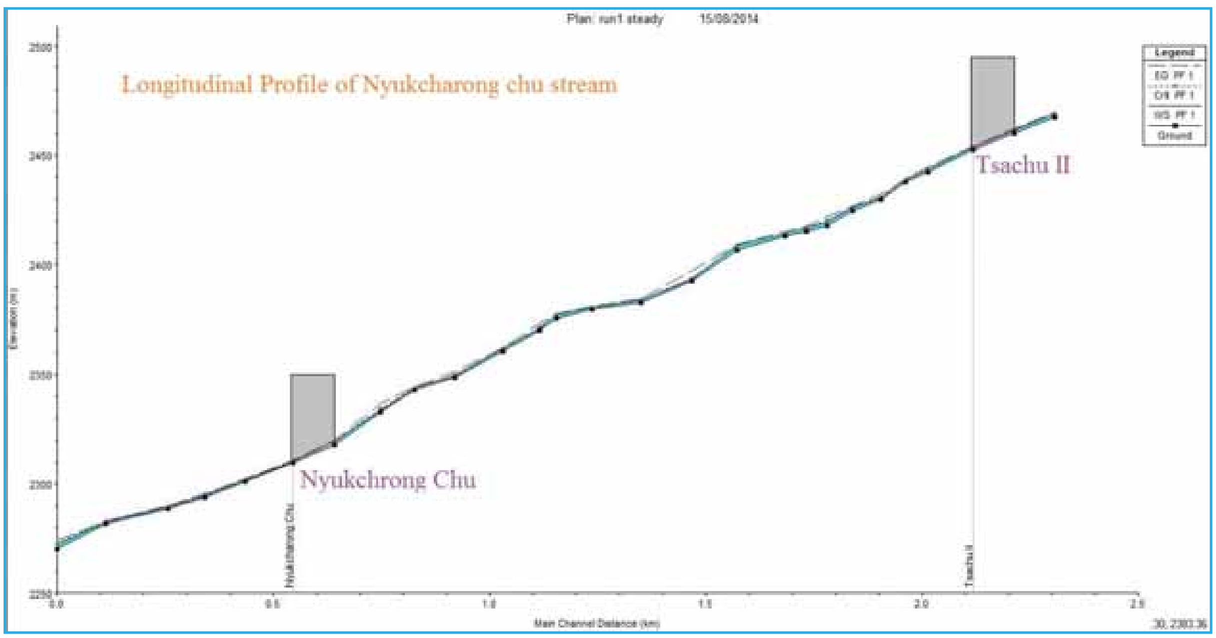


Figure IV. 3.3: Longitudinal profile of Nykcharong chu

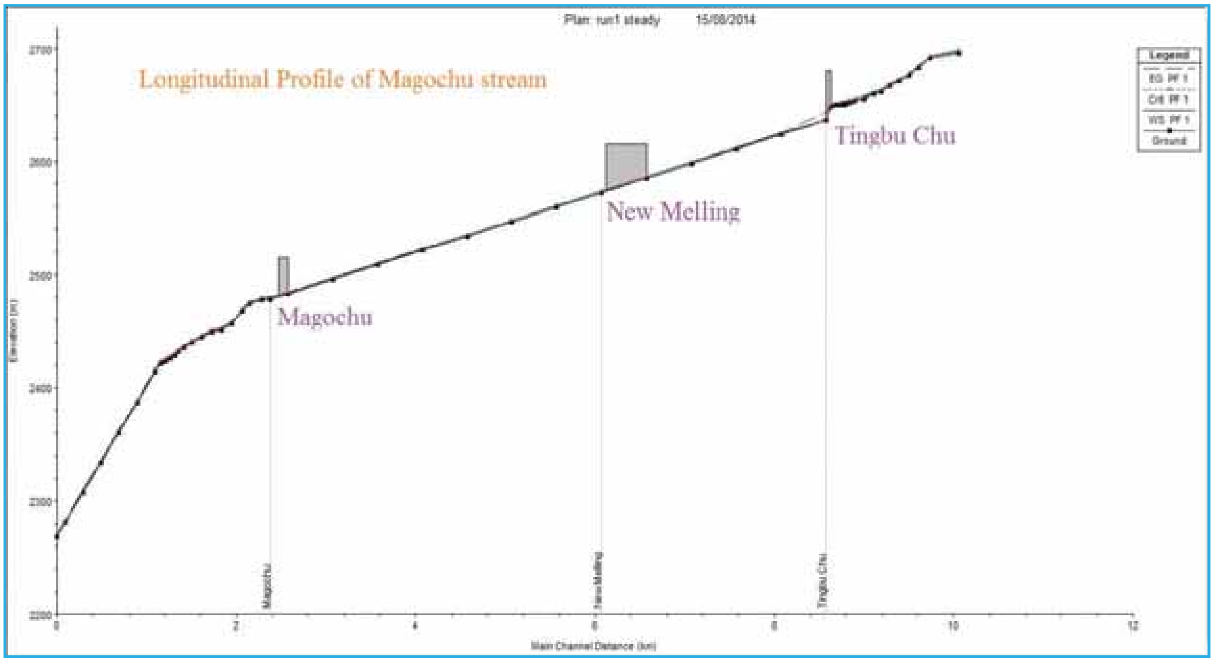


Figure IV. 3.4: Longitudinal profile of Mago chu

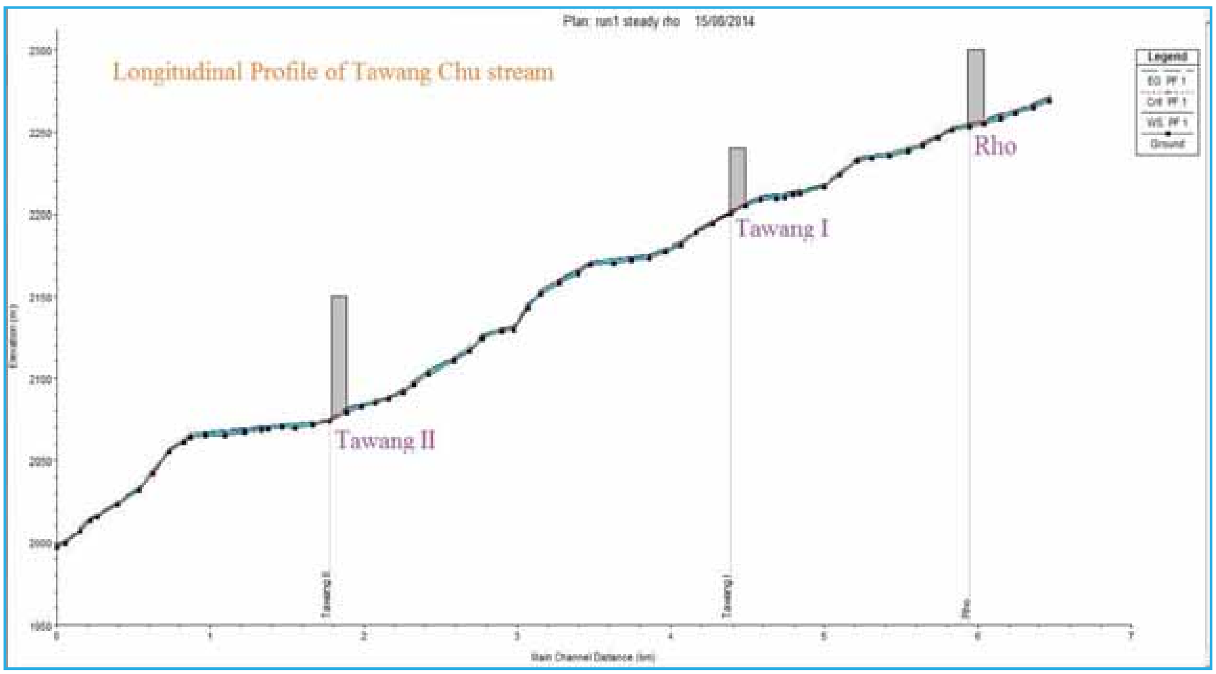


Figure IV. 3.5: Longitudinal profile of Tawang chu

3.2 MANNING'S ROUGHNESS COEFFICIENT USED IN HYDRAULIC MODELING

Manning's roughness coefficient used for modeling study is adopted based on different type of channels as suggested by Chow (1959). For the present study, the river reaches correspond to mountain stream with steep bank, no vegetation in channel, trees and brush along banks submerged at high stages and bed consist of gravels, cobbles, few boulders. Based on the bed composition of each HEP site the manning's roughness coefficient is considered (Table IV. 3.1 lists Manning coefficient used for modeling study)

Table IV. 3.1: Manning's roughness coefficient used for hydrodynamic modeling

Sl. No.	Name of HEP	Bank	Channel
1	Tawang–II	0.060	0.050
2	Tawang–I	0.060	0.050
3	Rho	0.060	0.050
4	Nykcharong chu	0.070	0.040
5	Mago chu	0.040	0.060
6	New Melling	0.035	0.060
7	Paikangrong chu	0.060	0.050
8	Jaswantgarh Stage–I	0.040	0.065
9	Tsa chu–1	0.040	0.060
10	Tsa chu–II	0.040	0.060
11	Thingbu chu	0.040	0.065

3.3 HYDRODYNAMIC SIMULATION

Hydrodynamic model setup for each HEP has been framed for three different seasons viz. monsoon average, lean average and non–monsoon average discharge. The model simulation result for each scenario provides water depth, flow velocity, flow top width for all the cross–section locations. To assess the environmental flow requirement for each project site, average value of calculated flow depth, velocity, top width for each seasons have been extracted and used. The simulated flow characteristics for some locations are given from Table IV. 3.2 to 3.4.

Table IV. 3.2: Model output for different releases of 90% dependable flow for Tawang–II HEP

Season	Release scenario	Discharge (cumecs)	Flow velocity (m/s)	Depth (m)	Top width (m)
Lean (39 cumecs)	10%	3.90	1.19	0.52	12.56
	20%	7.80	1.47	0.66	16.01
	30%	11.70	1.70	0.77	17.77
	50%	19.50	2.05	0.90	19.45
	70%	27.30	2.33	1.02	21.00
	100%	39.00	2.60	1.23	23.62
Monsoon (141 cumecs)	10%	14.10	1.76	0.82	18.44
	20%	28.20	2.37	1.04	21.08
	30%	42.30	2.74	1.21	23.25
	50%	70.50	3.15	1.53	27.20
	70%	98.70	3.45	1.79	30.40
	100%	141.00	3.82	2.13	31.64
Non–monsoon (67 cumecs)	10%	6.70	1.36	0.64	15.40
	20%	13.40	1.77	0.80	18.12
	30%	20.10	2.08	0.91	19.57
	50%	33.50	2.52	1.10	22.00
	70%	47.00	2.82	1.27	24.00
	100%	67.00	3.04	1.55	26.78

Table IV. 3.3: Model output for different releases of 90% dependable flow for Nykcharong chu HEP

Season	Release scenario	Discharge (cumecs)	Flow velocity (m/s)	Depth (m)	Top width (m)
Lean (20 cumecs)	10%	2.00	1.56	0.35	8.44
	20%	4.00	1.87	0.46	10.00
	30%	6.00	2.11	0.55	10.97
	50%	10.00	2.45	0.67	12.48
	70%	14.00	2.72	0.77	13.40
	100%	20.00	2.90	0.98	14.00
Monsoon (42 cumecs)	10%	4.00	1.87	0.46	10.00
	20%	8.40	2.32	0.63	11.76
	30%	12.60	2.63	0.74	13.14
	50%	21.00	3.06	0.91	14.80
	70%	29.00	3.35	1.06	16.60
	100%	43.00	3.90	1.20	19.00
Non–monsoon (37 cumecs)	10%	3.70	1.82	0.45	9.86
	20%	7.40	2.25	0.60	11.45
	30%	11.00	2.53	0.71	12.75
	50%	18.50	2.90	0.86	14.40
	70%	26.00	3.25	1.00	16.06
	100%	37.00	3.60	1.10	16.00

4.1 INTRODUCTION

Environmental flow of a river refers to quantity, quality and timing of water needed to sustain aquatic and terrestrial ecosystems, and the related ecosystem service on which people depend. In short, environmental flow assessment is a method to assess the flow needs of ecosystem, socio-economic and cultural activities for a river. In general approaches to access environmental flow have divided into four main categories.

1. Hydrologic based approach which defines the recommended environmental flow as a proportion of annual or monthly discharge.
2. Hydraulic rating approach which establishes a relation between flows to hydraulic conditions like depth, velocity, wetted perimeter.
3. Habitat simulation approach in which amount of suitable habitat available during different flows is estimated and environmental flow is recommended based on species habitat needs in future scenario.
4. Holistic approaches in which multiple use of rivers and their ecology, social importance are considered and flow recommendations for a river are made with a more integrated context.

The present study assessed the E-Flow of TRB at different proposed project sites following Building Block method taking a holistic approach.

4.2 BUILDING BLOCK METHOD

Building block method (BBM) is a broad approach to define environmental flow to sustain and conserve river ecosystems rather than focusing on a few target species like fish. It has been applied in different countries (Australia, UK, and South America).

The Building Block Methodology and its process: The building block method is a flexible participatory and robust multi-disciplinary method that can be applied for different levels of information and data availability. It allows the user to focus on key issues of local importance. The BBM is based on the following steps.

1. Using a stakeholder consultation process to set the objectives (thresholds) for the environmental condition of river.
2. Assessing a modified flow regime that will meet those objectives.
3. Using flow-dependent indicators and non–consumptive human requirements, as well as water quality metrics and sediment transport, to identify water depths, velocities, river widths, and substrate types that will provide the required habitats and conditions. Such hydraulic requirements can be then converted to flow characteristics.
4. Identifying the critical components known as building blocks of the flow regime that govern environmental conditions

4.3 DETERMINATION OF MINIMUM VALUES IN RESPECT OF INDICATORS UNDER EACH BUILDING BLOCK

The minimum discharge value for specific parameter was based on two criteria: (1) minimum corresponding acceptable value depending on the requirement/life cycle of the particular parameter (Table IV. 4.1), and (2) accommodating maximum observed data points as well as range within the acceptable limit (Figure IV. 4.1-4.9). All the minimum values of the water quality parameters analysed remained within the prescribed limit of CPCB. Therefore, the reduced water flow would not reduce the water quality beyond the tolerable limit including for the consumption by wildlife and agricultural use.

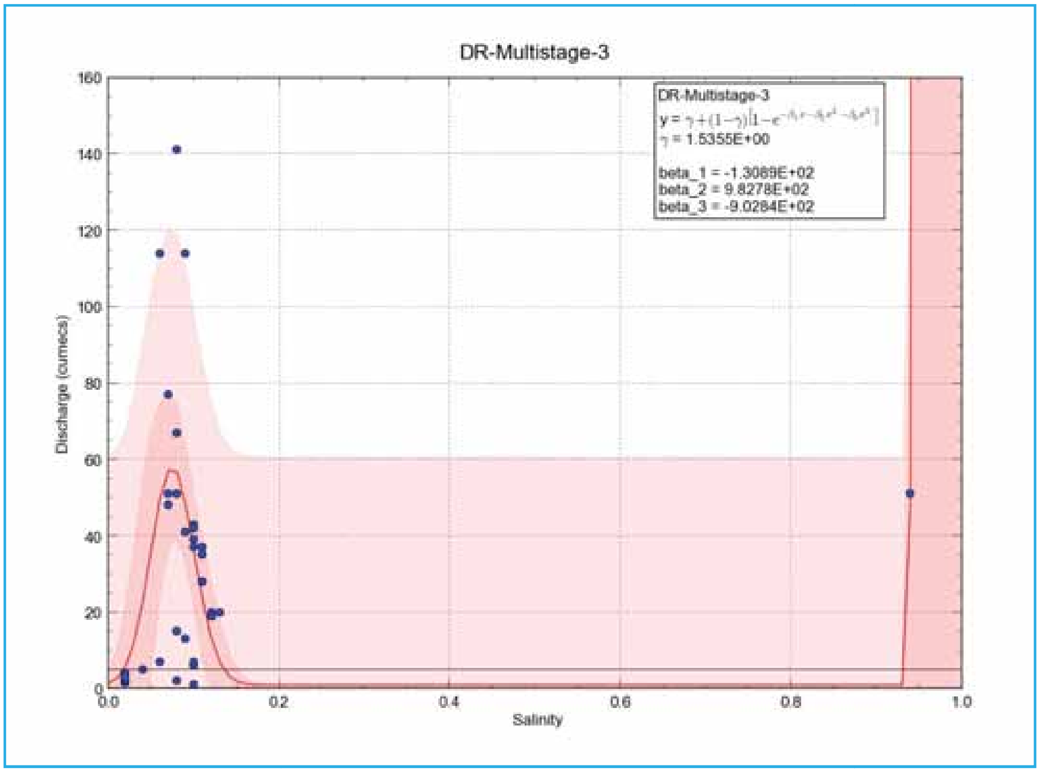


Figure IV. 4.1: Minimum salinity values and corresponding water discharge

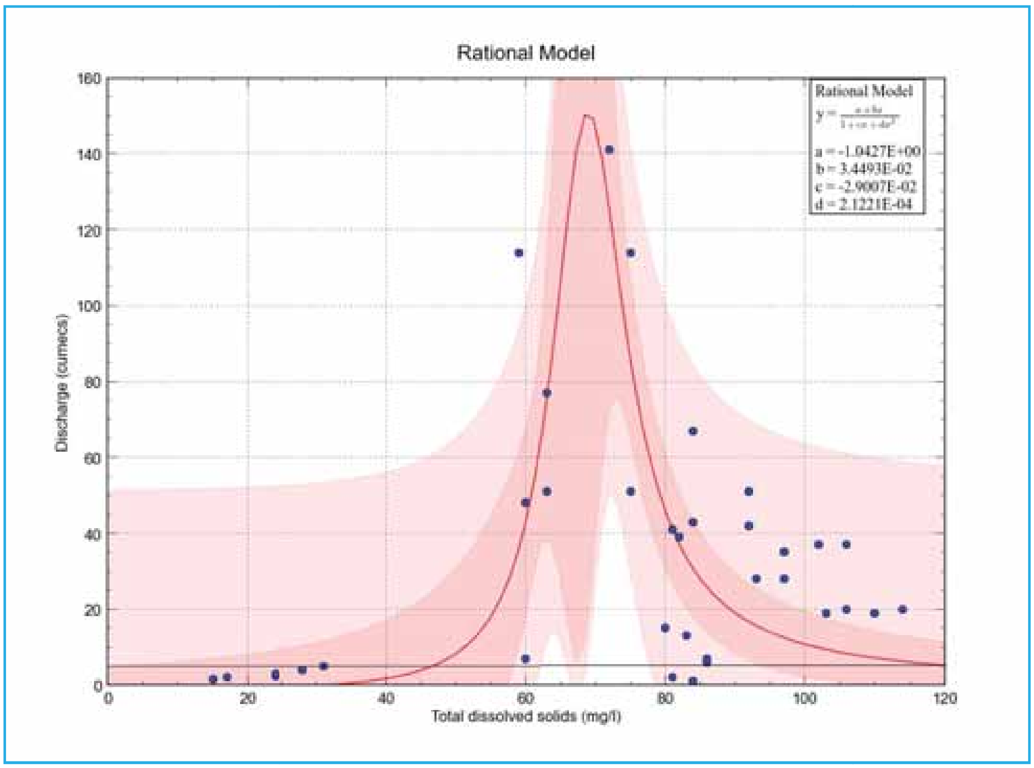


Figure IV. 4.2: Minimum values for total dissolved solids and corresponding water discharge

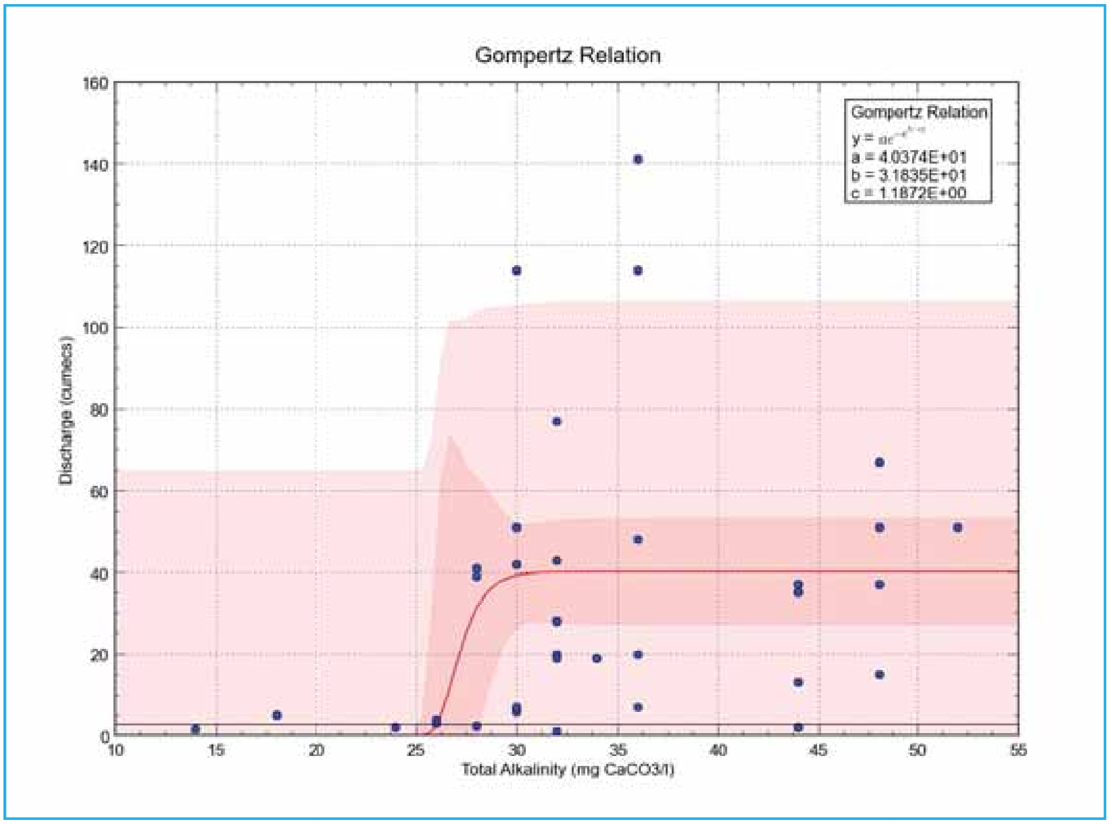


Figure IV. 4.3: Minimum values for total alkalinity and corresponding water discharge

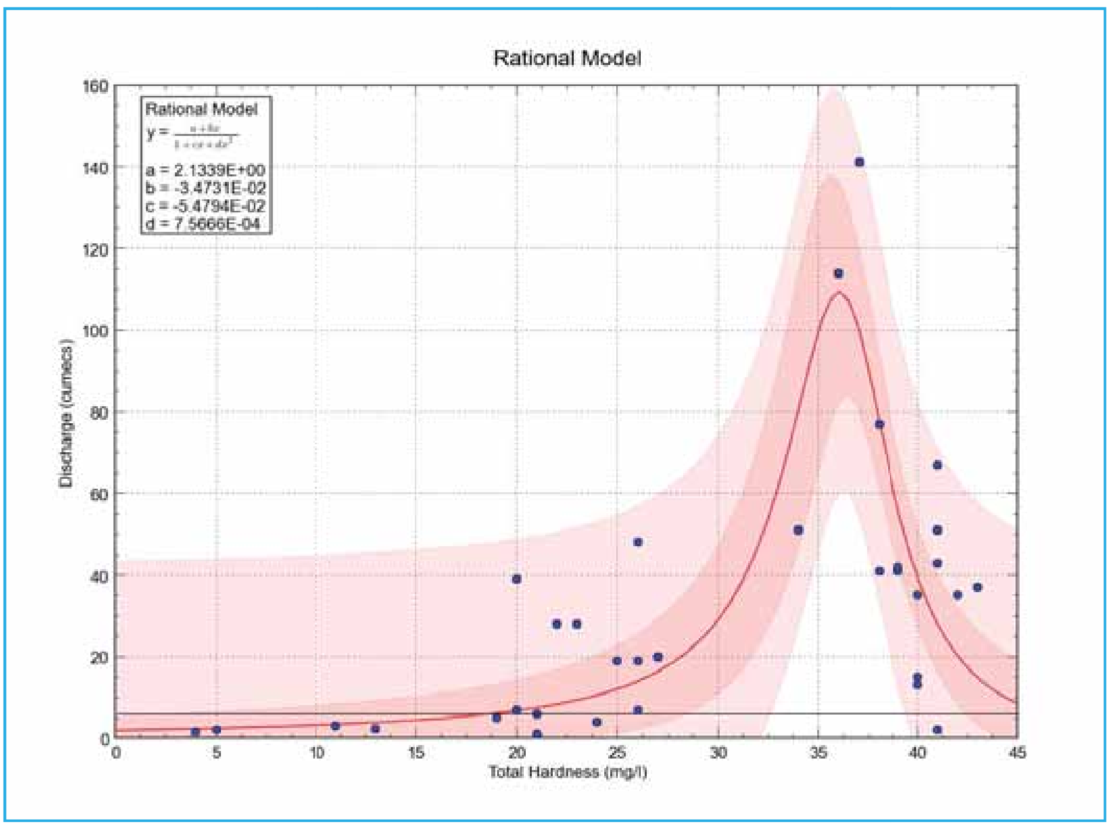


Figure IV. 4.4: Minimum values for total hardness and corresponding water discharge

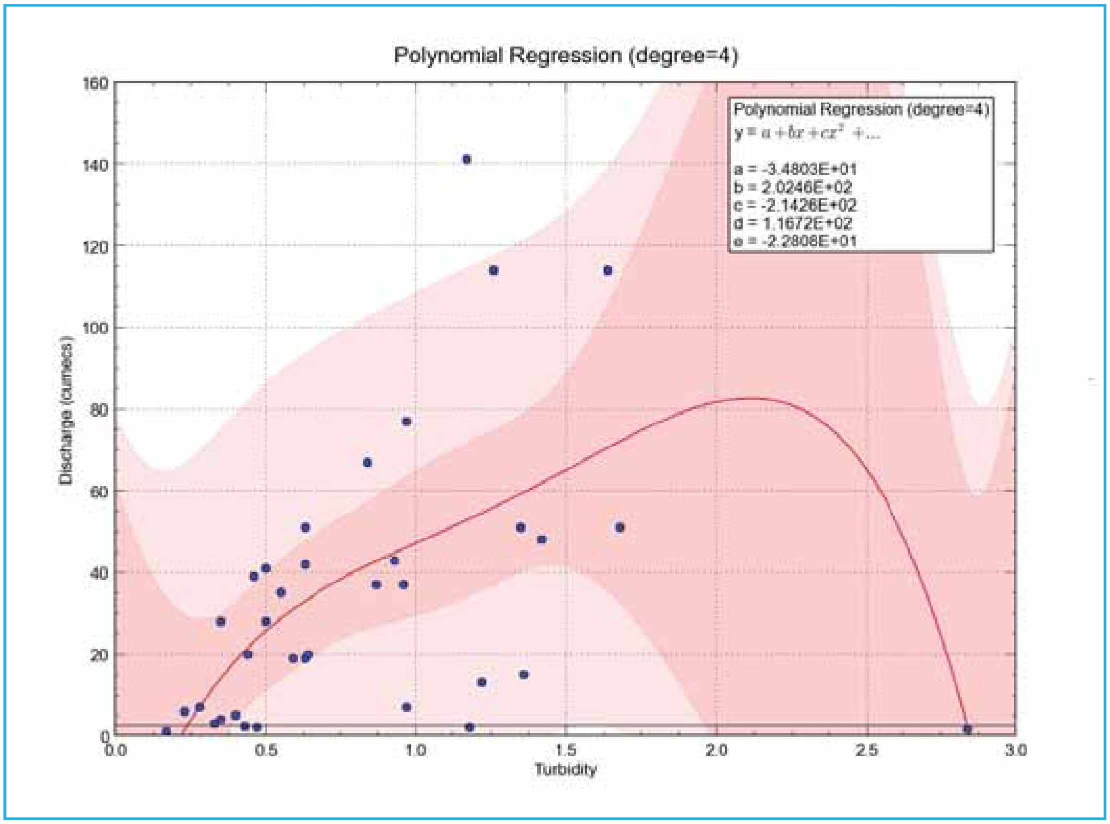


Figure IV. 4.5: Minimum values for turbidity and corresponding water discharge

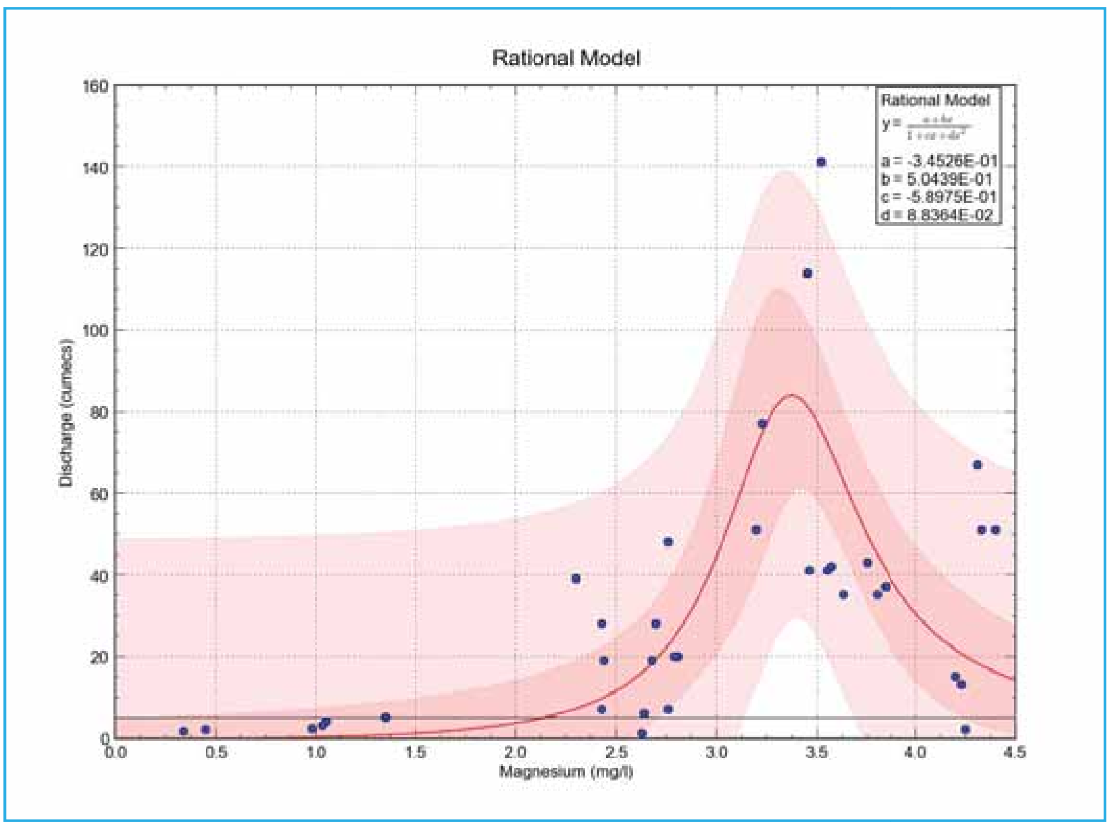


Figure IV. 4.6: Minimum values for magnesium and corresponding water discharge

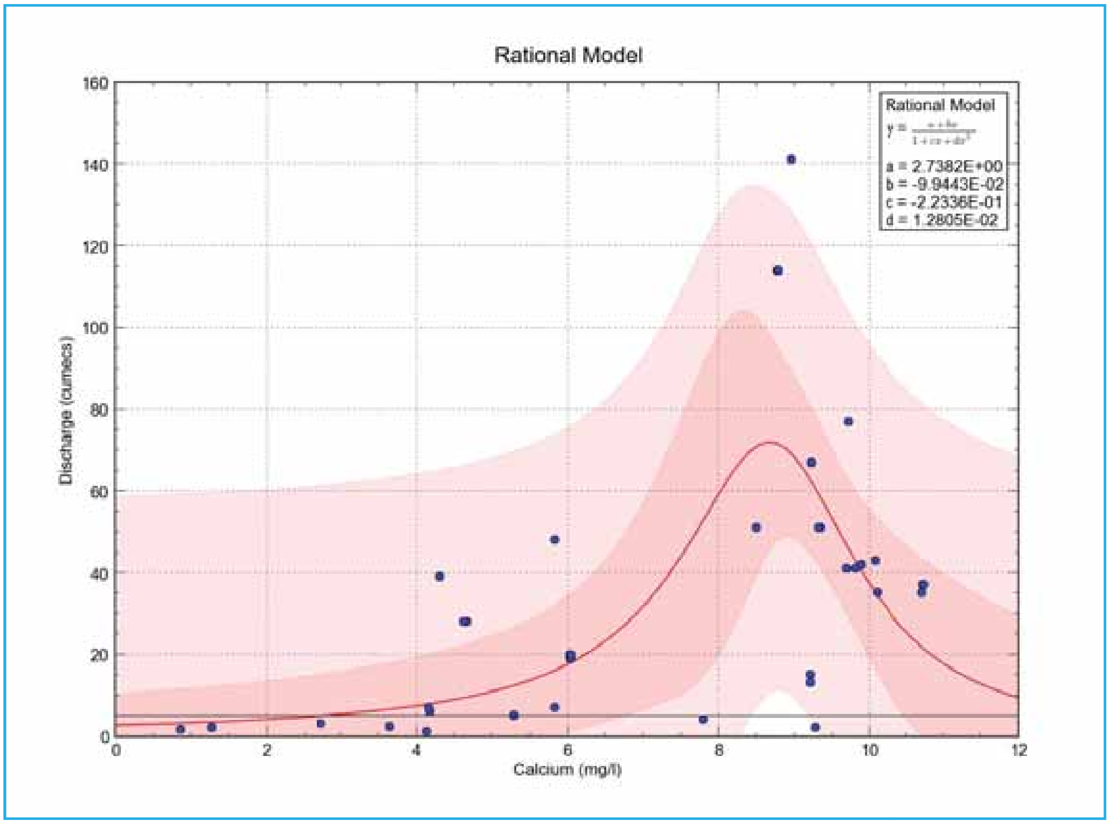


Figure IV. 4.7: Minimum values for calcium and corresponding water discharge

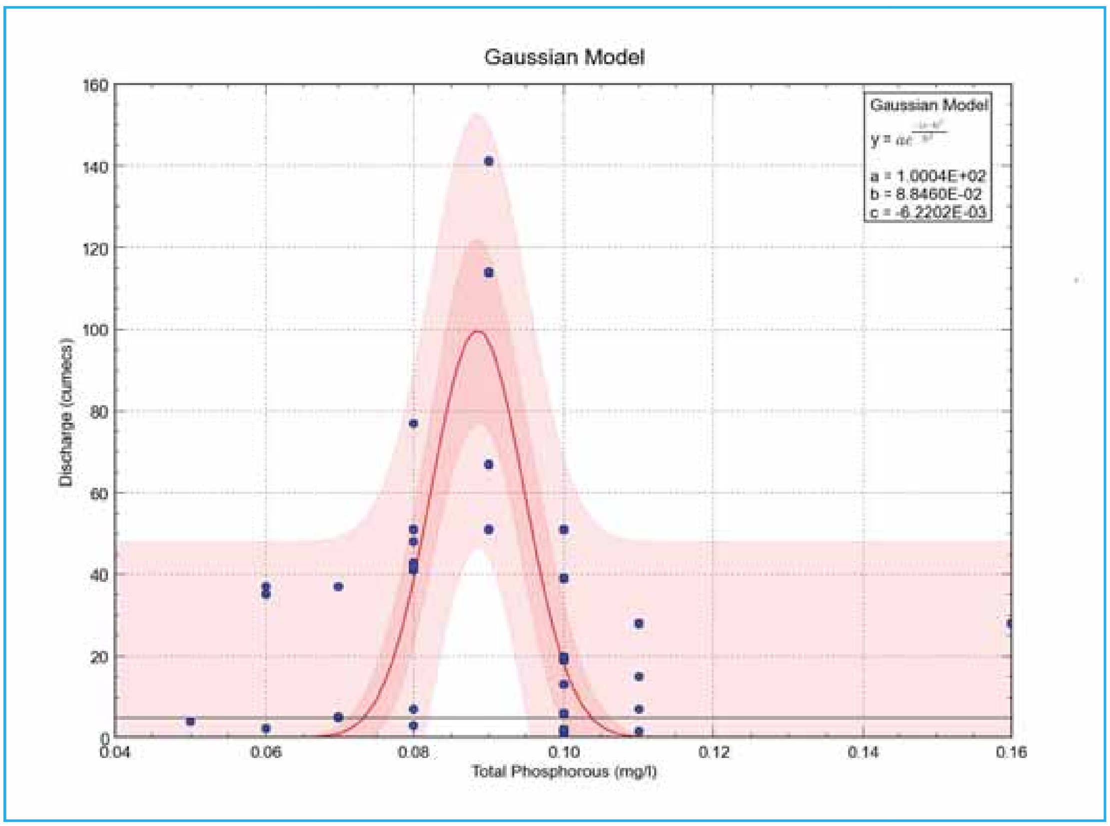


Figure IV. 4.8: Minimum values for total phosphorous and corresponding water discharge

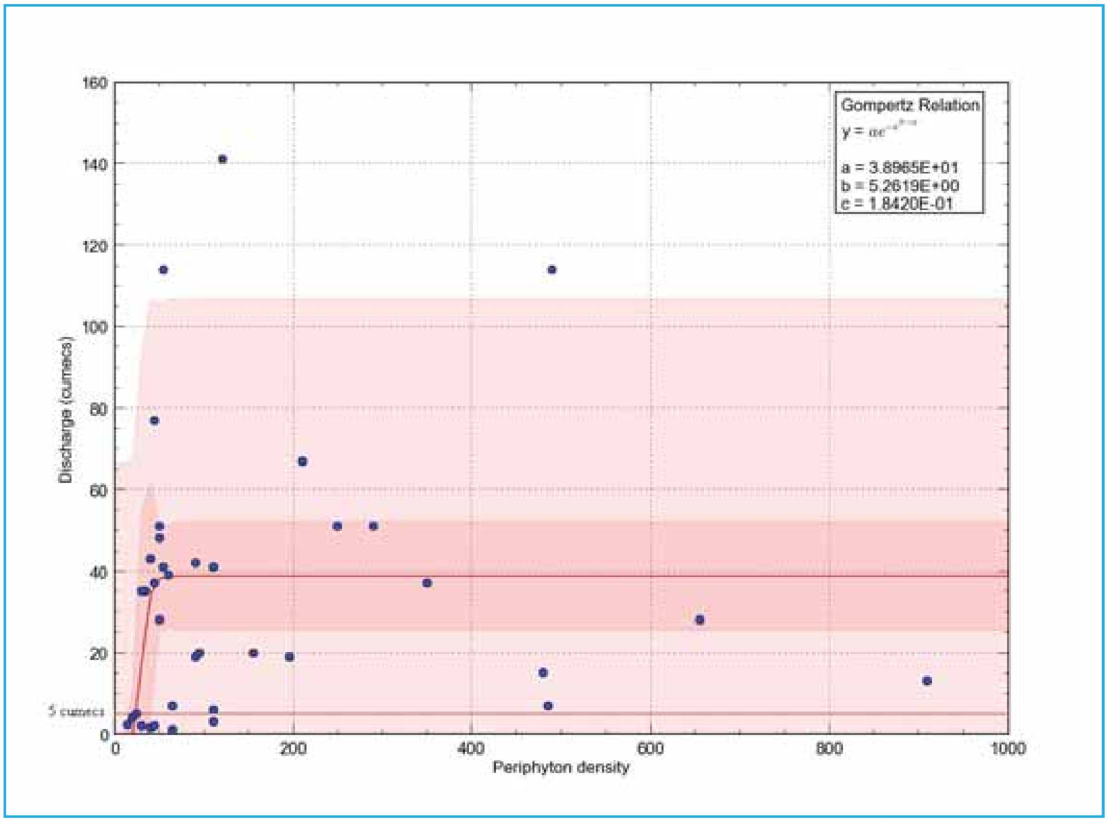


Figure IV. 4.9: Minimum values for periphyton density and corresponding water discharge

Table IV. 4.1: Acceptable limit for various indicators under different VECs and required discharge during lean season in TRB

Parameter	Lowest value of the river basin during lean season	Highest value of the river basin during monsoon season	Acceptable value for the river basin during lean season	Corresponding predicted water discharge (cumecs) during lean season
Ecosystem structure and function				
Water quality				
Salinity (ppt)	0.02	0.94	0.1	5
Total Dissolved Solid (mg/l)	15	114	60	5
Total Alkalinity (mg $CaCo_3$/l)	14	52	26.2	2
Total hardness (mg/l)	4	43	26.3	3
Turbidity (NTU)	0.17	2.84	0.5	2
Magnesium	0.34	4.4	2.13	5
Calcium	0.86	10.74	2.73	5
Phosphorous	0.05	0.16	0.07	5
Periphyton density	15	910	110	4
Biodiversity				
Water depth for *Schizothorax progastus*	0.39	2.26	0.5	5
Black necked crane	–	–	–	Not determined
Cultural				
Death rituals	–	–	–	9
Livelihood				
Water use	–	–	–	5
River resources	–	–	–	5
Edible algae	–	–	–	5

4.4 ENVIRONMENTAL FLOW ASSESSMENT

The Building Block Method followed in this study has five building blocks, based on baseline data and experts opinion. The components are: (i) river biodiversity, (ii) river hydraulics, (iii) cultural requirement, (iv) livelihood requirement, and (v) ecosystem structure and function. As discussed in the previous chapter, three indicators are appropriate for defining river biodiversity in the project sites. These indicators are threatened fish (*Schizothorax richardsonii, Schizothorax progastus*), endemic species (endemic periphyton, endemic zooplankton), and threatened bird (black necked crane). For the river hydraulics, bed composition is considered as an indicator. In the case of cultural requirement, dead body disposal and the habitat requirement of black necked crane were critical attributes which need the minimum flow depth throughout a year. Similarly water use, river resources, and edible algae are considered as major indicators for livelihood category. Not only are that four indicators in the ecosystem structure and function periphyton density, water quality, NPP, invasibility by IAS.

After identifying the indicators, seasonal requirement for flow depth and width at particular project site are assessed by concerned experts. This depth and width can be considered as a threshold limiting condition for maintaining river functioning. For example as given in Table IV. 4.2 at Tawang-I project site the limiting water depth for threatened fishes (*Schizothorax richardsonii, Schizothorax progastus*) ranges from 0.5-0.6 m and the flow width ranges from 10-15 m. This indicates that during the lean season the minimum flow of the river should have flow depth and width which are greater than or equal to the limiting value. As a result, the fish will survive under minimum E-Flow condition. In this case there are many indicators defining the river functioning. Therefore, for a particular season we try to find out the maximum range of flow depth and width from Table IV. 4.2 containing the range of hydraulic conditions and indicators. In this way, we obtain the range of hydraulic conditions for three seasons at a particular project site.

In order to obtain minimum flow rate, we use the simulation result of hydrodynamic model of different scenarios (10, 20, 30, 50, 70, and 100%) of the flow season average of 90% dependable flow. We compare the simulated hydraulic ranges with limiting hydraulic conditions requirement for obtaining the minimum flow for that particular season. It may be noted that E-Flow computation has been carried out by season-wise as well as site-wise. In the following section E-Flow computation for each project site has been carried out separately and documented.

4.4.1 Tawang–I

As given in Table IV. 4.2, flow depth and width requirement for three seasons at the project site have been prepared by concerned experts of river biodiversity, hydraulic, ecology and livelihood. It may be noted that if the flow depth and width requirement is indicated by non–available then, it means the particular indicator that does not exist at that site. In Tawang-I site, black neck crane birds are not seen and there is no hydraulic condition requirement for this indicator. For the lean season maximum range for e flow computation for depth and flow width are 0.5-0.6 m and 15-20 m respectively. Model simulation results of different scenarios (10, 20, 30, 50 and 70%) are given in Table IV. 4.2. By considering simulated hydraulic condition and limited ranges it can be found that 27% of lean average flow satisfy the limited ranges. Therefore 27% of lean flow (7.60 cumecs) is recommended as minimum E-Flow for lean season. By following the similar procedure for estimating E-Flow requirement in monsoon season the maximum range of hydraulic condition can be found from Table IV. 4.3. In this case flow depth and width at the project site are 0.8-0.9 m and 20-25 m, respectively. The flow depth requirement in monsoon season is higher than flow depth requirement in lean season. Subsequently we use the simulated hydraulic conditions to obtain the percentage of monsoon average flow which is greater than or equal to the maximum range of limiting hydraulic conditions. In this case 18% of monsoon average flow is found for this requirement. Thus, 18% of monsoon average flow (20 cumecs) is recommended as minimum E-Flow. For Non-monsoon season flow depth and width required for different river ecosystem and livelihood are listed in the same Table IV. 4.2. In this season, water depth requirement for threatened fish and cultural activities is found to be higher than water depth requirement for other actives function. The maximum limiting flow depth range is 0.6-0.7 m and the flow width requirement is within 17-20 m. The corresponding flow rate at that season is found to be 10 cumecs which is 20% of season averaged flow. Minimum environmental flow requirement for all three seasons at the project site are:

1. Lean season 7.60 cumecs
2. Non–monsoon season 10.00 cumecs
3. Monsoon season 20.00 cumecs

Table IV. 4.2: Model output for different releases of 90% dependable flow for Tawang–I HEP

Season	Release scenario	Discharge (cumecs)	Flow velocity (m/s)	Depth (m)	Top width (m)
Lean (28 cumecs)	10%	2.80	1.22	0.42	13.60
	20%	5.60	1.48	0.55	15.80
	27%	7.60	1.59	0.63	16.80
	50%	14.00	1.91	0.82	18.20
	70%	19.60	2.09	0.94	19.84
	100%	28.00	2.39	1.04	22.38
Monsoon (114 cumecs)	10%	11.40	1.79	0.74	18.59
	18%	20.52	2.06	0.92	21.00
	30%	34.20	2.49	1.16	23.48
	50%	57.00	2.90	1.45	25.68
	70%	79.80	3.27	1.66	27.80
	100%	114.00	3.66	1.91	30.2
Non–monsoon (51 cumecs)	10%	5.10	1.43	0.53	15.49
	20%	10.20	1.73	0.70	18.14
	30%	15.30	1.88	0.85	20.06
	50%	25.50	2.30	1.03	21.02
	70%	35.70	2.54	1.20	22.75
	100%	51.00	2.83	1.36	25.72

Table IV. 4.3: Hydraulic condition requirements for parameters used in building block for three seasons at Tawang–I HEP site

Type	Indicator	Lean season		Monsoon season		Non–monsoon	
		Depth (m)	Width (m)	Depth (m)	Width (m)	Depth (m)	Width (m)
River biodiversity	**Threatened fish**						
	Schizothorax richardsonii	0.5–0.6	10-15	0.7–0.9	10-15	0.5–0.6	10-15
	Schizothorax progastus	0.4–0.5	10-15	0.7–0.9	10-15	0.4–0.5	10-15
	Endemic species						
	Endemic periphyton	0.2–0.4	10–15	0.5–0.6	15–20	0.2–0.4	10–15
	Endemic zooplankton	0.3–0.4	11–15	0.4–0.5	15–20	0.3–0.4	11-15
	Threatened bird						
	Black neck crane	NA	NA	NA	NA	NA	NA
River hydraulics	Bed composition	0.4–0.6	15–20	0.7–0.9	20–25	0.6–0.7	15–20
Cultural	Dead body disposal	0.5–0.6	10–15	0.8–0.9	20–25	0.5–0.6	10–15
Livelihood	Water use	0.3–0.4	5–10	0.4–0.6	15–20	0.3–0.4	5–10
	River resources (fish)	0.5–0.6	15–20	0.8–0.9	20–25	0.5–0.6	17–20
	Edible algae	0.2–0.3	15–20	0.5–0.6	20–25	0.2–0.3	15–20
Ecosystem structure and function	Periphyton density	0.2–0.3	10–15	0.4–0.5	20–25	0.2–0.3	10–15
	Water quality	0.2–0.3	10–15	0.5–0.6	20–25	0.2–0.3	10–15
	NPP	0.2–0.3	10–15	0.5–0.6	20–25	0.2–0.3	10–15
	Invasibility by IAS	0.4–0.5	15–20	0.8–0.9	20–25	0.3–0.5	15–20
Optimum value used for recommending E-Flow		0.63	16.80	0.92	21.0	0.70	18.14

4.4.2 Tawang–II

The barrage of this project is located at the tail end of Tawang–I project. It receives maximum flow as compared to other upstream projects in Tawang chu river. Season average flow of 90% dependable year is given in Table IV.4.4. The simulated flow depth and flow width for different discharge conditions is listed in Table IV. 4.4.

The limiting hydraulic conditions for depth and width at the barrage location have been prepared by the respective experts. For lean season, the maximum range of flow depth is found to be 0.5–0.6 m and the flow width range from 16–20 m. By comparing data provided in both Table IV. 4.4 and 4.5, 25% of lean average flow of 9.75 cumecs is found to satisfy the limiting hydraulic conditions and is considered as minimum environmental flow requirement for the season.

By adopting the similar exercise, 18% average monsoon flow of about 26 cumecs is found to be the minimum environmental flow requirement for season. It may be noted that flow depth requirement for ecosystem structure and function is found to be higher as compared to the respective depth requirement in lean or non–monsoon seasons.

Hydraulic conditions required for non–monsoon season are flow depth 0.5–0.6 m and flow width 18–21 m. Simulated hydraulic conditions of 20% season average flow are found to be closer to the required hydraulic condition. Therefore, minimum environmental flow for the season is 20% of season average flow of about 13.40 cumecs (Table IV. 4.5). The minimum environmental requirement for Tawang–II are given below:

1. Lean season 10 cumecs
2. Non–monsoon season 13 cumecs
3. Monsoon season 26 cumecs

Table IV. 4.4: Model output for different releases of 90% dependable flow for Tawang–II HEP

Season	Release scenario	Discharge (cumecs)	Flow velocity (m/s)	Depth (m)	Top width (m)
Lean (39 cumecs)	10%	3.90	1.19	0.52	12.56
	20%	7.80	1.47	0.66	16.01
	25%	9.75	1.57	0.72	17.05
	50%	19.50	2.05	0.90	19.45
	70%	27.30	2.33	1.02	21.00
	100%	39.00	2.60	1.23	23.62
Monsoon (141 cumecs)	10%	14.10	1.76	0.82	18.44
	18%	25.38	2.27	1.00	20.60
	30%	42.30	2.74	1.21	23.25
	50%	70.50	3.15	1.53	27.20
	70%	98.70	3.45	1.79	30.40
	100%	141.00	3.82	2.13	31.64
Non–monsoon (67 cumecs)	10%	6.70	1.36	0.64	15.40
	20%	13.40	1.77	0.80	18.12
	30%	20.10	2.08	0.91	19.57
	50%	33.50	2.52	1.10	22.00
	70%	47.00	2.82	1.27	24.00
	100%	67.00	3.04	1.55	26.78

Table IV. 4.5: Hydraulic condition requirements for parameters used in building block for three seasons at Tawang–II HEP site

Type	Indicator	Lean season		Monsoon season		Non–monsoon	
		Depth (m)	Width (m)	Depth (m)	Width (m)	Depth (m)	Width (m)
River biodiversity	**Threatened fish**						
	Schizothorax richardsonii	0.5–0.6	10-15	0.7–0.9	10-15	0.5–0.6	10-15
	Schizothorax progastus	0.4–0.5	10-15	0.7–0.9	10-15	0.4–0.5	10-15
	Endemic species						
	Endemic periphyton	0.2–0.4	15–20	0.8–0.9	18–20	0.2–0.4	15–20
	Endemic zooplankton	0.3–0.4	15–20	0.7–0.8	18–20	0.3–0.4	15–20
	Threatened bird						
	Black neck crane	NA	NA	NA	NA	NA	NA
River hydraulics	Bed composition	0.4–0.6	16–20	0.8–1.2	18–21	0.4–0.6	18–21
Cultural	Dead body disposal	0.5–0.6	16–20	0.9–1.5	19–20	0.5–0.6	18–20
Livelihood	Water use	0.3–0.4	10–15	0.8–0.9	18–20	0.3–0.4	10–15
	River resources (fish)	0.5–0.6	10–15	0.9–1.2	18–20	0.5–0.6	18–20
	Edible algae	0.2–0.3	16–20	0.7–0.8	20–21	0.2–0.3	18–20
Ecosystem structure and function	Periphyton density	0.2–0.3	16–20	0.6–0.7	18–20	0.2–0.3	18–20
	Water quality	0.2–0.3	16–20	0.8–0.9	20–21	0.2–0.3	18–20
	NPP	0.2–0.3	16–20	0.8–0.9	20–21	0.2–0.3	18–20
	Invasibility by IAS	0.3–0.5	16–20	0.9–1.5	20–23	0.3–0.5	18–20
Optimum value used for recommending E-Flow		0.72	17.05	1.00	20.60	0.80	18.12

4.4.3 Rho

The maximum range of flow depth and top width which satisfy all the critical indicators are 0.6–0.8 m and 15–20 m. The flow satisfying these requirements which can be observed from Table IV. 4.8 is 27% of average lean season of 90% dependable year. The simulated flow depth and width for this discharge are 0.64 and 15.64 m. Thus, the 27% average about 7.60 cumecs is recommended environmental flow for Rho HEP site during lean season. For monsoon season, the maximum range of flow depth and width for environmental flow estimation is 0.9–1.5m and 19–20 m. From the Table IV. 4.8 the flow of 20.52 cumecs satisfy these requirements i.e. 18% of average monsoon 90% dependable year flow. Therefore, 20.52 cumecs flow in monsoon season is recommended as minimum environmental flow. For the non–monsoon season the maximum range of hydraulic variables flow depth and width are 0.7–0.8 m and 16–18 m. The flow meeting this criteria is 20% of average non–monsoon 90% dependable flow i.e. 10 cumecs, which is recommended as environmental flow requirement for the season (Table IV. 4.9). The minimum environmental flow requirements for the three seasons at Rho HEP site are:

1. Lean season 7.6 cumecs
2. Non–monsoon season 10 cumecs
3. Monsoon season 20 cumecs

Table IV. 4.6: Model output for different releases of 90% dependable flow for Rho HEP

Season	Release scenario	Discharge (cumecs)	Flow velocity (m/s)	Depth (m)	Top width (m)
Lean (28 cumecs)	10%	2.80	1.20	0.44	12.63
	20%	5.60	1.47	0.57	14.66
	27%	7.60	1.60	0.64	15.64
	50%	14.00	1.91	0.82	18.20
	70%	19.60	2.09	0.94	19.84
	100%	28.00	2.39	1.04	22.38
Monsoon (114 cumecs)	10%	11.40	1.81	0.75	17.30
	18%	20.52	2.12	0.95	19.85
	30%	34.20	2.51	1.17	22.53
	50%	57.00	2.90	1.45	25.68
	70%	79.80	3.27	1.66	27.80
	100%	114.00	3.66	1.91	30.2
Non–monsoon (51 cumecs)	10%	5.10	1.43	0.55	14.36
	20%	10.20	1.75	0.72	16.77
	30%	15.30	1.95	0.85	18.63
	50%	25.50	2.30	1.03	21.02
	70%	35.70	2.54	1.20	22.75
	100%	51.00	2.83	1.36	25.72

Table IV. 4.7: Hydraulic condition requirements for parameters used in building block for three seasons at Rho HEP site

Type	Indicator	Lean season		Monsoon season		Non–monsoon	
		Depth (m)	Width (m)	Depth (m)	Width (m)	Depth (m)	Width (m)
River biodiversity	**Threatened fish**						
	Schizothorax richardsonii	0.5–0.6	10-15	0.7–0.9	10-15	0.5–0.6	10-15
	Schizothorax progastus	0.4–0.5	10-15	0.7–0.9	10-15	0.4–0.5	10-15
	Endemic species						
	Endemic periphyton	0.6–0.8	14–18	0.8–0.9	19-20	0.6–0.8	15–18
	Endemic zooplankton	0.6–0.8	14–18	0.7–0.8	19-20	0.6–0.8	15–18
	Threatened bird						
	Black neck crane	NA	NA	NA	NA	NA	NA
River hydraulics	Bed composition	0.6–0.8	14–18	0.8–1.2	19-20	0.7–0.8	16–18
Cultural	Dead body disposal	0.6–0.8	14–18	0.9–1.5	19-20	0.7–0.8	16–18
Livelihood	Water use	0.6–0.8	10–15	0.7–0.9	18–20	0.7–0.8	10–15
	River resources (fish)	0.5–0.6	15–20	0.8–1.2	18–20	0.5–0.6	15–18
	Edible algae	0.4–0.5	15–20	0.6–0.8	19-20	0.4–0.5	15–18
Ecosystem structure and function	Periphyton density	0.5–0.6	15–18	0.5–0.7	18–20	0.5–0.6	16–18
	Water quality	0.5–0.6	14–18	0.7–0.9	19-20	0.5–0.6	16–18
	NPP	0.4–0.5	14–18	0.6–0.9	19-20	0.4–0.5	16–18
	Invasibility by IAS	0.6–0.8	14–20	0.8–1.5	19-20	0.7–0.8	16–18
Value obtained for recommended E–Flow		0.64	15.64	0.95	19.85	0.72	16.77

4.4.4 Nykcharong Chu

The maximum range of hydraulic conditions requirement for all the seasons at the project site is shown in Table IV. 4.10. From the Table IV. 4.11 it has been observed that at Nykcharong chu site location threatened fish (*Schizothorax richardsonii*, *Schizothorax progastus*) and threatened bird (Black neck crane) are not seen. Therefore, there are no hydraulic conditions requirements for these indicators. Therefore based on other indicators, the maximum range for E–Flow estimation are given in the last row of Table IV. 4.11.

For lean season, the maximum range for hydraulic conditions found for flow depth and flow width are 0.5–0.6 m and 10–15 m. In Table IV. 4.10 simulated hydraulic conditions for different percentages of 90% dependable flow in the lean season are enumerated and by considering simulating hydraulic conditions and requirements for E–Flow assessment, it has been found that 30% of the lean flow is about 6 cumecs. This amount of discharge for the site can be considered as minimum E–Flow for the lean season.

For monsoon season the maximum range for hydraulic condition found for flow depth and flow width are 0.7–1.0 m and 12–15 m. By comparing the ecological requirements and model simulation results for different release scenario of average monsoon flow of 90% dependable year it is observed that 30% of average monsoon flow satisfies the requirements. This discharge is about 12.60 cumecs which is considered as the E–Flow requirement at the site.

For non–monsoon season, hydraulic variables required for the ecosystem functioning are flow depth (0.6–0.7 m) and flow width (12–15 m). The simulation results for different percentages of dependable flow provide the variation of hydraulic condition depth and top width. By combining simulating conditions and requirements 27% of season average flow is found to be appropriate. This discharge for environment flow is about 9.92 cumecs. The minimum environment flow for three seasons at Nykcharong chu project are:

1. Lean season 6 cumecs
2. Non–monsoon season 10 cumecs
3. Monsoon season 13 cumecs

Table IV. 4.8: Model output for different releases of 90% dependable flow for Nykcharong chu HEP

Season	Release scenario	Discharge (cumecs)	Flow velocity (m/s)	Depth (m)	Top width (m)
Lean (20 cumecs)	10%	2.00	1.56	0.35	8.44
	20%	4.00	1.87	0.46	10.00
	30%	6.00	2.11	0.55	10.97
	50%	10.00	2.45	0.67	12.48
	70%	14.00	2.72	0.77	13.40
	100%	20.00	2.90	0.98	14.00
Monsoon (42 cumecs)	10%	4.00	1.87	0.46	10.00
	20%	8.40	2.32	0.63	11.76
	30%	12.60	2.63	0.74	13.14
	50%	21.00	3.06	0.91	14.80
	70%	29.00	3.35	1.06	16.60
	100%	43.00	3.90	1.20	19.00
Non–monsoon (37 cumecs)	10%	3.70	1.82	0.45	9.86
	20%	7.40	2.25	0.60	11.45
	27%	9.92	2.45	0.68	12.40
	50%	18.50	2.90	0.86	14.40
	70%	26.00	3.25	1.00	16.06
	100%	37.00	3.60	1.10	16.00

Table IV. 4.9: Hydraulic condition requirements for parameters used in building block for three seasons at Nykcharong chu project site

Type	Indicator	Lean season		Monsoon season		Non–monsoon	
		Depth (m)	Width (m)	Depth (m)	Width (m)	Depth	Width
River biodiversity	Threatened fish						
	Schizothorax richardsonii	NA	NA	NA	NA	NA	NA
	Schizothorax progastus	NA	NA	NA	NA	NA	NA
	Endemic species						
	Endemic periphyton	0.2–0.4	10–15	0.7–0.8	12–15	0.2–0.4	12–15
	Endemic zooplankton	0.3–0.4	10–15	0.7–0.8	12–15	0.3–0.4	12–15
	Threatened bird						
	Black neck crane	NA	NA	NA	NA	NA	NA
River hydraulics	Bed composition	0.5–0.6	10–12	0.7–0.9	10–15	0.5–0.6	10–12
Cultural	Dead body disposal	0.5–0.6	10–15	0.7–0.9	10–15	0.5–0.6	10–15
Livelihood	Water use	0.3–0.4	10–12	0.6–0.9	10–14	0.3–0.4	10–12
	River resources (fish)	0.5–0.6	10–15	0.6–0.9	12–14	0.5–0.6	10–15
	Edible algae	0.2–0.3	10–15	0.7–0.8	12–14	0.2–0.3	10–15
Ecosystem structure and function	Periphyton density	0.2–0.3	10–15	0.6–0.7	12–14	0.2–0.3	10–15
	Water quality	0.2–0.3	10–15	0.7–0.9	12–14	0.2–0.3	10–15
	NPP	0.2–0.3	10–15	0.7–0.9	12–14	0.2–0.3	10–15
	Invasibility by IAS	0.6–0.7	10–15	0.7–1.0	12–14	0.6–0.7	10–15
Value obtained for recommended E–Flow		0.55	10.97	0.74	13.14	0.68	12.40

4.4.5 Mago Chu

The minimum hydraulic conditions required for all the critical parameters that maintain the river ecosystem functioning and service for this project site is given in Table IV. 4.13. The maximum range for E–Flow estimation is mentioned in the last row of the Table IV. 4.13. It may be noted that black neck crane is not seen in this location. For the lean season, the maximum range for hydraulic conditions flow depth and flow width that satisfy all the critical requirements are 0.5–0.6 m and 10–15 m. By comparing the eco system structure and function requirements and model simulated results, 70% of lean flow is about 4.9 cumecs which is recommended as the minimum environmental flow requirement for the lean season.

For monsoon season, the maximum range for hydraulic conditions flow depth and flow width are 0.7–0.9 m and 14–18 m. Following the procedure mentioned above for lean season, environmental flow requirement for monsoon season is found to be 20 % of the average season flow of 90 % dependable year and estimated E–Flow at the site is about 10 cumecs (Table IV. 4.12).

For non–monsoon season hydraulic conditions flow depth and flow width for the ecosystem functioning are 0.6–0.7 m and 13–15 m. On comparison with simulated results it is found that 53% of the non–monsoon season average flow is appropriate. This discharge for environmental flow about 8.00 cumecs is recommended. The recommended environmental flow requirement for all the three seasons are listed below:

1. Lean season – 5.00 cumecs
2. Non–monsoon season – 8.00 cumecs
3. Monsoon season – 10.00cumecs

Table IV. 4.10: Model output for different releases of 90% dependable flow for Mago chu HEP

Season	Release scenario	Discharge (cumecs)	Flow velocity (m/s)	Depth (m)	Top width (m)
Lean (7 cumecs)	10%	0.70	0.96	0.27	5.99
	20%	1.40	1.17	0.35	7.66
	30%	2.10	1.29	0.41	8.84
	50%	3.50	1.52	0.48	10.46
	70%	4.90	1.60	0.56	11.85
	100%	7.00	1.40	0.60	13.16
Monsoon (51cumecs)	10%	5.00	1.65	0.55	11.77
	20%	10.00	1.96	0.73	14.65
	30%	15.30	2.23	0.85	16.28
	50%	25.50	2.61	1.04	18.38

	70%	35.70	2.90	1.19	20.00
	100%	51.00	2.80	1.30	23
Non–monsoon (15 cumecs)	10%	1.50	1.19	0.36	7.84
	20%	3.00	1.41	0.46	10.03
	30%	4.50	1.57	0.54	11.52
	53%	8.00	1.85	0.66	13.61
	70%	10.50	1.99	0.74	14.86
	100%	15.00	1.90	0.90	17.00

Table IV. 4.11: Hydraulic condition requirements for parameters used in building block for three seasons at Mago chu HEP site

Type	Indicator	Lean season		Monsoon season		Non–monsoon	
		Depth (m)	Width (m)	Depth (m)	Width (m)	Depth (m)	Width (m)
River biodiversity	**Threatened fish**						
	Schizothorax richardsonii	0.5–0.6	10-15	0.7–0.9	10-15	0.5–0.6	10-15
	Schizothorax progastus	0.4–0.5	10-15	0.7–0.9	10-15	0.4–0.5	10-15
	Endemic species						
	Endemic periphyton	0.2–0.4	10–15	0.7–0.9	14–18	0.2–0.4	11–13
	Endemic zooplankton	0.3–0.4	10–15	0.7–0.8	14–18	0.3–0.4	11–13
	Threatened bird						
	Black neck crane	NA	NA	NA	NA	NA	NA
River hydraulics	Bed composition	0.4–0.5	10–12	0.6–0.8	14–16	0.4–0.5	10–12
Cultural	Dead body disposal	0.5–0.6	10–15	0.7–0.9	14–18	0.5–0.6	13–15
Livelihood	Water use	0.4–0.5	10–12	0.7–0.8	12–15	0.4–0.5	10–12
	River resources (fish)	0.4–0.6	10–12	0.7–0.8	12–15	0.6–0.7	10–12
	Edible algae	0.4–0.5	10–11	0.7–0.9	14–15	0.4–0.5	10–11
Ecosystem structure and function	Periphyton density	0.4–0.5	7–8	0.7–0.8	14–16	0.4–0.5	7–8
	Water quality	0.4–0.6	10–11	0.7–0.9	10–15	0.5–0.6	10–11
	NPP	0.4–0.5	10–11	0.7–0.9	14–16	0.4–0.5	10–11
	Invasibility by IAS	0.3–0.5	10–12	0.7–0.9	13–16	0.3–0.5	11–12
Value obtained for recommended E–Flow		0.56	11.85	0.73	14.65	0.66	13.6

4.4.6 New Melling

The experts' suggestions for various critical parameter requirement during all seasons is shown in Table IV. 4.15. From the Table IV. 4.15, it is observed that at New Melling HEP site threatened bird and threatened fish are not seen.

In lean season the maximum range of hydraulic conditions like flow depth and flow width are 0.5–0.6 m and 10–15 m. Model simulated results for various scenario of lean season (10, 20, 30, 50 and 70%) are shown in Table IV. 4.14. By comparing both the ecological requirements and model simulation results, it has been found that 50% of the lean flow is about 3 cumecs. This amount of discharge for the site is recommended as minimum environmental flow requirement for the lean season.

For Monsoon season the maximum range for hydraulic conditions flow depth and flow width are 0.8–1.2 m and 16–21 m. By comparing ecosystem requirements and model simulated results 20% of monsoon average flow is recommended as a minimum environmental flow. This discharge is about 9.60 cumecs.

For non–monsoon season hydraulic conditions required for the ecosystem, livelihood are flow depth 0.6–0.7 m and flow width 10–15 m. The hydrodynamic simulation results for different percentage of dependable flow provide hydraulic condition depth and top width. 50% of the season average flow showing the limiting hydraulic conditions is found to be appropriate. The corresponding discharge for environmental flow about 6.5 cumecs is recommended.

The recommended environmental flow requirement for three seasons at New Melling project site are:

1. Lean season – 3 cumecs
2. Non–monsoon season – 7 cumecs
3. Monsoon season – 10 cumecs

Table IV. 4.12: Model output for different releases of 90% dependable flow for New Melling HEP

Season	Release scenario	Discharge (cumecs)	Flow velocity (m/s)	Depth (m)	Top width (m)
Lean (6 cumecs)	10%	0.60	0.76	0.28	6.58
	20%	1.20	0.88	0.37	8.40
	30%	1.80	0.97	0.43	9.61
	50%	3.00	1.11	0.52	11.30
	70%	4.20	1.21	0.59	12.50
	100%	6.00	1.325	0.68	14.09
Monsoon (48 cumecs)	10%	4.80	1.25	0.62	13.06
	20%	9.60	1.50	0.81	16.42
	30%	14.40	1.70	0.94	18.72
	50%	24.00	1.97	1.14	21.70
	70%	33.60	2.15	1.32	24.20
	100%	48.00	2.30	1.37	27.05
Non–monsoon (13 cumecs)	10%	1.30	0.90	0.38	8.65
	20%	2.60	1.07	0.49	10.81
	30%	3.90	1.19	0.57	12.27
	50%	6.50	1.35	0.69	14.50
	70%	9.10	1.48	0.79	16.15
	100%	13.00	1.60	0.90	16.50

Table IV. 4.13: Hydraulic condition requirements for parameters used in building block for three seasons at New Melling HEP site

Type	Indicator	Lean season		Monsoon season		Non–monsoon	
		Depth (m)	Width (m)	Depth (m)	Width (m)	Depth (m)	Width (m)
River biodiversity	**Threatened fish**						
	Schizothorax richardsonii	NA	NA	NA	NA	NA	NA
	Schizothorax progastus	NA	NA	NA	NA	NA	NA
	Endemic species						
	Endemic periphyton	0.2–0.4	10–11	0.8–1.1	16–20	0.2–0.4	10–11
	Endemic zooplankton	0.3–0.4	10–11	0.7–0.8	16–20	0.3–0.4	10–11
	Threatened bird						
	Black neck crane	NA	NA	NA	NA	NA	NA
River hydraulics	Bed composition	0.4–0.5	10–11	0.8–1.0	16–20	0.4–0.5	10–11
Cultural	Dead body disposal	0.5–0.6	10–15	0.8–1.2	16–20	0.6–0.7	10–15
Livelihood	Water use	0.3–0.4	10–15	0.8–0.9	16–20	0.3–0.4	10–15
	River resources (fish)	NA	NA	NA	NA	NA	NA
	Edible algae	0.2–0.3	10–15	0.7–0.8	16–21	0.2–0.3	10–15
Ecosystem structure and function	Periphyton density	0.2–0.3	10–12	0.8–1.0	16–20	0.2–0.3	10–12
	Water quality	0.2–0.3	10–12	0.8–1.0	16–21	0.2–0.3	10–12
	NPP	0.2–0.3	10–12	0.8–1.0	16–20	0.2–0.3	10–12
	Invasibility by IAS	0.3–0.5	10–12	0.8–1.0	16–21	0.3–0.5	10–12
Value obtained for recommended E–Flow		0.52	11.30	0.81	16.42	0.69	14.5

4.4.7 Tsa Chu–I

Hydraulic condition requirements for proper functioning of ecosystem functions and river sustainability are shown in Table IV. 4.17. At this site location threatened fish threatened bird are not noticed. The simulated hydraulic conditions for various percentage of 90% dependable flow scenarios are shown in Table IV. 4.16.

For lean season the maximum range for hydraulic conditions found for flow depth 0.6–0.8 m and flow width 12–15 m. By comparing the ecological flow requirements and model simulated results it has been found that 25% of the lean flow about 4.75 cumecs is appropriate. This amount of discharge for the site is recommended as minimum environmental flow requirement for the lean season.

For monsoon season the maximum range for hydraulic conditions found are flow depth (0.8–1.1 m) and flow width (15–20 m). Corresponding these conditions, environmental flow requirement for the monsoon season is found to be 25% of the average flow of 90% dependable year and the estimated environmental flow at the site is about 10.25 cumecs.

For non–monsoon season hydraulic conditions required for the ecosystem, livelihood and culture are flow depth 0.6–0.8 m and flow width 13-18 m. The hydrodynamic simulation results for different percentage of dependable flow scenarios provide list of flow depth and top width. By comparing simulating conditions and ecological requirements 17% of the season average is found to be appropriate. Thus, the discharge for environmental flow for about 6 cumecs is recommended. The environmental flow requirement for three seasons at Tsa chu–I HEP site are:

1. Lean season 5 cumecs
2. Non–monsoon season 6 cumecs
3. Monsoon season 10 cumecs

Table IV. 4.14: Model output for different releases of 90% dependable flow for Tsa chu–I HEP

Season	Release scenario	Discharge Q (cumecs)	Flow velocity (m/s)	Depth (m)	Top width (m)
Lean (19 cumecs)	10%	1.90	0.75	0.47	10.85
	20%	3.80	0.90	0.60	13.79
	25%	4.75	0.98	0.65	14.22
	50%	9.50	1.28	0.83	15.60
	70%	13.30	1.46	0.94	16.48
	100%	19.00	1.65	1.08	17.67
Monsoon (41 cumecs)	10%	4.10	0.93	0.62	13.96
	20%	8.20	1.21	0.78	15.27
	25%	10.25	1.32	0.85	15.79
	50%	20.50	1.71	1.12	17.85
	70%	28.70	1.93	1.28	18.82
	100%	41.00	2.21	1.49	21.35
Non–monsoon (35 cumecs)	10%	3.50	0.88	0.59	13.53
	17%	6.0	1.06	0.70	14.00
	30%	10.50	1.33	0.86	15.85
	50%	17.50	1.61	1.05	17.31
	70%	24.50	1.82	1.20	18.44
	100%	35.00	2.07	1.38	19.60

Table IV. 4.15: Hydraulic condition requirements for parameters used in building block for three seasons at Tsa chu–I HEP site

Type	Indicator	Lean season		Monsoon season		Non–monsoon	
		Depth (m)	Width (m)	Depth (m)	Width (m)	Depth (m)	Width (m)
River biodiversity	**Threatened fish**						
	Schizothorax richardsonii	NA	NA	NA	NA	NA	NA
	Schizothorax progastus	NA	NA	NA	NA	NA	NA
	Endemic species						
	Endemic periphyton	0.2–0.4	12–15	0.8–0.9	15–18	0.2–0.4	13–18
	Endemic zooplankton	0.3–0.4	10–15	0.7–0.8	15–18	0.3–0.4	10–15
	Threatened bird						
	Black neck crane	NA	NA	NA	NA	NA	NA
River hydraulics	Bed composition	0.6–0.8	10–15	0.8–1.1	15–18	0.6–0.8	10–15
Cultural	Dead body disposal	0.6–0.8	10–15	0.8–1.0	15–20	0.6–0.8	10–15
Livelihood	Water use	0.6–0.8	10–15	0.8–0.9	15–20	0.6–0.8	10–15
	River resources (fish)	NA	NA	NA	NA	NA	NA
	Edible algae	0.3–0.6	10–15	0.7–0.8	15–20	0.3–0.6	10–15
Ecosystem structure and function	Periphyton density	0.2–0.3	10–15	0.8–0.9	15–18	0.2–0.3	10–15
	Water quality	0.6–0.8	10–15	0.8–0.9	15–18	0.6–0.8	10–15
	NPP	0.6–0.8	10–15	0.8–0.9	15–18	0.6–0.8	10–15
	Invasibility by IAS	0.6–0.8	10–15	0.8–1.1	15–18	0.6–0.8	10–15
Value obtained for recommended E–Flow		0.65	14.22	0.85	15.79	0.86	15.85

4.4.8 Tsa Chu–II

The experts recommendations for various critical parameters that maintain river ecosystem and service is shown in Table IV. 4.19. In this HEP site also threatened fish and threatened bird are not noticed. By comparing hydraulic condition requirements with the simulated results shown in Table IV. 4.18, the following environmental flow for three seasons are estimated.

For lean season the maximum range for hydraulic conditions found are flow depth (0.6–0.8 m) and flow width (12–15 m). It has been found that 25% of the lean flow is about 5 cumecs. This amount of discharge for the site is recommended as minimum environmental flow requirement for the lean season.

For monsoon season the maximum range for hydraulic conditions found are flow depth (0.8–1.1 m) and flow width (15–20 m). It is found that 25% of the average flow of 90% dependable year which is minimum environmental flow at that site shows the required hydraulic condition and is about 10.50 cumecs.

For non–monsoon season hydraulic conditions required for the ecosystem, livelihood and culture as give in Table IV. 4.19 are flow depth 0.6–0.8 m and flow width 13–18 m. It is observed that 15% of the season average shows the limited hydraulic condition. This discharge for minimum environmental flow is about 5.55 cumecs. The environmental flow for all the three seasons at Tsa chu–II project site are:

1. Lean season 5 cumecs
2. Non–monsoon season 6 cumecs
3. Monsoon season 10 cumecs

Table IV. 4.16: Model output for different releases of 90% dependable flow for Tsa chu–II HEP

Season	Release scenario	Discharge (cumecs)	Flow velocity (m/s)	Depth (m)	Top width (m)
Lean (20 cumecs)	10%	2.00	0.76	0.48	11.06
	20%	4.00	0.92	0.62	13.90
	25%	5.00	1.00	0.66	14.31
	50%	10.00	1.31	0.84	15.73
	70%	14.00	1.49	0.96	16.63
	100%	20	1.72	1.10	17.70
Monsoon (42 cumecs)	10%	4.20	0.94	0.62	14.00
	20%	8.40	1.23	0.79	15.32
	25%	10.50	1.33	0.86	15.85
	50%	21.00	1.73	1.13	17.93
	70%	29.40	1.95	1.29	18.88
	100%	42	2.26	1.58	21.59
Non–monsoon (37 cumecs)	10%	3.70	0.89	0.60	13.72
	15%	5.55	1.04	0.69	14.49
	30%	11.10	1.36	0.88	15.99
	50%	18.50	1.65	1.07	17.50
	70%	25.90	1.86	1.23	18.58
	100%	37	2.15	1.43	19.85

Table IV. 4.17: Hydraulic condition requirements for parameters used in building block for three seasons at Tsa chu–II HEP site

Type	Indicator	Lean season		Monsoon season		Non–monsoon	
		Depth (m)	Width (m)	Depth (m)	Width (m)	Depth (m)	Width (m)
River biodiversity	**Threatened fish**						
	Schizothorax richardsonii	NA	NA	NA	NA	NA	NA
	Schizothorax progastus	NA	NA	NA	NA	NA	NA
	Endemic species						
	Endemic periphyton	0.2–0.4	12–15	0.8–0.9	15–18	0.2–0.4	13–18
	Endemic zooplankton	0.3–0.4	10–15	0.7–0.8	15–18	0.3–0.4	10–15
	Threatened bird						
	Black neck crane	NA	NA	NA	NA	NA	NA
River hydraulics	Bed composition	0.6–0.8	10–15	0.8–1.10	15–18	0.6–0.8	10–15
Cultural	Dead body disposal	0.6–0.8	10–15	0.8–1.0	15–20	0.6–0.8	10–15
Livelihood	Water use	0.6–0.8	10–15	0.8–0.9	15–20	0.6–0.8	10–15
	River resources (fish)	NA	NA	NA	NA	NA	NA
	Edible algae	0.3–0.6	10–15	0.7–0.8	15–20	0.3–0.6	10–15
Ecosystem structure and function	Periphyton density	0.2–0.3	10–15	0.8–0.9	15–18	0.2–0.3	10–15
	Water quality	0.6–0.8	10–15	0.8–0.9	15–18	0.6–0.8	10–15
	NPP	0.6–0.8	10–15	0.8–0.9	15–18	0.6–0.8	10–15
	Invasibility by IAS	0.6–0.8	10–15	0.8–1.1	15–18	0.6–0.8	10–15
Value obtained for recommended E–Flow		0.66	14.31	0.86	15.85	0.69	14.49

4.4.9 Tsa Chu–I Lower

The critical parameters for proper functioning of ecosystem functions and river sustainability at the site are shown in Table IV. 4.21. At this site location threatened fish threatened bird are not noticed. The model simulated results for various percentage of 90% dependable flow scenarios are shown in Table IV. 4.20.

For lean season the maximum range for hydraulic conditions found are: flow depth 0.6–0.8 m and flow width 12–15 m. By comparing the hydraulic condition requirements and model simulated results, it has been found that 25% of the lean flow about 4.75 cumecs is appropriate. This amount of discharge for the site is recommended as minimum environmental flow requirement for lean season.

For monsoon season the maximum range for hydraulic conditions found are flow depth (0.8–1.1 m) and flow width (15–20 m). Following the procedure as mentioned above, environmental flow requirement for the monsoon season is found to be 25% of the average flow of 90% dependable year and the corresponding environmental flow at the site is about 10.25 cumecs.

For non–monsoon season hydraulic conditions required for the ecosystem, livelihood and culture are flow depth 0.6–0.8 m and flow width 13–18 m. The hydrodynamic simulation results for different percentage of dependable flow scenarios provide hydraulic condition depth and top widths. By comparing simulating hydraulic conditions and its requirements 17% of the season average scenario is found to be appropriate. This discharge for environmental flow is recommended about 6 cumecs. The environmental flow requirement for three seasons at Tsa chu–I HEP site are:

1. Lean season 5 cumecs
2. Non–monsoon season 6 cumecs
3. Monsoon season 10 cumecs

Table IV. 4.18: Model output for different releases of 90% dependable flow for Tsa chu–I Lower HEP

Season	Release scenario	Discharge (cumecs)	Flow velocity (m/s)	Depth (m)	Top width (m)
Lean (19 cumecs)	10%	1.90	0.75	0.47	10.85
	20%	3.80	0.90	0.60	13.79
	25%	4.75	0.98	0.65	14.22
	50%	9.50	1.28	0.83	15.60
	70%	13.30	1.46	0.94	16.48
	100%	19.00	1.65	1.08	17.67
Monsoon (41 cumecs)	10%	4.10	0.93	0.62	13.96
	20%	8.20	1.21	0.78	15.27
	25%	10.25	1.32	0.85	15.79
	50%	20.50	1.71	1.12	17.85
	70%	28.70	1.93	1.28	18.82
	100%	41.00	2.21	1.49	21.35
Non–monsoon (35 cumecs)	10%	3.50	0.88	0.59	13.53
	17%	6.0	1.06	0.70	14.00
	30%	10.50	1.33	0.86	15.85
	50%	17.50	1.61	1.05	17.31
	70%	24.50	1.82	1.20	18.44
	100%	35.00	2.07	1.38	19.60

Table IV. 4.19: Hydraulic condition requirements for parameters used in building block for three seasons at Tsa chu–I Lower HEP site

Type	Indicator	Lean season		Monsoon season		Non–monsoon	
		Depth (m)	Width (m)	Depth (m)	Width (m)	Depth (m)	Width (m)
River biodiversity	**Threatened fish**						
	Schizothorax richardsonii	NA	NA	NA	NA	NA	NA
	Schizothorax progastus	NA	NA	NA	NA	NA	NA
	Endemic species						
	Endemic periphyton	0.2–0.4	12–15	0.8–0.9	15–18	0.2–0.4	13–18
	Endemic zooplankton	0.3–0.4	10–15	0.7–0.8	14–17	0.3–0.4	10–15
	Threatened bird						
	Black neck crane	NA	NA	NA	NA	NA	NA
River hydraulics	Bed composition	0.6–0.8	10–15	0.8–1.0	15–18	0.6–0.8	10–15
Cultural	Dead body disposal	0.6–0.8	10–15	0.8–1.0	15–20	0.6–0.8	10–15
Livelihood	Water use	0.6–0.8	10–15	0.8–0.9	15–20	0.6–0.8	10–15
	River resources (fish)	NA	NA	NA	NA	NA	NA
	Edible algae	0.3–0.6	10–15	0.7–0.8	15–20	0.3–0.6	10–15
Ecosystem structure and function	Periphyton density	0.2–0.3	10–15	0.8–0.9	15–18	0.2–0.3	10–15
	Water quality	0.6–0.8	10–15	0.8–0.9	15–18	0.6–0.8	10–15
	NPP	0.6–0.8	10–15	0.8–0.9	15–18	0.6–0.8	10–15
	Invasibility by IAS	0.6–0.8	10–15	0.8–1.1	15–18	0.6–0.8	10–15
Value obtained for recommended E–Flow		0.65	14.22	0.85	15.79	0.70	14.00

4.4.10 Thingbu Chu

The maximum range of flow depth and top width which satisfy requirement for critical parameters like river biodiversity, ecosystem structure and function for lean season at the project site are 0.4–0.5 m and 5–6 m (Table IV. 4.23). The flow satisfying these requirements is shown the last row of Table IV. 4.23. It may be noted that in this project, flow rate is too low: varying from 1 cumecs in lean season to 7 cumecs season. Interestingly, 50% of the 90% average lean season flow is 0.5 cumecs. Considering this low discharge, the recommended environmental flow for Thingbu chu site during lean season is at least of 1 cumecs. For monsoon season the maximum range of flow depth and width for E–Flow estimation are 0.6–0.8 m and 8–10 m. From the Table IV. 4.22 the flow of 2.10 cumecs satisfy these requirements i.e.30% of 90% dependable flow. Therefore 2.1 cumecs is recommended as E–Flow for monsoon season. Similarly, for non–monsoon season at least 1 cumecs is recommended as minimum E–Flow at this site. The environmental flow requirement for three seasons at Thingbu chu project site are:

1. Lean season 1.0 cumecs
2. Non–monsoon season 2.1 cumecs
3. Monsoon season 1.0 cumecs

Table IV. 4.20: Model output for different releases of 90% dependable flow for Thingbu chu HEP

Season	Release scenario	Discharge Q (cumecs)	Flow velocity (m/s)	Depth (m)	Top width (m)
Lean (1 cumecs)	10%	0.10	0.53	0.32	3.89
	20%	0.20	0.61	0.37	4.61
	30%	0.30	0.68	0.40	5.07
	50%	0.50	0.75	0.46	5.83
	70%	0.70	0.82	0.50	6.40
	100%	1.00	0.90	0.55	7.00
Monsoon (7 cumecs)	10%	0.70	0.82	0.50	6.40
	20%	1.40	1.00	0.61	7.92
	30%	2.10	1.08	0.69	9.17
	50%	3.50	1.24	0.80	10.75
	70%	4.90	1.37	0.89	11.97
	100%	7.00	1.52	0.99	14.20
Non–monsoon (2 cumecs)	10%	0.20	0.61	0.37	4.61
	20%	0.40	0.72	0.43	5.49
	30%	0.60	0.90	0.48	6.03
	50%	1.00	0.91	0.55	7.13
	70%	1.40	1.00	0.61	7.92
	100%	2.00	1.08	0.67	9.00

Table IV. 4.21: Hydraulic condition requirements for parameters used in building block for three seasons at Thingbu chu HEP site

Type	Indicator	Lean season		Monsoon season		Non–monsoon	
		Depth (m)	Width (m)	Depth (m)	Width (m)	Depth (m)	Width (m)
River biodiversity	**Threatened fish**						
	Schizothorax richardsonii	NA	NA	NA	NA	NA	NA
	Schizothorax progastus	NA	NA	NA	NA	NA	NA
	Endemic species						
	Endemic periphyton	0.2–0.4	4–5	0.6–0.8	5–10	0.2–0.4	4–5
	Endemic zooplankton	0.3–0.4	4–5	0.6–0.8	5–10	0.3–0.4	4–5
	Threatened bird						
	Black neck crane	NA	NA	NA	NA	NA	NA
River hydraulics	Bed composition	0.3–0.4	5–6	0.6–0.8	6–10	0.4–0.5	5–6
Cultural	Dead body disposal	NA	NA	NA	NA	NA	NA
Livelihood	Water use	0.3–0.4	5-10	0.6–0.7	5–10	0.3–0.4	5-10
	River resources (fish)	NA	NA	NA	NA	NA	NA
	Edible algae	0.2–0.4	4–6	0.6–0.8	7–10	0.2–0.4	4–6
Ecosystem structure and function	Periphyton density	0.3–0.4	5–6	0.6–0.8	8–10	0.3–0.4	5–6
	Water quality	0.3–0.4	5–6	0.6–0.8	8–10	0.3–0.4	5–6
	NPP	0.3–0.4	5–6	0.6–0.8	8–10	0.3–0.4	5–6
	Invasibility by IAS	0.4–0.5	5–6	0.6–0.8	8–10	0.4–0.5	5–6
Value obtained for recommended E–Flow		0.55	7.00	0.69	9.17	0.55	7.13

4.5 ENVIRONMENTAL FLOW VARIATION

Hydraulic condition requirements has been assessed project–wise for three seasons based on BBM and hydrodynamic modeling results. Table IV. 5.1 summarizes the seasonal E–Flows requirements for all the projects. It can be observed from the Table IV. 5.1 in lean season environmental flow vary from 1 to 10 cumecs. The percentage of lean season flow in terms of 90% dependable year varies from site to site. In Mago chu project site 70% of lean average flow is required as minimum environmental flow for lean season. For monsoon season 18–25% of monsoon average 90% dependable year is found to be appropriate. However maximum E–Flow required at Tawang–II is about 26 cumecs. In the case of non–monsoon there is variation in percentage of average non–monsoon flow as considered as E–Flow.

The recommended E–Flow requirements for all the studied HEPs in TRB are presented in Table IV. 5.1 and Figure IV. 5.1.

Table IV. 5.1: Seasonal E–Flows requirements for all the studied HEPs

Sl. No.	Name of HEP	Recommended environmental flow in discharge (cumecs)			Recommended environmental flow in percentage of 90% dependable flow		
		Lean	**Monsoon**	**Non–Monsoon**	**Lean**	**Monsoon**	**Non–Monsoon**
1	Tawang–II	10	26	13	25	18	20
2	Tawang–I	7.6	20	10	27	18	20
3	Rho	7.6	20	10	27	18	20
4	Nykcharong chu	6	13	10	30	30	27
5	Mago chu	5	10	8	70	20	53
6	New Melling	3	10	7	50	20	50
7	Tsa chu–I	5	10	6	25	25	17
8	Tsa chu–I Lower	5	10	6	25	25	17
9	Thingbu chu	1	2	1	100	30	100
10	Tsa chu–II	5	10	6	25	25	15

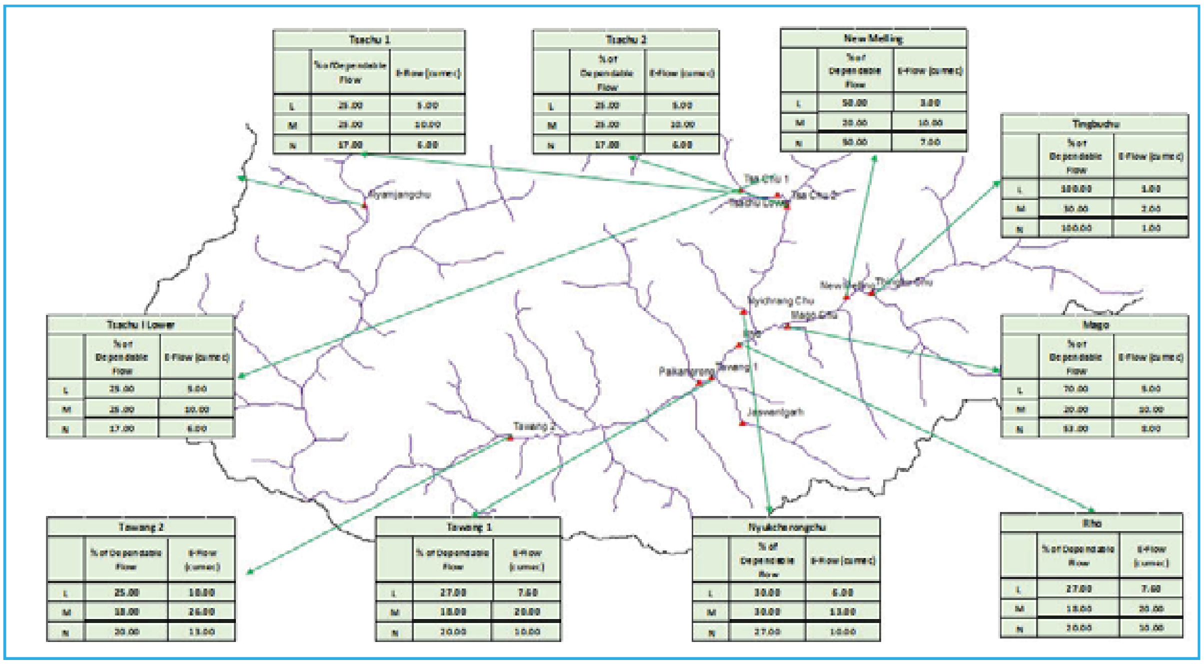


Figure IV. 5.1: Recommended environmental flows at all project sites

SECTION-V

CARRYING CAPACITY ANALYSIS

SUMMARY

Carrying capacity in the ecological context is defined as the threshold of stress below which populations and ecosystem functions can be sustained. As a method for evaluating cumulative effects, carrying capacity analysis serves to identify thresholds for the resources and systems of concern (as constraints on development), and provides mechanisms to monitor the incremental use of unused capacity.

The carrying capacity has been assessed taking a holistic approach by considering: (i) combined social and environmental impact threshold, (ii) human population influx threshold, (iii) E-Flow, (iv) free-flow river length (total river length as well as intermediate free-flowing river length between two consecutive projects), and (v) forest loss threshold. Since biodiversity in the forest area was the most dominant component of the total biodiversity of the basin, forest cover loss was used as the proxy indicator both for biodiversity and vegetation loss.

Given the ecological fragility and the resource limitation of TRB, it was essential to develop a future vision including the threshold limits for identified resources/parameters. Out of several parameters for which data were collected, the following parameters were identified as key indicators for determining carrying capacity of TRB: (1) upper elevation limit based on paraglacial deposits and location of the glaciers, (2) human population influx, (3) prescribed E-Flow based on availability of water at different points, (4) minimum acceptable free-flow length between the two successive projects, (5) forest/vegetation loss, and (6) combined socio-environmental index.

- 40 percent of the main river length should be free-flowing i.e., free of any projects,
- 66 percent of the total geographical area will be under forest cover.
- The total population of Tawang at any given point of time should not exceed 57,474 persons i.e. 15% more than the present population of 49,977 to protect the culture of ethnic community and maintain the demographic balance.
- No project above 3,200 m asl should be constructed.
- Minimum level of water flow must be maintained round the year to ensure the sustainability of the river ecosystem structure, function and services.
- Minimum acceptable free-flow length between the two successive projects is to be maintained.

The 'K' values for CIA index, population, E–flow, free–flowing river length, and forest cover for TRB are 1.0 (0.84 + 95% confidence limit), 57,474 persons, 3 cumecs of water, 60 km (out of total 148 km of main river length), and 1,43,352 ha, respectively. The CIA index which was developed by combining several socio–environmental indicators was used to model the carrying capacity of TRB. The maximum carrying capacity value or the upper asymptote (K) was considered as CIA 1.0 (0.84 + 95% confidence limit). Thus, the projects falling below this value have been suggested to be allowed for project implementation. The name of these projects are Jaswantgarh Stage–I, Paikangrong chu, Nykcharong chu, Tawang–I, Tawang–II, Nyamjang chu, Rho, Mago chu, New Melling, Tsa chu-I Lower and Tsa chu-II. The remaining two projects viz., Tsa chu-I and Thingbu chu were above this value, and therefore are recommended for rejection.

Given the ecological fragility and the resource limitation of TRB, it will be detrimental to initiate all the proposed projects at a time. In order to keep the developmental activities within the carrying capacity of the basin, it is suggested that the projects falling within the carrying capacity limit viz., Jaswantgarh Stage–I, Paikangrong chu, Nykcharong chu, Tawang–II, Nyamjang chu, Tawang–I, Rho, Mago chu, New Melling, Tsa chu-I Lower and Tsa chu-II may be taken up in two time phases. For diffusing the impact both spatial and temporal segregation of the construction phase is suggested. While phasing several parameters were considered to minimize the impact. For instance, to maintain the influx of population within the carrying capacity limit, i.e. presumed to be 15% increase from the base population, the phasing resulted in keeping the total population size of TRB including the influx within the carrying capacity limit, which exceeded if all the projects are taken up together. Thus, the phasing was as follows:

Phase–I (0–5 years): Nykcharong chu, Tawang–I, Tawang–II, Nyamjang chu, Jaswantgarh Stage–I and Paikangrong chu.
Phase–II (5–10 years): Rho, Mago chu, New Melling, Tsa chu-I Lower, and Tsa chu-II.

CHAPTER 1
INTRODUCTION

Carrying capacity analysis is based on the inherent limits, or thresholds that exist for many environmental and socioeconomic systems. Carrying capacity in the ecological context is defined as - the threshold of stress below which populations and ecosystem functions can be sustained. In the social context, the carrying capacity of a region is the sum of human activities that can be maintained while providing the level of services desired by the population. When cumulative effects exceed the carrying capacity of a resource, ecosystem, and human community, the consequences are significant.

As a method for evaluating cumulative effects, carrying capacity analysis serves to identify thresholds for the resources and systems of concern (as constraints on development), and provides mechanisms to monitor the incremental use of unused capacity. Carrying capacity analysis begins with the identification of potentially limiting factors. Mathematical equations are then developed to describe the capacity of the resource or system in terms of numerical limits (thresholds) imposed by each limiting factor. In this way, projects can be systematically evaluated in terms of their effect on the remaining capacity of limiting factors. The determination of carrying capacity is straightforward for public facilities such as water supply systems, sewage treatment systems, and traffic systems. For instance, a reservoir can only supply water to a finite number of consumptive users. In the case of air and water quality control programs, statutory limits (or standards) are regulatory thresholds of the carrying capacity of air or water in the region of interest. In Indian context, threshold for air and water pollution can be derived from the CPCB Notification pertaining to air and water quality. Similarly, the threshold for forest cover maintenance in a given area should be as per National Forest Policy, 1988. Being a mountainous river basin, the threshold value for forest cover may be considered as 66 percent of the total geographical area.

Cumulative effects can be estimated through physical and mathematical models and then compared with these standards. Thus, in this study, the CIA index of the respective projects developed in 'Section III' through modeling can be used as an indicator of carrying capacity. The index indicates the level which is sustained by the environment i.e., threshold limit of cumulative impacts is an indirect measure of the environmental carrying capacity. In natural systems, the carrying capacity of well-studied populations (usually game species) can be adequately modelled, but the capacity of whole ecosystems to withstand and recover from stress (i.e., their resilience) is yet to be modelled precisely, and at best is expressed in gross probabilistic terms (i.e., the likelihood of a set of events occurring).

When applied to human communities, carrying capacity can be defined as 'the ability of a natural and man-made system to absorb population growth or physical development without significant degradation or breakdown' (Schneider *et al*., 1978). In the present study, carrying capacity of TRB has been analysed from four resource perspectives: (1) water, (2) forest, (3) human population, and (4) combined socio-economic and environmental resources.

The carrying capacity has been assessed taking a holistic approach by considering combined social and environmental impact threshold, human population influx threshold, E-Flow, free-flow river length and forest loss threshold. Since biodiversity in the forest area was the most dominant component of the total biodiversity of the basin, forest cover loss was used as the proxy indicator both for biodiversity and vegetation loss.

The holistic approach of the study resulted in collection of primary data on maximum possible parameters that was used to develop the combined social and environmental impact index for assessing the impact of proposed hydropower development programme in the basin (Table V. 2.1).

Table V. 2.1: Parameters studied to characterize different VECs in TRB

(VECs	Parameters studied
Ecosystem Structure, Function and Services	(i) Forest area loss/MW (Ha), (ii) Carbon stock loss/MW, (iii) Ambient air quality, (iv) Periphyton and zooplankton density, (v) NPP, (vi) Change in turbidity (NTU), (vii) Total coliforms (CFU/ml), (viii) IAS invasibility, (ix) Dependency of villagers on hill stream/spring water.
Biodiversity	(i) Proportion of total plant diversity to be affected, (ii) Proportion of total bird diversity to be affected, (iii) Proportion of total mammal diversity to be affected, (iv) No. of butterfly species to be affected, (v) No. of fish species, (vi) Periphyton richness, (vii) Endemic and/or threatened plants, (viii) Endemic and/or threatened mammals, (ix) Endemic and/or threatened birds, (x) Endemic and/or threatened fish, (xi) Endemic periphyton and zooplankton.
Ecosystem vulnerability	(i) Soil and landslide vulnerability of impact area (%), (ii) Vulnerability of core area and (iii) Glacial lake outburst discharge.
Hydrology	(i) Ecological flow percentage, (ii) Intermediate river length per megawatt, (iii) Ecological flow (lean season in cumec)
Cultural and livelihood	(i) Dead body last rites, (ii) Totem worship (iii) Employment opportunities, (iv) Health risks, (v) Quality of life
Dependency on natural resources	(i) Forest dependency (%), (ii) Water dependency (%)

However, subsequently, the designed/projected power generation capacity was related with a few key selected indicators and was modelled to determine the threshold/minimum level to sustain the river and adjoining ecosystems. The selection of indicators was based on their higher relative contribution to the cumulative impact, discussion with the knowledgeable personalities from the project affected areas, and expert opinion/discussion. In addition, although to a lesser extent, several other socio-economic and environmental parameters were important for determining the threshold upper limit for TRB's carrying capacity. Therefore, the combined social and environmental impact index computed in 'Section III' was also used to determine the power generation carrying capacity of the basin.

3.1 DEVELOPING A FUTURE VISION WITH THRESHOLD LIMIT

Given the ecological fragility and the resource limitation of TRB, it was essential to develop a future vision including the threshold limits for identified resources/parameters. Out of several parameters for which data were collected, the following parameters were identified as key indicators for determining carrying capacity of TRB: (1) upper elevation limit based on paraglacial deposits and location of the glaciers, (2) human population influx, (3) prescribed E-Flow based on availability of water at different points, (4) minimum acceptable free-flow length between the two successive projects, (5) forest/vegetation loss, and (6) combined socio-environmental index.

1. 40 percent of the main river length should be free-flowing i.e., free of any projects,
2. 66 percent of the total geographical area will be under forest cover,
3. The total population of Tawang at any given point of time should not exceed 15% more than the present population i.e. 57,474 persons
4. No projects above 3,200 m asl should be constructed.
5. Minimum level of water flow must be maintained round the year to ensure the sustainability of the river ecosystem structure, function and services.
6. Minimum acceptable free-flow length between the two successive projects is to be maintained.

3.2 CARRYING CAPACITY DETERMINATION

3.2.1 Upper Elevation Limit for HEPs

Based on the available imagery evidences duly supported by adequate ground truthing, it was concluded that paraglacial deposits (Ballantyne, 2002) are present in Tawang district above the elevation of 3,500 m a.s.l. Although winter snowline is at about 2,700-2,800 m a.s.l., the Himalaya in Tawang harbors considerable vegetation cover at this elevation and is relatively stable. Therefore, the snow cover at this elevation should not cause any disaster like paraglacial sediment outburst. Current glacial line in Tawang district is at an elevation of 5,000 m and above. A recent study in Sikkim Himalaya i.e., the glacial study available for the nearest area shows that the retreat rate of glaciers during 1976-2005 period was on an average 13.02 m per year (Raina, 2010). Thus, the glacial retreat in the last century should not be more than 1300 m. Since no glacier retreat data for Eastern Himalaya in Tawang is available, we considered the above mentioned rate of glacier retreat in Tawang district, and concluded that the glaciers were at least 3,700 m a.s.l. before 100 years. Therefore, the paraglacial deposit in no case was visible at or below 3,200 m asl. Based on the above facts, it is recommended that no HEP should be constructed above 3,200 m. However, project-specific strict environmental safeguards/mitigation measures must be undertaken for the projects above 2,500 m elevation.

3.2.2 Combined Socio-Environmental Index

The CIA index which was developed by combining several socio-environmental indicators in 'Section III' was used to model the carrying capacity of TRB. The maximum carrying capacity value or the upper asymptote (K) was considered as CIA 0.84. Thus, the projects falling within or below the upper limit of the 95% confidence band of this value have been suggested to be allowed for project implementation. The names of these projects are Jaswantgarh, Paikangrong, Nykcharong chu, Tawang-I, Tawang-II, Nyamjang chu, Rho, Mago chu, New Melling, Tsa chu-I Lower and Tsa chu-II (Figure V. 3.1). The remaining two projects were above this value, and therefore are recommended for rejection.

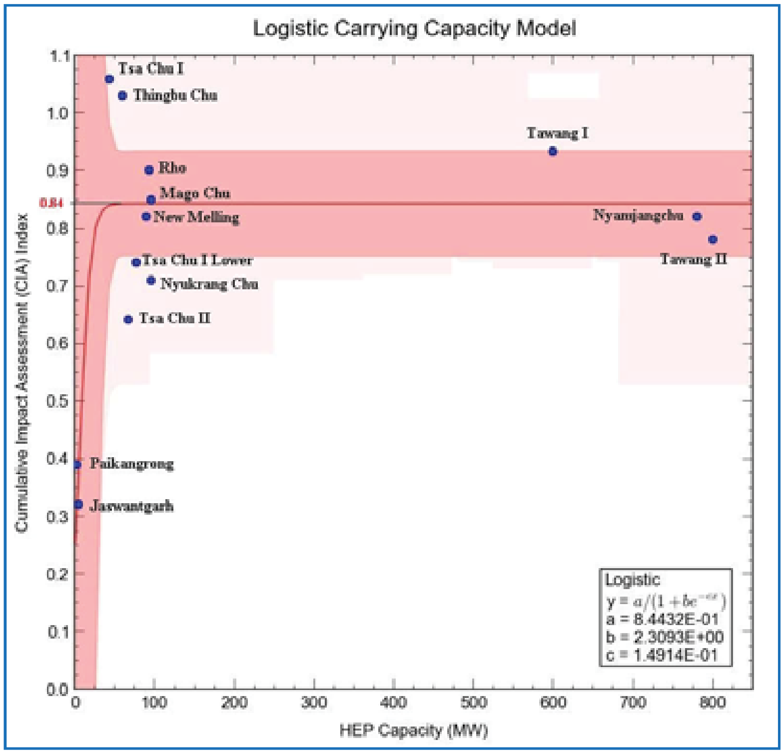


Figure V. 3.1: Acceptable projects within the maximum limit of carrying capacity 1.0 (0.84 + 95% confidence limit) based on CIA index.

3.2.3 Human Population Influx

The larger projects have much greater potential to add to the problem of human population influx than the smaller ones (Table V. 3.1 and Figure V. 3.2) because of the large man-power involvement in the former.

Table V. 3.1: Human population influx in the proposed projects

Project sites	Capacity (MW)	Human influx
Mago chu	96	92
Nykcharong chu	96	92
Rho	93	92
Tawang-I	600	2350
Tawang-II	800	2200
Nyamjang chu	780	3500
Tsa chu-I Lower	77.3	80
Tsa chu-II	67	80
New Melling	90	92

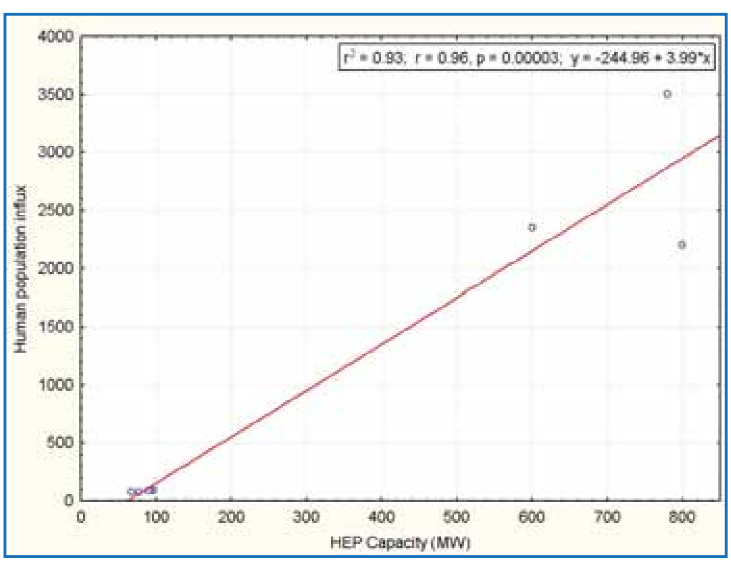


Figure V. 3.2: Significant positive correlation between power generation capacity and human population influx

Carrying capacity of human population including influx was analysed that helped in phasing the projects into two groups. Six projects in the phase-I together contributed about 15% increase from the current base population of ≈49,977 which may be considered as the upper limit (K) of the river basin. In the phase-II, the increase in the population was below 'K'. If all the projects are taken together, the increase in population size far exceeds 'K' (Figure V. 3.3). Only the projects falling within the carrying capacity limit as per CIA index have been taken for analysis.

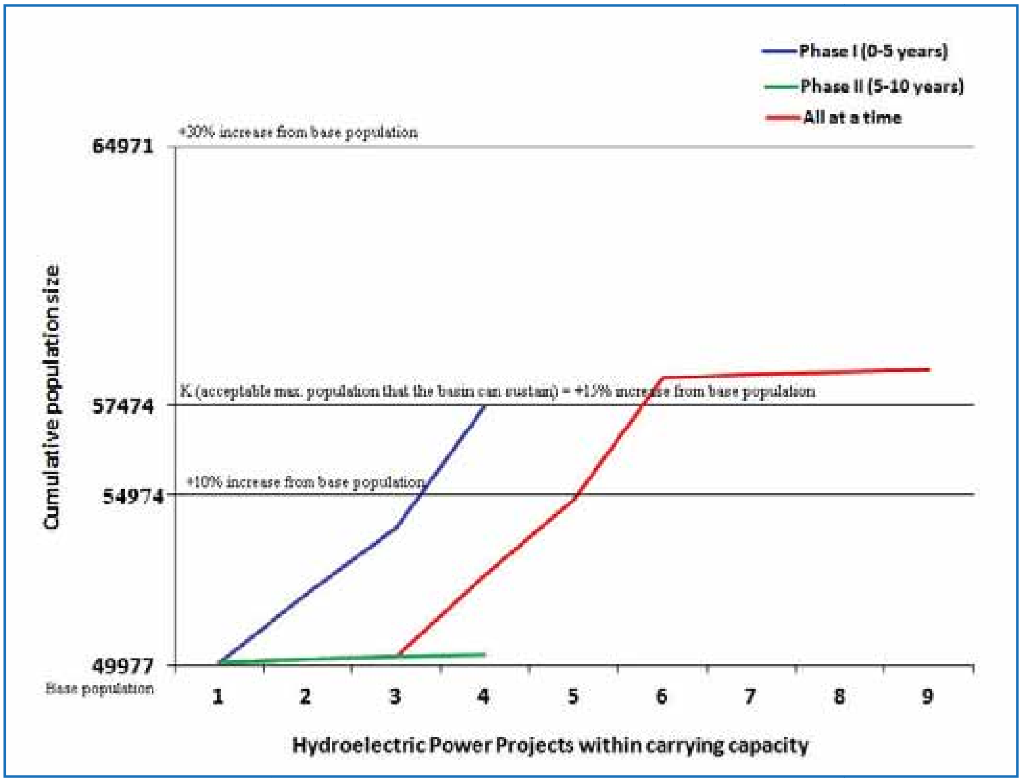


Figure V. 3.3: Analysis of carrying capacity of TRB considering human population growth as an indicator

3.2.4 E-Flow

The E-Flow is the proxy variable of minimum water availability threshold. Thus, E-Flow is an indirect indicator of carrying capacity, below which sustenance of the river and adjoining terrestrial ecosystems will be difficult. The recommended E-Flow for different projects as obtained in 'Section III' is given in Table V. 3.2. These values are based on the acceptable level of the parameters pertaining to ecosystem, biological, and socio-economic VECs (Table V. 3.3).

Table V. 3.2: Minimum threshold level of waterflow in the intermediate river stretches pertaining to each of the 11 HEPs based on the analysis in Section-III. Two micro-hydel projects and Nyamjang chu have not been included

Sl. No.	Name of HEP	Recommended environmental flow in discharge (cumec)		
		Lean	Monsoon	Non–Monsoon
1	Tawang–II	12	43	14
2	Tawang –I	9	35	11
3	Rho	9	35	16
4	Nykcharong chu	10	13	11
5	Mago chu	5	16	8
6	New Melling	3	15	7
7	Tsa chu–I	6	13	7
8	Tsa chu –I Lower	6	13	7
9	Thingbu chu	1	2	1
10	Tsa chu–II	6	13	8

Table V. 3.3: Minimum threshold lean season value for different environmental indicators and corresponding discharge in TRB determined from the respective models described in Section-III

Parameter	Minimum threshold lean season value for the river basin	Minimum threshold lean season discharge at any point of the basin
Ecosystem structure and function		
Water quality		
Salinity (ppt)	0.1	5
Total Dissolved Solid (mg/l)	60	5
Total Alkalinity (mg $CaCo_3$/l)	26.2	2
Total hardness (mg/l)	26.3	3
Turbidity (NTU)	0.5	2
Magnesium	2.13	5
Calcium	2.73	5
Phosphorous	0.07	5
Periphyton density	110	4
Biodiversity		
Water depth for *Schizothorax* spp.	0.5	5
Black necked crane	–	Not determined
Cultural		
Death rituals	–	9
Livelihood		
Water use	–	5
River resources	–	5
Edible algae	–	5

3.2.5 Forest Loss

The smaller projects had much greater per capita (MW) forest loss than the larger ones (Figure V. 3.4). This suggests that from forest loss point of view, the larger projects at least up to 800 MW as the case in TRB should be preferred over the smaller ones which had very high per capita forest loss. However, even all the proposed projects are allowed to be implemented, the total forest loss will be 519.54 ha which is much lower than the presumed carrying capacity limit of forest cover i.e. 66% of the total geographical area of TRB (as per National Forest Policy, 1988) (Figure V. 3.5).

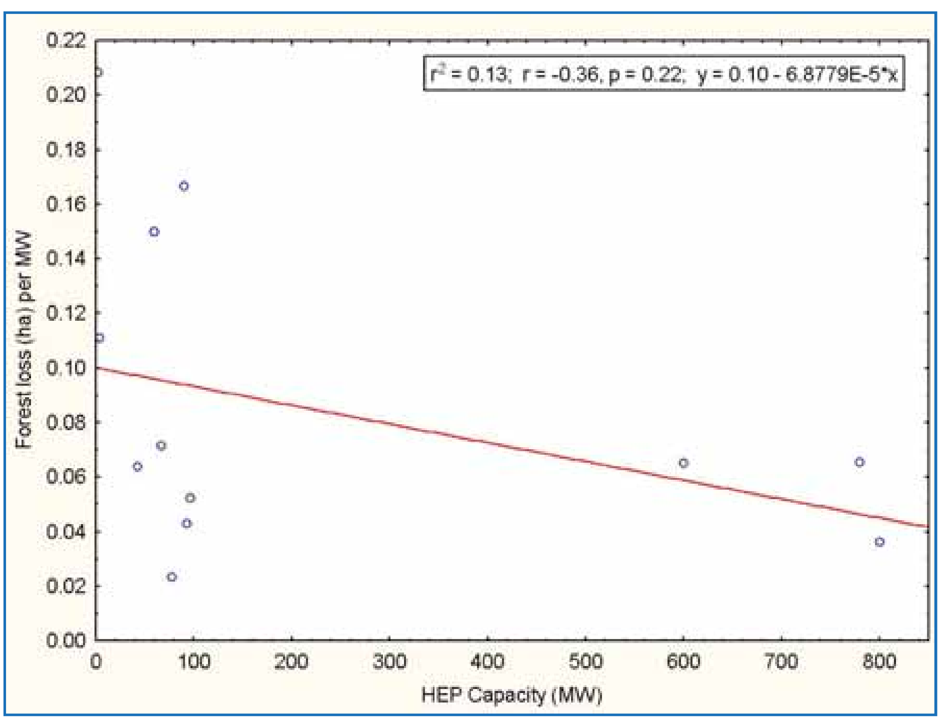


Figure V. 3.4: Significant negative correlation between per megawatt forest loss and power generation capacity

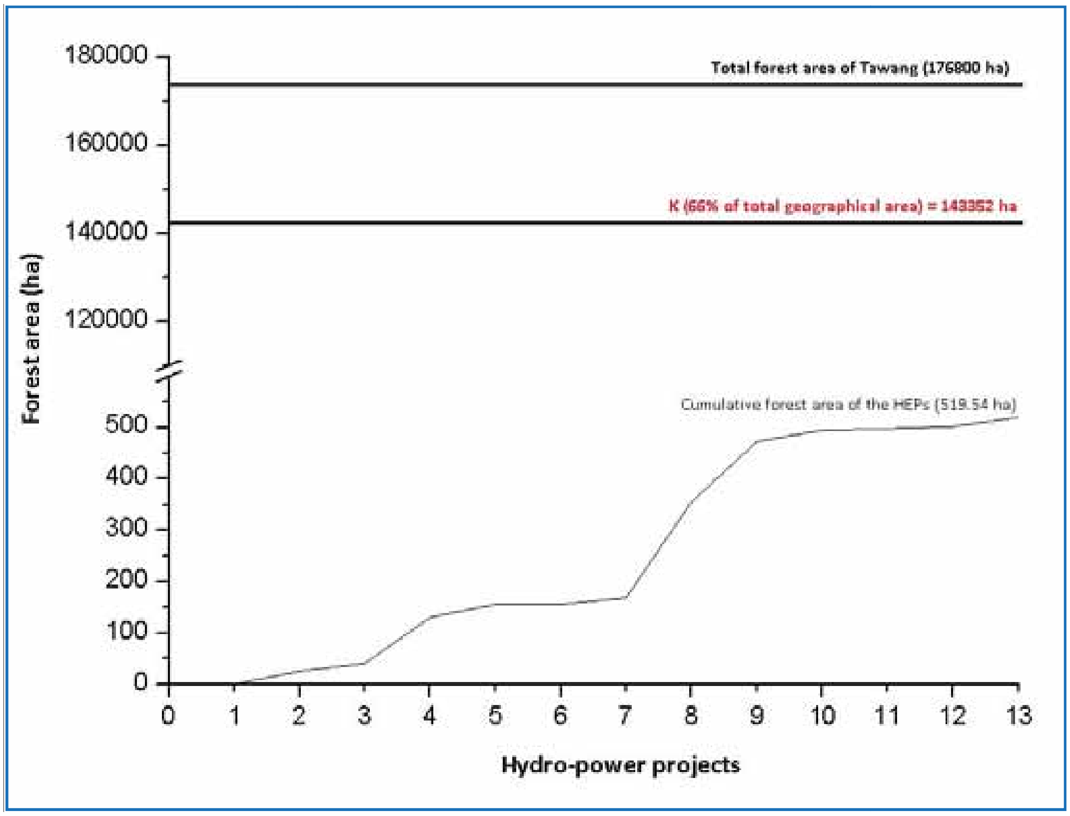


Figure V. 3.5: Cumulative forest area proposed to be diverted for all the 13 HEPs. The total cumulative loss is far below than the projected optimum carrying capacity forest cover i.e. 66 percent of the total geographical area of TRB

3.2.6 Maintaining the Threshold Limit for Free Flowing River Length in TRB

3.2.6.1 Total free-flowing river length: The total length of the river that would be free from any project activities was calculated. Out of the total river length of ca. 148 km that consists of the main river channels of Tsa chu, Nykcharong chu, Thingbu chu, Mago chu, Tawang chu and Nyamjang chu, a net river length of ca. 60 km will be free-flowing i.e. free from any project, with the implementation of the recommended 8 projects. This constitutes ≈40.5% of the total river length that will be undisturbed.

Total river length = 148 km (Nyamjang chu = 35 km, Tawang chu = 91 km, and Nyukcharong chu and Tsa chu = 22 km)

Free flowing river length = 60 km (Tsa chu = 9 km, Tawang chu = 45 km, Nyamjang chu = 6 km)

This remains within the envisaged threshold limit of free-flowing river length i.e. more than 40 percent river length will be allowed to flow free without any disturbance to the river and adjoining ecosystems..

3.2.6.2 Minimum acceptable intermediate free-flowing distance between the two successive projects: Based on expert consultation during this study as well as taking into consideration the current norm followed by MoEF & CC, it was agreed to maintain a minimum free-flowing distance of 1 km river length between the powerhouse and the barrage site of two consecutive (successive) projects. The free-flowing stretches between the consecutive projects are presented in Table V. 3.4 and Figure V. 3.6.

Table V. 3.4: Inter-project free-flow river length in TRB

Names of two consecutive projects	Free-flowing length (km)
Tsa chu-I Powerhouse – Tsa chu-I Lower Weir	0.31
Tsa chu-I Lower Powerhouse – Tsa chu-II Weir	3.08
Tsa chu-II Powerhouse – Nykcharong chu Barrage	3.70
Thingbu chu Powerhouse – New Melling Barrage	4.03
New Melling Powerhouse – Mago chu Barrage	1.23
Mago chu Powerhouse – Rho Barrage	1.10
Nykcharong chu Powerhouse – Rho Barrage	1.10
Rho Powerhouse – Tawang-I Barrage	1.00
Tawang–I Powerhouse – Tawang-II Barrage	2.50
Tawang–II Powerhouse – Bhutan Border	0.30

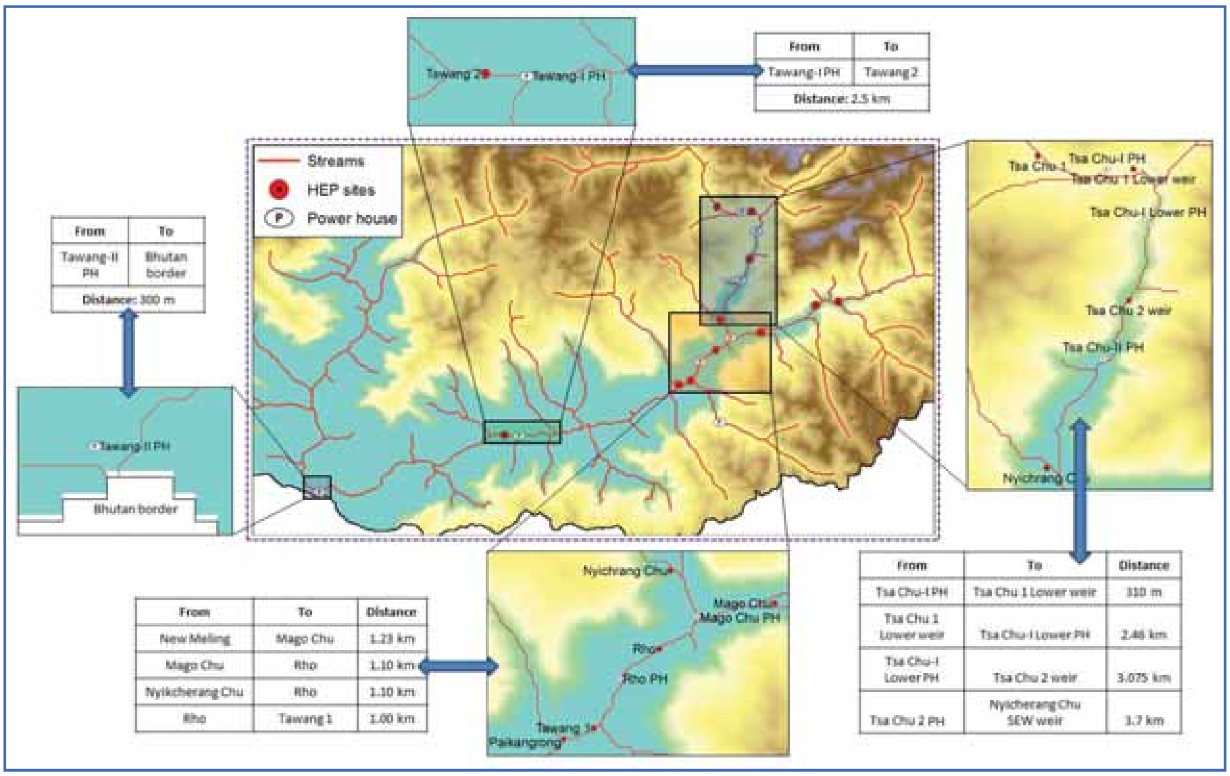


Figure V. 3.6: Map showing the inter-project free-flow river length in TRB

Population influx, forest loss and reduced flow in the river emerged as the three most adversely impacting factors in TRB if the HEPs are to be implemented. The 'K' values for CIA index, population, E-Flow, free-flowing river length, and forest cover for TRB are: 1.0 (0.84 + 95% confidence limit), 57474 persons, 3 cumecs of water, 60 km (out of total 148 km of main river length) and 1,43,352 ha, respectively.

4.1 PHASING OF THE PROJECTS TO MAINTAIN THE CARRYING CAPACITY OF THE BASIN

Given the ecological fragility and the resource limitation of TRB, it will be detrimental to initiate all the proposed projects at a time. In order to keep the developmental activities within the carrying capacity of the basin, it is suggested that the projects falling within the carrying capacity limit as depicted in Figure V. 3.1, viz., Jaswantgarh Stage-I, Paikangrong chu, Nykcharong chu, Tawang-I, Tawang-II, Nyamjang chu, Rho, Mago chu, Tsa chu-I Lower, Tsa chu-II, and New Melling may be taken up in two time phases. For diffusing the impact both spatial and temporal segregation (Figure V. 4.1) of the construction phase is suggested. While phasing several parameters were considered to minimize the impact. For instance, to maintain the influx of population within the carrying capacity limit, i.e., presumed to be 15% increase from the base population, the phasing resulted in keeping the total population size of TRB including the influx within the carrying capacity limit, which far exceeded if all the projects are taken up together. Thus, the phasing was as follows:

Phase-I (0-5 years): Nykcharong chu, Tawang-I, Tawang-II, Nyamjang chu, Jaswantgarh Stage-I and Paikangrong chu.

Phase-II (5-10 years): Rho, Mago chu, New Melling, Tsa chu-I Lower and Tsa chu-II.

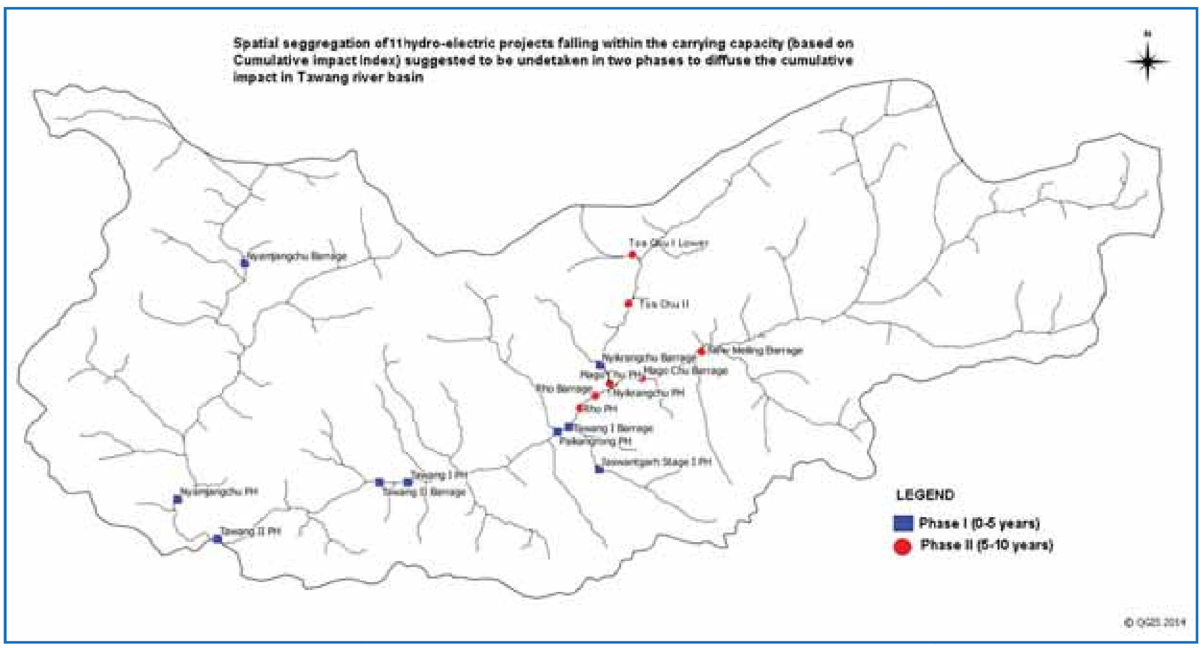


Figure V. 4.1: Spatial segregation of phase-I and phase-II projects in TRB

SECTION VI

A 20-YEAR PERSPECTIVE PLAN FOR DEVELOPMENT OF TAWANG RIVER BASIN

SUMMARY

The planning for hydropower development needs to evolve from a project-based approach to a more holistic one i.e., an approach incorporating river basin planning and integrating potential social and environmental issues across multiple projects and the entire river basin. Therefore, adequate and comprehensive planning is attempted to maximise the positive effects while minimizing the negative or adverse consequences of any development project. A balanced approach has been proposed for harnessing the hydropower energy and development needs of Tawang River Basin (TRB) with equal concern for environment as well as the well being of the population. Thus, the development plan for TRB has been prepared taking an integrated basin development approach to achieve the agreed vision and objectives through developing basin strategies and detailing the implementation. Achievement of the objectives would contribute to the socio-economic development and quality of life of the indigenous people of TRB.

Objectives and Scope of the Plan

1. To formulate a strategic hydropower integrated development plan of TRB in the context of existing policies and legislations.
2. To develop a clear-cut action agenda that reflect the aspirations of the people inhabiting the influence zone of proposed HEPs in TRB. This should be based on the ground reality relating to current scenario, the needs and requirements of the people of TRB.
3. To suggest appropriate institutional mechanism for plan implementation.
4. To emphasize the protection of environment, and conservation and development of forest and biodiversity in the face of adverse effects that arise out of HEP implementation.
5. To develop mitigation measures and management of disaster risk while also accentuate the need for preparedness if such events occur.

Strategic Process

The development plan was formulated for the development of TRB in 20 years. Because the development plan was related to HEPs, the scope of the plan was restricted to the influence zones of the 13 proposed HEPs. Thus, 46 villages falling within this zone were covered under the basin plan. The planning process outlined by Pegram *et al*., (2013) was adapted for strategizing the plan. Accordingly, the first stage in the process was to conduct the situation assessment to gain understanding of the current conditions as well as identify and prioritize key issues. The second stage was formulating the vision and goals to provide the long–term target for TRB development. The third stage was developing the basin strategies. Four strategic components that form the foundation of TRB development are: (i) Institutional, (ii) Development, (iii) Protection, and (iv) Disaster risk.

The fourth stage is detailing the implementation to define actions and give effect to the basin strategy. The activities as detailed under the four strategic components are as follows:

Institutional: Institutional management system was formulated wherein the Tawang River Basin Development Authority (TRBDA) was proposed to be constituted as an autonomous body by the state government. The TRBDA will be the implementing agency which would work closely with the HEP developers and collaborate with various existing institutions in TRB. In addition to implementing the TRB Development Plan (TRBDP), TRBDA will also be entrusted with the responsibility to undertake regular monitoring of activities so that appropriate iterative and adaptive management can be done.

Development: The socio–economic and infrastructure development system focussed on community development of TRB. The current baseline scenario under each sector as well as the identified gaps in infrastructure, human resource and socio–economic requirements/issues, and aspiration of the people were considered while detailing the actions. The potential impacts that HEP implementation might result are also outlined under each sector and appropriate measures that the developer needs to follow were suggested. Subsequently, articulate plans/grants and schemes were proposed, and specified for the development of each infrastructure and socio–economic sector. The following R&R scheme and CSR activities were proposed:

1) Land compensation for acquisition of private land.
2) Compensation towards customary rights over community and UFs

3) *School infrastructure development schemes:* This includes setting up of schools at project sites, providing facilities to existing schools in affected and/or influenced villages, financial assistance for computer lab, furniture, library, books and laboratory.
4) Merit scholarship scheme for different education levels (from Primary upto Graduate level)
5) Salary support for teachers and staff to ensure qualified and adequate teaching manpower
6) Training grant for teachers and support staff
7) Exposure tours/visits for school students to technical institutions outside TRB
8) *Initiate Worker health program (WHP) and Public health delivery plan (PHDP):* For WHP, activities to be conducted are health education, prevention of diseases, rules and regulations, pre-employment screening, setting up of health centres at project sites. PHDP involves provision of health service in the affected and/or influenced villages and setting up of community health care centres and also providing adequate financial and technical support to the existing government health services such as appointing specialist doctors in district headquarters hospital and paramedical staff to run the equipments procured.
9) *Road construction and network expansion scheme:* This includes providing road connectivity to affected and/or influenced villages, expansion of road network and access road to important locations such as agricultural land and farmland as desired by the people by providing RCC bridges and footpath wherever road is not feasible.
10) Adopt sustainable transport system during construction phase to minimize adverse impacts on forests, environment and landscape.
11) *Power supply scheme and power subsidies:* Power supply will be extended to the affected villages particularly the Project Affected Families (PAFs). These include 100 units of power free of cost to each family of PAFs every month for 10 years, and an additional 1% from the state governments share of 12% subject to condition and approval by the state government. The developers will also earmark 1% free power of the project capacity to local area development i.e., to TRBDA to be utilized for income generation and community welfare.
12) *Water supply and irrigation schemes:* Provision of safe drinking water to the affected villages and PAFs, provision of storage tanks and pipelines to channelize water for irrigation and community use. Public drinking water facilities and school drinking water facilities.
13) *Sanitation and solid waste management plan:* Provision of toilet at public locations and especially at workers camp and construction sites. Toilet to person ratio should not be more than 1:20.
14) *Agricultural land compensation:* Appropriate and equitable compensation of agricultural land by land–for–land procedure, employment or financial compensation whichever feasible/desired by the PAFs.
15) *Agriculture development package:* Financial allocation for *Jhum* land cultivation, agricultural land preparation grant for newly allotted agricultural land, training assistance for skill upgradation and technology adoption, provision of polyhouse/greenhouse, supply of QPM (quality planting material), setting up of Rural Bio–resource Complex (RBC) for value addition.
16) *Veterinary assistance:* Assist in building manpower at existing veterinaries, if non–existence, to set up veterinaries at appropriate locations.
17) *Livestock development:* Support for procuring additional livestock, construction of cattle shed and upgradation of milk storage and processing machineries, provision of feed and fodder to compensate for affected gazing and pasture land.
18) *Grant for craft centres and skill development scheme:* Creation/upgradation of existing work shed including water supply, electricity, tools and machineries, development of training manual, support for procurement of raw materials etc. Establishment of small paper making unit, small scale food processing unit.
19) *Compensation for horticultural land and horticulture development scheme:* Compensate affected horticultural land, financial assistance for procurement of seedlings.
20) *Tourism development grant:* Construction of homestay and tourist lodge(s). Improvement and creation on new trekking trails and camping sites, souvenir shops, restaurants and food stalls etc.
21) *Income generation scheme, subsistence grant and control of influx:* Provide financial assistance for diversifying income source, assistance to training for skill development and competency.
22) *Electric crematorium:* In order to compensate the loss/damage of last rite sites, electric crematorium in all the affected villages will be provided.

Protection: The resource protection and conservation are other important aspects covered in the development plan. This includes the protection of environment, and plan for forest and biodiversity management and conservation. The following measures were proposed and recommended.

1) *Public awareness programmes:* Providing financial assistance for social awareness and support
2) Adoption of strict rules and regulation during construction for protection of local environment including air, water and soil.
3) *Soil and catchment area protection:* An appropriate plan has been outlined to check soil erosion and sedimentation which will be followed during construction phase.
4) *Catchment Area Treatment Plan (CAT Plan):* CAT Plan will be initiated by all HEP developers and four key components were generalized to be followed viz., engineering measures, biological measures, infrastructure, and monitoring. Maintenance under CAT Plan would be for 3 years after construction/establishment, which may be extended whenever required.
5) *Other environment management plans that will be taken up by developers include:* Muck management /disposal plan, water, air quality and noise environment management, water pollution control plans, environmental management in labour camp, environmental management in road construction, control of pollution from labour camps, reservoir rim treatment and soil erosion control, maintenance of air and water quality and noise level.
6) *Forest and biodiversity conservation:* This includes afforestation programmes, habitat improvement and conservation for avifauna, fisheries, and black–necked crane, anti–poaching manpower and infrastructure. Many more ecosystem/landscape level plans have been suggested in landscape level biodiversity management plan.

Disaster risk: The disaster management system involves an area of planning that is focussed on the impacts of extreme or unplanned events, particularly around the mitigation and management of public safety and property risks associated with man–made disaster that can occur either relating to or due to hydropower structure and also with unexpected natural phenomenon. The following events were covered and their mitigation and management have been proposed.

1) *Dam breakage:* This includes preventive measure, surveillance and evacuation plan. As such, the impact of dam breakage in TRB is minimum because all the proposed HEPs have barrage structure, and all the villages in the basin are located at least 600m above the river bed.
2) *Un–regulated barrage water discharge:* Water discharge should be regulated, strong warning systems should be installed and disaster management cell should be constituted in each HEP.
3) *Earthquake and landslide:* Seismic disaster management and safety measures were proposed. Landslide prevention and mitigation measures were also recommended.
4) *GLoF:* Nine HEP sites were found to be vulnerable to GLoF. Effective management and mitigation plan for GLoF including inter–developer coordination have been proposed. Monitoring, early warning systems, mitigation and preparedness were outlined.

CHAPTER 1
INTRODUCTION

1.1 HYDROPOWER AND RIVER BASIN DEVELOPMENT

The river basin development planning and management has been in vogue all over the world, for at least a century now. It has been defined as 'a planned, complex, continuous and interdisciplinary process which is controlled on a systems analysis basis' (United Nations, 1976). It has also now been recognized that integrated river basin development with a focus on human well being, offers a framework for integrating water planning and management with environmental, social and economic development. In the context of energy security for the rapidly developing India's economy, cleaner, cheaper and environmentally less damaging modes of power generation has become a foremost imperative. The Government of India has since formulated ambitious targets to harness this power potential in many river basins in general and in Himalayan states in particular.

Hydropower is as an important development opportunity for the people of TRB. The state government has taken steps to realize this hydropower potential by employing both public and private sector organizations for sustainable hydropower development in the basin. The need to improve the sustainability of the basin's hydropower developments is a key strategic priority in the integrated hydropower and TRB development strategy. Such a plan needs to follow certain resource management principles.

It is estimated that only 16% of the hydro power potential in the country has been harnessed. Arunachal Pradesh alone holds about 34% of the hydel power potential of the entire country (Chowdhury and Ghosh, 2013). However, it has been argued that large scale hydropower development within a short time span runs a risk of being 'rapid' hydropower development at the expense of long term sustainability. For the long term benefit of the hydropower sector it is important that 'responsible' hydropower development becomes the underlying philosophy in India (Chowdhury and Ghosh, 2013). This is especially true in fragile Himalayan mountainous ecosystems such as the TRB.

1.2 RATIONALE FOR PERSPECTIVE DEVELOPMENT PLAN FOR TRB

It is imperative that any development planning in context of hydropower projects must consider TRB as an integrated unit. The TRB with an area of 2172 sq km, falls into the smaller river basin category (Chitale, 1992), with a power potential of 2,057 MW constituting 3.6% of the estimated total hydel potential of 57027 MW of the entire Arunachal Pradesh. (Government of Arunachal Pradesh, 2008).

With an estimated 56.4% of the geographical area under forest cover (Forest Survey of India, 2009), Tawang district has a population density of only 13 persons per sq km. Hence, TRB can have a focussed and relatively simpler developmental objective that would optimize generation of hydro power and environmental conservation in the river basin.

1.2 TRB DESCRIPTION

The boundary of TRB and the administrative boundary of Tawang district coincide. The detailed description of TRB has been presented in Section-I.

1.3 SCOPE OF THE PERSPECTIVE PLAN

As per the mandate given to North-Eastern Hill University by the Government of Arunachal Pradesh, this report attempts to provide an HEP integrated plan package for TRB development based on existing policies, to be implemented in the short-term period corresponding from one to five years of HEP design and construction phase, in the medium term corresponding to five to ten years in construction and operation phase, and in the long-term i.e., upto 20 years during operation phase. This report can be further aligned and complemented with the goals and targets of the State Government for the development of TRB. Hence, it may be emphasised that the river basin development effort of the government combined with HEP implementation can provide an enhanced opportunity to achieve both short-term and long-term development goals of TRB.

The Government of Arunachal Pradesh that governs the hydropower development in Tawang seeks to embrace all the potential benefits of developing multiple projects confined to a single river basin. With this backdrop, the present development plan confined its perspective planning process to the development of 'influence zone' of all the proposed projects. Special emphasis has been given to the socio-economic development of the families directly 'affected' by the project (s) within the influence zone. The 'influence zone' of a project in the context of the present development plan has been defined as the area within 10 km radius of the barrage and powerhouse sites of the proposed projects. Since no submergence of human habitation is involved, there is no displacement of human population as such. Therefore, 'affected families' in this plan means the families whose land(s) have been/would be acquired by the government for various project components. The baseline information on socio-economic conditions and livelihood of the project 'influenced' and 'affected' villages/villagers, existing infrastructure, and dependence on natural resources of the people were collected for impact assessment study of individual projects. These data have been used to produce a comprehensive database for prioritizing development needs and preparing a management plan in respect of the 'affected' and 'influenced' villages in the entire TRB.

This plan will be complementary to the on-going development efforts of the State Government and Central Government through numerous infrastructure and social development schemes/programmes in the river-basin. For instance, there are various rural, health and environment sector development schemes in the state being implemented such as Swarnajayanti Gram Swarozgar Yojana (SGSY), Indira Awas Yojana (IAY), Pradhan Mantri Gram Sadak Yojana (PMGSY), Integrated Wasteland Development Programme (IWDP), Mahatma Gandhi National Rural Employment Guarantee Act (MG-NREGA), National Rural Health Mission (NRHM) and National Afforestation Programme (NAP). Besides, Arunachal Pradesh being one of the Special Category States, Central government continues to provide financial support to the state government for the overall development of the state. This underlines the need for an active collaboration among all the executing agencies and stakeholders involving project developers, national and state governments, district administration and local Panchayati raj and traditional institutions to realize the goal of this development plan.

1.2.1 Prioritising the villages

The 13 proposed HEPs in a small river basin consequently would have effects that may be detrimental to the basin as a whole. This could result in fundamental, functional or structural changes. The concept of cumulative environmental effects in this study recognises that the environmental effects of individual HEPs can combine and interact with each other to cause synergistic effects on the socio-economy and environment of the impacted villages. Such a combined effect may also be different in nature or extent from the effects of the individual project. Consequently, the capability to cope against such combined effects varies from one local village to another. Analytical assessment can therefore assist in decision making and in the process of prioritizing villages in the development plan.

Five types of indices were computed viz., Socio-economic index (IS), Cumulated Project Effect Index (CIA), Standardized Cumulated Project Effect Index (SCIA) and Environmental Effect of Projects (VSCIA). Detailed methodology for the analysis has been described in Section-III of this Report. VSCIA and IS were used to classify 46 villages on the basis of the cumulative impact/effect.

Prioritization of villages was undertaken based on three indices/parameters. These are: (i) socio-economic condition/vulnerability index (VSCIA), (ii) combined environment and socio-economic effects/vulnerability index (SCIA), and (iii) 3-level cumulative effects/vulnerability based on terciles Euclidean distance measure. The scheme of analysis is shown in Figure VI. 1.1

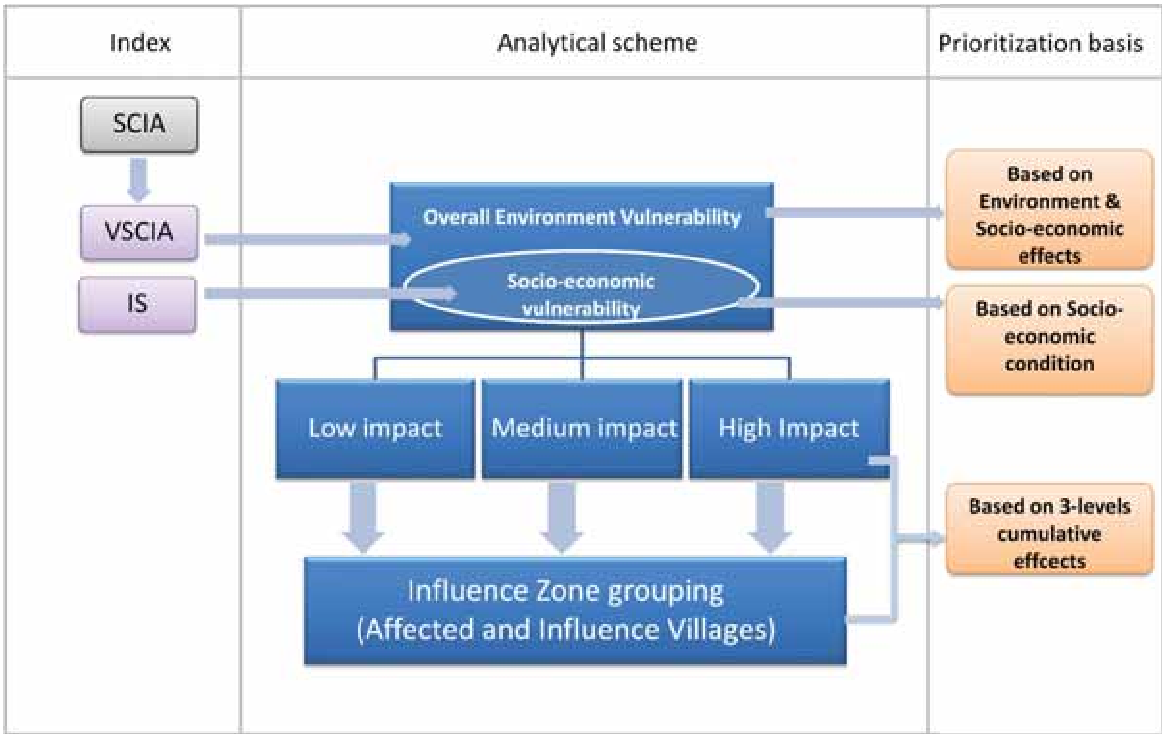


Figure VI. 1.1: Mechanism of village prioritization

The process involved the following steps:

- Determination of socio-economic condition of each village (IS index)
- Aspect-wise and cumulative effects of each HEP (SCIA).
- Determination of village-wise environmental and socio-economic effects by HEPs combined (VSCIA). This was derived from the SCIA index of HEPs.
- Comprehensive classification of effects into 3 classes based on terciles followed by grouping of sampled affected and influenced villages in the river basin.

1.4.1.1 Socio-economic condition

The Socio-economic index (IS) ranged from 0 to1.0 and the results were categorized into five classes as follows:

Sl.No.	Class	Socio-economic category
1	0 to 0.20	Very low
2	>0.20 to <0.40	Low
3	>0.40 to <0.60	Medium
4	>0.60 to <0.80	High
5	>0.80 to 1.0	Very High

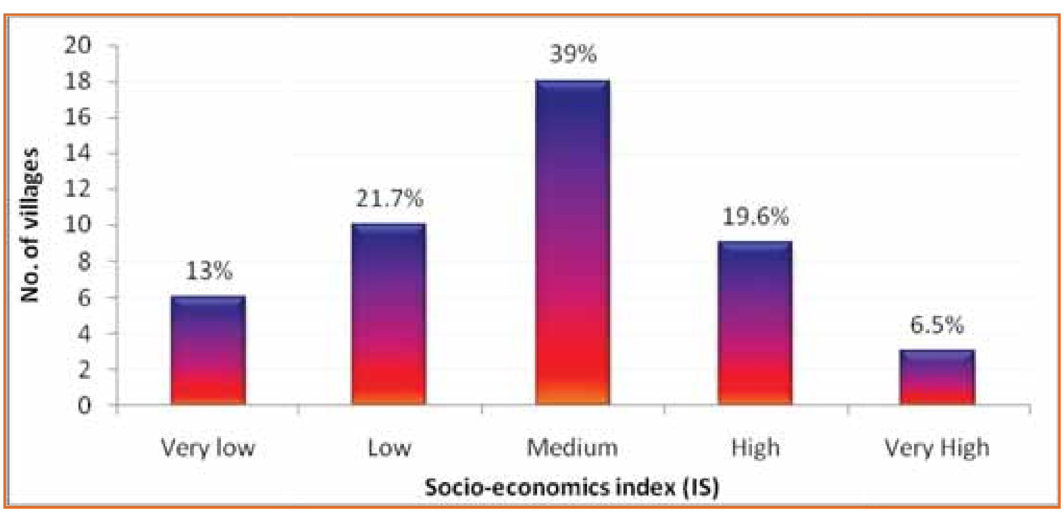


Figure VI. 1.2: Socio-economic status of 46 impacted villages (affected and influenced) under five categories.

Out of the 46 villages, a maximum of 18 villages (39.0%) fall under the medium category of socio-economic condition, while 9 villages (19.6%) were under high category, 10 villages (21.7%) were in low category. Only 6 villages (13%) were in very low category whereas 3 villages (6.5%) were in very high category of socio-economic conditions and these villages are Nam Tsering (IS=1.0), Dungse (IS=0.914) and Thrillam (IS=0.815) (Figure VI. 1.2).

1.4.1.2 Individual attribute-wise and cumulative effect of HEPs

All the 13 HEPs proposed had varying impact on various facet of the environment as well as economy of the villages in the study area (Table VI. 1.1). Several possible effects have been measured and classed into six 'aspects' as described in Section-III. The aspect-wise effects of the 13 proposed projects are as follows:

***Ecosystem structure, function and services*:** This represents an important aspect of TRB particularly because the region is characterised by forest vegetation and ecosystem services that play an important role in the lives of the local people. Thingbu chu and New Melling had the highest effect index of 1.21 and 1.0 each and consequently are impacting the ecosystem of TRB more than the other projects, while Jaswantgarh is impacting less with a low index of 0.62.

***Biodiversity*:** The TRB is known for its rich biodiversity and wildlife there are four projects with very high effect index, these are Tsa chu-I Lower, Rho, Mago chu, Thingbu chu and Tawang-I with 1.24, 1.04, 1.02, 0.96 and 0.91 respectively. Nykcharong chu and Paikangrong chu are expected to have least impact on biodiversity with their corresponding effect index of 0.48 and 0.24.

***Ecosystem vulnerability*:** The TRB region represents a typical Eastern-Himalayan landscape which is prone to soil erosion, landslide among others. The projects that are likely to have a strong effect on this aspect is Rho, Tawang-I with estimated effect index of 1.06 each followed by Nykcharong chu and Thingbu chu with effect index of 0.94 each. Jaswantgarh and Paikangrong chu with effect index 0.2 each will not likely have adverse impact.

***Hydrology*:** The proposed project is expected to have an impact on hydrology involving water flow, water current including river and tributaries network of the TRB. Two projects Thingbu chu and Mago chu had high effect index of 1.62 and 1.27 and are naturally having more impact on hydrology and river characteristics. Tawang-II and Tsa chu-II each had relatively low index with 0.59 while Paikangrong chu and Jaswantgarh had zero index value.

***Culture and livelihood*:** The livelihood and socio-economy of the local people especially those in the influence zone is intricately linked with the forest, land and river resources. This aspect is also important from the ethnic point of view since the Monpa tribe is one of the most distinct communities of the region. Hence implementation of several projects is perceived to have an effect on the livelihood of the affected people. Comparatively, the effect on livelihood by the HEPs is more equitable that the effects on other five 'aspects' with eight projects having index ranging from 0.41 to 0.5. Five projects had high index i.e., Tsa chu-I Nyamjang chu and Rho with 1.47, 1.41 and 1.17 respectively while Tawang-I and Tawang-II with 1.14 each. The lowest index is by Mago chu and New Melling with 0.41 each.

***Dependency on natural resources*:** Three projects are expected to impart highest influence on this aspect viz., Tsa chu-I, Tawang-I, and Thingbu chu with environmental effect of 1.16, 1.02 and 1.01respectively. Tsa chu-I Lower and Tsa chu-II is expected to have least impact with 0.58 each.

Table VI. 1.1: Aspect-wise environmental effects of different projects

Projects	Aspect						SCIA
	Ecosystem	Biodiversity	Vulnerability	Hydrology	Culture and livelihood	Dependency on natural resources	
Thingbu chu	1.21	0.96	0.94	1.62	0.47	1.01	1.03
New Melling	1.00	0.68	0.93	1.19	0.41	0.73	0.82
Mago chu	0.80	1.02	0.86	1.27	0.41	0.73	0.85
Nykcharong chu	0.93	0.48	0.94	0.65	0.50	0.73	0.71
Rho	0.66	1.04	1.06	0.62	1.17	0.87	0.90
Tsa chu-I	0.86	0.85	0.80	1.20	1.47	1.16	1.06
Tsa chu-I Lower	0.63	1.24	0.80	0.75	0.47	0.58	0.74
Tsa chu-II	0.63	0.67	0.91	0.59	0.47	0.58	0.64
Tawang-I	0.74	0.91	1.06	0.77	1.14	1.02	0.94
Tawang-II	0.64	0.53	0.91	0.59	1.14	0.87	0.78
Nyamjang chu	0.74	0.77	0.40	0.75	1.41	0.87	0.82
Jaswantgarh	0.62	0.62	0.20	0	0.47	0	0.32
Paikangrong	0.56	0.24	0.20	0	0.47	0.87	0.39

The Standardized Cumulated Project Effect Index (SCIA) of all the proposed projects is given in Table VI. 1.1. Tsa chu-I had that highest cumulated impact with SCIA= 1.06 followed by Thingbu chu (SCIA=0.93), Tawang-I (SCIA=0.94) and Rho (SCIA=0.90). The three projects with the lowest SCIA index are Tsa chu-II (SCIA=0.64), Paikangrong chu (SCIA=0.39) and Jaswantgarh (SCIA= 0.32).

1.4.1.3 Comprehensive classification of effects on impacted villages

Cumulated Environmental Effect of Projects (VSCIA) on the individual village was derived based on SCIA index. Taking into consideration the VSCIA and their socio-economic status (IS), village-wise length measurement based on Euclidean distance (L) was computed for each of the villages and grouped into three categories, and coded as low=1, mid=2 and high=3. Village-wise length measure (L) is given in Table VI. 1.2.

Table VI. 1.2: Classification of sample villages according to environmental effect of projects (VSCIA) and socio-economic index (IS)

Sl. No.	Sample villages/ projects	VSCIA	Socio-econ index (IS)	Median-based lexicographic class code (VSCIA & IS)	Tercile-based lexicographic class code (VSCIA & IS)	Length measure code (L)
1	Baghar	0.113207	0.460791	12	22	2
2	Dugumba	0.107519	0.338412	11	22	1
3	Hoongla	0.107519	0.586718	21	22	2
4	Kharteng	0.113207	0.618666	22	32	3
5	Lumla	0.220726	0.551042	22	23	2
6	Maio	0	0.612197	21	22	2
7	Pharmey	0	0.361171	11	22	2
8	Phomang	0.113207	0.459359	12	22	2
9	Poito	0.107519	0.656088	21	32	3
10	Sazo	0.107519	0.535481	21	22	2
11	Sherbang	0.113207	0.392367	12	22	2
12	Thrillam	0.107519	0.815229	21	32	3
13	Yabab	0	0.480401	11	22	2
14	Kelenteng	0.113207	0.039661	12	12	1
15	Dung	0	0	11	12	1
16	Gorsam	0	0.42185	11	22	2
17	BTK	0.113207	0.566609	22	22	2
18	Brokenthang	0	0.394471	11	22	2
19	Muchut	0.113207	0.248268	12	12	1
20	Zimithang	0	0.6946	21	32	3
21	Kharman	0	0.035219	11	12	1
22	Lumpo	0.113207	0.328279	12	12	1
23	Rho	0.983902	0.354307	12	23	3
24	Thingbu	0	0.178223	11	12	1
25	Shyro	0.129362	0.233286	12	12	1
26	Jangda	1	0.23483	12	13	3
27	Khamba	0.129362	0.594761	22	22	2
28	Yuthembu	0.242625	0.522071	22	23	2
29	Kharsa	0.129362	0.524271	22	22	2
30	Dungse	0	0.914823	21	32	3
31	Nam Tsering	0	1	21	32	3

32	Gomkelleng	0.129362	0.165383	12	12	1
33	Mirba	0.129362	0.43989	12	22	2
34	Gomkang	0.129362	0.495235	12	22	2
35	Kharthut	0	0.61996	21	32	2
36	Kudung	0.236880	0.503173	22	23	2
37	Gyankhar	0	0.561041	21	22	2
38	Seru	0.129362	0.701999	22	32	3
39	Teli	0.129362	0.62368	22	32	3
40	Yusum	0.129362	0.108304	12	12	1
41	Tsaikhar	0.129362	0.514765	22	22	2
42	Gyada	0	0.591735	21	22	2
43	Menteng	0	0.21247	11	12	1
44	Gemreteng	0	0.621231	21	32	2
45	Regyang	0	0.705262	21	32	3
46	Kregyang	0	0.460302	11	22	2

The villages were also categorized into three classes corresponding to the Euclidean terciles and two classes based on median (Table VI. 1.2). Based on tercile-based lexicographic class codes, the level of impact (first digit being the environmental impact and the second digit being the social impact) for each village was interpreted. The affected and influenced villages were arranged into the three priority levels under each HEP (Table VI. 1.3).

Priority 1	:	High impact villages
Priority 2	:	Medium impact villages
Priority 3	:	Low impact villages

Table VI. 1.3: List of Priority villages under the proposed HEPs

Affected villages			
Site	**Priority 1: High impact**	**Priority 2: Medium impact**	**Priority 3: Low impact**
Tsa chu-I	Rho, Jangda		
Tsa chu-I Lower	Rho, Jangda		
Tsa chu-II	Rho, Jangda		
Thingbu chu	Rho, Jangda		
New Melling	Rho, Yuthembu	Jangda	
Mago chu	Rho, Yuthembu		
Nykcharong chu	Rho, Jangda		
Rho	Rho, Jangda		
Tawang-I	Jangda Yuthembu and Seru	Khamba, Yuthembu, Kharsa, Mirba, Gomkang, Kudung, Tsaikhar	Shyro, Gomkelleng, Yusum
Tawang-II	Poito, Thrillam.	Hoongla, Lumla, Sazo, Kudung	Dugumba
Nyamjang chu	Kharteng	Baghar, Lumla, Phomang, Sherbang, BTK	Kelenteng, Muchut, Lumpo
Paikangrong chu	Rho, Jangda		
Influenced villages			
Site	**Priority 1: High impact**	**Priority 2: Medium impact**	**Priority 3: Low impact**
Tsa chu-I			
Tsa chu-I Lower			
Tsa chu-II			
Thingbu chu			Thingbu
New Melling	Jangda	Mirba, Kharsa	Thingbu, Shyro
Mago chu		Regyang, Yuthembu, Kharsa, Mirba, Gemreteng, Kregyang	Thingbu, Shyro
Nykcharong chu		Regyang, Yuthembu, Kharsa, Mirba, Gemreteng, Kregyang	Thingbu, Shyro
Rho	Dungse, Regyang	Yuthembu, Kharsa, Mirba, Kregyang	Shyro, Gomkelleng
Tawang I	Thrillam, Rho, Dungse, Regyang	Hoongla, Lumla, Kharthut, Gyankhar, Gyada, Gemreteng, Kregyang	Menteng
Tawang II	Kharteng, Nam Tsering, Seru	Baghar, Maio, Pharmey, Phomang, Sherbang, Yabab, Gomkang, Gyankhar, Yusum, Gyada, Gemreteng	Menteng
Nyamjang chu	Poito, Zimithang, Nam Tsering	Hoongla, Maio, Pharmey, Sazo, Yabab, Gorsam, Brokenthang	Dugumba, Dung, Kharman
Paikangrong chu		Yuthembu, Mirba	Shyro

CHAPTER 2
PROCESS FOR TAWANG RIVER BASIN DEVELOPMENT PLAN

The present integrated hydropower and Tawang River Basin (TRB) development plan (herein after referred to as 'Development Plan for TRB') aims to establish a framework on agreed set of strategies and actions such that a balanced and acceptable approach to land, water and natural resource management can be achieved.

The development plan aims to establish a strategic and comprehensive structure for the development of TRB for 20 years in future starting from the time of implementation of first batch of hydropower projects. It also offers a long-term perspective and seeks to develop and improve in a sustainable manner the social, economic, cultural, and environmental assets of TRB. The Plan covers the influence zones of the proposed projects as defined in the previous chapter within the administrative area of Tawang district. There are four key stages in basin planning viz., conducting the situation assessment, formulating the vision, developing the basin strategies and detailing the implementation (Box VI. 2.1).

Box VI. 2.1: Four key stages in basin planning

	Process stage	Outline
1	Conducting the situation assessment	Conducting the situation assessment to gain an understanding of the current and future conditions in the basin, as well as identify and prioritize the key issues.
2	Formulating the vision	Formulating the vision and goals to provide the long-term desired state for the basin together with goals (preliminary objectives) and principles to achieve this over time.
3	Developing the basin strategies	Developing the basin strategies to specify a coherent suite of strategic objectives, outcomes and actions related to protection, use, disaster and institutions in the basin, designed to achieve the vision.
4	Detailing the implementation	Detailing the implementation to define actions that give effect to the basin strategies and ultimately achieve the vision and objectives.

2.1 CONDUCTING THE SITUATION ASSESSMENT

- Process inception and design, which includes delineation of the basin boundary.
- Baseline assessment of the current situation and historical evolution.
- Future development and trends provide forecasts or scenarios of development pathways.
- Priority issues and principles indicate the key challenges and concerns for planning.
- Basin vision for the long-term desired state of the basin.
- Environmental zonation providing the desired state in river or catchment that reflects a balance between social, economic and ecological imperatives.
- Social and economic consequences indicating the implications of achieving the objectives.

2.1.1 Process inception

2.1.1.1 Policy framework

The development plan for TRB has been carried out within the framework of state and national policies, acts, rules and regulations. The guidelines of existing State and Central Government policies will be followed in executing the hydropower projects starting from design phase upto construction and operation phase. In case of conflicting policy clauses, whichever guidelines and policies are higher in hierarchy were followed for the preparation of the development plan. The legislations and policies relevant to integrated hydropower and TRB development plan are given in Box VI. 2.2.

Box VI. 2.2: Legislations and policies pertaining to hydropower project implementation

LAND AND PEOPLE

Land Acquisition Act of 1894: This is the old Act in India that allowed the government to acquire private land. "Land Acquisition" literally means the acquisition of land for some public purpose by a government agency from individual landowners, as authorised by the law, after paying a government-fixed compensation to cover losses incurred by landowners for surrendering their land to the concerned government agency. This Act has been repealed with the enactment of the Right to Fair Compensation and Transparency in land acquisition, Rehabilitation and resettlement Act, 2013.

The Right to Fair Compensation and Transparency in land acquisition, Rehabilitation and resettlement Act, 2013: This is a new Act in India replacing the Land Acquisition Act of 1894. This is the first post-independence national/central law on the subject of Rehabilitation & Resettlement of families affected and displaced as a result of land acquisition. The Act has provisions to provide fair compensation to those whose land is taken away and ensure transparency to the process of acquisition to set up factories, buildings and infrastructure projects assuring rehabilitation of those affected. It also regulates land acquisition and provides procedure and rules for granting compensation, rehabilitation and resettlement to the affected persons in India.

The Scheduled Tribes and Other Traditional Forest Dwellers (Recognition of Forest Rights) Act, 2006: This is an Act to recognize and vest the forest rights and occupation in forest land by the forest dwellers. The Scheduled Tribes and other traditional forest dwellers who have been residing in such forests for generations but whose rights have not been recorded, the act provides a framework for recording the forest rights and vesting it on the dwellers in respect of forest land.

The Arunachal Pradesh (Land Settlements and Records) Act, 2000: This is an act to provide a comprehensive law for land revenue administration for the whole state of Arunachal Pradesh incorporating customary rights on the land and certain measures of land reforms. This Act in the history of Arunachal Pradesh is the first ever attempt to formalize the land and revenue administration.

Arunachal Pradesh (Land Settlement and Records) Rules 2002: This came into being on 20 July, 2005. Under the provisions of the rules, land settlement and records are proposed to be maintained. Those in actual possession/occupation of land, other than Government land, may be necessarily given land possession certificate (LPC). The LPC is considered to be the authentic record for possession of land.

National Rehabilitation and Resettlement Policy, 2007: The provisions of this policy provide for the basic minimum requirements, and all projects leading to involuntary displacement of people must address the rehabilitation and resettlement issues comprehensively.

Arunachal Pradesh Rehabilitation and Resettlement Policy, 2008: In order to provide the adequate compensation to affected families, and develop infrastructure facilities in the area, Arunachal Pradesh Government has formulated its own Rehabilitation and Resettlement policy on the lines of the National Rehabilitation & Resettlement Policy (NRRP), 2007. The new policy supplements the existing NRRP with a few more definitions and compensatory provisions. The main objectives of the new R & R policy are to provide appropriate and adequate compensation to affected families against the diversion of land, especially forest land (Unclassified State Forest), to minimize the displacement, to provide adequate infrastructure facilities at rehabilitation site, to improve the living standard of affected zone and to facilitate the harmonious relationship between requiring body and inhabitants of affected zone. The policy also emphasizes the Social Impact Assessment in case of the displacement of more than 20 families.

Contract Labour (Regulation & Abolition) Act, 1970: This central Act governs the engagement of labour and the necessity for provision of basic facility to them. The Act also outlines the procedure for licensing of contract labour.

Industrial Employment (Standing Orders) Act, 1946: This central Act requires that employers have terms including working hours, leave, productivity goals, dismissal procedures or worker classification approved by a government body.

The Bonded Labour System (Abolition) Act, 1976: This is a central Act to provide for the abolition of bonded labour system with a view to preventing the economic and physical exploitation of the weaker sections of the people and for matters connected therewith or incidental thereto.

The Inter-State Migrant Workmen (Regulation of Employment and Conditions of Services) Act, 1979: This central Act regulates the employment of inter-state migrant workmen and provides conditions of their services and for matters connected therewith. The purpose of the Act is to protect workers whose services are requisitioned outside their native states in India. Whenever there is shortage of skills among locally available workers, the act creates provision to employ better skilled workers available outside the state.

The Child Labour (Prohibition and Regulation) Act, 1986: Whereas it is expedient to prohibit engagement of child in factory, mining and similar other risky work and to make necessary provision for health, Child's safety and services and facilities while engaging them in other work.

FOREST AND WILDLIFE

Forest (Conservation) Act, 1980: The act pertains to the cases of diversion of forest area for non-forestry use. The process of obtaining forest clearance under this varies with the area of the forestland to be diverted. The proposal for diversion of forest land upto 40 hectares shall be forwarded by the concerned State Government or as the case may be, the Union Territory Administration, along with its recommendations, to the Additional Principal Chief Conservator of Forests or the Conservator of Forests of the concerned Regional Office of the Ministry of Environment and Forests, Government of India, who shall, within a period of 45 days of the receipt of the proposal from the concerned State Government or the Union Territory Administration, as the case may be (a) decide the diversion proposal upto 5 hectare other than the proposal relating to mining and encroachments, and (b) process, scrutinise and forward diversion proposal of more than 5 hectares and upto 40 hectares including all proposals relating to mining and encroachments upto 40 hectares, along with the recommendations, if any, to the MoEF, New Delhi for obtaining the decision of the Central Government and inform the State Government or the Union Territory Administration, as the case may be, and the User Agency concerned. The proposal involving forest land of more than 40 hectares shall be forwarded by the concerned State Government or as the case may be, the Union Territory Administration, along with its recommendations, to the MoEF, New Delhi.

Wild Life Protection Act, 1972: According to this Act, "wildlife" includes any animal, bees, butterflies, crustaceans, fish and moths; and aquatic or land vegetation which forms part of any habitat. In accordance with Wildlife (Protection) Amendment Act, 2002 “no alteration of boundaries/National Park/Sanctuary shall be made by the State Govt. except on recommendation of the National Board for Wildlife (NBWL)”. This act has allowed the government to establish a number of National Parks and Sanctuaries over the past 25 years, to protect and conserve the flora and fauna.

The Indian Fisheries Act, 1897: The Indian Fisheries Act, 1897 contains seven sections. Section 5 of the Act prohibits destruction of fish by poisoning waters.

ENVIRONMENT

The Environment (Protection) Act, 1986: This act was passed as an overall comprehensive act “for protection and improvement of environment”. According to this Act, the Central Government has the power to take all such measures as it deems necessary or expedient for the purpose of protecting and improving the quality of environment and preventing, controlling and abating environmental pollution. Under this act, rules have been specified for discharge/emission of effluents and different standards for environmental quality. These include Ambient Noise Standard, Emission from Motor Vehicles, Mass Emission Standard for Petrol Driven Vehicles, General Effluent Standards, etc.

Water (Prevention and Control of Pollution) Act, 1974: This act makes provision for the establishment of the Central and State level Pollution Control Boards, whose responsibility includes managing water quality and effluent standards, as well as monitoring water quality, prosecuting offenders and issuing licenses for construction and operation of any facility. This will include generation of liquid effluent during construction of road from Civil Engineering activities or from domestic activities in workers colony. There are specific penalties for violation, which include imprisonment for responsible officials.

Air (Prevention and Control of Pollution) Act, 1981: This act empowers Central and State Pollution Control Boards for managing air quality and emission standards, as well as monitoring air quality, prosecuting offenders and issuing licenses for construction and operation of any facility. National ambient air quality standard for different regions e.g., industrial, residential and sensitive is notified under this act. Air quality during construction and operation phases, particularly for obtaining consent for establishment and operation of crushing plant, batching plant etc. are regulated under this Act.

The Explosive Act 1984: This Act deals with use and storage of explosive for blasting work.

Manufacture Storage and Import of Hazardous Chemical Rules 1989: These rules deal with storage of fuel, oil, lubricants, diesel etc. at construction camp.

Mines and Minerals (Development and Regulation) Act, 1957: As per the act, "minor minerals" means building stones, gravel, ordinary clay, ordinary sand other than sand used for prescribed purposes, and any other mineral which the Central Government may, by notification in the Official Gazette, declare to be a minor mineral. The latest amendments to Mines and Minerals Act was passed in 2010 to substantiate this Act. Therefore, quarrying operation is covered under these Acts.

Environmental Impact Assessment Notification, 2006: In order to balance the environmental concerns and the developmental activities, the provisions of EIA Notification under Environmental Protection Act, 1986 is the cardinal regulation for clearing the development projects of the country.

Some of the Acts listed in Box VI. 2.2 are followed in conjunction with one another. Besides, synchronization of state and national laws/rules are carried out while implementing the HEPs.

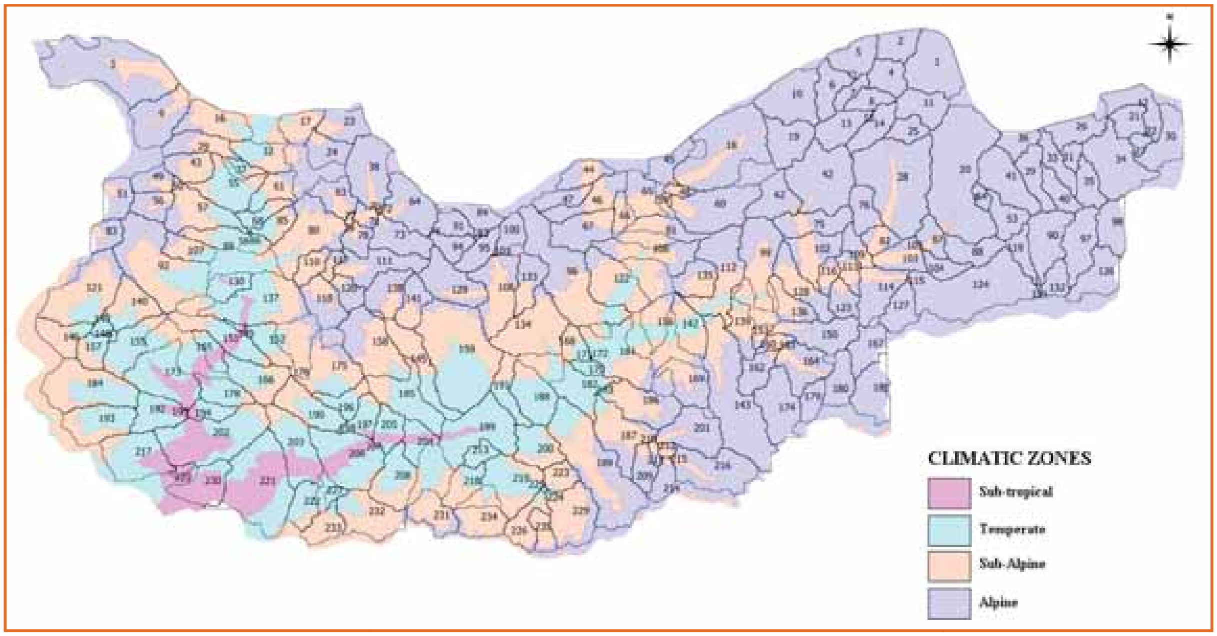


Figure VI. 2.1: Climatic zonation of micro-watersheds (100-1000 ha) and macro-watersheds (1000-10,000 ha) in TRBL. Numbers in the map represent the individual watershed units in the river basin.

2.1.1.2 Basin delineation

One of the approaches used to reconcile the trade-offs in river basin planning is to assign different functions to different parts of the river basin, recognizing that some stretches of river should be maintained at high environmental standards, while in others there should be more of a focus on socio-economic development. The system is based on two types of classification: development prohibited region, and development region. These are applied to each river section, based on the characteristics of rivers, current and future water resources use, environmental water needs, and socio-economic development scenarios. Accordingly, the zones above 3,200 m elevation in TRB were classified as no HEP region because of highly fragile ecosystems and absence of any villages. The HEPs and ancillary development activities, therefore, would be mostly confined to the zones/micro-watersheds between 1000-2500 m elevation. Small/medium HEPs in the elevation range of 2500-3200 m may be taken up with strict environmental compliances (Figure VI.2.1).

2.1.1.3 Information review

An information review results in compiling the available information that identifies potential challenges, gaps and inconsistencies. Information on TRB was obtained from literature and secondary sources on various aspects such as socio-economic, infrastructure, environment and biodiversity. Some of the important referred sources are Census of India, and District Statistical Handbook of Tawang district, Arunachal Pradesh.

2.1.2 BASELINE ASSESSMENT

The present baseline assessment was mostly based on the primary data. However, the baseline data collection did pose several challenges. Firstly, the database was poor or non-existent for most aspects. Secondly, there were cases of non-cooperation or opposition to data collection by a section of the people. However, with consistent efforts, data on most aspects could be collected. Due to these adversaries, and given the logistic and terrain related constraints of TRB, certain elements of error in the dataset cannot be ruled out. Several data gaps were identified and guided for follow up survey. Prioritization of key issues emerging from the baseline assessment resulted into four strategic areas viz., development, protection, disaster risk, and institution. The analysis of the existing conditions in the TRB may be divided into three areas:

- *Institutional assessment*
- *Socio-economic and Infrastructure assessment*
- *Environment, biodiversity and disaster risk assessment*

2.1.2.1 Institutional assessment
Institutional assessment was conducted with a view to have a full understanding of the current institutional arrangement governing TRB communities, especially in the context of developmental activities. A basin plan is likely to have a profound impact on the institutional environment within the TRB. The institutional assessment aimed to identify and understand the organizational capacity of key stakeholders in the development plan of TRB.

2.2.1.2 Socio-economic assessment and infrastructure assessment
Typically, the baseline situation assessment describes the social and economic conditions in a basin and develops an understanding of possible future growth in key sectors. Similar analyses are used to assess the potential social and financial implications of different management options as a part of the strategy formulation process. As in case of environmental assessment, the social and economic assessment may also be broadly divided into basic descriptive material relating to socioeconomic characteristics of the basin, and more analytic attempts to understand priorities and trends in the basin. In terms of the baseline economic and social assessments, the following information was collected at TRB scale:

- structure of the economy depicting geographic differences in the basin
- economic growth and sectoral distinctions
- employment characteristics
- income distribution and inequality
- human development (indices)
- health and education status
- access to services.

In addition to these baseline data, a number of analyses were undertaken to understand the social and economic priorities in the basin:

2.1.2.3 Environmental, forest and biodiversity assessment
The detailed assessment relating to environment, forest and biodiversity has been presented in the Sections II and III.

2.1.3 Priority issues and principles
There are following two types of planning principles used for the TRB plan:

1. Procedural principles are those principles that guided the way in which the basin development planning process was conducted. This reflected the institutional, political, and historical management context in the basin.

2. Substantive principles guided in defining the strategic development systems for the basin plan itself. This reflected planning priorities and development imperatives of the core stakeholders.

2.1.3.1 Procedural planning principles
The following procedural principles were followed in TRB plan, which were adapted from the Global Environment Facility's (GEF's) trans-boundary diagnostic analysis (TDA)/strategic action programme (SAP) guidelines (Bloxham *et al*., 2005):

1. Full stakeholder participation in developing the objectives and strategic options for the development of the basin plan.

2. Transparency in information sharing and decision-making, with information in the public domain and made available by the Government of Arunachal Pradesh

3. Joint fact-finding between the planners, developers, Government organizations, related institutions, and other stakeholders should be encouraged to build credibility and trust between the groups.

4. Integrated management recognizes the interrelated nature of hydrological, ecological, social and economic systems.

5. Adaptive management requires flexibility in approaches to respond to unforeseen circumstances or inadequate management decisions.

6. Causal understanding of the underlying economic and social drivers, and the balance between equity, sustainability, and efficiency is clearly motivated by the need for integrated and adaptive management.

7. Intersectoral (and intrasectoral) focus, recognizing the relationships (in terms of impact and influence) of all the sectors for implementation of the development plan.

8. Pragmatism in selecting implementable options, considering capacity and resource availability in the short and medium term.

9. Institutionalizing the process by linking to existing structures with a basin level coordinating body and empowering stakeholders.

2.1.3.2 Substantive planning principles

Besides confirming to the policy and legal framework, the development plan considered the following environmental and social targets to be achieved:

1. Uplifting the socio-economic condition of the affected and influenced villages, particularly the marginalised and landless families.

2. Maximising employment opportunities in every aspect of the project to the local communities by controlling influx, and hence diversifying their means of livelihood.

3. Raising the education standards, skills, and hence competency of the affected villagers.

4. Building the capacity of local institutions and strengthening social capital/cohesion in TRB development.

5. Prioritized attention on issues based on people's perception and implement an iterative process for the achievement of long-term goals.

6. Development and upgradation of basic infrastructure in the affected and influenced villages.

7. Complementing forest development activities to meet the current national forest cover target.

8. Diversion of forest due to project construction should be minimal.

9. Biodiversity should be conserved in totality, and existence value of species should be respected.

10. Landscape and catchment area protection/treatment should be given priority in the face of future uncertainties of events such as landslide, earthquake, and climate change.

2.2 FORMULATING THE VISION

2.1.1 Vision statement: Sustainable development of TRB

The basin vision is a high-level statement of the goals and priorities that the basin plan is attempting to promote. Because the vision reflects and addresses the main concerns and aspirations within a given basin at a particular point in time, including the broader social, economic and environmental development concerns, these visions provide an insight into the purpose and objectives of basin planning. The basin vision may also give an indication of priorities in the context of the trade-offs and conflicts that will need to be addressed in the basin plan, for example by indicating economic priorities that need to be satisfied or environmental limits that need to be respected or restored. The vision statement for TRB was agreed as Sustainable development of TRB, through stakeholder consultation process.

The vision plan (or goal) for TRB may be stated as follows:

1. To ensure the future state of Tawang chu river to such an extent that the river biodiversity and water quality is maintained
2. To ensure minimum flow of water in the river to maintain the health of the downstream river ecosystem in respect of each proposed project.
3. To ensure the continuity of the network of habitats so that migration of aquatic fauna and other plant and animal species is not affected.
4. To enhance public health, safety, and quality of life of the people through sustained economic growth and diversified livelihood opportunities for the people residing in the basin with special emphasis on project influenced and affected villages.
5. To protect and restore all the ecosystems in the basin, unique biological diversity, ecological values and cultural life of the people.

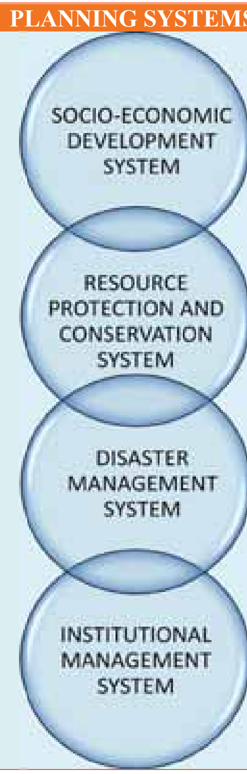
2.3 DEVELOPING THE BASIN STRATEGIES

The vision and objectives of the basin plan are aimed to be of high level with cross-cutting outcomes. Implementation will require actions across a range of different areas which ultimately need to be set out in structure and detailed thematic implementation plans. The process of TRB development plan is structured into four components viz., Institutional, development, protection and disaster risk. The underlying thematic plans are aligned/linked to fit into each of these structures sequentially. The overall structure and contents of the basin plan is presented in Table VI. 4.21.

In order to achieve the key considerations/vision and objectives, these are linked to the thematic plans and the strategic actions are grouped into four distinct systems corresponding to the four-structure of the TRB development plan, these are: Institutional management system, socio-economic development system, protection and conservation system, and disaster management system (Table VI. 2.1). Each system has its own focus and logic and can be interconnected with each other.

Table VI. 2.1: Interface between the strategic structural components with the thematic plans and the corresponding overlapping systems

	STRUCTURE	THEMATIC PLANS	PLANNING SYSTEMS
1.	DEVELOPMENT	Habitation and land Basic infrastructure (health, education etc) Human resource development: Skills and training Socio-economic Farming (agriculture, animal husbandry etc) Diversifying economic resource	
2.	PROTECTION	Air Water Soil Forest Biodiversity Catchment area	
3.	DISASTER RISK	Barrage breakage Unregulated barrage discharge Landslide, soil erosion Earthquake, GLoF	
4.	INSTITUTIONAL	Financial mechanisms Stakeholder engagement Institutional mechanism: TRBDA Inter-developer coordination Monitoring and evaluation	



2.3.1 Socio-economic development system

This area of planning forms the most important of the four structures in the present plan. It focuses on infrastructure, social, and economic development. Specific plans and issues therefore include:

- Infrastructure development
- Socio-economic development

2.3.2 Protection and conservation system

This area of planning is focussed on the protection environment, forest and biodiversity assets and ecosystem health, water resource functioning in providing goods and services. Specific plans and issues include:

- Environment regulation
- Water and air quality management regulation
- Forest management
- Biodiversity conservation
- Fisheries management, and
- Catchment protection and soil conservation.

2.3.3 Disaster risk management system

As per the Disaster Management Act, (Government of India, 2005), 'Disaster' is defined as a catastrophe, mishap, calamity or grave occurrence in any area, arising from natural or man-made causes, or by accident or negligence which results in substantial loss of life or human suffering or damage to, and destruction of, property, or damage to, or degradation of, environment, and is of such a nature or magnitude as to be beyond the coping capacity of the community of the affected area**.**

This area of planning is focussed on the impacts of extreme or unplanned events, particularly around the mitigation and management of public safety and property risks associated with unexpected disaster:

- Landslide and unabated erosion control
- GLoF
- Dam-break and/or unregulated water discharge
- Earthquake

2.3.4 Institutional management system

This includes the plans that provide the supporting cooperative arrangements and requirements for implementing the strategies. It includes the following:

- Institutional development and capacity building
- Stakeholder engagement, awareness and communication
- Information and monitoring

2.4 DETAILING THE IMPLEMENTATION

This is the fourth stage in the development of strategies under which actions were defined that will bring about the desired consequences and effect to the basin strategies and ultimately achieve the vision and objectives.

- Implementation plan outlining the activities, milestones, responsibilities and resources to achieve the basin strategies.
- Thematic plans detailing the interventions around specific issue.
- Regional plans detailing the interventions within a defined subarea of the basin.

2.4.1 The process

The planning was jointly done through a series of discussions with the project developers, and both affected and influenced villagers. Consultation with district administration, forest department, fishery department, and statistical department officials were also carried out for acquiring necessary data and understanding the development perceptions and needs. Additionally, the people's view and perception including those of public leaders were considered. The execution of the plan would be a joint responsibility of the developers and the state government authorities. However, the developer will be committed and comply with relevant policies to extend special plan for community development.

A Tawang River Basin Development Plan (TRBDP) is proposed which will encompass all the sector-wise schemes, grants and plans to be funded by the HEP developers. The TRBDP will be exploited to the fullest so that the Corporate Social Responsibility (CSR) activities and contribution under the R&R plan from the developers should fulfil most of the people's aspirations particularly the Project Affected Families (PAFs). All financial assistance to be received from the developers will be kept in the 'Tawang River Basin Development Fund (TRBDF)' which will be managed by TRBDA.
Strategic planning process was made keeping in view PAFs requirements and their concern and perception. Hence it was important to:

- Prioritize components based on people's need assessment surveys and infrastructural gap identification.
- Prioritize development activities to the most affected villages and the marginalized PAFs and social groupings within the affected and influenced villages, while also targeting those farthest from access to education, training and employment, and those at highest risk of social exclusion.
- Special emphasis was given to overlapping villages especially those being impacted by several hydropower projects. For this purpose, village prioritization was an important component of the development plan (Figure VI. 2.2).

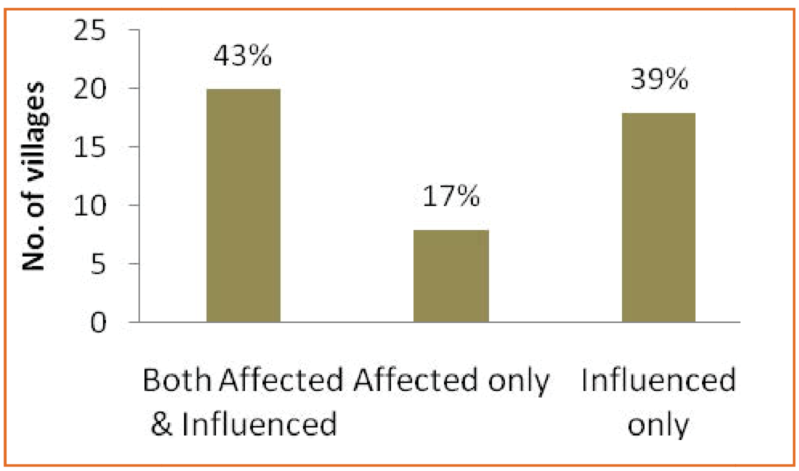


Figure VI. 2.2: Number of villages being affected, influenced and both affected and influenced by the 13 proposed HEPs

This integrated development plan in context of the proposed HEPs advocates a number of core values of community development during implementation. These are: participation, empowerment, social justice and equality for those who are affected or influenced by the projects. To achieve these core values, following principles should be followed during implementation of the plan:

- Promote active and constructive engagement between the State and communities about the development and enactment of public policy priorities at local level; and
- Encourage integrative and coordinated work in communities by bringing together people, groups, agencies, voluntary and statutory bodies to work together and make a positive contribution to the HEP integrated development of TRB.

3.1 IMPLEMENTING AGENCY: TAWANG CHU BASIN DEVELOPMENT AUTHORITY OR TRBDA

The TRBDA will be constituted to act as a nodal agency for implementation of the development plan. Hence, the TRBDA will be set up as a Society under the Societies Registration Act, 1860 of Arunachal Pradesh. The organisational structure, roles, mission, rules and guidelines will be formulated and decided by the Government of Arunachal Pradesh.

The TRBDA member may also be drawn from local Societies and NGOs such as:

- Tawang LAMP (Large and Multi-purpose Cooperative Society)
- Jang LAMP
- Tawang ME School Coop Societies Ltd.
- Animal Husbandry Dairy Development Coop Society
- Himalayan Industrial Entrepreneur Society, Kitpi
- Monyul Handloom & Handicraft Coop. Society, Lhou

All social and biophysical development related activities would be undertaken by this autonomous body i.e., TRBDA. TRBDA would work under the overall supervision of the local district authority. Village-level representatives such as Village Panchayats or village-level councils, representatives of local NGOs and Zilla Parishad Chairman will be included as members of the Management Committee of TRBDA besides the district authorities and representatives of the state government as members/chairman. The funds and schemes of HEP developers will be channelized through this authority and the activities proposed under the plan including those for biodiversity conservation will be implemented by this body. This body would also be coordinating with all the line departments of Government of Arunachal Pradesh at Tawang district level, decentralized peoples' organizations such as Panchayati raj institutions at all the three tiers, program specific organisations such as JFMCs, BMCs, DRDAs and FDAs in the district.

3.1.1 Roles and responsibilities

(i) *Executing agency*: The TRBDA will be the executing agency and will have the primary responsibility of implementing all developmental activities.

(ii) *District administration*: Tawang district administration is required to oversee the entire hydropower project-integrated development plan of TRB. For this purpose, a District Working Committee (DWC) will be constituted by the state government who will be working and coordinating closely with HEP developers and TRBDA. The members of the DWC will be drawn from various departments for overseeing developmental activities of different sectors (education, health, labour, transport, agriculture, forests etc.). Sub-committees in each of the identified sectors will be constituted who will oversee/monitor/investigate/assist all developmental activities under TRBDA and the roles of the sub-committees will be to:

- Provide active association and collaboration with the developers, provide guidance and authorization, and offer technical inputs to the resettlement and livelihood restoration/upliftment and improvement process.
- Participate in capacity building for village facilitators and village representatives.
- Provide human resource and informational input to infrastructure and livelihood activities.
- Assist with training activities in the respective domains.

3.1.2 Inter-developer coordination

The Hydropower policy (Government of India, 2008) clearly stated that -"*Very close co-ordination and co-operation is required among developers working and operating in a river basin both during planning, implementation and operation of hydro projects. Sharing the costs of geological and hydrological data collection and of infrastructure development, proper sequencing of implementation so that infrastructure is not over-strained, and co-ordinated releases of water for optimized generation are some examples of such co-ordination. The framework of such arrangements ranges from informal to statutory. There is need to study various practices within the country and abroad to arrive at some likely models which the States can follow within their jurisdictions. It is proposed to deliberate this and related issues in the Task Force on Hydro Power*". Therefore, it is imperative that the developers share a very close coordination and rapport with each other starting from design and construction phase upto operation phase. This is so because the entire basin will be significantly impacted in all aspects; Socio-economic development, rehabilitation, land holding, environment, forests and biodiversity are among the important aspects that will be impacted. Therefore, the coordination among the developers needs to be maintained through the active initiative of TRBDA.

3.2 SOCIAL CAPITAL

Social Capital is a concept that has significant implications for enhancing the quality and effectiveness of the developmental activities particularly those that are based on community action and ensure sustainability of existing village communities during the entire development process. During the entire development period it will be necessary to delegate to an organization (TRBDA) the responsibility for leading the community participation process and identify tasks at the grassroots level. Various sections of the society need to work together with the TRBDA to achieve a common goal of developing the TRB in a long-term perspective. This includes the village-level representatives down to entities responsible for local operation and most importantly the people and community as a whole. Social cohesion, trust, cooperation and awareness are some of the important principles and dimension of social capital that needs to be built particularly in the development process involving the entire region of TRB. Some of the local institutions that will play an important role are:

1.	Panchayats
2.	Village Development Committee
3.	Self Help Groups (SHGs)
4.	Youth organisation
5.	Farmers group
6.	Marketing groups, and
7.	Tourism groups

These organizations will also play an important role in the following principles and dimensions that capture both the structural and cognitive forms of social capital.

1	Groups and networks	Collections of individuals that promote and protect personal relationships which improve welfare.
2	Trust and Solidarity	Elements of interpersonal behaviour which fosters greater cohesion and more robust collective action.
3	Collective Action and Cooperation	Ability of people to work together toward resolving communal issues.
4	Social Cohesion and Inclusion	Mitigates the risk of conflict and promotes equitable access to benefits of development by enhancing participation of the marginalized.
5	Information and Communication	Breaks down negative social capital and also enables positive social capital by improving access to information.

The developers will also have to play their role to build social capital, and in this regards, grants for community hall may be earmarked by the developers where regular meetings can be held and develop the four principles mentioned above.

3.3 FINANCING TRB PLAN IMPLEMENTATION

Implementation of TRB plan will be costly and the sustainable funding for all the actions may not be easy to achieve. Although there has been a compensation mechanism and rehabilitation compensation and corporate social responsibility by the developers, out of the perceived benefit from the HEPs. However, the contribution from the developers would not be adequate to fund all the proposed activities under the four systems suggested in this development plan. Therefore, Government investment has to be ensured to implement the plan in totality. In addition to arranging special package for TRB from Government of India for a sustainable development, ecological compensation should be leveraged in the form of payment to be made by the downstream water and power user states.

Other potential sources of funding to implement this plan other than the government, include through development assistance from international bilateral and multi-lateral funding agencies. Efforts may be made to recover basin development and management costs from those who derive benefit from the river system, such as through water user fees or polluter fees.

The appropriate mechanisms and institutions mainly TRBDA should be empowered for collecting and directing funding. Ideally, TRBDA with responsibility for implementing strategies under this plan should have control over their funding arrangements.

The local operation of the various schemes/activities under TRBDP will also be decided by the TRBDA. However, it is suggested that wherever feasible local contractors be given the task to avoid institutional conflicts and grievances.

3.4 MONITORING AND EVALUATION

The ultimate purpose of a basin plan is to enable coherent and strategic management of the basin water resources to support associated social, economic and ecological systems. While every endeavour is usually made to develop an implementable and effective basin plan, the specified actions might not be implemented adequately, their implementation might not contribute to the desired outcomes, or the environment might change unexpectedly. Therefore monitoring, together with evaluation and reporting on the results, is a critical aspect of the implementation of the basin plan. Broad monitoring may relate to water resources, environmental, social, economic or institutional information, and plays a number of roles in basin plan implementation:

Operational monitoring: of the current conditions in the basin assists in making operational decisions and implementing strategic actions by water managers, stakeholders and other role-players, typically on a daily, weekly or monthly timeframe.

Compliance monitoring: of actions and activities by water users or those with an impact on the water resources, as well as those responsible for implementing strategic actions under the basin plan, typically on a monthly to annual timescale

Strategic monitoring: of the state of the basin overtime to provide ongoing understanding of the system or fill information gaps to support longer-term planning, refinement or revision of the basin plan, typically on a multiyear timescale. From the perspective of the basin plan implementation, monitoring has three related areas of focus:

- implementation of the specified actions within the agreed time frames (on an annual basis)
- achievement of the defined objectives of the plan, resulting from the actions specified in the plan (on a one to five-year basis)
- contribution to broader social, economic and ecological imperatives related to the vision (within the timeframe of the plan – typically five to twenty years).

3.4.1 Monitor and review for adaptive management

Adaptive management for TRB development planning is important because modification may be required over time because of the:

- complexity of the basin, implying that it will seldom be possible to get complete information, understanding,
- knowledge and solutions during the planning process
- uncertainty of the future, implying that it is not possible to accurately predict development and climate pathways during the basin planning process.

Adaptive management systems are usually developed around good monitoring and information system, which is why monitoring form an important component in 'Institutional management system. The iterative nature of the entire basin planning processes is illustrated in Figure VI. 3.1.

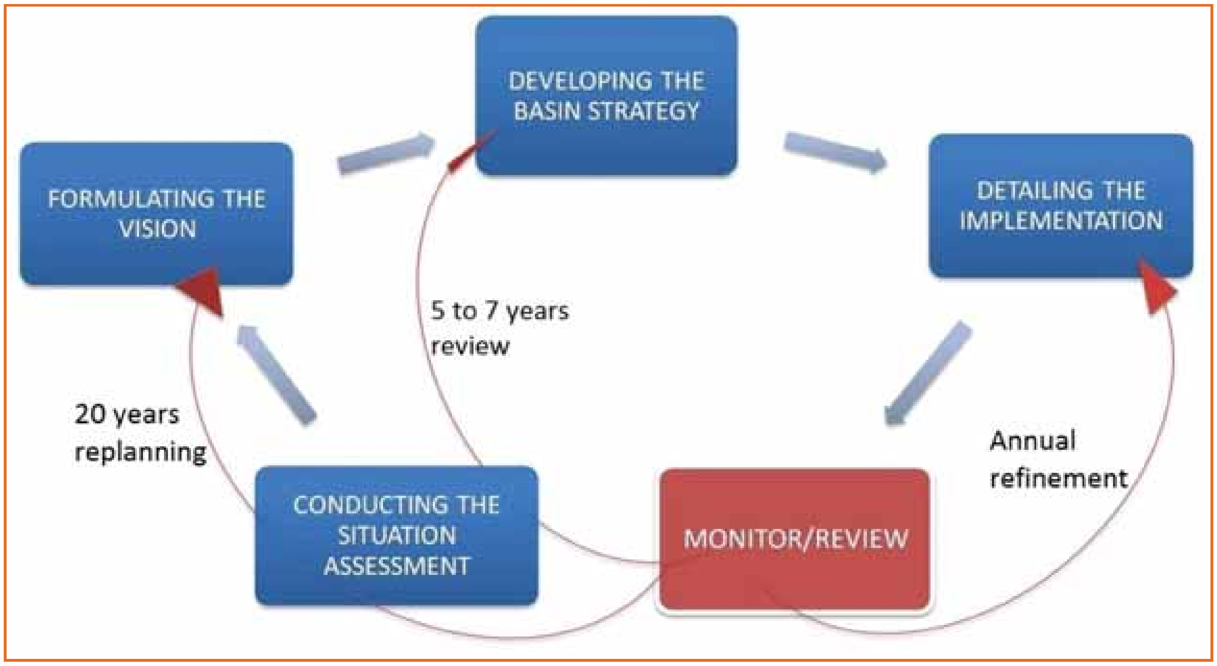


Figure VI. 3.1: The generic process of TRB development planning, iteration and adaptation

- *Annual refinement*: In dynamic situations, it is appropriate to conduct annual refinement of the implementation plans, focusing on actions, resources and responsibilities to achieve the agreed strategic outcomes and objectives (of the thematic and area-based plans).

- *Five to seven year review*: The planning processes should have a five to seven year review, during which the achievements of the plan will be evaluated so that whenever required, a revised strategy can be developed. This involves a review not of the long-term vision, but rather of the priorities and progress towards achieving it.

- *Twenty-year revision*: In order to maintain continuity and stability in implementation, a review and revision of the longer-term objectives and basin vision statements should not occur less than every twenty years, unless major changes in the basin invalidate the original assumptions and a fundamentally new planning process is initiated.

CHAPTER 4
SOCIO-ECONOMIC AND INFRASTRUCTURE DEVELOPMENT

4.1 INFRASTRUCTURE

Detailed survey and identification of various social and infrastructural components relating to TRB was conducted. Major points raised during interactions were considered in developing strategies in the form of sector-wise plans, grants and schemes discussed in the following paragraphs. Some of the points raised are given in Box VI. 4.1).

The hydropower development strategies for a high Himalayan basin such as the TRB demand that a balance of infrastructure development, socio-economic upliftment and, conservation of the ecosystems and biodiversity and protection of the environment be achieved. Therefore, the strategies and actions were formulated in conformity with these fundamental components.

Box VI. 4.1: Important Points that emerged during interactions

- Socio-economic and infrastructure development is required but implementation of project will cause severe damage to the environment.
- Some of the areas such as Zimithang are endowed with rich biodiversity and wildlife and these needs to be preserved.
- Agriculture and livestock farming will be severely affected. Project construction will cause loss of farmland and disrupt water availability for livestock needs.
- Influx of a large number of migrants will affect the Monpa culture, indigenous practices, and demographic and political structure.
- Disease incidence may occur due to influx and disruption of environment.
- In Zimithang circle, project implementation will affect seasonal resettlement during winter as makeshift habitation is located in lower altitude close to the project area.
- A few projects should be implemented first as trial and if successful, bigger projects can be taken up

Infrastructure need survey was conducted to appraise peoples' view/needs relating to basic infrastructure and the response was obtained during interaction with people in the influence zone is given in Table VI. 4.1.

Table VI. 4.1: Sector-wise development priority based on people's perception

Sl. No.	Sector	% of peoples response
1	Community welfare	57
2	Education	53
3	Agriculture	47
4	Road & transport	41
5	Water	35
6	Health	29
7	Power & Electricity	14
8	Animal Husbandry	10
9	Sanitation	8
10	Traditional skills	4

4.1.1 Rehabilitation

Resettlement (physical relocation) and rehabilitation (social and economic displacement) or R&R is an important component in any hydropower project. The TRB is inhabited by Monpa tribal since 500 BC and their livelihood depends mainly on forests and natural resources. They naturally have customary right over their land and forests which is realised/recognised and appreciated. As such, R&R is an important component of the hydropower policies of State Government and Government of India and also the National Rehabilitation and Resettlement Policy (NRRP), 2007.

There is no requirement for Resettlement as there is no displacement of families from the proposed 13 project sites. The impact in this regard will be confined to land acquisition required for the project components. These lands are mostly private and community forests/USFs. Therefore, rehabilitation is the only active component of R&R in the present HEP related development plan. The tribal communities of TRB have strong reservations on the diversion of land under USF, over which they enjoy customary rights. A major portion of the USF was therefore subjectively classified under private holdings from socio-economic survey and the total area along with total private land, agricultural land, horticultural land and habitation and home-garden of each affected and influenced villages was described in Section-II&III of this Report. Total land holding of affected and influenced areas under each proposed project site is given in Figure VI. 4.1.

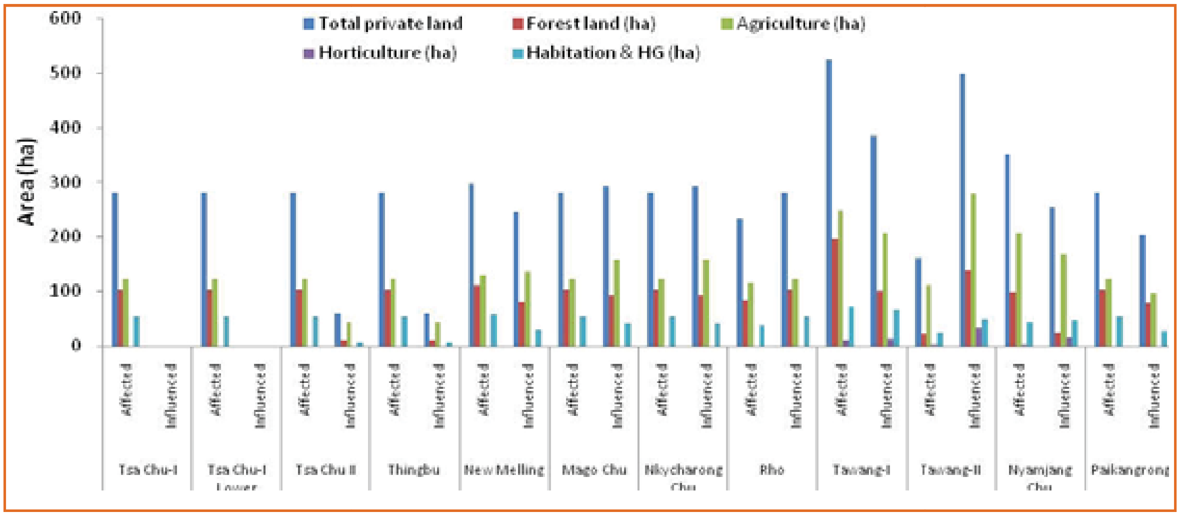


Figure VI. 4.1: Land holding pattern in affected and influenced villages in 10 HEPs project sites

4.1.1.1 R&R/TRBDP: Land compensation and compensation towards customary rights

All PAFs residing in affected villages inhabiting and having rights over resources within the project area as per the categorization and provisions for eligibility in the policy are entitled for compensation for their lost of land such as agricultural land, horticultural lands and customary rights over forests. The objective of the incentives is to assist PAFs to regain and also improve their previous standard of living. Special attention will also be given to those who practice transhumance or winter shifting to lower altitudes for cattle grazing.

The total population of affected and influenced villages under each of the proposed project is given in Table VI. 4.2.

Table VI. 4.2: Number of PAFs and number of villages under each proposed HEP

Sl. No.	Proposed project	Affected villages		Influenced villages	
		No. of villages	Number of HH	No. of villages	Number of HH
1	Tawang–I	13	742	12	429
2	Tawang–II	7	263	15	633
3	Rho	2	184	8	417
4	Mago	2	184	8	406
5	New Melling	2	183	5	354
6	Nykcharong chu	2	184	8	406
7	Tsa chu–I	2	184	0	0
8	Tsa chu–II	2	184	1	52
9	Tsa chu–I Lower	2	184	0	0
10	Nyamjang chu	9	453	13	378
11	Thingbu chu	2	184	1	52
12	Paikangrong chu	2	184	3	194

Most or all of the households listed in Table VI 4.2 above under affected villages will lose certain customary rights over their forest for NTPF collection, agricultural use, settlement expansion and any other activities, and the level of lost/impact will vary from one household to another. Compensation is therefore complicated and further complication also arises due to overlapping of the households under different HEPs. Moreover, quantification of affected land value and the total area belonging to each household is a perquisite to establish an unbiased compensation mechanism. However, this is beyond the scope of the present assessment. Therefore, further investigation is required by the implementing agency and close coordination and cooperation with the Village Panchayati Rajs/village heads will be vital in achieving this goal.

The subsequent approach is to develop a strong mechanism and guidelines based on existing policies of R&R and categorize households further within the concept of 'Project Affected Families (PAFs)' as defined in the Hydropower policy of India (Government of India, 2008). This is to ascertain that all sections of PAF so categorized, will get their rightful and equitable compensation due to them. Under such a mechanism, PAFs will be compensated appropriately by land-for-land, employment or by financial compensation, whichever is more feasible and/or more desired by the individual PAFs.

A separate fund will also be earmarked by the developers for the construction of electric crematorium wherever there is loss of cremation sites in the affected villages.

4.1.2 Education

Schools are the building blocks for learning and socialization. The quality of basic schooling system impacts significantly on further education. As per Census of India, there is an increase in number of all school institutions between 2006 and 2011 census in Tawang district (Table VI. 4.3). Consequently, there is an increase in literacy rates of male and female as well (Table VI. 4.5). Till 2011, the district had 78 primary schools, 60 pre-primary schools, 39 middle schools, 9 secondary schools and 4 higher secondary schools. Growth in educational institutions is only Primary, Middle and Secondary Schools while the number of Higher Secondary Schools remained same during the 5 years period. There was also growth in the number of students. The average teacher pupil ratio in Tawang district is 1:16 as of 2011 and the circle-wise teacher-pupil ratio is given in Table VI. 4.4.

Student population is expected to rise considerably with the implementation of HEPs. The projected literacy rate by 2031 for males and females are about 82% and 78.5% respectively (Table VI. 4.5). Therefore, more institutions should be set up including appointment of qualified teachers/staff and facilities to meet the demand. Additionally, a Government College should also be set up in the district because at present there is no college in TRB.

Table VI. 4.3: Total number of student, teachers, schools and college in Tawang district

Total No.	2006	2011	Growth between 2006 and 2011
College	NIL	NIL	-
Higher Secondary school	4	4	0
Secondary School	4	9	3
Middle School	23	39	17
Primary School	57	78	21
Pre-Primary School	-	60	-
Total Number of students	7408	10116	2708
a) Boys	3525	4466	941
b) Girls	3883	5650	1767
Total number of teachers	406	615	209
a) Men	279	401	122
b) Women	127	214	87

Source: Statistical Abstract of Arunachal Pradesh, 2006 and 2011

Table VI. 4.4: Circle-wise teacher pupil ratio in Primary School, Middle School and High and Higher Secondary School

Sl.No.	Name of Circle	Primary School	Middle	High and Higher Secondary
1	Tawang	1:12	1:14	1:16
2	Kitpi	1:10	1:10	1:16
3	Mukto	1:13	1:11	1:08
4	Bonghar	1:18	1:11	-
5	Jang	1:11	1:30	1:14
6	Thingbu	1:18	1:09	-
7	Lumla	1:11	1:11	1:18
8	Zemithang	1:14	1:10	-
9	Dudughar	1:16	1:08	-
10	Lhou	1:12	-	1:18

Table VI. 4.5: Average literacy as per Census 2001 and 2011 in Tawang district

	2001	2011	2031
Male literacy	60.32	67.54	81.99
Female literacy	30.04	46.53	78.51

In the influence zone, the average literacy rates among affected villages was least in Nyamjang chu affected villages and highest in New Melling affected village. With the exception of New Melling and Thingbu chu, the overall average literacy rates of the affected village in most sites is fairly poor being almost half of the state's literacy rate of 70%. This pattern is also the same for influenced villages with Namjang chu falling below 20%. Influenced villages of Mago chu, Nykcharong chu, Rho, Tawang-I and Paikangrong chu had similar trend being close to 50% (Figure VI. 4.2).

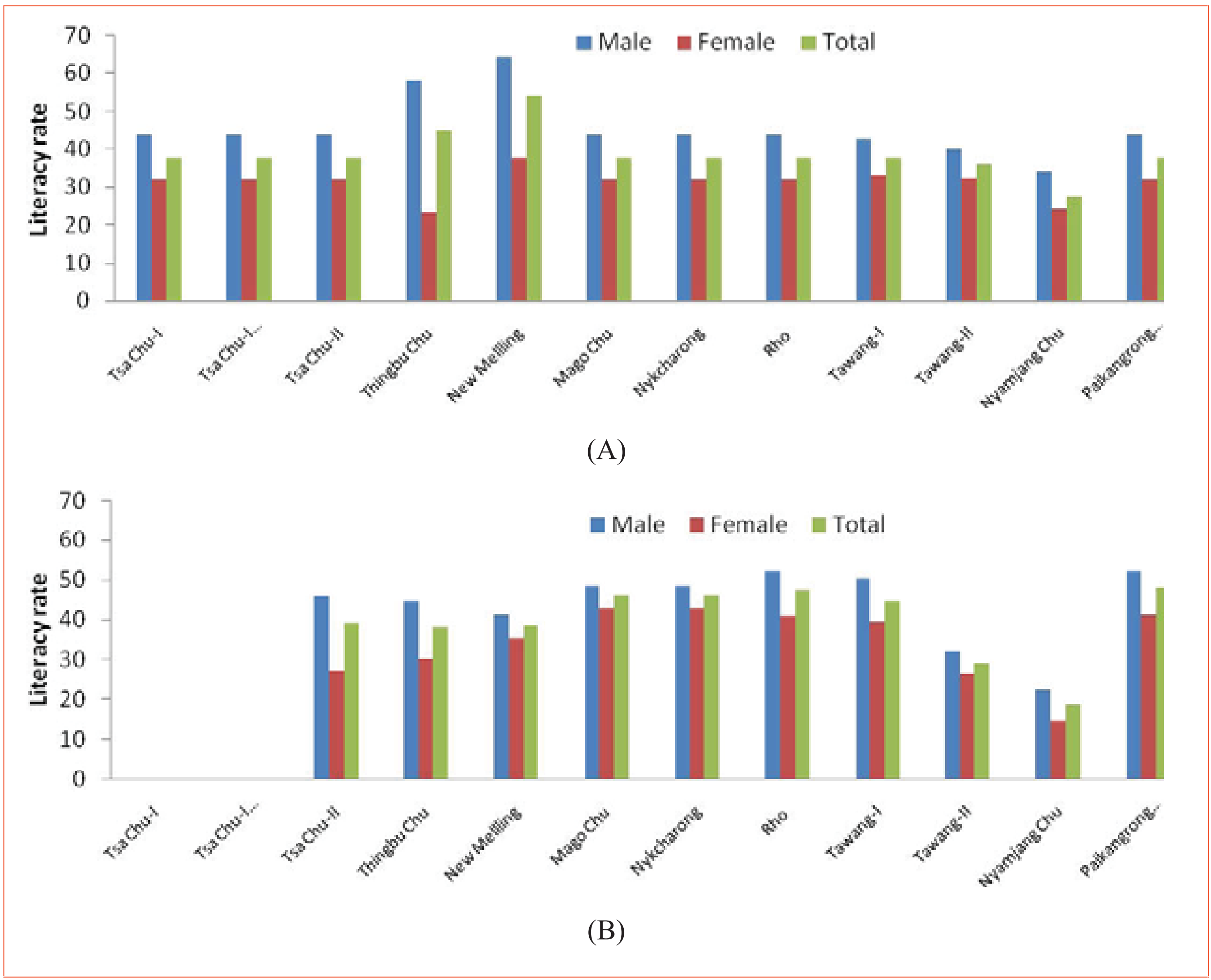


Figure VI. 4.2: Overall literacy rate of (A) affected and (B) influenced villages in 13 HEP sites

4.1.2.1 Need assessment and identification of infrastructure gaps

Schools in affected and influened villages are generally short of facilities and basic necessities such as drinking water, proper toilets. There is also a general need for repairing and extension in several institutions. The shortage of teachers and support staff was also informed during interaction with people and district adminisration. While this problem is not very severe in the district headquarters and towns, there is a general lack of not only teaching manpower but also ack of skilled/trained teachers in rural and villages in influence zone and hence quality of education is poor. A detailed list of needs identified during the survey and also as informed by the people are discussed below.This study identified the following requirements in basic education infrastructure in Tawang district (Table VI. 4.6).

Table VI. 4.6: Education related requirements for the PAFs identified during the socio economic and need assessment survey

Sl. No.	Requirement	Area
1	Teacher Shortage	In all the project areas
2	Computer Training Centre	District HQ
	District college	District HQ
3	Literate Staff at Aanganwadis (specially where nursery school is absent)	Yusum
4	Adult Education	District HQ
5	Career Counselling Centre	District HQ
6	Polytechnic College	Tawang District
7	Scholarships for Higher Education	Meritorious Class XII students
8	Educational Tours	Class IX, XI
9	Sports Training	Jang Circle
10	Develop School Grounds	In all the 4 Higher Secondary Schools

In addition to the above requirements, a comprehensive list of the circle-wise infrastructure needs in education sector of Tawang is given in Table VI. 4.7.

Table VI. 4.7: Estimated School infrastructure needs in 10 circles of Tawang district

Component			Tawang	Zemithang	Lumla	Dudunghar	Kitpi	Jung	Lhou	Mukto	Bongkhar	Thingbu
New Schools	Physical	New School	0	-	0	0	-	0	0	1	1	0
		New Classrooms	5	-	5	0	-	0	6	0	0	0
		Repairing, extension, construction, etc	0	-	0	4	-	1	6	12	7	1
		No. of Students	20	-	30	600	-	70	1080	400	600	30
	Financial (in Lakhs)		50	-	-	-	-	-	-	-	-	-
New Teachers Quarters	Physical		4	2	7	7	-	32	16	27	12	6
	Financial (in Lakhs)		44	22	70	66	-	33	66	-	-	33
Girls & boys hostel	Physical	No. of Boys	-	-	-	-	-	0	0	90	-	50
		No. of girls	-	-	-	-	-	0	0	50	-	25
		Hostels	-	-	-	-	-	2	2	0	-	0
	Financial (in Lakhs)		-	-	-	-	-	-	-	-	-	275
Mid-day Meal Kitchen	Physical		5	2	4	4	1	2	3	7	2	3
	Financial (in Lakhs)		5	2	16	4	1	-	-	-	-	3
Furniture in schools	Physical		1810	-	463	-	-	70	120	710	76	25
	Financial (in Lakhs)		118.7	-	5.5	-	-	-	-	-	-	-

Source: District gap assessment document

4.1.2.2 Education requirements in affected and influenced villages

Socio-economic survey revealed that there are no schools in 16 affected and influenced villages (Table 4.1.8). While some of these may have schools in the adjacent villages, basic education is however required in each of the villages to ensure that all PAFs have convenience access to basic education for their children. Priority assistance to education may be given to the affected villages in this list i.e., Dugumba, Poito, BTK, Kelenteng and Teli. There is also a general lack of proper facilities such as drinking water and toilets in schools in affected villages. The need for upgrading basic infrastructure, teachers' requirements, furniture and computer facilities in schools has been expressed by the people of Teli, Shyro, Gyada, Tsaikhar, Maio and Poito, Hoongla, Tsaikhar and Yusum. The respective HEP developers should consider these villages on priority basis as listed in Table VI. 1.3. The new Schools should recruit adequately skilled teachers and support staff.

Table VI. 4.8: List of affected and influenced villages with no schools

Sl. No.	Village	Total no. of impacting HEP		Name of impacting HEP	
		Affected	Influenced	Affected	Influenced
1	Gemreteng		4		Mago chu, Nykcharong, Tawang-I, Tawang-II
2	Kregyang		4		Mago chu, Rho, Tawang-I
3	Regyang		4		Mago chu, Nykcharong, Rho, Tawang-I
4	Dugumba	1	1	Tawang-II	Nyamjang chu
5	Dungse		2		Rho, Tawang-I
6	Gyada		2		Tawang-I, Tawang-II
7	Maio		2		Tawang-II, Nyamjang chu
8	Menteng		2		Tawang-I, Tawang-II
9	Pharmey		2		Tawang-II, Nyamjang chu
10	Poito	1	1	Tawang-II	
11	Brokenthang		1		Nyamjang chu
12	BTK	1		Nyamjang chu	
13	Dung		1		Nyamjang chu
14	Gorsam		1		Nyamjang chu
15	Kelenteng	1		Nyamjang chu	
16	Teli	1		Tawang-I	

4.1.2.3 R&R/TRBDP: School infrastructure development schemes, merit scholarship scheme and grants for teachers' training

A quality education and literacy enhancement plan will be initiated by the developers and they are bound by State and National R & R Policy (2008) to provide assistance to education and to offer scholarships to the eligible persons from the affected families as per the criteria fixed by the government. Educational infrastructure is also required to be enhanced and assistance from the developers is imperative in this regard. This is important in order to improve literacy and encourage education in the project affected areas. The developers are required to introduce a scholarship scheme based on merit for children of PAFs to encourage students in pursuing studies (Table VI. 4.10). This is especially important considering the plausible impact that HEP construction and implementation will have on education (Table VI. 4.9).

It maybe suggested that the criteria for eligibility will be set by the Education Department of Tawang district. If the wards from the affected families are not available, the merit scholarship scheme would be extended to families of nearby influenced villages. The students should not at the same time receive any other scholarship of State and Central government and they should be studying in school, college or any other educational institute recognized by the state and central government. Besides offering scholarship, the developers will provide assistance to education infrastructure.

The project developers are expected to strengthen the existing educational facilities of affected villages. The project developers can set priority and setup schools in affected villages with no school as listed in Table VI. 4.8 in comparison with the list of villages prioritized in Table VI. 1.2. The project proponents will decide the ideal places for the establishment of schools in consultation with State Education Department and Village Councils of the respective affected villages. The project authorities would provide all the infrastructure, salaries and maintenance grant for the schools for at least 10 years.

Most of the affected villages only have access to secondary and higher secondary education at nearby circle headquarters and hence, the developers are expected to set up a secondary or higher secondary school in colony area for their staff, worker and PAFs, besides, villagers in adjacent areas can also be beneficiaries of the facilities.

Training grants for teacher will also be allocated by the developers for schools set up by them in their project areas. Training and support can also be conducted by Education Department. Training support can also be extended to government teachers and funds for which can be drawn from the TRBDF subject to decisions and conditions to be set by the TRBDA. The TRBDA will be responsible for checking and monitoring school dropouts that may arise out of HEP implementation.

Table VI. 4.9: Perceived impact on HEP implementation on education

Potential impact*	Action required/Mitigation measure	Responsibilities
Increase in students during construction	Assist and improve existing facilities to required standard and capacity to accommodate students population from PAF workers families	HEP developers
School children dropouts that may arise from resettlement etc	Support and encourage students to continue with studies, HEP developers will offer merit scholarships	Department of education, HEP developers, Village level society/organisation

* Education agencies can be subcontracted to monitor and investigate the enrolment, dropout of students, and to monitor the efficient implementation of scholarship schemes/educational assistance.

Table VI. 4.10: Proposed TRBDP activities education sector for affected/influenced villages in each HEP area

Sl. No.	Activity/component
	Infrastructure
1	New Schools at project sites
1	Infrastructure facilities to School
2	Infrastructure facilities to HS School
3	Infrastructure facilities to the College
4	Construction/renovation of School Building
5	Furniture and laboratory
6	Computer lab
7	Library and books
	Merit Scholarship Scheme
1	Scholarships for the Primary School Children
2	Scholarships for Upper Primary (Class VI-VIII)
3	Scholarships for the Secondary/School Leaving (X Class)
4	Scholarships for the Higher Secondary (XII Level)
5	Scholarships for the Graduate level
6	Salaries for teachers
7	Salaries for staff
	Training grant
1	Training for teachers and/or support staff
2	Exposure visits for school students to technical institutions outside TRB

4.1.3 Health

Health and well-being of the people in villages depend on their access to local health systems and these are often located at the nearest town and headquarters which are not very easily accessible particularly for remote villages. The only proper health care centres with good facilities are Tawang district hospital and circle level health centres. The absence of proper road connectivity and the distance of the villages from the nearest headquarters are also detrimental particularly for emergency health care requirements.

4.1.3.1 Need assessment and identification of infrastructure gaps

The requirement of health facilities in 10 circles of Tawang is given in Table VI. 4.11.

Table VI. 4.11: Estimated health infrastructure needs in 10 circles of Tawang district

Infastructure		Tawang	Zemithang	Lumla	Dudunghar	Kitpi	Jung	Lhou	Mukto	Bongkhar	Thingbu
New Health Units	CHC	0	0				0	0	0	0	0
	PHC	0	0				0	2	3	2	1
	Quarters (Type I-IV)	19	2				4	0	4	0	0
	District Hospital	1	0				0	0	12	0	0
	Total units	20	2				4	2	19	2	1
	Financial (in Lakhs)	-	-				-	-	-	-	-

	Villages covered	1	1				1	2	3	2	1
Quarters for Doctors and paramedical staff	Physical (total units)	30	6	6		6	31	15	9	8	
	Financial (in lakhs)	-	-	-		-	-	-	-	-	
	Villages covered	1	1	1		1	1	2	4	2	

Source: District gap assessment document

Health requirements of PAFs from affected villages were identified (Table VI. 4.12).

Table VI. 4.12: Health requirements of PAFs identified from need assessment and socio-economic survey

Sl. No.	Requirement	Area
1	Adoption of health centres	*Thingbu circle, Mukto Circle
2	Visiting doctor	(for villages far from any circle HQ)
3	Ambulance service	From every circle HQ to District Hospital
4	Pharmacy, pathology collection centre	At every circle HQ
5	Aid to students suffering from dental, eye care issues	Identified through School Health Programmes
6	Mobile health clinics	All HEPs
7	Paramedical staff support	district headquarters and circle hospitals
8	Specialists doctor support	District headquarter hospital
9	Establishment of two modern health centres by project proponents one each in Jang and Lumla.	Jung and Lumla

4.1.3.2 Health requirements of affected and influenced villages

Assessment of health facilities has been carried as part of the socio-economic survey within the affected and influenced villages. It was found that 34 different villages falling under affected and influenced areas had no community/primary health centres but rely on those located in their nearest circle/town/headquarters (Table VI. 4.13). There are 13 of the listed villages which are more than 10 km from their respective headquarters. Setting up of basic health facilities and community health centres in these villages is the main concern, particularly 3 villages viz., Jangda, Gomkang and Kudung which are affected by more than one HEP. These villages will be most subjected to hydropower project activities, resettlements and immigration of workers. Hence, expose to new diseases and demographic pressure may result to incidence of diseases and greater chances for epidemic.

The other villages in the list (Table VI. 4.13) can be prioritized from the list of prioritized villages prepared (Table VI. 1.3).

Table VI. 4.13: List of affected and influenced villages with no health centres

Sl.No.	Village name	Distance from the nearest circle HQ (km)	No. of HEP impacting	
			Affected	Influenced
1	Baghar	13	1	1
2	Brokenthang	3		1
3	BTK	10	1	
4	Dugumba	5.7	1	1
5	Dung	3		1
6	Gemreteng	4		2
7	Gomkang	19	2	
8	Gorsam	8		1
9	Gyada	18		2
10	Gyankhar	12	1	1
11	Hoongla	4	1	2
12	Jangda	15	9	1
13	Kelenteng	3	1	
14	Kharman	2	1	1
15	Kharthut	13		1
16	Kregyang	2		2
17	Kudung	28	2	
18	Maio	4		2
19	Menteng	4		2
20	Mirba	10	1	3
21	Nam Tsering	20		2
22	Pharmey	5		2
23	Phomang	12		1
24	Poito	8	1	1
25	Regyang	3	1	1
26	Sazo	7		2
27	Seru	16		1

28	Sherbang	11		1
29	Shyro	7	1	5
30	Teli	14	1	
31	Thrillam	17	1	
32	Tsaikhar	18	1	
33	Yabab	12		2
34	Yusum	21	1	

Source: District gap assessment document

4.1.3.3 R&R/TRBDP: Worker health program (WHP) and Public health delivery plan (PHDP)

There was no particular health risk both in the affected and influenced villages as well as the entire district as a whole. The protective strategy is to combat if such disease occurs in future especially from project activities (Table VI. 4.15). This is because project implementation is likely to affect the environment and density of population is bound to change; there is a possibility that untreated run-off from project area flows into the streams and other water sources. There is also a concern for hygiene in the absence of proper sanitation facilities (Table VI. 4.14).

Table VI. 4.14: Perceived impact on HEP implementation on health

Potential impact	Action required/Mitigation measure	Responsibilities
1. Introduction and spread of disease during project construction phase	-Carry-out pre employment screening -Support existing health services with both facilities and human resources	HEP developers
2. Health issues from noise, air, dust, vehicles and environmental contaminations	-Set up heath centre at the project sites that can be accessed by workers and PAFs/villagers.	
3. Health impact from crowding etc	-Health awareness/campaign, education and communication on hygiene and prevention of diseases	Department of health, Village level society/organisation

The public health action plan is being proposed keeping in view the needs of the PAFs living in the affected villages. The HEP developers can develop two main health and safety plans i.e., the Worker health program and the public health delivery plan.

(i) The WHP will be the entire responsibility of the developers' management board and can be supported by government hospitals for referral purposes. The program will include preventive and education for the workers throughout the project period, and will include rules and regulations. The developers are required to set up a health care clinic for workers in their respective clusters e.g., at Jung for SEW projects and at Lumla for NHPC projects.

(ii) The PHDP is aimed firstly at providing the local PAFs of affected villages including the influenced villages with proper health facilities. Secondly and more importantly, this program is aimed at mitigating negative impacts on the population's health due to the immigration of workers and crowding during construction and operation of HEPs. If required under this plan, creation of separate health centres is proposed to be sanctioned by the developers to meet the health needs of the local community particularly where there are many affected and/or influenced villages in the vicinity of the project site.

To ensure sustainability, the provision of health service in the affected villages remains the primary responsibility of the developers in providing adequate financial and technical support to the existing government health services so that implementation of all health plans related to the primary health care is carried out uninterrupted and secondary health services are available on a referral basis to the impacted population.

The district health administration will provide guidance in determining the number of health specialist and medical staff so that adequate health services are rendered. The TRBDA will play a key role in decision making relating to setting up health centres for local community. The TRBDA in collaboration with district health office will also monitor and coordinate with the health specialists to ensure that health programs and preventive health measures under the hydropower plans are carried out effectively.

Table VI. 4.15: TRBDP activities in health sector for affected/influenced villages in each HEP area

Sl. No.	Activity/Component
1	Primary Health Care (New two health centres at respective HEP sites)
2	Secondary health care (Assistance to existing PHCs/other health centres)
3	Health screening prior to employment
4	Health awareness/campaign

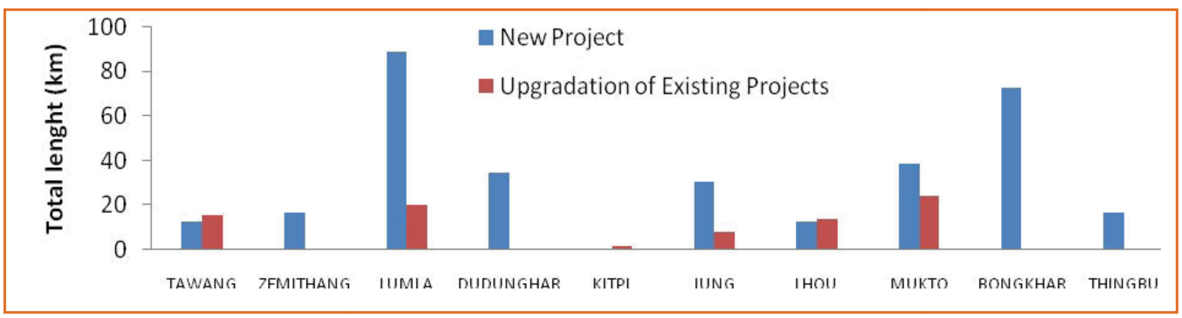
4.1.4 Road connectivity and transport

The entire TRB is characterised by difficult terrain and hence road infrastructure is poorly developed in the entire region. In fact, the entire state lacks proper road connectivity. In the Human Development Report (2005) of Arunachal Pradesh, it was estimated that in rural areas of Tawang district, 20.10% of the population had access to *pucca* roads, 27.78% to *kutcha* roads, and 52.12 % had absolutely no road connectivity. In Tawang district, 25.66% of the villages had road connectivity while 74.34% were not connected (Connectivity of villages, Public Works Department, Government of Arunachal Pradesh, 1997).

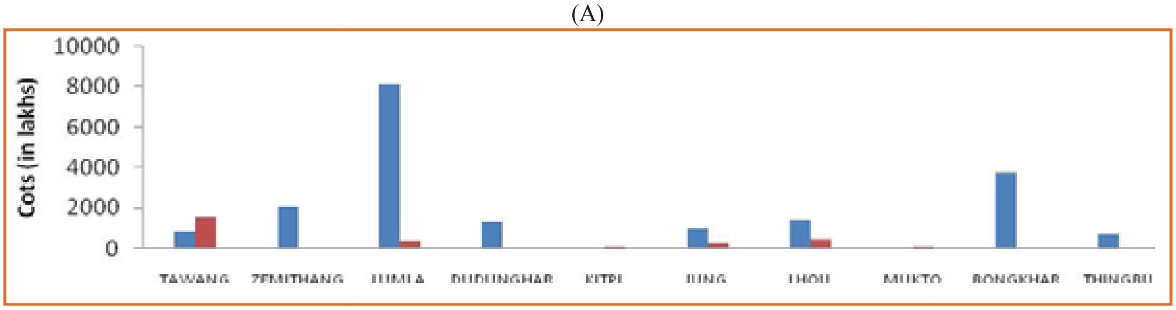
Development of road infrastructure forms the most important aspect of not only socio-economic development of the region but also of HEP implementation. As such, this will be treated as one of the most important priority during design and construction phase.

4.1.4.1 Need assessment and identification of infrastructure gaps

The requirement of road infrastructure within Tawang is given in Figure VI. 4.3.



(A)



(B)

Figure VI. 4.3: Gap assessment in road infrastructure in ten circles of Tawang district. (A) Physical and its corresponding (B) Financial estimation (Source: District gap assessment document)

4.1.4.2 Road requirements of affected and influenced villages

Most of the affected and influenced villages have basic road connectivity and only three villages were completely unconnected (Table VI. 4.16).

Table VI. 4.16: List of affected and influenced villages with no road connectivity

Sl.No.	Village name	Distance to Headquarter (km)	Circle	HEP site
1.	Gomkang	19	Tawang	Tawang-I (Affected) Tawang-II (Influenced)
2.	Khamba	4	Lhau	Tawang-I (Affected)
3.	Gyankhar	12	Tawang	Tawang-I (Influenced) Tawang-II (Influenced)

4.1.4.3 R&R/TRBDP: Road construction and network expansion scheme

A major contribution to building road infrastructure comes from and during HEP construction phase where road connectivity is an important component of all project activities. However road construction for project related works may not cover the affected and/or influenced villages. As such, the concerning HEP developers should earmark a separate fund for road construction for local accessibility under TRBDP. Under the combined road construction for project activities and TRBDP schemes, the villages should become accessible by large vehicle such as trucks and buses. Proper roads network will also be extended to the three villages i.e., Gomkang, Khamba and Gyankhar by the impacting project developers of Tawang-I and Tawang-II sites. It is also imperative that the developers meet some of the demand of the people such as the creation of access road network to areas such as agricultural lands.

There are many positive impacts of developing road infrastructure. For example, villages will be more accessible by cars and large vehicles, bus routes network will be extended and visits by other departments such as service providers, postal service and health departments will be frequent, marketing channel and business for local agricultural produce will be improved. Nonetheless, there are also adverse impacts that should not be overlooked (Table VI. 4.17).

Table VI. 4.17: Perceived impact of road construction

Potential impact	Action required/ Mitigation measure	Responsibilities
1. Forest destruction and habitat loss 2. Landscape vulnerability to landslide and mud-slide 3. Greenhouse gas emissions from road, air pollution and smog.	Adopt sustainable transport system and proper planning during design construction phase.	HEP developers, District transport office

The developers will play its role in road construction in the interest of implementing their project. However, the district office can be effectively involved as planners in implementing road construction under TRBDP for communities of affected and influenced villages (Table VI. 4.18). Village-level organization will be responsible for identifying sites and providing lands for construction, propose relocation of village road if the existing ones will be affected by project activities. The funds from various relevant government schemes may be leveraged for this activity.

Table VI. 4.18: Proposed TRBDP activities in road sector for affected/influenced villages in each HEP site

Sl.No.	Activity/Component
1	Access Road Construction/Expansion/Realignment
2	RCC bridge
3	Construction of footpaths
4	Transportation facilities
5	Bus Stops/Rain shelters

4.1.5 Power and electricity

Electricity can be seen as an essential infrastructure in the same category as road. Hence, development of power infrastructure for the entire TRB is an important priority for the project developers.

4.1.5.1 Need assessment and identification of infrastructure gaps

The power and electricity need in different circles of Tawang is given in Table VI. 4.19.

Table VI. 4.19: Gap assessment in power sector in ten circles of Tawang district

		Tawang	Zemithang	Lumla	Dudunghar	Kitpi	Jung	Lhou	Mukto	Bongkhar	Thingbu
New Projects	High mast light	6		0	1		20	11	0	1	0
	Street light	400		150	1		1	37	0	1	0
	LT line	153		13	0		0	0	0	0	0
	Electric post	0		0	0		0	0	15	0	0
	Others	3	0	1	0	0	1	0	1	4	1

	Financial (in Lakhs)	**6120.74**		**202.76**	**-**		**894.37**	**-**	**115.19**	**-**	**-**
Upgradation of existing projects	High mast	0		0				0	0	0	
	Street light	0		0				6	0	0	
	LT line	0		0				0	0	0	
	Electric post	0		5				0	288	1	
	Others	1	0	0	0	0	0	1	0	0	0
	Financial (in Lakhs)	**72.43**		-				-	-	-	

Source: District gap assessment document

4.1.5.2 Power requirements of affected and influenced villages

The survey revealed that all of the affected and influenced villages have electricity connection. However, it is generally noted that the loss in electricity is prevalent and the main causes are attributed to the poor maintenance, transmission and distribution (Table VI. 4.20).

Table VI. 4.20: Need assessment of PAFs in affected/influenced villages

Category	Requirement	Area
Electricity	24 hrs electricity/fixed hour power cut	Tawang township and interiors

4.1.5.3 R&R/TRBDP: Power supply scheme and tariff subsidies

As stated in the hydropower policy (2008) of Arunachal Pradesh, the project developers will earmark 1.0% free power of the project capacity for local development, income generation and community welfare activities. Hence, the same will be credited to the TRBDF and is to be used and decided by the TRBDA. In addition to this, the affected villages are also entitled an additional 1.0% from the state government's share of minimum 12.0% free power as recommended in the Government of India's hydropower policy (2008). This entitlement however depends on State Government's decision keeping in view the developmental needs of affected and/or influenced villages within the project domain of each HEP sites.

Under the provision 3 of the Electricity Act, 2003 of the hydropower policy of the Government of India, the PAFs of affected villages are also sanctioned to receive electricity corresponding to 100 units free of costs every month for a period of ten years from the date of commissioning. However, the lists of PAFs from the designated resettlement areas and/or project areas entitled under this Act, has to be passed and approved by the state government.

4.1.6 Water and sanitation

The aspect of water for drinking, domestic, agricultural uses and irrigation is an important component in infrastructure development of the entire Tawang district which is characteristically a rural domain (Table VI. 4.21).

*4.**1.6.1 Need assessment and identification of infrastructure gaps***

Table VI. 4.21: Need assessment of PAFs in affected/influenced villages

Requirement	Area
Drainage System, Water Connections, Nalas	All over rural Tawang

The physical requirements in power sector under different circles of Tawang are given in Table VI. 4.22).

Table VI. 4.22: Physical and financial estimation of infrastructure gaps in water supply in ten circles of Tawang district

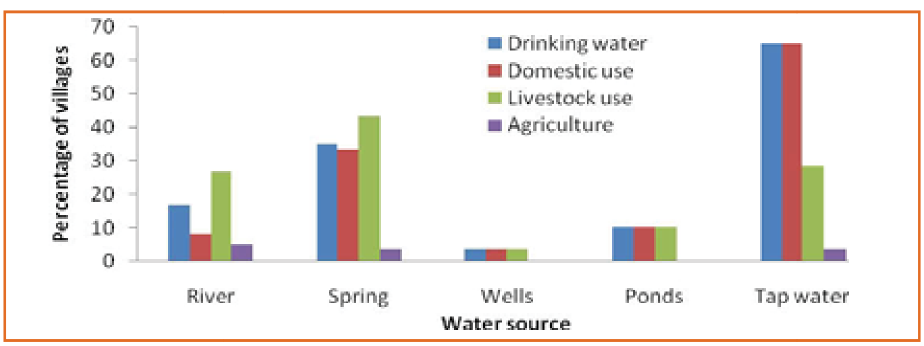
			Tawang	Zemithang	Lumla	Dudunghar	Kitpi	Jung	Lhou	Mukto	Bongkhar	Thingbu
Water supply	New projects	Physical(water connection, platform, water tank, pipeline, upgradation)	5		14	6		5	35	8	23	8
		Financial (in lakhs)	501		256.6	84.2		-	-	-	-	-
		Villages covered	5		14	6		5	10	6	5	4
	Upgradation of existing projects	Physical (water connection, platform, water tank, pipeline, upgradation)	3	1	1	1		1	2	7	1	-
		Financial (in lakhs)	96.2	50	30	35		-	8.9*	79.5	35.8	-
		Villages covered	1	1	1	1		2	2	5	1	1
Irrigation	New projects	Physical(method of irrigation)	1	1	11	3	1		-	2	8	
		Financial (in lakhs)	20	20	237	155	60		-	-	60*	
		Villages covered	1	1	11	3	1		1	1	5	
Urban and rural sanitation	New projects	Physical(units)	1		12			9	24	91	70	22
		Financial (in lakhs)	493.5		-			72.3*	-	-	-	-
		Villages covered	1		4			2	3	6	1	2
*Estimation is for 1 unit only												

Source: District gap assessment document

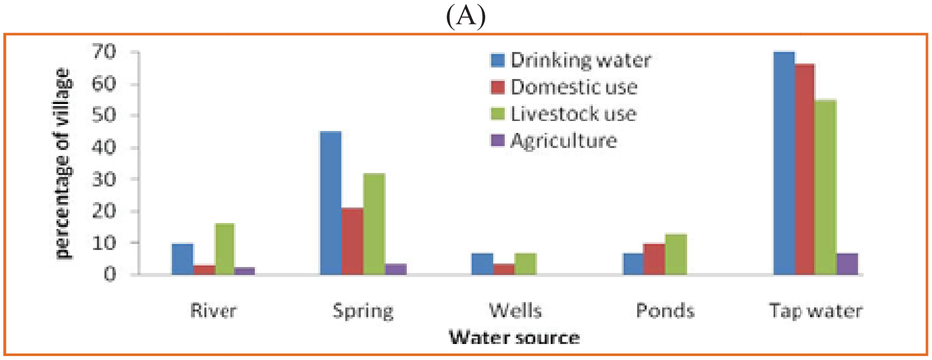
4.1.6.2 Requirements of affected and influenced villages

Drinking water supply and sanitation in TRB is presently not very adequate. Moreover, the project implementation and construction is liable to disrupt the normal supply of water especially from natural stream and other water bodies, particularly in the face of growing population from immigration of workers.

The dependence of drinking water and for domestic use is mostly from tap water sources. Livestock requirement of water is dependent mostly on hill streams/spring followed by tap water and river. The dependence on wells and ponds is relatively less, although wells are more important source in influenced villages than in affected villages, whereas river is more important for affected villages compared to influenced villages (Figure VI.4.4).



(A)



(B)

Figure VI. 4.4: People's dependence on water source in (A) affected and (B) influenced villages

4.1.6.3 R&R/TRBDP: Water supply & irrigation schemes, Sanitation and Solid Waste Management Plan

Of all the uses, drinking water has health implications and affects the overall quality of life and poorer PAFs who have to manage water from distant sources in the absence of nearby tap water source. Although dependence of water for different uses comes chiefly from tap water, it is important to note that its major source in all the affected and influenced villages is from nearby rivers and seasonal springs. Such tap water systems in rural areas were constructed mainly through small government schemes.

The National Water Policy (Government of India, 2012) envisaged that water is a prime resource and water allocation priority should broadly be in the order of drinking water, irrigation, hydro power,, navigation and other uses. It is imperative that the water supply be given utmost importance in TRBDP (Table VI. 4.23). HEP developers will provided appropriate schemes for water supply to the affected and influenced villages and PAFs in particular. The convenient location of public water source may be identified by village councils of the respective villages.

Table VI. 4.23: Proposed TRBDP activities in water sector for affected/influenced in each HEP area

Sl. No.	Activity/Component
1	Safe drinking water source for PAFs
2	Storage and water treatment facilities
3	Pipelines to channelize water to public locations
4	Drinking water facilities in schools of affected and influenced villages
5	Public drinking water facilities in community area
6	Irrigation facilities
7	Sanitation facilities for community and workers camp/construction sites

Sanitation and Solid Waste Management Plan: It is important to ensuring hygiene, protect water sources, and prevent contamination of surface water by human waste and the transmission of water-related diseases in the influence villages. Therefore, proper sanitation facilities will be provided in the workers camps and at major HEP construction sites and with a ratio of one toilet for no more than 20 workers. The designed capacity of the facilities will have to accommodate the expected load over the full construction period. A maintenance program of the facilities will be presented in the construction plan, to approval by health & sanitation committee of TRBDA.

4.2 SOCIO-ECONOMIC

There are socio-economic vulnerabilities associated with HEP development in TRB which will cause rehabilitation of many PAFs of affected families. What follows is the economic pressure that may arise from immigration of workers etc. The social and economic effects of rehabilitation though less adverse than resettlement, may include, joblessness, food insecurity, community disarticulation, increased morbidity, loss of community resources.

The project areas are mountainous and socio-economic development is poor. Although affected people will be provided with TRBDP/TDP and R&R schemes from which they will receive improved access to education and medical services. Still, many of the vulnerabilities are likely to prove challenging for the affected populations. Survey results revealed that 10% of the annual earnings of PAFs is contributed by agriculture, 15% from traditional skills, 19% comes from daily wage activities, while a major contribution comes from animal husbandry with 43%. Other less important contribution comes from Government Service (7%), others (5%) and least importantly by horticulture (Figure VI. 4.5). While the economy is based mostly on animal husbandry accounting for almost half of the total income, agriculture and cultivation is still an important part in the livelihood of the local people.

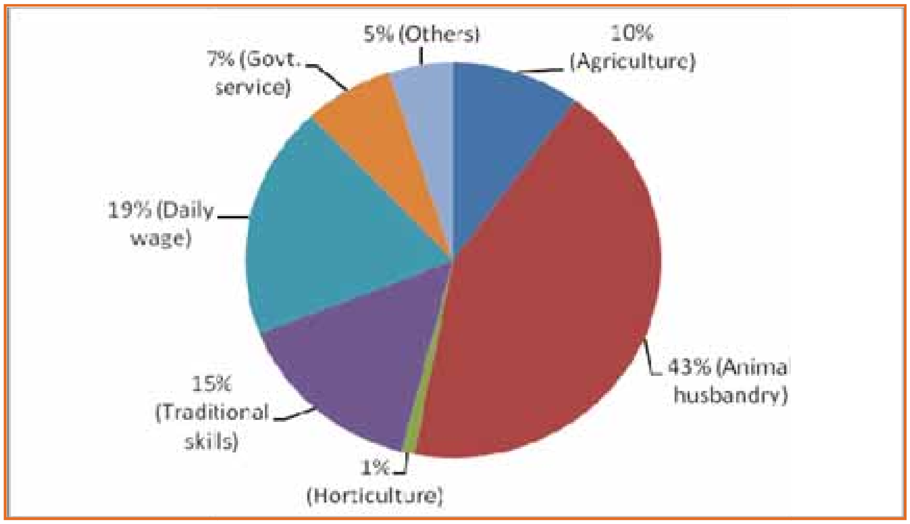


Figure VI. 4.5: Percentage contribution of different sector towards average annual earnings of PAFs in HEP impacted villages of TRB

Out of the seven economic sectors provided in Figure VI. 4.5, four contributed significantly to the overall economy of the affected villages viz., animal husbandry, traditional skills, agriculture and daily wage. Daily wage can be considered as an unrelated component since it is dependent on other sectors. As such, the other three most significant sectors are elaborated in this Section.

4.2.1 Agriculture

Hydropower development will adversely affect agricultural activity of TRB. The combined total area of agricultural land in affected villages is more than in influenced villages. Therefore many hectares of agricultural land will be affected. Positive impact may also occur depending on if it can be harnessed and exploited efficiently or not. For example, construction of dam can ensure availability of water for irrigation, drinking and domestic uses particularly for villages which depend on water source from seasonal streams. Irrigation water needs in Tawang district is given in Table VI. 4.24.

Table VI. 4.24: Physical and financial estimated irrigation infrastructure needs in 10 circles of Tawang district

	Tawang	Zemithang	Lumla	Dudunghar	Kitpi	Jung	Lhou	Mukto	Bongkhar	Thingbu
Physical (method of irrigation)	1	1	11	3	1	-	-	2	8	-
Financial (in Lakhs)	20	20	237	155	60	-	-	-	60*	-
Villages covered	1	1	11	3	1	-	1	1	5	-

* Estimation is for one unit only; (Source: District gap assessment document)

The percentage of area under agricultural land out of the total private land holding is given in Figure VI. 4.6. There is not much difference in the percentage of agricultural land in affected and influenced villages in all project sites. In affected areas, it ranged from 44% in Tsa chu-I, Tsa chu-I Lower, Tsa chu-II and Thingbu chu, to a very high percentage of 74% in Tawang-II. New Melling, Mago chu, Nykcharong chu, Rho, Nyamjang chu and Paikangrong chu have percentage agricultural land ranged from 51% to 61%. Influenced villages in all sites ranged from 43% to 73% except Tsa chu-I and Tsa chu-I Lower which had no influenced villages.

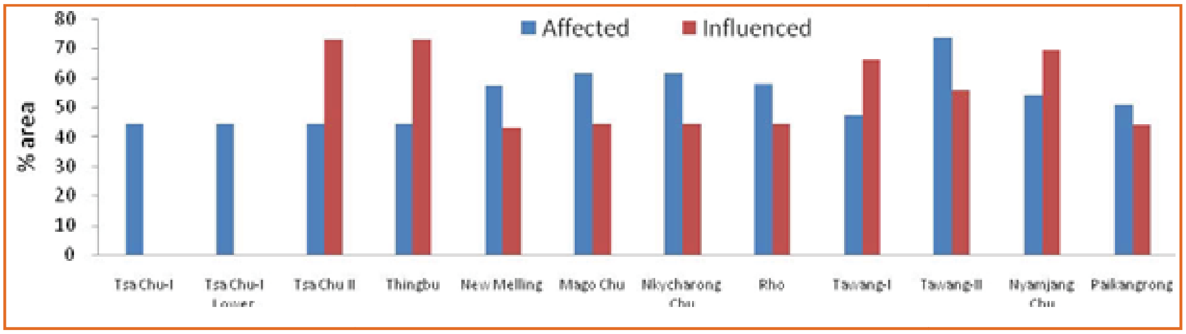


Figure VI. 4.6: Average percentage of agricultural land out of the total land holding in affected and influence villages in each HEP sites

The average annual earnings from agriculture are similar in all sites with income ranged from 25 lakh to 35 lakh except in Tawang-I, Tawang-II and Nyamjang chu where average annual earning was from 5 lakh to 15 lakh. Among influenced villages, Thingbu village which is being influenced by Tsa chu-II and Thingbu chu had highest average annual earnings of 22 lakh while the various influenced villages of Tawang-I, Tawang-II and Nyamjang chu had the least average annual earnings of 6 to 9 lakh (Figure VI. 4.7).

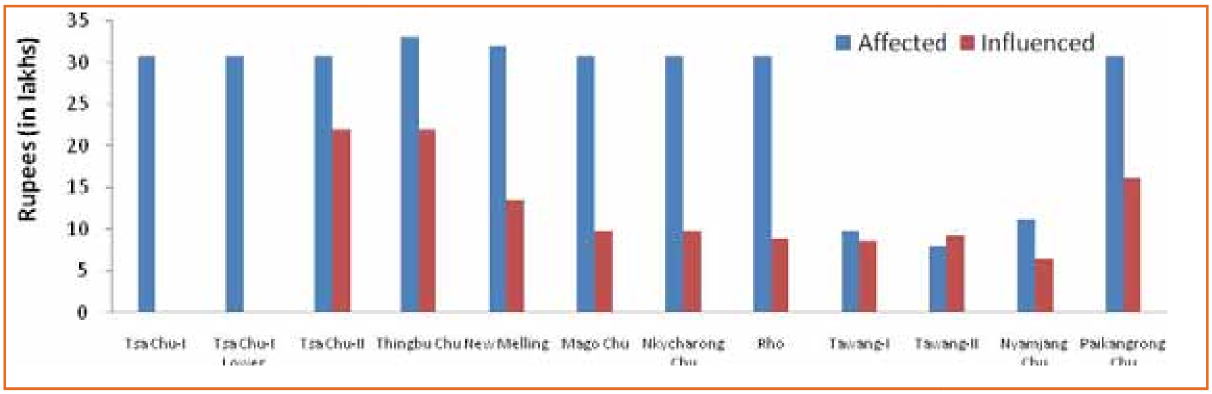


Figure VI. 4.7: Average annual earning of people in affected and influenced villages under each project site

Tawang-I, Tawang-II, and Nyamjang chu had high percentage of land under agricultural land however the economic return from agricultural sector is among the lowest. Investigation is needed to ascertain the cause for this incongruity so that appropriate development scheme can be granted by the developers of these sites. Polyhouses for vegetable cultivation for supply to expanding army establishments and for local consumption may be initiated. Similarly, horticulture such as large scale walnut cultivation may be promoted.

4.2.1.1 R&R/TRBDP: Land compensation and agriculture development package

For agricultural land compensation to the affected PAFs, the R&R scheme-Compensation towards customary rights of land mentioned under the sub-head "*Rehabilitation*" will be followed. However, it is important to note that PAFs that are provided with new agricultural land under land-for-land procedure for new and settled cultivation are likely to see reductions in income because the most fertile land in the area has been inundated. As a result, incomes of PAFs may fall regardless of where they are rehabilitated especially during the first years of cultivation which is likely to involve high costs for land clearing, soil preparation, terrace making etc. Keeping this in mind, appropriate and justified compensation should be availed to the PAFs by the concerned developers.

Agro-forestry may also be introduced and farmers may be trained to upgrade skills and adopt new technology to enhance productivity of agricultural land, reduce soil erosion among others. Agricultural sub-committee of TRBDA can be given the task to identify technology that can be used in this aspect. Agriculture development package will encompass the plans listed in Table

VI. 4.25. In addition to the package, irrigation scheme mentioned earlier will also assist towards development of agriculture.

Table VI. 4.25: Break-up of the proposed agricultural development package

Activity/Component	
1. Compensation	Land-for-land system/employment Financial compensation
2. Agricultural land development	Jhum mitigation plan Agro-forestry development plan
3.Technical assistance	Land preparation grant Irrigation water supply plan Training assistance for skill upgradation & technology adoption
4. Infrastructure	Quality planting materials (QPM)* Supply of fertilizers/pesticides* Rural bio-resource centre for value addition of agricultural produce

* Agriculture Department may also provide additional support by supplying improved varieties of seeds, fertilizers and pesticides under a separate government scheme

4.2.2 Animal husbandry

Animal husbandry plays an important role in the rural economy of TRB villages. A large number of affected villagers depend on animal husbandry for their livelihood. In addition to supplying basic necessities such as milk, meat, eggs, manure etc., livestock is an important component in cultural and traditional ethics. The value of economic output from this sector is the highest (Figure VI. 4.5). Population-wise, the cattle population is highest in the affected village category in all project areas, followed by Yak and sheep population. Mithun and other animals had the least population size (Figure VI. 4.8).

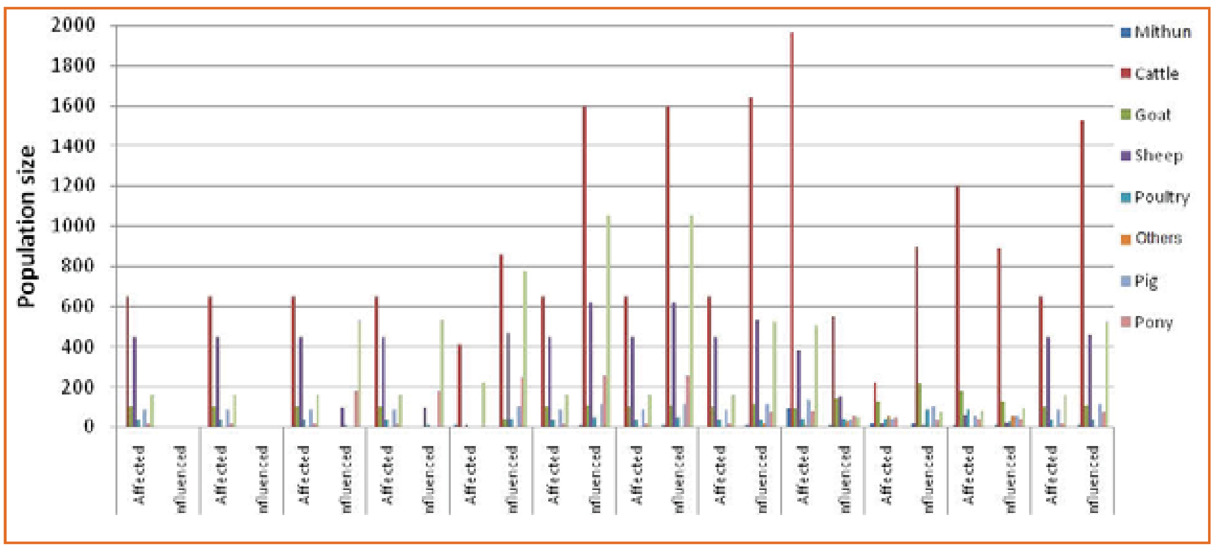


Figure VI. 4.8: Population size of livestock in affected and influenced villages in different HEP sites

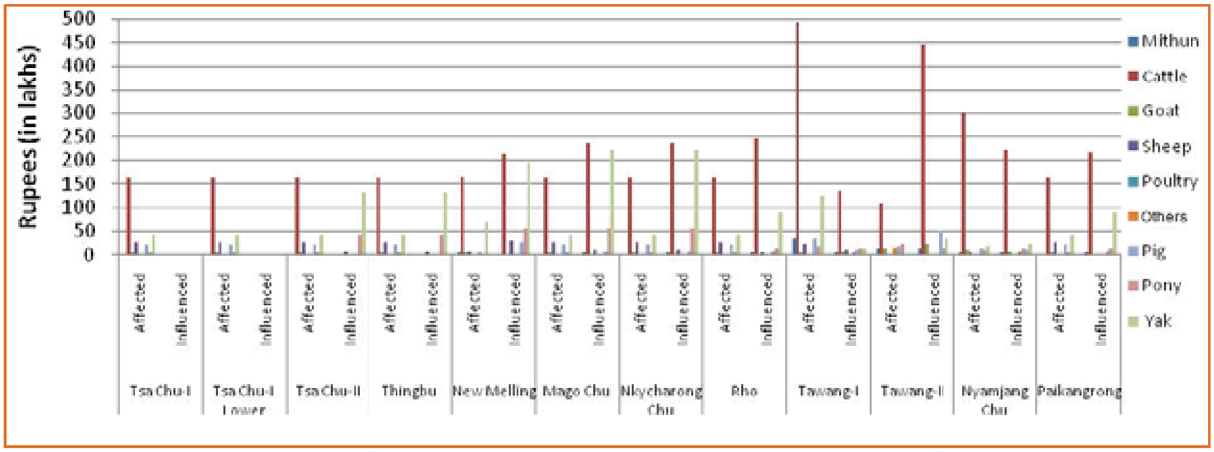


Figure VI. 4.9: Estimated value livestock in affected and influenced villages in different HEP sites

The livestock animal-wise estimated value is given in Figure VI. 4.9. The implementation of HEP is expected to affect animal husbandry by way of loss of pastures land for domestic animals, creating additive financial difficulties for the people. The average annual earning of affected and influenced village under each project is given in Figure VI. 4.10.

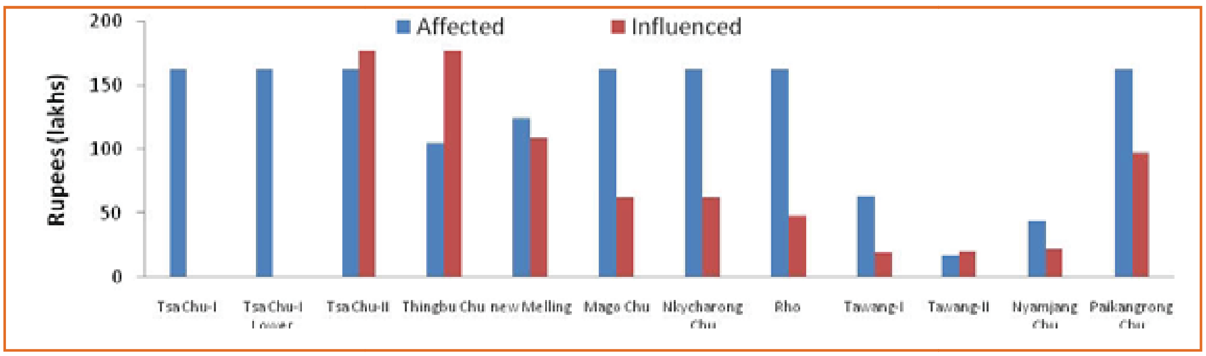


Figure VI. 4.10: Average annual earning of people in affected and influenced villages under each project site

4.2.2.1 R&R/TRBDP: Veterinary assistance and livestock development

Veterinary assistance scheme is an important part of R&R/TRBDP scheme considering the fact that a disruption of pasture and feeding nature of livestock can trigger outbreak of diseases and may in-turn affect human health besides affecting the families' income from this sector. Figure VI. 4.10 depict that except Tawang-I, Tawang-II and Nyamjang chu, high income of affected villages from animal husbandry is seen in many projects. Accordingly, the financial allocation under veterinary scheme will vary from one project developer to another. The financial estimation will therefore be finalized by the developers in consultation with the TRBDA (Table VI. 4.26).

Table VI. 4.26: Upgradation/creation of cattle cum dairy development centre

Sl. No.	Activity/Component
1	Cattle shed construction (20 cows)
2	Support for procurement of additional livestock/dairy cattle
3	Support for upgradation of milk storage and processing machineries
4	Support/training for hygienic processing and handling of local milk/cheese/etc.
5	Creation/operation/maintenance of artificial insemination facilities
6	Feeds and fodder development
7	Support for livestock veterinary and animal nutrition services
8	Assist in human resource, Cross breeding and Veterinary care by existing veterinary and animal husbandry department (if non-existent, set-up a Veterinary clinic)

4.2.3 Traditional skills

The people of Tawang possess a great skill in craftsmanship and weaving which is quite apparent in the beautifully designed traditional and artistic crafts available in the local market and craft centres. Wood carving, carpet weaving, bamboo works and wood are well known and widely documented. There are two Craft Centres in Tawang district and the production of crafts in

2007-2008 was 0.67 lakh (Deb, 2013). In-spite of the presence of only two Craft centres, the contribution of traditional skill in craft making to the income of the affect villages is 15%. The average annual earning of the affected villages in each project is given in Figure VI. 4.11. Economic return of affected villages from traditional skills is between 20 to 35 lakh in most project sites and least in Tawang-II and Nyamjang chu.

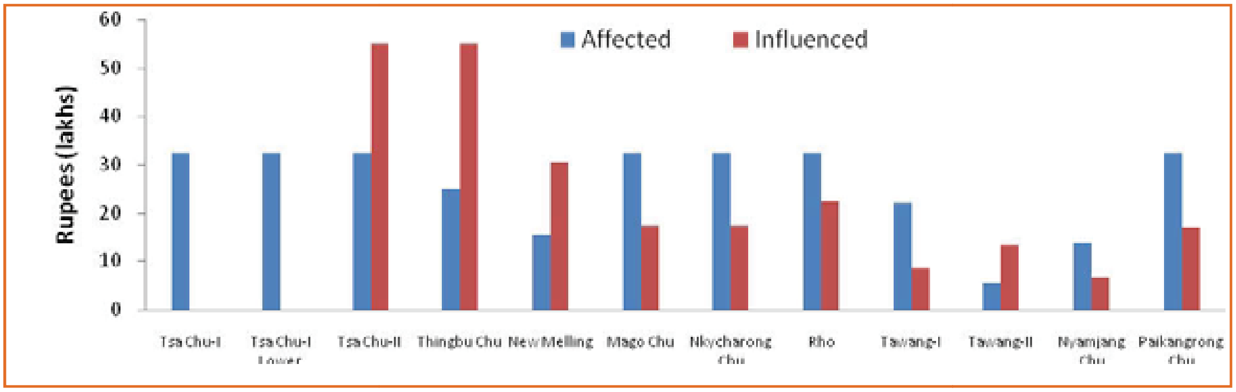


Figure VI. 4.11: Average annual earning form traditional industries

This sector can be emphasised for economic development of the affected villagers and assistance scheme from HEP developers can boost the traditional industries and help mitigate the adverse economic effects on other sectors as well

4.2.3.1 R&R/TRBDP: Grant for craft centre and skill development scheme

The local communities are traditionally involved in weaving and various craft activities like bamboo works, wood works, painting, paper making, incense making, pottery and others. Textile or Craft Centres in each of the affected areas or in selected villages is proposed to be constructed for youths, women and the under-privileged in the project affected areas for learning and taking up crafts-related activities. Training funds will also be allocated to the talented and eligible PAFs (Table VI. 4.27). The number of trainees to be supported under this grant, and also the stipend validity, amount and duration will decided by the concerned developers in consultation with TRBDA. A set of rules can be formulated by which the selected trainees on completion of training will be bound to impart and assists skill development to other interested people which will help in income generation.

Table VI. 4.27: Creation of craft centres*

Sl. No.	Activity/Component
1	Creation/upgradation of existing working shed
2.	Operation & Maintenance cost (electricity, water supply, etc.)
3.	Repairs/maintenance of existing machineries/tools & implements
4.	Purchase of new machines/tools & implements
5.	Training of Trainers
6.	Development of training manuals and advocacy materials
7.	Support for procurement of raw materials including cultivation of critical raw materials
8.	Support for miscellaneous input materials such as paints, varnishing, preservatives, etc.
9.	Support for marketing (such as storage, showrooms, packaging, transportation, advertisement, etc.)
10	Training and support for management of craft centre (record keeping, account keeping, marketing records, sharing of benefits, raw materials records, etc.
11	Establishment for small scale paper making unit (financial estimate-Rs 200.00 lakhs)
12	Establishment of small scale food processing unit: (financial estimate Rs 200.00 lakhs)

* In order to estimate the cost, information and data for the above 10 components was requested from the district administration. However, this was not available

4.2.4 Other prospective economic resource

The principal occupations of the rural people in Tawang remained to be agriculture, animal husbandry and traditional handicrafts industry. However, a section of the modern day populace is taking up non-traditional occupations such as government service which contributed 7% to the overall economy, and other categories including non-farming businesses which contributed 5%. Other perspective economic resource in the region includes horticulture and tourism.

4.2.4.1 Horticulture

Although horticulture account for a marginal contribution of only 1% to the overall annual income of the affected and influenced villages in TRB, horticulture farming is nevertheless has immense potential for development in Tawang as a whole. This potential has been recognized by various departments including the District Horticultural Office, Tawang. In 2013, the National Bank for Agriculture and Rural Development (NABARD) has initiated a horticulture development farms in few villages in Tawang district under Tribal Development Fund (TDF) program. A positive response was obtained from the villagers during their consultation and interaction.

In this regard, the present development plan can integrated horticulture development to complement with the existing horticultural activities such that the economic condition of the people can be improved and also to ease the dependency of people on agriculture. Average annual income from horticulture in the affected and influenced villages under each project is shown in Figure VI. 4.12.

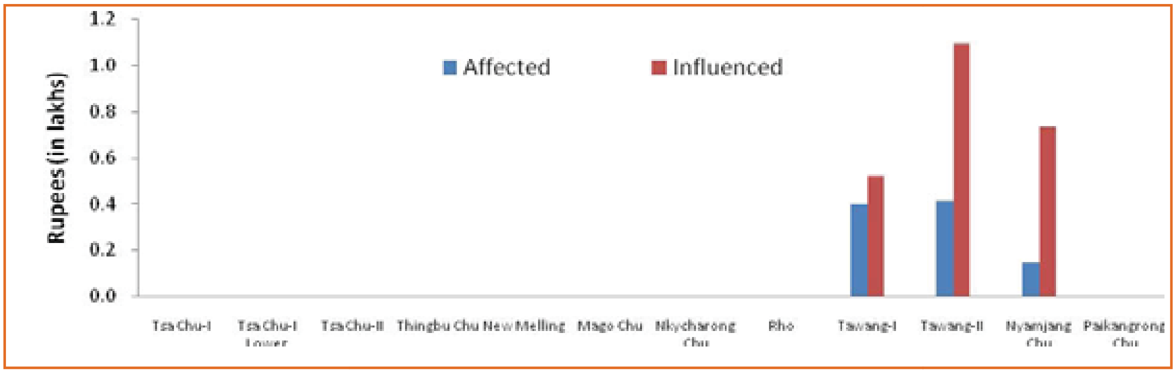


Figure VI. 4.12: Average annual earning of affected and influenced villages from horticulture

Only affected and influenced villages of Tawang-I, Nyamjang chu and Paikangrong chu had economic return from horticulture. Affected villages earned an average income ranging from 0.1 to 0.4 lakh, whereas influenced villages earned higher with average income from 0.4 lakh to over 1 lakh.

R&R/TRBDP: Compensation of horticultural land and development scheme: Some of the horticultural land is under the project area and is likely to be affected by the project construction. Hence, appropriate compensation will be given by the concerned developers. Further, other horticulture development schemes will also be given including training and financial assistance for procurement of seedlings. Details of compensation procedure and development schemes will be finalized in consultation with the DWC, TRBDA and stakeholders.

4.2.4.2 Tourism

The contribution of tourism to economy of PAFs in TRB is not quantified. It can be assumed that it comes mostly as daily wage in the form of seasonal occupation as porter and trekking guide. HEPs can give a huge boost to the tourism potential of TRB, hence may accelerate economy of indigenous people. Oh the other hand, construction of HEP plants can have some negative impact on the region’s tourism. This is so because tourism in TRB is internationally known for trekking along the landscape where there is predominance of natural undisturbed vegetation and wildlife. Therefore, tourism development has been based on natural resources and natural landscape beauty and eco-tourism which involved exploration of the natural environment and low levels of human interference.

TRBDP-Tourism development grant: To alleviate this negative impact, the project developers need to allocate a special fund under TRBDP towards development of tourism sector. The development authority will carry out inventory to identify locations and build up new trekking tracks and also identify new camping sites to maintain tourists and adventurers’ visit in the

region. Additionally, an emphasis on different aspect of tourism needs to be focussed such as fishing, lake boating and rural accommodation. Another untapped component is the integration of agro-eco-tourism in the region. As desired by people during the survey, a district level museum needs to be set up to represent and show casing traditional wealth, culture and heritage of Arunachal Pradesh, the presence of such a facility will encourage cultural tourism as well. Roads on key tourist routes and critical tourism related infrastructure needs to be developed.
During village interactions, it was felt that there is a need to develop homestay and tourist lodge in Gorsam and Sungetsar in Zimithang Circle. Some of the tourism related developmental activities have been identified and the estimated costs have been worked out under the development plan (Table VI. 4.28).

Table VI. 4.28: Tourism related component-wise financial estimation

Sl No	Activities	Estimates per unit (lakhs)	No of units	Total Amount (lakhs)
1	Support for development of homestay facilities (improvement of night halt stay/rooms with improved sanitation – toilets, water supply, geyser, etc)	4	6	24
2	Improvement of existing trekking trails (including repairs/construction of small bridges, etc)	-	-	-
3	Development of new trekking trails (including construction of small bridges/culverts, refreshments cafeteria, toilet blocks etc.)	7.0	4	28
4	Development/improvement of outdoor camping sites (with facilities including tents, sleeping bags, mats, shoes tables, chairs etc.)	1.0	20	20
5	Support/trainings for making of local souvenir items.	5.0	20	100
6	Training for local tourist guides,	5.0	7	35
7	Training for cook, hospitality, household hygiene, waste management, etc.	2.0	7	14
8	Training for local tour operators/tourism NGOs on tourism management including exposure visits, etc.	10.0	7	70
9	Preparation for advocacy materials	-	-	-
10	Support to local youths/youth groups for tourism enterprise: Tourist vehicle operation (on pilot basis)			
11	Tourist lodge/hotel operation and maintenance	3.0	7	21
12	Souvenir shops/tourist-interest item selling shops	4.0	5	20
13	Restaurants/local food stalls	4.0	7	28
14	Hiring of trekking and camping materials	1.0	20	20
15	Establishment of nature interpretations centres (capital and recurring cost for maintenance and salaries)	200	2	400
16	District Museum	-	1	-
	Total	**246**	**113**	**780**

* This cost was estimated for a period of 10 years

4.2.4.3 Livelihood enhancement opportunity and influx control

It is seen that most of the rural economy comes from agriculture, animal husbandry, traditional skill and daily wage activities from which a relatively stable source of income can be obtained by most of the affected families, who can also benefit from all the R&R/TRBDP schemes. However, there is a need to diversify people's source of income further since the adverse impact of multiple HEP implementation on economic condition can exceed all expectations, moreover, there may be families among the poorer and marginalized section among the affected or influenced villages that may not be able to effectively exploit or who will not benefit adequately from developmental schemes because of several factors such as landlessness, lack of skills and competencies. Hence these families are prone to extreme economic instability arising from the HEP implementation.

Although the construction contractors will employ skilled and trained personnel labour drawn from non-local communities. It is important that influx be checked so that pressure on local capacity and competencies will not be drastically affected especially considering the fact that approximately 80-3500 labours and workers will immigrate in each project area during construction phase.

R&R/TRBDP: income generation scheme, subsistence grant, community welfare centres: In addition to the various welfare schemes outlined in this Section of the Report that will be initiated by project authorities, they will also be required to prioritize assistance to the poor and marginalized families. This can be achieved as flows:

- Provide maximum employment to them during the entire project construction phase.
- Conduct regular vocational training programmes to impart skills and uplift their economy. In this regard, the developers will be required to undertake training and capacity building to the local population as outline in the Hydropower policy of India. This also includes special training programmes at least 6 months prior to commencement of construction.
- Facilitate income generation schemes for cooperatives and SHGs them in consultation with the respective village heads.
- Provide grants for Community Welfare Centre.

The developers will also facilitate emergency livelihood opportunities in the form of 'Subsistence grant'. The project implementation agencies will have to take proactive steps particularly since these families may not have the skill or competencies. Therefore, other potential economic resource can be tapped as new livelihood opportunities such as farming development (horticulture, fishery, apiculture, sericulture etc), non-farming business, tourism and eco-tourism related occupations (guides and cooks) among others. In this regard, the implementing agency may collaborate with other institutions specializing in R&R and developmental works involving all stakeholders.

CHAPTER 5
ENVIRONMENT AND BIODIVERSITY PROTECTION

The integrated hydropower development activities outlined above takes into consideration the progress of the entire TRB in respect of the various existing social, economic and infrastructural needs. The various R&R activities and TRBDP plans is being proposed for the development of the region in a long term-perspective. Another equally important aspect that needs to be covered in the development plan is the protection of environment and forest and biodiversity management and conservation. This will be executed in two phase i.e., construction phase and post-construction/operation phase.

5.1 ENVIRONMENT PROTECTION

Social awareness and support: The study area mainly comprises of tribal population, mainly Monpa Tribe. They have well developed traditional governance system for the management of environment and natural resources. No one is allowed to cut any tree without prior permission from the village committee. Many of the trees and wild animals are considered to be sacred. Extending the activities like afforestation, local bodies need to be strengthened financially. Committees would be constituted in each project affected village with a head selected by them.

A special massive awareness campaign (Public Awareness Programmes) among the local people and especially construction workers will be initiated by TRBDA which will be funded by the developers for protection of the environment and also biodiversity. The inhabitants of the area would be encouraged to adopt sustainable forest conservation practices and economic activities. This would ensure habitat continuity as well as minimize the loss of species-populations, preventing disruption, disturbance and fragmentation of the wildlife habitats. The main objective of the campaign is basically to inform and educate the community on biodiversity conservation and sustainable development issues.

5.1.1 Air Quality

The air quality in the entire TRB area is good. There are two main factors from the construction of several projects in the region that may locally alter it: dust and exhaust fumes. Dust is potentially the most significant component, at least during the dry season, from October to May. During this period it may be generated by wind action on cleared and bare soils, and by traffic on tracks and roads. To limit as much as possible this impact near populated areas (villages, camps, work sites), the following measures will be implemented:

- Minimization of bare areas at any particular time by appropriate work organization and progressive revegetation of sites.
- Provision for improved surfacing of roads in populated areas to reduce the production of dust.
- Appropriate maintenance of engines in order to generate as clean exhaust fumes as possible.
- Appropriate location of facilities (generators, crushers, waste disposal site for burning) under prevailing wind conditions.

5.1.2 Water Quality

Protection and maintenance of water quality is also an important aspect in developing HEPs particularly during construction phase. Water management plans will be developed to meet acceptable and appropriate standards. Under these plans, drainage works, sediment traps, diversions, culverts and related structures will be specified and designed to treat water to an acceptable quality and will be installed prior to the commencement of earthworks in any area and inspected regularly to ensure effectiveness. Additionally, the following measures can be taken:

- All rubbish and sewerage will be kept away from any water course to avoid contamination through seepage or direct runoff.

- All storage areas for fuels and other hazardous liquids will be bundled to an adequate capacity to mitigate potential spillage problems and pollution of surface water. A sump will be provided to allow pump out of any contained liquid.
- To minimize the risks of pollution, refuelling of heavy construction machinery will generally be undertaken using a service vehicle.
- Workshop facilities will be kept at least 50 m away from watercourses, and will have grease and oil traps which are properly maintained to ensure clean runoff from the sites even during rain events. Field maintenance will be done as far as practicable from the watercourses.
- Workers camps and working sites will be provided with clean and potable water.
- Drainage systems for the construction area will be designed and located to restrict alteration of water regimes in adjacent areas to a practical minimum.
- Whenever required, the water source will be protected from any pollution risk from animal or human origin. The Contractor will carry out regular control of water quality.

5.1.3 Soil Conservation

5.1.3.1 Soil erosion and sedimentation

The process of erosion of top soil and deposition of sediment is one of the primary concerns of any catchment areas. The underlying factors that accelerate soil erosion and sedimentation is the depletion of vegetation and forest cover in the project areas. This often results in severe run off, and subsequently premature siltation of the reservoir and construction activities accelerates these processes. This problem is one of the primary concerns HEP implementation. The intensity of which differs from one project site to another depending on landscape terrain, soil properties etc. The eroded sediment from catchment when deposited on streambeds and banks causes braiding of river reach. The removal of top fertile soil from catchment also adversely affects the agricultural production. Another important factor that adds to the sediment load and which contributes to soil degradation is grazing pressure. A large number of livestock graze the pastures continuously for about six months in a mountainous region.

Consequently, soil erosion and sedimentation controls would be the first measures installed at any new work and stabilization measures will be progressively installed as area are developed. Drainage systems for the construction area will be designed and located to restrict alteration of water regimes in adjacent areas to a practical minimum. Hence, certain measures need to be taken to mitigate the problem. Specific erosion and sediment control measures applicable during construction is outlined below:

Drains and banks: Catch drains, diversion drains, table drains, windrows and associated drop-down drains shall be used to ensure runoff from the works is directed into existing water courses. Periodic inspections are conducted to repair damage caused by scour, sediment deposition, channel obstruction, excessive traffic can loss of vegetative cover.

Temporary banking shall be used when required to divide slope lengths into non-erodible segments through the interception of runoff and its diversion to stable outlets at non-erosive velocities. Temporary baking shall be utilized from the time of initial clearing to the time of the final landform is attained.

Stable outlets for such temporary banking shall be located at natural drainage lines such as the point where cut and fill sections meet at natural ground level. Temporal banking shall be constructed with adequate capacity to cater for runoff from high intensity storm flows and to ensure channel grades are not excessive.

Sediment controls**:** Silt entering drains shall be controlled where appropriate by either of two devices depending on the size of the catchment, intended duration of the structure, and other local physical and environmental constraints.

Silt trap fences: Silt trap fences may be placed across minor drainage lines to control sheet flows. They require regular maintenance to ensure that the toe of the filter fence remains buried and anchored.

Sedimentation basins: Sedimentation basins can be constructed off-stream and can be used to remove the sediment load generated on construction sites. They shall be installed prior to development activity and remain in place until such activity is completed.
Silt shall be removed from the basins on a regular basis such that the capacity of the pond remains adequate to control the runoff generated within each catchment area. This is generally when the capacity of the basin has been reduced by 30%.
Regular maintenance shall be carried out to the basins themselves such that the integrity of the structure is maintained at all times.
Silt trap fences may be located at the lip of the spillway of each basin should the capacity of the basin be surcharged during storm events.

Clearing and stripping topsoil: Clearing and stripping shall be limited only to those areas where the commencement of work in that area is imminent having due respect for the progress on site and the construction program in general.

Stockpile construction and maintenance: Topsoil shall be stripped, separated and stockpiled for respreading on all exposed areas when final shaping has been completed.
Stockpiles shall be constructed to be smooth and free draining and better slopes shall not exceed 1.5: 1. The height of the topsoil stockpiles shall be limited to three meters and compacting of the stockpile shall be only by equipment necessary for the hauling, placing and spreading of the topsoil material (excessive compacting alters quality and fertility of topsoil). All topsoil stockpiles shall be deep ripped to ensure the retention of moisture and the promotion of regrowth.
Soil erosion and sediment control shall be implemented around stockpiles. Stockpiles shall be located in areas of convenient access for recovery and away from drainage lines.

Construction site and storage depot protection: All earthworks shall be conducted in such a manner so as to mitigate the possibility of erosion. To prevent the possibility of the discharge of storm and construction water into areas outside the limit of the works, the areas of excavation and fill shall be shaped in a concave manner, where possible, such that the water is contained within the works areas.

Road construction: The locations of roadways shall be slightly off contour for drainage control and to aid in reducing erosion. Apart from the erosion and control measures already mentioned, cleared areas shall remain in a rough condition to absorb water and minimize runoff. Road development along the escarpment, between the water intake and the power plant, will require particular attention regarding slope stability. Construction techniques will require the approval from the Consulting Engineer prior to implementation. Cut materials will not be indiscriminately tipped along the downhill side of the road, as it can induce major instability on steep slopes. Wherever possible, cut material will be used as filling material for the road and for the eventual rehabilitation of the area.

5.1.3.2 Catchment Area Treatment (CAT) Plan

A Catchment Area Treatment (CAT) Plan is an essential component of environment management for all HEP developers. It involves the understanding of the erosion characteristics of the terrain and suggesting remedial measures to reduce the erosion rate. For this reason the catchment of the directly draining rivers, streams, tributaries, etc. Should be treated and CAT Plan will be the main component in the broader Environment Management Plans (EMPs) of all the project developers. The technicality and procedure relating to CAP will also need to be developed by the Environment Management Division of each developer in coordination with relevant administration and departments and also involving the village representative. In general, CAT Plan encompasses three important components that HEP developers should initiate:

(i) *Engineering measures:* This include gully, plugging, contour bunding and bench terracing
(ii) *Biological measures:* This include afforestation, NTFP regeneration, pasture improvement, assisted natural regeneration in existing forests
(iii) Infrastructure development, barbed-wire fencing, and
(iv) Monitoring

The level of activity under each of the above components, their time frame and budgeting will be decided and finalize by the concerned developers and TRBDA taking into consideration the various basin properties documented in this Report such as (a) drainage area (b) Soil physical and chemical characteristics (c) slope and aspect of the project area, and (d) Land Use/Land Cover characteristics. CAT Plan should start with the construction and implementation of the projects; ideally it would take 5 years for creation and 3 years should be allotted for maintenance. Monitoring will be conducted regularly including another 3 years after creation and whenever required, additional time for maintenance will be extended.

5.2 FOREST AND BIODIVERSITY CONSERVATION

The detailed description on forests and biodiversity under TRB has been covered in Section-VII of this report. In this regard, various biodiversity management plans as suggested will be taken up by the developers in their respective project areas

5.2.1 Afforestation Programme

Area under forest and tree cover will be expanded through systematic planning and implementation of afforestation and rehabilitation programme in degraded and open forests and available non forest lands. Regeneration of felled areas will be ensured in a time bound manner and productivity of plantations will be increased through use of improved seeds and planting stock. The indigenous fruit bearing plants, vital from wildlife point of view are proposed to be planted so as to enrich the habitat & ensure the sufficient availability of food. Monoculture will be discouraged and mixed plantations of broad-leaved fodder, fuel wood and wild fruit species will be promoted. This activity will increase forest cover and will provide habitat to the animals. Afforestation programme in the degraded lands, is proposed to be carried out and species for this shall be finalized by the Forest Department.
Schemes that can be covered under this are Compensatory Afforestation Plan, Forest Protection Plan, Creation of Greenbelt,

5.2.2 Habitat Improvement Programme

Habitat improvement programme is an integral part of biodiversity management. This programme consists of bringing into useful association of those condition needed by a species to reproduce and survive. The following activities have been proposed for habitat improvement programme:

5.2.2.1 Avi-fauna

Forests are vital for the survival, foraging, breeding and nesting of avifauna. Natural forests provide a variety of food materials to the birds not only in the form of nectar of flowers, fruits, seeds etc. in the trees, shrubs, herbs and grasses but they also contain a large number of insects eaten by birds. In the forests, food is always available for the faunal component. Although most floral species flower during spring through summer but fruit maturation and seed ripening takes place in them throughout the year. Therefore, first strategy of improvement of habitat for birds is avoiding nest predation or brood parasitism through maintenance of large contiguous forest tract. These areas have the ability to support the largest number of forest interior birds and will also be more likely to provide habitat for area sensitive species. It is more practicable to protect the existing forest area rather than creating new forest area.

In this measure, Tawang-II developers is planning to undertake a scheme “Creation and maintenance of Alternate Habitat for Avifauna” to be formulated in consultation with the State Government. A total budget of 49 lakhs has been earmarked for this purpose.

5.2.2.2 Fisheries

The presence of several HEPs in TRB is most likely to affect aquatic life particularly fish species inhabiting downstream areas. Consequently, their density and overall populations’ health may be affected. Since Monpas do not catch fish, fish farming is not a viable livelihood option. However, adequate protection measure is to be taken for fish species conservation and workers will be prohibited from fishing activities which may harm the river fisheries, e.g., using explosives or poison. The conservation of the available fish species and fisheries development can also be achieved by way of establishing fish reservoirs at selected sites, hatchery and fish farms. To combat the problem of habitat fragmentation for fish migration, management of aquatic ecology and provision of Fish Ladder will also be required.

Complementary to this aspect, it may be noted that the State Government has proposed a mini trout hatchery at Nuranang, Tawang district for supply and release into the natural lakes. HEP developers may also assist in upgradation of existing Hatchery which will be implemented and maintained by the district fishery department.

5.2.3 Protection Measures

***Constitution of BMCs*:** The Biodiversity Management Committees (BMCs) be constituted for this purpose under the State Biodiversity Board which will help line agencies in capacity building and micro-planning of the various eco-developmental activities formulated for community development. The activities under this programme are aimed at improvement of livelihood of people living in the project area. Under this programme, the following activities are proposed, which would ensure success in conservation efforts:

- Training should be imparted to the school teachers in the project area for introduction of environmental education among the school children and exchange to knowledge on environment and ecology between the monastic and village schools. Publishing of research documents, pamphlets, brochures, hoardings
- Opening of biodiversity register in every village
- Advertisement of hazardous effect of fire through press, sign boards and public meetings will form the important activities under this component.

For the improvement of vigilance and measures to check poaching number of measures described below would be undertaken. During construction phase in and around the main construction areas, i.e., the barrage site, powerhouse site, etc. where construction workers congregate, some disturbance to the wildlife population may occur. Therefore, marginal impacts may be on wildlife due to various construction activities. In view of this it is recommended that 4 check posts be developed in the major construction area i.e., one near intake and one near power house along the boundary of labour camps to implement anti-poaching measures during project construction phase. Each check post shall have 3 guards to ensure that poaching does not take place in the area. The guards will be supervised by a range officer. It is also recommended that the staff manning these check posts have adequate communication equipment and other facilities. Apart from inter-linking of check posts, communication link needs to be extended to Divisional Forest Office and the local police station.

5.2.3.1 Anti-poaching infrastructure

To capture and translocate wild animals out of human habitations or agricultural lands, various trapping equipments pertaining to anti-poaching activities are needed. The anti-poaching kits will include equipments for self defence of the staff support as well. Infrastructure and basic amenities for the field staff will also be provided to enable them to do effective patrolling in the areas. Some of the requirements are anti-poaching huts, rock shelters development and residential quarters for forest guards. In areas having high pressure of biotic interference, one watch tower is also proposed to be established at an identified place under each project area.

In order to improve network and vigilance it is required to procure equipment such as G.P.S., spotoscope, binoculars, video recorder as well as digital still cameras are essential. Field vehicle may also be acquired which will help in survey and observation. Check posts may also be installed to improve vigilance for anti-poaching, better protection, enforcement for control grazing practices the construction of control grazing-cum-anti poaching check posts.

5.2.4 Other Environment Management Plans during Project Construction

Besides undertaking the above protection measures and activities to protect the environment and biodiversity, various environment management plans will be implemented to ensure environment (air, water and soil) protection. These are:

1. Muck management/Disposal Plan
2. Water, Air quality & Noise Environment Management.
3. Water pollution control plans
4. Environmental Management in labour camp
5. Environmental management in road construction
6. Control of Pollution from Labour Camps
7. Reservoir Rim Treatment &Soil Erosion Control
8. Maintenance of Air & Water Quality and Noise Level.

Environmental Management Division of HEP developers should propose and formulate technical plans under each of the above and substantial financial allocation will be decided which will need to be approved by the State Government/relevant department. Activity phasing for the above plans and also all the TRBDP plans have been suggested and given in Appendix VI 5.1. Many other aspects of landscape level biodiversity management issues had been discussed in Section-VII.

CHAPTER 6
DISASTER RISK MANAGEMENT

Disaster Management is a continuous and integrated process of planning, organizing, coordinating and implementing measures which are necessary or expedient for prevention of danger or threat of any disaster resulting from project construction and operation. It involves mitigation or reduction of risk of any disaster or its severity or consequences, preparedness to deal with any disaster, prompt response to any threatening situation and assessing the severity or magnitude of effects of any disaster. Effective mechanism should be placed so that appropriate evacuation, rescue and relief and be carried out including rehabilitation and reconstruction after disaster incidence.

For any types of disaster, it is important that early warning system be set in place. Early warning is defined as: "The provision of timely and effective information, through identified institutions, that allows individuals exposed to a hazard to take action to avoid or reduce their risk and prepare for effective response" (United Nations 2006). For an early warning system to be effective, it must integrate four elements: knowledge of the risk, a monitoring and warning service, dissemination and communication, and response capability.

Disaster management may be coordinated with Arunachal Pradesh Disaster Management Authority for assistance, guidance and monitoring of the management process.

6.1 BARRAGE BREAKAGE

Barrage failure, though unlikely to happen, poses serious threat to human lives, property and infrastructures located downstream from the dam. In order to save people's life and damage to the property, an integrated disaster management approach is essential. This should include disaster prevention, mitigation and preparedness. Failure of dam (barrage) is a low risk but high impact hazard as they do not occur often but can be extremely catastrophic. An inundation map depicting the downstream areas likely to be inundated by the dam break flood should be prepared. In the event of the dam break, none of the village/settlement will be affected because they fall out of the inundation zone. However, infrastructural assets like short length of the road and existing bridge are located on the margins of the likely flooded area. In such a scenario loss of property could be anticipated in the downstream due to barrage break. The time required in reaching the flood wave elevation to the maximum is of the order of few minutes. It hardly leaves any possibility of any rescue or evacuation. Since the time available is very short, therefore Disaster management plan should concentrate on preventive actions. Preventive measures are surveillance, infrastructural development, emergency action and preparedness plan. Communication plan should be restored immediately as it is absolutely essential when time is of great essence. Beside, evacuation plan and evacuation team, medical team is also needed. Mitigation and rehabilitation plan should be worked out.

6.2 UNREGULATED BARRAGE-WATER DISCHARGE

The potential scale of disaster resulting from unregulated and abrupt barrage-water release is low. Yet it can affect human lives, farmlands, agriculture lands, vegetation and river fauna during high monsoon. Therefore, the present plan proposes that the HEP developers maintain three mechanism of action i.e., prevent, prepare and prompt action:

- Regulate water discharge so that there is no abrupt release which is bound to create strong water current downstream.
- Adopt strong warning systems so that areas downstream can be imitated in-time before water discharge.
- Sound alarm should be legible in all potentially affected areas downstream.
- Disaster Management Cell should be created to prevent and prepare for prompt action should any unfortunate incidence occurs.

6.3 NATURAL DISASTER

6.3.1 Earthquake

6.3.1.1 Seismic disaster management plan

As recommended by the earthquake studies the following measures need to be taken for possible seismic disaster.

- The site specific design earthquake parameters for MCE condition is estimated to be magnitude 8.0 earthquake occurring at MCT.
- The PGA values for the MCE and DBE conditions are estimated as 0.34-0.38 g and for DBE as 0.17-0.19 g.
- Based on the comparison of the results from Probabilistic Seismic Hazard Analysis (PSHA) and Deterministic Seismic Hazard Analysis (DSHA), conservatively the design acceleration response spectra are recommended to be used.
- Vertical acceleration spectral values shall be taken as 2/3 of the corresponding horizontal values.
- Data for time history of earthquake ground motion for the dynamic analysis of the weir are normalised to peak ground accelerations of 1.0 g. For MCE and DBE time history analysis ground motion data as given in the respective reports have to be multiplied by respective MCE and DBE values.

6.3.1.2 Safety criteria

Where the structure is checked for MCE, either the response spectra or the time history analysis of the structure could be carried out. Factor of safety against sliding and overturning for MCE condition should not be less than 1.0. For concrete gravity dam the maximum tension under MCE may be allowed to exceed 50% more than those specified for DBE.
Factor of safety against sliding for DBE condition should not be less than 1.5. Factor of safety against overturning should not be less than 1.5. For concrete/masonry dam the maximum tension under DBE may be allowed to exceed upto 12.5% of the ultimate compressive strength.

An important output of this study is to set out a forward programme of research and development on CEA for the Agency. Further action is necessary in order to minimize the risks of not implementing the SEA Directive fully in terms of the CEA requirements. It will also help to ensure that the opportunities afforded by CEA are fully realized.

The forward programme of research and development is set in terms of three different timescales based upon the amount of work that would be required to bring them into effect and what can realistically be achieved.

Short-term recommendations (2003-2004) are for application before the Directive becomes a statutory requirement in 2004. These deal with the delivery of tools and techniques that are available now but may not be fully applied in the different spheres of Agency tasks. Other short term recommendations relate to the outward facing activities of the Agency and include such ideas as the provision of advice notes to other plan and programme making authorities in areas that the Agency considers to be highly sensitive to cumulative effects.

Medium term recommendations (2003-2006) are for application by 2006. Among the medium timescale recommendations are those that will require some trial application of tools and techniques or the building of databases to allow their use.

Longer timescale recommendations focus upon R&D activities that would be expected to be delivered over a 5-10 year period (2006 – 2013) before the results were in widespread use.
On the basis of this scoping study it is possible to identify the following themes that the Agency may wish to explore in its desire to promote wide consideration of cumulative effects within both its plan and programme making activities and in its role as a statutory consultee:

- Raising general awareness of cumulative effects assessment
- Guidance and procedural mechanisms
- Training
- Research

6.3.2 Landslide

Landslide one of the most severe problems associated with landscape particularly in the steep and hilly terrain of Tawang. Whatever be the causes, landslide is known to affect land, road connectivity, forests fragmentation, habitat fragmentation and is also know to affect HEP production. The problem therefore needs to be tackled for mitigation and management of landslide in TRB for which hazard zones have been identified as also required in the EIA guidelines. Landslide prone areas, their degree of vulnerability was assessed in each proposed HEP site and documented in Section-II of this Report.

6.3.2.1 Prevention and mitigation plan

Construction activities particularly during road construction and quarrying operation should be done responsibly to minimize the occurrence landslide. Additionally, appropriate slope stabilizing structure in the form of terracing should be constructed in sensitive areas under 'High' landslide and erosion vulnerability category (HEP-wise detailed in Section-II). Monitoring and early warning systems and should also be placed at specific slides/slopes that has potential for occurrence of large scale landside. These specific slides/slopes may be identified from the 'erosion and landslide vulnerability' map presented site-wise in Section-II. Vulnerable areas locating near the construction sites (road, quarry etc) can be given priority for mitigation plan.

6.3.3 Glacial Lake outburst Flood (GLoF)

9 HEP sites are vulnerable to threats from Glacier Lake Outburst Floods (GLoF) as mentioned in Section-III. Effective mitigation plan is required to control the possible occurrence of flash floods from glaciers in the future.

6.3.3.1 Monitoring

Monitoring GLoF hazard levels requires a multi-staged, interdisciplinary approach using multi-temporal data sets. Key indicators include changes in the lakes and their impoundments which should be observed using different data sets at varying time scales to evaluate glacier hazard and stability of moraine dams. A considerable amount of information can be derived using remote sensing approaches to identify changes in lake size, and flight observation with small format cameras to observe lakes more closely. Monitoring of critical lakes may require direct periodic observation. To be effective, this should be carried out in cooperation with all stakeholders: communities, government departments, institutions, agencies, and broadcasting media, and others.

6.3.3.2 Early warning

An automated monitoring system should be set up for TRB HEP to achieve early warning of GLoF occurrences. To be really effective, sensors need to be installed in areas such that upper catchments are cover as well. Communication networks must be capable of relaying the warning to the appropriate authorities. Maximum effectiveness would most likely be achieved if the warning systems are monitored with the help and cooperation of local communities.

6.3.3.3 Mitigation

There are several possible methods for mitigating the impact of GLoFs and these will be implemented and installed by the developers not only for their own interest but for the safety and well-being of the people and TRB as a whole.

The most important mitigation measure is to reduce the volume of water in the lake, thus reducing the magnitude of the possible peak discharge at the time of breach. Structural mitigation measures can also be applied downstream to protect infrastructure from peak floods.

Another mitigation measure that can be adopted is the building of tunnels and drains down the lake and channelling water into the reservoirs used by the hydropower projects.

The volume of water can be reduced by means of one or more of the following: controlled breaching of the moraine dam; construction of an outlet control structure; pumping or siphoning the water from the lake; and tunnelling through the moraine barrier or under an ice dam. Preventative measures can also be carried out around the lake to secure against potential threats such as loose rocks or snow/ice avalanches that could trigger displacement waves.

Infrastructure downstream (diversion weirs, intakes, bridges, or river bank settlements) can be protected against a possible surge through proper construction that allows sufficient space for the flow of water and avoids damming. Bridges should have appropriate flow capacities at elevations higher than expected GLoF levels and the spans of piers should not be obstructed by uprooted tree trunks. Land use zoning should also be considered as an effective approach to mitigation by reducing the structures and elements at risk. Among others, settlements should not be built on or near low river terraces within the GLoF hazard zones. River banks with potential or old landslides and screen slopes near settlements should be stabilised and appropriate warning devices installed.

6.3.3.4 Awareness raising

It is essential to raise local awareness and increase knowledge about how to respond when the event occur. Community and local government bodies should focus on monitoring the lakes, mitigating their vulnerability to GLoF, and preparing to cope with such events should they occur: early warning begins with disaster preparedness. This involves raising awareness about glacial lakes, their characteristics, level of hazards, and the required responses during and after GLoF events.

6.3.3.5 Proposed risk management

National strategies and approach to GLoF risk management is practically non-existent. This is primarily due to the fact that monitoring studies on GLoF in the country is scarce. The National Disaster Management Authority has published guidelines on management of landslide and snow avalanche (National Disaster Management Guidelines—Management of Landslides and Snow Avalanches, 2009) in which GLoF is mentioned as one of the emerging disaster concerns and a plan action where collaboration of government agencies with universities and academic institutions is suggested.

Prediction of GLoF risk is not an easy task and there is no guarantee for absolute safety. Moreover, the construction of HEP plants may amplify the intensity of floods downstream which in-turn might severely affect TRB catchment areas and may result in the loss of lives and property. Hence, it is imperative that HEP developers invest in GLoF prediction and risk management in their own interest and also in the interest of the TRB. However, this undertaking can be costly. Therefore, inter-developer investment may be required to pool funds in this regard and a GLoF risk management body will be constituted which will be entrusted for research, prediction, mitigation and management of GLoF.

For effective GLoF risk management, it is essential to define components and their relevant issues so that appropriate strategies can be established. The main components that need to be addressed were adapted from ICIMOD (2011) and are outlined as follows.

Knowledge about risks: It is essential to know the GLoF risk in order to manage it properly. It requires the following:

- Detection – mapping and classifying glacial lakes and ranking them using remote sensing and aerial photographs
- Field visits to the potentially critical lakes to determine the GLoF hazard

- Assessment of GLoF hazards in terms of magnitude and frequency, including mapping of GLoF hazard and flooding zones
- Vulnerability assessment in the hazard zones; assessment of environmental and socioeconomic impact is essential for this
- Risk mapping through an analysis of the possible interaction of a GLoF hazard and vulnerability

Monitoring risk

- Regular repeated mapping of lakes using remote sensing and monitoring of key indicators of glacier and GLoF hazards
- Regular investigation of the development of hazards and risk in a periodic manner.
- Field-based monitoring of GLoF hazard and risk in critical lakes in the field
- Regular monitoring of seepages, ice cores, and slope instability in the end moraine complex and of the stability of the natural moraine dam
- Regular monitoring of exceptional input of drainage as discharge and debris from side valleys into the lake as well as discharge from the lake
- Monitoring of lake storage volume, bottom of the lake, and shape
- Regular monitoring of surroundings of lakes, e.g., hanging glaciers, for changes in snow mass, position, and slope instability to evaluate possibility of triggering

Preparedness: Early warning should provide information in time for response. The preparedness strategy should address as a minimum, but not only, the following:

- Ensure that hazard maps are prepared of potentially dangerous lakes and their flow paths.
- Land-use planning should determine development planning.
- Structural mitigation measures should be undertaken to eliminate protection deficiencies.
- Establishment of early warning systems is essential: one related to communicating changes in water level in the lake with community participation, and another in the form of a mechanical system with sirens.
- Provisions must be made in legislation and policies so that infrastructure developers, especially private hydropower developers, are engaged in GLoF early warning and risk reduction activities.
- GLoF risk reduction should be considered as a national as well as a local priority.

Community participation in risk reduction: Dissemination and communication of GLoF risk information and early warnings to individuals and communities threatened by hazards is an essential part of risk management. Risk management activities can be effectively managed with local communities and authorities, this will also encourage their ownership and participation at all levels. The following actions are necessary to ensure community involvement:

- Communicate and disseminate at least the key findings of GLoF hazard and vulnerability mapping and risk assessment to key stakeholders and community.
- Awareness creation programmes should be developed and implemented. Training manuals should also be prepared.

SECTION VII

BIODIVERSITY MANAGEMENT PLAN AT LANDSCAPE LEVEL

SUMMARY

Assessment of the status of biodiversity, and understanding their distribution in different landscape elements, and recommending effective conservation measures across the landscape are the main objectives of this BMP. The BMP has the following structure: (1) overview of biodiversity elements of TRB, (2) people–biodiversity relationships, (3) biodiversity and natural resource management systems, (4) landscape level impact assessment on biodiversity and mitigation measures, and (5) species–specific and landscape level biodiversity management plan.

The landscape of TRB is a mosaic of natural and man–made ecosystems situated in high Himalayan mountains. The natural ecosystems consist of primary sub–tropical forests, temperate forests, alpine scrubs/forests, alpine meadows, and wetland ecosystems. The secondary forest patches are found near human habitations and along the roads after the removal of primary forests. The man–made ecosystems are upland agroecosystems with millet, rice and maize crops along small terraces, and small horticultural gardens surrounding the homestead. The forest type in TRB change with elevation, and mainly composed of subtropical pine/broadleaved forests between 1000–1800 m elevation, temperate broad–leaved and conifer forests between 1800 to 3000 m, sub–alpine forests between 3000–4000 m and alpine forest/scrub>4000 m elevation.

Bird abundance is not very high as majority of the species (out of 241 species) were recorded to have less than 25 individuals. However, wintering habitat of black necked crane in one of the proposed project areas needed a special habitat conservation plan. Six species of mammals reported in TRB are of high conservation significance as per International Union for Conservation of Nature (IUCN) listing, and relevant schedules of Wildlife (Protection) Act, 1972. Of these, Arunachal macaque and capped langur however, can be commonly seen. The herpetofauna of TRB is of very low conservation significance. Survey of butterflies covering three seasons in the entire TRB showed overall low species richness (42 species, 28 genera, 5 families), and none belongs to threatened category.

TRB is very rich in domesticated biodiversity and most of them are linked with the socio–economic–cultural system of the local communities. In fact, since time immemorial, the life of the Monpas, the dominant ethnic community in the basin, revolves around large varieties of crops, livestock and economically important non–timber plants available in their forest areas.

Since all the 13 HEPs are located at different elevations and across different rivers/tributaries confluencing into the main Tawang river, project–specific impacts in the upper reaches are likely to have cumulative impact on the basin. Based on the understanding of the nature of the proposed projects and associated activities, and existing biodiversity values assessed under baseline status survey in the project areas, the following possible cumulative impacts have been identified and evaluated for appropriate mitigation measures and management plans. The socio–cultural–spiritual needs of Monpas were also considered while developing the mitigation/conservation plan.

A total of 25 impacts of the proposed project activities have been identified at three levels, viz., (i) possible impacts on ecosystems i.e., on the river, riverine and adjacent terrestrial ecosystems, (ii) possible impacts on the biological elements i.e., the flora and fauna, and (iii) possible impacts on threatened floral and faunal species, and mitigation measures for each impact have been suggested. The mitigation plan for impacts on biological elements and ecosystems include: (1) Development of natural resources, and (2) Managerial, technical and legal interventions. Compensatory afforestation has been proposed to mitigate the loss of forest land. Mitigation plans for biological, managerial, technical and legal interventions have been proposed for sustaining ecological processes of the river ecosystem, maintenance of floral and faunal diversity, minimising the impact of muck dump yards on the river, floral and faunal species, controlling the impact of noise pollution on faunal groups, avoiding accidental road mortality due to vehicle pressures in the forest areas, and evading biotic pressures from labour force.

'Ecosystem based approach' (EBA) was considered as the strategy for developing the landscape level biodiversity management plan for TRB. Therefore, constituent ecosystems were identified for each landscape element and ecosystems were used as unit of planning for developing landscape level biodiversity management plan. Given the (1) wide altitudinal variation in TRB, and (2) varied landscape elements, the landscape level biodiversity management plan considered two layers of classification for

developing the plan. TRB was classified into four climatic zones based on the elevation viz., montane sub–tropical (1000–1800 m), temperate (1800–3000 m), sub–alpine (3000–4000 m), and alpine (>4000 m). The dominant landscape elements at each climatic zone were represented by the combinations of different ecosystems such as forests, scrubland, cropland, wetlands, etc. based on the climatic zone. A landscape level management plan considering the above mentioned landscape matrix has been formulated with the following salient activities:

Net area of 1,94,986 hectares need to be established/maintained under the four climatic zones. The identified activities are: (1) Protection of existing dense forests as community conserved reserves, (2) Creation of 1 km buffer forest on both sides of river/stream, (3) Area under scrubland to be afforested under aided natural regeneration (below 2500 m asl), (4) Creation of corridors for important wildlife, (5) Conservation/rehabilitation of Rhododendron scrubs (above 2500 m asl), and (6) Creation of a sanctuary of 40 ha area surrounding Tsa chu–I Lower project considering its location and availability of degraded lands surrounding the proposed barrage site (Tables VII 6.5 and VII 6.6).

The landscape level biodiversity conservation plan has taken into consideration traditional and contemporary knowledge systems and understanding on biodiversity and its varied elements. The plan has been participatory in nature ensuring meaningful engagement of local communities and other stakeholders in decision making as well as implementation of various strategies and actions. The suggested actions are in tune with local socio–cultural practices and belief systems. The plan recommends for creating an efficient and transparent organizational mechanism to coordinate and implement different measures and empowering local institutions and communities for adopting conservation friendly livelihood practices through capacity building. Following strategies and measures are suggested for long term biodiversity conservation in TRB landscape:

- Facilitate creation of Biodiversity Management Committees (BMCs) in each village *Panchayat*.
- Filling the knowledge gap by undertaking comprehensive inventory and status survey of key taxonomic group; conduct research on structure, function, and interactions amongst and within ecosystems; monitor the status of ecosystems in the district; documenting traditional knowledge of community through preparation of people's biodiversity register (PBR); and create a comprehensive, multi–layered biodiversity data base in GIS domain.
- Promoting *in–situ* conservation efforts through creation and support to the proposed high altitude biosphere reserve; expand network of community conserved areas; protection measures to biodiversity rich areas in influence zones of different projects; conservation and protection of other biodiversity rich areas; and conservation and protection of high altitude wetlands.
- Wildlife habitat improvement by regenerating and restoring degraded and open forest and pasturelands; removal/control of IAS; fire prevention; and education awareness.
- Regeneration of species of Non Timber Forest Products (NTFP) values.
- Establishment of natural resource based value addition facilities for livelihood improvement such as *Citronella*, plum, peach, pears, kiwi, pomegranate, gooseberry, walnut, broom grass, and Rhododendron flower.
- Orchid species conservation.
- Promote conservation friendly agro–pastoral system.
- Mitigate human–wildlife conflicts.
- Promote biodiversity and nature education/awareness programme.
- Promote infrastructure for eco–tourism development.
- Support to existing VFMCs, and
- Program implementation mechanism.

The species–specific conservation measures, particularly for the following threatened species/important faunal groups have been suggested:

- **Alternate habitat including artificial nest boxes for avi–fauna:** Although applicable to all the recommended project sites, the high abundance of birds in Tawang–II project area necessitates to install at least 1500 nest boxes in the 1 km riverine buffer proposed to be created on both side of the river. Besides, it is also proposed to create special feeding habitats for birds at 4 to 5 different locations. Each such block shall be of 2 to 2.5 ha dimension and would provide different habitat types to cater to diverse avifauna. The existing herbaceous vegetation in all these blocks shall be kept intact and additional planting of 10–15 species of native plants for meeting diverse food needs (insects, fruits, seeds, and other vegetable elements) and nesting sites of avifauna shall be done. Very strong awareness programmes are necessary for the local villagers and schools in the nearby areas about the ecological role of bird community to enhance the ecosystem services and the benefits we gain from them.

- **Protection of wintering habitat of black–necked crane by suggesting the following measures:** Considering the conservation importance of the species, the experts were unanimous to protect the habitat of the species. Appropriate E–Flow should be determined considering the protection of the habitat of the black–necked crane. In addition, the project proponents should strictly follow and adopt other mitigation measures as suggested to minimise the impact of noise pollution (drilling, blasting and tunnelling), water pollution, regulation of vehicle movements, and impacts from labour force.
- **Conservation of Arunachal Macaque (*Macaca munzala*):** Though Arunachal macaque was sighted in 9 project areas, due to its endemic and threatened status, the following mitigation and management plans are suggested: (1) Awareness education programme, (2) Crop protection, (3) Habitat improvement, (4) Management oriented research programmes, and (5) Wildlife tourism.
- **Conservation of Red Panda (*Ailurus fulgens)*:** Even though, no sighting of red panda occurred during the study period, its presence in and around the Zimithang project area was confirmed based on the two stuffed animals. Red panda subsists entirely on plant diet, predominately on higher altitude bamboo *Arundinaria maling*. They also feed on berries and fruits of *Sorbus cuspidata* and *Sorbus microphylla*. With understanding of its habitat requirements and existing threats, it is very crucial to adopt some mitigation measures through management plans as suggested below to protect this threatened species. (1) Population status and assessment, (2) Habitat protection and restoration, and (3) Awareness and education programme.
- **Conservation of butterfly species:** In TRB 42 species of butterflies were reported. This may be considered as low species richness. None of the species was under threatened categories of IUCN and WPA. Even then, adequate care should be taken to conserve their host plants in the forests.
- **Conservation of herpetofauna:** The reported presence of four threatened reptiles viz., keeled box turtle–*Cuora mouhotii*, common mock viper–*Psammodynastes pulverulentus*, short–nosed vine snake–*Ahaetulla prasina* and red–necked keelback–*Rhabdophis subminiatus* in TRB indicates the need of taking conservation measures for this animal group.
- **Conservation of Capped langur (*Trachypithecus pileatus*):** Capped langur was reported in one project area (Tawang–II) with 13 individuals. It is a vulnerable primate species listed in IUCN and also under the Schedule–I of WPA. Because Capped langur is very common across north–eastern states as reported from 18 protected areas, and due to its capability to use diverse habitats and food plants, the impact of project activities would be very minimal. Therefore, the mitigation plan as suggested for Arunachal macaque would also take care capped langur as well.
- **Conservation of threatened plants:** There are quite a few threatened species of plants in the landscape which also have high use values for local communities. These species need to be propagated in natural conditions through aided natural regeneration efforts. However, in order to achieve the above, following needs to be done: (1) Standardization of propagation protocols and techniques for different species, (2) Develop nurseries to raise quality planting materials, (3) Threatened plant species distribution mapping for conservation, (4) Reintroduction of species in minimum 2 ha area of suitable natural habitats, and (5) Create *in–situ* germplasm bank. Out of the 10 identified threatened species, adequate distribution records for 4 species could be mapped viz., *Acer hookeri*, *Panax bipinnatifidus*, *Taxus wallichiana*, *Toricellia tillifolia* etc. The potential area distribution mapping for these 4 threatened species has been made using ecological niche modeling (ENM). These areas are also suitable for reintroduction of the species for their recovery. In addition to the above 10 species, 12 more species have been identified that show conservation concern needing further studies on their populations, species biology, and regeneration in nature. These species are: *Clethra delavayi, Fritillaria cirrhosa, Picrorhiza kurroa, Rhododendron anthopogon, Bergenia ciliata, Podophyllum hexandrum, Polygonum verticillatum, Cornus capitata, Botrychium virginianum, Pleione precox, Fraxinus griffithii,* and *Schizophragma heterophyllum*.

CHAPTER 1
INTRODUCTION

1.1 LANDSCAPE LEVEL BIODIVERSITY CONSERVATION

Conservation of biodiversity occupies a very high ethical value in the backdrop of rapid pace of development. The explosive growth of human population and use of natural resources i.e., land, soil, water, wood, biomass and energy, are affecting biodiversity at various levels throughout the world (Mooney *et al*., 1995). The unending human needs have led to depletion of bioresources and degraded the forest land of India (Puri *et al*., 1983). Large tracts of species rich forests are being cleared to make way for agriculture, human habitation, industrial development (Turner *et al*., 1996), network of roads and railways, urban and other energy related developmental projects causing forest fragmentation (Rajvanshi *et al*., 2001). Loss of natural habitat, reduction in habitat size, and isolation of habitat patches are the results of forest fragmentation that contributes to decline in biological diversity within the original habitat (Wilcox, 1980 and Wilcox and Murphy, 1985).

Biodiversity has diverse ecological functions, and an increase in species richness in an ecosystem increases the functional diversity and ecological stability (Tilman *et al*., 1996). Therefore, the need of biodiversity conservation is significant.

Although, there is clearly a need to assess biological diversity in selected areas (Noss, 1990), its values would be enhanced if this is combined with consideration of landscape condition and quality (Majer and Beeston, 1996). Landscape harbours all grades of biological hierarchy, from ecosystem level to species and genes that are targeted for biodiversity inventories and conservation (Noss and Harris, 1986). Landscapes also include agriculture, forested, protected and ecologically sensitive areas, which interact among themselves (Forman and Gordon, 1986), and upon which humans have a major influence (Naveh and Lieberman, 1990).

While there is a worldwide concern over the extent to which the biodiversity is being lost, at the same time there is a growing appreciation of the importance of biodiversity, measured in economic, social and aesthetic or moral terms (Heywood and Baste, 1995). The values placed on biodiversity are strongly linked to the human influences on it and their underlying social and economic driving forces. They are also dependent on the role of a particular element or process in the functioning of the ecosystem (Heywood and Baste, 1995). It has now been recognized that the environmental values transcend economic costs.

With the understanding of the above issues, the present study was undertaken to assess the biodiversity values in and around the proposed HEPs of the TRB and to develop a Biodiversity Management Plan (BMP) at landscape level to minimize the possible adverse impacts of the proposed projects. The plan also intends to ensure ecological and economic sustainability of the TRB and its dependent community.

1.2 SCOPE OF WORK

The Government of Arunachal Pradesh has proposed to develop 13 HEPs in TRB. In order to minimize the adverse impacts of these hydel projects on ecosystems, species and genetic diversity, and to sustainably manage the biodiversity of TRB, North–Eastern Hill University (NEHU) was assigned to prepare a BMP at landscape level. Assessment of the status of biodiversity, and understanding their distribution in different landscape elements, and recommending effective conservation measures across the landscape are the main objectives of this BMP. The BMP has the following structure:

1. Overview of biodiversity elements of TRB
2. People–Biodiversity relationships
3. Biodiversity and natural resource management systems
4. Landscape level impact assessment on biodiversity and mitigation measures
5. Mitigation measures and species–specific conservation plan landscape level BMP.

CHAPTER 2
OVERVIEW OF BIODIVERSITY ELEMENTS OF TAWANG RIVER BASIN

2.1 INTRODUCTION

The landscape of TRB is a mosaic of natural and man–made ecosystems situated in high Himalayan mountains. The natural ecosystems consist of primary sub–tropical forests, temperate forests, alpine scrubs/forests, alpine meadows, and wetland ecosystems. The secondary forest patches are found near human habitations and along the roads after the removal of primary forests. The man–made ecosystems are upland agroecosystems with millet, rice and maize along small terraces, and small horticultural gardens surrounding the homestead.

2.2 ECOSYSTEM LEVEL DIVERSITY

2.2.1 Forests

The forests of TRB are primarily sub–tropical evergreen, temperate forest, subalpine forest, and alpine scrub and forest. The secondary forests are mainly composed of *Alnus nepalensis*, *Betula pubescens*, *Erythrina arborescens,* and *Elaeagnus parvifolia.* Based on elevation and structural and compositional characteristics, the forest vegetation of the river basin can be broadly classified into following four major types (following Champion and Seth, 1968, Kaul and Haridasan, 1987):

The forests change with elevations and mainly composed of subtropical pine/broadleaved forests between 1000–1800 m, temperate broad–leaved and conifer forests between 1800 to 3000 m, sub–alpine forests between 3000–4000 m and alpine forest/scrub>4000 m (Kaul and Haridasan, 1987) (Table VII.2.1).

2.2.1.1 Sub–tropical broadleaved/pine forests

These forests are found between an elevation of 1000–1800 m elevation and are of two types viz. broadleaved and pine forests. The differentiation between these two forest types cannot be made on the basis of elevation. Generally, the following the degradation of the broadleaved forest *Pinus wallichii* establishes and forms the pine forests. The broadleaved forests are dominated by *Quercus* spp., *Castanopsis indica*, *Schima wallichi*, *Prunus* spp., *Magnolia campbelli*. The secondary forests particularly along the riverside and landslide areas are pure patches of *Alnus nepalensis*.

2.2.1.2 Temperate broad leaved and coniferous forests (1800–3000 m)

These are mostly temperate broadleaved forests having dominant species forming top canopy by tall trees like *Acer hookeri, A. oblongum, A. pectinatum, Betula alnoides, Exbucklandia populnea, Quercus lamellosa, Q. glauca, Acer hookeri, Castanopsis* spp*., Magnolia campbellii, Populus ciliata, Rhododendron arboreum*, etc.

The middle storey is dominated by small to medium sized trees and shrubby species. Common species met with are *Illicium grifithii, Lyonia ovalifolia, Corylopsis himalayana, Myrsine semiserrata, Berberis wallichii, Caryopteris odorata, Debregeasia longifolia, Vaccinium sprengelii, Acer pectinatum, Pyrus polycarpa, Prunus cerasoides, Spiraea arcuata, Symplocos rasimosum* and species of *Rhododendron*.

The ground flora mainly consists of herbaceous species like *Anemone elongata, Anaphalis adnata, Corydalis leptocarpa, Sedum multicaule, Drymaria villosa, Potentilla peduncularis, P. polyphylla, Fragaria nubicola, Cardamine elegantula, Oenanthe javanica, Rorippa indica, Stellaria sikkimensis, S. vestita,* etc.

Some epiphytic species of *Rhododendron*, *Agapetes* and *Vaccinium* and a few Orchids are usually met with.

The coniferous forests are dominated by *Pinus wallichiana,* and often pure stands of *Cupressus torulosa* are encountered.

2.2.1.3 Sub–alpine broadleaved and coniferous forests (3000–4000 m)

This type occurs between 3000–4000 m above the temperate broad–leaved and coniferous forests. Such forests are dominated by *Abies densa* and show succession of forests with dominance of *Tsuga dumosa, Abies spectabilis, Taxus wallichiana, Salix* spp., *Acer* spp., and *Rhododendron* spp.

2.2.1.4 Alpine forest/scrubs (>4000 m)

The most dominant tree in this area is *Abies densa,* which occur in Fir–*Rhododendron* association. It forms the dominant component for most of this type of vegetation in association with shrubby and bushy species of *Rhododendron, Juniperus, Berberis, Salix, Cotoneaster, Lonicera*, etc. This vegetation type has herbaceous species such as *Anemone, Aconitum, Cassiope, Primula denticulata, Primula capitata, Potentilla, Pedicularis, Meconopsis, Fritillaria, Corydalis*, etc. *Rhododendron hodgsoni* is the common species on the upper slopes at Sela and Yumthang.

Abies delavayi (fir) grows on northern slopes at higher elevation in association with trees like *Rhododendron falconeri, R. barbatum, R. hodgsonii, R. fulgens, R. maddenii, Lyonia ovalifolia*, etc. with sporadic patches of hill bamboos like *Arundinaria aristata*.

A mat of very dwarf Rhododendron species rarely exceeding 0.5m occur between 4200–4600m. This representing typical alpine moorland type of vegetation consisting of dwarfed association of hardy cushion with thick perennial deep root–stocked herbaceous species like *Rheum, Arenaria, Saussurea, Ephedra, Saxifraga, Sedum, Festuca, Anaphalis, Fagopyrum, Meconopsis, Juncus, Aster, Anemone*, etc. mixed with stunted crawling bushes of *Rhododendron anthopogon, R. nivale Sassurea gossypiphora Arenaria musciformis, Leontopodium himalayana* along with *Meconopsis horridula* and *Urtica hyperborean* (yak fodder) are common.

2.2.1.5 Alpine meadows (4000–5676 m)

High altitude grassy meadows occur between 4000 and 5676 m. These are open rocky areas. The woody vegetation is very restricted and trees are absent. These regions are more humid and characterized by gregarious patches of *Primula colderiana, Rheum nobile, Swertia hookerii* and species of *Saxifraga Artemisia, Leontopodium* and dwarf *Rhododendrons*. Towards higher elevation the landscape is relatively drier and stony deserts are seen with litter of scree and rock encrustation with lichen and deep rooted plants like *Sedum*, etc. growing amongst the rocks.

2.2.2 High altitude lakes

As part of preparation of National Wetland Atlas for entire country, ISRO had mapped different types of wetlands of Arunachal Pradesh using satellite imageries of period between January 2005 and January 2007 (ISRO, 2009). The atlas also provides wetland maps and statistics for each districts including for Tawang. Accordingly, there exist good number of high attitude wetlands (i.e., wetlands that occur above 3000 meter elevation) in the district. In general, high altitude wetlands are the areas located at altitudes between the continuous natural forest border and the permanent snow line.

Out of total estimated wetland area of 1822 ha for the entire district, 1084 ha (i.e., about 60%) was categorized under high altitude natural inland wetlands. A total of 204 high altitude wetlands exist in the Tawang district, which, considering the geographical area of the district could be highest among all other districts of the state.

WWF–India under their Himalayan high altitude wetland program identified two major wetland complexes in Tawang district–(i) Bhagajang Wetland Complex comprising nearly 20 lakes in the altitudinal range of 4000–4400 m asl, known for its rich faunal assemblage , and (ii) Nagula Wetland Complex comprising of more than 100 permanent alpine lakes in the altitudinal range of 3500–4500 m asl. Besides, WWF–India has also identified PT Tso, Oriangdukpu, Sangetsar and Paradise lakes as high conservation priority wetlands of the district (Chatterjee *et al*., 2006).

Most of these high altitude water bodies are playing significant role in maintaining ecological and hydrological balance and maintaining various other ecological services. Many of these high altitude lakes provide ideal habitat for unique assemblage of migratory aquatic birds. Many of these wetlands are considered sacred and there are taboos associated with it.

2.2.3 Agriculture

As per 2010–11 district statistics, of the total agriculture land of 6318 ha, about 66% (4148 ha) was under sowing and 907 ha area was fallow. Of the total sown area, only about 13% was under irrigation through minor irrigation schemes (Table VII. 2.1).

Table VII. 2.1: Agriculture related landuse statistics of Tawang district (2010–11)

	Net sown area	Current fallow	Other fallow	Culti–vable waste	Unculti–vated land	Land not use for cultivation	Total agricul. land	Net irrigated area
Area (ha)	4148	637	270	144	337	782	6318	538
% of total agriculture land	65.7	10.1	4.3	2.3	5.3	12.4	100.00	13.0

Source: District Agriculture Officer, Tawang

In general, the agriculture lands are categorized in three broad categories i.e., top hill agriculture, middle hill agriculture and foothill agriculture. Traditionally, the agriculture system produces barley, wheat, paddy, millet, maize and potato as major crop while soybean, buck wheat, ginger and chilies form the minor crops (Table VII.2.2). Thus, maize and paddy crops are grown in foothills, while finger millet is planted in the middle hills and wheat and barley are grown in top portions of the hill. In majority of cases agriculture field are located quite close to the village.

Table VII. 2.2: Area (ha) under different crops in Tawang district

Year	Rice	Maize	Wheat	Millet	Barley	Buck wheat	Soya bean	Pulses	Potato	Seasonal veg.	Chilies	Garlic	Tur–meric	Ginger
2010	767	700	868	1015	230	56	170	156	455	340	75	16	15	20
2014	780	680	650	1020	240	60	175	160	380	350	78	18	16	22

Source: District Agriculture Officer, Tawang

2.3 FLORAL DIVERSITY

Kanjilal *et al*. explored the Tawang flora during 1934–40. Later, Deka, Srinivasan and Rao explored Rupa and Dirang Valleys during 1951 and 1955. Recently, however, Mahapatra did comprehensive surveys and collection of plants of the district. Mahapatra (2010) reported a total of 767 species exhibiting wide range of diversity in terms of taxa, habit and growth forms belonging to 347 genera and 100 families.

The genus *Rhododendron* exhibits maximum diversity with 19 species followed by *Primula* (16 species). *Polygonum* (13 spp.), *Potentilla* (11 spp.), *Saxifraga, Junus* and *Rubus* (10 species each), *Gentiana* (9 spp.) are some other genera exhibiting higher species diversity. The high altitude climatic and edaphic conditions infact provide suitable niche for many species of *Rhododendron, Saxifraga, Pedicularis Meconopsis, Swertia, Sedum, Rhodiola, Primula, Gentiana*, etc.

Gymnosperms are represented by 21 species under 11 genera and 6 families out of which the genus *Pinus* exhibits maximum diversity with 6 species and 1 variety, followed by *Abies* with 4 species, *Picea* and *Juniperus* with 2 each and *Cedrus, Cycas, Larix, Tsuga, Taxus, Podocarpus* and *Gnetum* 1 species each. The district supports a few species of 'primitive' flowering plants indicating its conservation significance. Two such species include: *Betula alnoides (*Betulaceae) and *Decaisnea insignis (*Lardizabalaceae) (SBSAP, 2005).

2.3.1 Rhododendron Richness

Rhododendron is one of the important dominant plant groups in the temperate, subalpine and alpine regions of Tawang. Paul *et al*. (2010) extensively surveyed the district (along with neighboring West Kameng district) and recorded 47 *Rhododendron* taxa, which varied in size from tiny shrubs to large trees. Maximum diversity of *Rhododendron* was reported between 2500 to 3500 m elevation. Out of these, 13 species were found endemic, endangered, rare or threatened and thus had very high conservation significance. Also, more than 50% Rhododendron taxa of the entire Arunachal Himalaya occur in Tawang and Western Kameng districts. This further highlights the conservation values of Rhododendron in this part of the State. The taxa are, however, facing severe anthropogenic pressures in the form of uncontrolled and indiscriminate harvesting for fuel wood, livestock grazing, clearfelling and subsequent forest fires.

2.3.2 Orchid Richness

Orchids are a threatened plant group. Arunachal Pradesh has about 550 species of Orchids out of total 750 species in North–eastern India. Mahapatra (2010) recorded 25 species of orchids from Tawang district. Orchids are widely used as ornamental plants and also having varied medicinal values. Thus, their trade is very common practice, leaving serious conservation issues for many species. Orchid trade is regulated under the Convention of International Trade for Endangered Species (CITES) since India is signatory to this convention. Orchids have been brought under Schedule VI of Wild Life (Protection) Act.

2.4 FAUNAL DIVERSITY

Tawang district is located within the Himalayan Biodiversity Hotspot, which is also listed among the 200 Globally Important Eco–regions (Myers *et al*., 2000). The district is located in the tri–junction of south–eastern Bhutan, southern China and northern Assam–all these three regions are known for their rich floral and faunal diversity. Elevations range from 1000 to 5676 m. The district is known for a rich diversity of animal life (Mishra *et al*., 2004). However, the remoteness of the region and difficult terrain make it extremely difficult to document the faunal diversity of the region in a limited time span under one year.

Under biodiversity component, status of selected faunal groups such as: Butterflies, Herpetofauna (Amphibian and Reptiles), Avifauna (terrestrial and aquatic) and Mammals were assessed covering three seasons. Among the faunal groups, Butterfly was assessed through check list, while other groups were assessed through quantification and enumerating the individual animals abundance estimates. Since the biodiversity attributes varied among the project areas and therefore to understand the cumulative values of different faunal groups surveyed, all the field data collected were pooled and analysed at the Tawang River Basin Landscape (TRBL) level.

2.4.1 Birds

The International Council for Bird Preservation, United Kingdom, identified the Assam plains and the eastern Himalaya as an endemic bird area (Bibby *et al*., 1992), including Arunachal Pradesh. Similarly, under Important Bird Area (IBA) program initiated by BirdLife International, a total of 59 IBAs have been identified within the eastern Himalayan region, including 28 sites from Arunachal Pradesh. Out of these, one site Zemithang–Nelya falls in Tawang region.

2.4.1.1 Status of Species Richness and Diversity of birds in Project Areas

The richness status of avifauna species in TRBL (based on number of species reported in different project areas), has revelaed that it varied from lowest (43 species) in Tsa chu–II and Tsa chu–I Lower with the diversity of 3.1 and 2.7, respectively, to the highest in Tawang–II (136 species of 83 genera and 37 families) with estimated diversity at 4.3. Tawang I with 114 species of 81 genera and 34 families, stood at second highest (species diversity 4.1). The distribution of avifauna community showed clear pattern with less species at higher altitude project areas (46 and 43 species at Tsa chu–I, and Tsa chu–II and Tsa chu–I Lower, respectively) and higher number of species at lower reaches (110, 114, and 136 species at Rho, Tawang–I, and Tawang–II, respectively) (Table VII. 2.3).

Table VII. 2.3: Status of species richness and diversity of avifauna of different project areas

S.No	Project name	Species	Genera	Families	Diversity 'H
1	Jaswantgarh Stage–I	73	50	25	3.9
2	Mago chu	95	65	34	3.6
3	New Melling	67	46	25	3.6
4	Nykcharong chu	106	68	32	3.9
5	Paikangrong chu	86	61	31	3.9
6	Rho	110	77	34	4.1
7	Tawang I	114	81	34	4.1
8	Tawang–II	136	83	37	4.3
9	Thingbu chu	67	45	28	3.6
10	Tsa chu–I	46	31	17	2.9
11	Tsa chu–II	43	30	19	3.1
12	Tsa chu–I Lower	43	31	16	2.7
13	Nyamjang chu*	86	64	33	3.8

* based on one season study

2.4.1.2 Status of Species Richness and Diversity

Overall seasonal (three seasons) avifaunal richness at Tawang Study Landscape was almost similar in all seasons with comparatively marginally more in monsoon (144 species and diversity of H'4.2) compared to winter and summer (Table VII.2.4). This could be due to presences of denser vegetation cover during monsoon. A total of 241 species (132 genera; 48 families; diversity 4.5) from the Tawang Study Landscape for all the seasons showed that the species composition was fairly evenly distributed among the species and resulted in high diversity index. Infact, the landscape diversity is extraordinary in not less than 2% of the geographical area of Arunachal Pradesh, harbours more than a third of Avian biodiversity.

Table VII. 2.4: Status of birds recorded in TRB

Details	Summer	Monsoon	Winter	Overall
Family	34	43	38	48
Genera	85	94	85	132
Species	142	144	138	241
Abundance	4291	4708	2948	11947
Diversity H'	3.9	4.2	4.0	4.5

2.4.1.3 Abundance Status

The abundance status of birds was derived by classifying the number of individual birds counted for each species into five categories (Very Low = 1–25 birds, Low = 26–50, Moderate = 51–75, High = 76–100 & Very High =>100 individuals). The result showed that overall abundance of the birds in the TRL was very low as most species (74.7%) belonged to very low (61.8 %) to low (12.9%) abundance categories. However, 40 species (16.6%) recorded very high (29 species: 12 %) to high (11 species: 4.6%) bird abundance and most of these species were common and generalists (Table VII.2.5).

Table VII. 2.5: Number of species and relative % of birds in different abundance classes in TRB

Abundance class	No.of species	Relative %
Very low–1–25 birds	149	61.8
Low–26–50 birds	31	12.9
Moderate–50–75 birds	21	8.7
High–76–100 birds	11	4.6
Very high>100 birds	29	12.0
Total	**241**	**100**

Among the very high abundant species, a total of 8 species were with more than 300 individuals, namely, Nepal House–martin (*Delichon nipalense*=734), Himalayan Swiftlet (*Aerodramus brevirostris*=694), Himalayan Black Bulbul (*Hypsipetes leucocephalus*=603), Rufous Sibia (*Heterophasia capistrata*=552), Asian House Martin (*Delichon dasypus*=330), Blue Whistling–

thrush (*Myophonus caeruleus*=330), Red–vented Bulbul (*Pycnonotus cafer*=325) and Bhutan Laughingthrush (*Trochalopteron imbricatum*=301). Of these eight species, house–martins, swiflet and laughing thrush are group/flock living bird species.

2.4.1.4 Migratory Status

The area supports more of resident birds (170 species) than migratory (71 species, including 33 species each of winter visitors and breeding visitors). The seasonal surveys carried out in the study landscape also showed a similar trend as in the case of overall migratory status (Table VII.2.6).

Table VII. 2.6: Status of birds recorded in TRB

Migratory status	Summer	Monsoon	Winter	Overall
Breeding Visitor	25	22	16	33
Isolated Record	1	1	4	5
Resident	94	106	98	170
Winter Visitor	22	15	20	33

2.4.1.5 Status of Foraging Guilds

In the Tawang basin study landscape, the birds were represented by nine different foraging guilds, of which maximum (162 species) were insectivores followed by granivorous (24 species), omnivores (20 species), carnivores (18 species) and nectarivores (9 species). The frugivore, nucivore, piscivore and aquatic feeder guilds were represented by five and less than five species. The high richness of insectivores was also reported across the seasons and it showed the presences of diverse habitat and niches in this project site (Table 2.7). Though, true aquatic feeders mainly feed on submerged vegetation, macro benthos and fish fauna were found to be absent in the river systems.

Table VII. 2.7: Status of foraging guild of birds recorded in TRB

Foraging guild	Summer	Monsoon	Winter	Overall
Aquatic Feeder	0	1	0	1
Carnivore	9	6	11	18
Frugivore	1	3	3	5
Granivore	15	11	16	24
Insectivore	99	98	88	162
Nectarivore	6	6	6	9
Nucivore	1	1	1	1
Omnivore	11	17	13	20
Piscivore	0	1	0	1

2.4.1.6 Status of Threatened Species

Only one individual of Rufous–necked Hornbill (*Aceros nipalensis*), a vulnerable species of IUCN Red List (Rahmani, 2012; IUCN, 2013), was recorded from this landscape.

World Wide Fund (WWF), Tezpur has reported presence of five Black–necked Cranes (*Grus nigricollis*) along the Nyamjang chu basin in Zimithang during the winter of 2013. The population of Black–necked Crane recorded for the past five years by WWF Tezpur in the Zemithang project area are given in the Table VII (Table VII.2.8**)**. In addition, the area where these birds are reported has also been identified as an IBA mainly due to the presences of this vulnerable species as listed by IUCN, Schedule–I species of Wildlife Protection Act (1972) and listed in Appendix I & II of CITES (Rahmani, 2012). This landscape, particularly Nyamjang chu river basin and specifically the black–necked Crane habitat is identified as one among few wintering grounds, in Arunachal Pradesh and India.

Table VII. 2.8: No. of black–necked crane recorded in the Zimithang area during winter of 2009–10 to 2013–14–Nyamjang chu project area (Source: WWF, Tezpur, Assam)

Year	No. of birds	Remarks
2009–2010	3	All Adults
2010–2011	7	Six Adults & one Juvenile
2011–2012	4	All Adults
2012–2013	2	All Adults
2013–2014	5	All Adults

Considering overall high altitude of Tawang district, the reported bird life is not very rich compared to overall record of around 700 species from entire Arunachal Pradesh as reported by Choudhury (2006). Singh (1994) conducted surveys in Tawang and Jung–Broksar–Thingbu–Mago–Churna–Chirila track and provided some information on the avifauna of this area. Mishra *et al*. (2004) during their faunal survey in high altitude areas of Tawang regions recorded 112 species. Kumar (2008) reported only 81 bird species from Tawang chu valley, while Maheshwaran (2012) reported 113 species of birds from Tawang District. WWF–India, however, reported 159 bird species from Nyamjang chu valley.

These surveys revealed that Tawang district support a sizable number of avian species. The district supports many regionally and globally important bird species including high–altitude pheasants such as satyr tragopan (*Tragopan satyra*), Himalayan monal pheasant (*Lophophorus impejanus*) and Ibis bill (*Ibidorhyncha struthersii*), etc.
Overall, in the entire TRL, the bird abundance is not very high as most out of 241 bird species recorded only less than 25 individuals. Also, the species recording more than 300 individuals are very common and generalists and are not likely to get impacted from the project proposal to lose viability.

Box VII. 2.1: Conservation of habitat of Black–necked crane in TRB

Black–necked crane also known as Tibetan Crane (*Grus nigricollis*), locally known as Dhung Dhung Karma in Monpa, is the only high altitude species among the 15 species of crane in the world. It was first discovered by a Russian naturalist, Count Prazewalski near Lake Koko Northeastern Tibet in 1876. This species is generally found in the range between altitudes of 3500m to 5500m ASL. The estimated population of the Black–necked Crane is between 8800 and 11000 individuals. The largest populations are in China and Tibet with smaller numbers extending into Vietnam, Bhutan and India (Collar *et al*., 2001).

Legend is that the bird is the embodiment of the spirit of the 6th Dalai lama. In this story, when 5th, or 6th, Dalai lama was enclosed in a cowhide bag by insurrectionists, his understrappers asked him in vexation: do you just have the ability like this? He answered: I can’t see light, so I have no way. Then his understrappers speared a hole on the cowhide. At this time, Dalai lama saw a Black necked crane through the hole, and the crane brought his spirit to Mongolia, whereupon the reincarnation of Dalai lama was found in Mongolia. It is believed to be an embodiment of the sixth Dalai Lama by Tibetan Buddhists and is revered by the Monpas.

In Indian Himalayas it breeds only in Ladakh (Jammu and Kashmir). It is known as "State bird of the Kashmir". It was first recorded in Ladakh by the naturalist, F. Ludlow at Tsokar Lake during 1919 (Ludlow, 1920). In Himalayan region of north–west India Black necked cranes has a very small population as well as breeding ground in cold desert area of Ladakh in Jammu and Kashmir. The wetlands of Changthang are the only known nesting sites of the Black–necked crane in India.

A wintering population of 27 birds has been reported from Apatani valley of Arunachal–Pradesh in India (Beetis, 1954). However, at present there is no record of the species in the valley (Choudhury, 2002). In north Bengal, the species was recorded at the Moinabari Forest Beat near Bhutanghat and on the fringe of the Buxa Tiger Reserve.

The Black necked crane is included in Schedule I Part III of Indian Wild life (Protection) Act. It is evaluated as vulnerable under criteria A1b, c, d A 2cC 1. on the IUCN Red List of Threatened Species. It is listed on Appendix I and II of CITES. Seven of the world's fifteen species are listed in the international council for Bird Preservation's (ICBP, Birdlife international) checklist of threatened birds (Collar and Andrew, 1988). Loss and degradation of habitats are the main threats to Black–necked Crane. Habitat modification, drying of lakes and agriculture are threats to the populations.

Photo Courtesy: WWF India

2.4.2 Mammals

While no systematic faunal survey was conducted in the Tawang district, there were quite a few short term explorations conducted in past suggesting that the region houses some important and rare faunal species including common leopard (*Panthera pardus*), Himalayan black bear (Ursus *thibetanus*), Asiatic wild dog (*Cuon alpinus*), Himalayan serow (*Capricornis thar*), Alpine musk deer (*Moschus chrysogaster*), red panda (*Ailurus fulgens*), etc.

Recently, one of the was conducted by Mishra *et al*. (2004), during explorations of part of high altitude areas of Tawang district, reported 28 species of mammalian faunal (16 of this are high altitude mountain fauna), including a new species of macaque, Tawang Macaque (*Macaca munjala*) (Table VII. 2.9). Absence of two globally important species, namely, musk deer and bharal suggest shrinking of their distributional range in the region.

Red Panda (*Ailurus fulgens*), Capped Langur (*Trachypithecus pileatus*), Asiatic Black Bear (*Ursus thibetanus*), Wild dog, (*Cuon alpines adjutes*) and Common Leopard (*Panthera pardus*), are considered to be of high conservation significance because either they fall under Schedule I of Wildlife (Protection) Act, 1972 or as endangered species under IUCN Red Data category.

Table VII. 2.9: Mammal species recorded in different areas of TRB

Attribute	Upper Nyamjang chu	Lower Nyamjang chu	PT Tso	Mukto	Mago chu
Number of mammal species recorded	16	15	13	13	20
No. of high altitude mammal species	9	9	9	6	15
Species of global conservation importance	4	3	5	4	6
Hunting intensity	Low	High	High	Very high	Medium
Disturbance level	Low	Medium	High	Medium	Medium
Main forms of disturbance	Army bases	Habitation	Army bases	Habitation	Habitation

Source: Mishra *et al*., 2004

Box VII. 2.2: Tawang or Arunachal Macaque

Tawang district support 3 species of primates including Capped Langur, Slow Loris and Rhesus macaque. However, a new species of macaque was reported by Mishra *et al*. (2004). The species closely resembles Assamese and Tibetan macaques. Its similarities with the Assamese and Tibetan macaque suggest that the Tawang macaque presumably belongs to the same *sinica* group of the genus *Macaca*. At the same time, its distinctive features set the Tawang macaque apart from either of them. Thus, it was believed that the population of the Tawang macaque potentially represents a distinct species within the *sinica* group of the genus *Macaca*. The species, with the recent genetic analysis by NCBS, is confirmed as a new species and identified as *Macaca munzala* commonly known as Tawang macaque or Arunachal macaque.

Although the elevation in Tawang district ranges between 2000 to >6000 m elevation, Tawang macaques were generally encountered between 2000 and 2700 m. The animals were found in group ranging from 4 to 18 animals. Subtropical broadleaved forests dominate the vegetation within this elevation interspersed with agriculture lands. Tawang macaque frequently damage crops and sometime farmers killed them in retaliation. The people of Tawang, belonging predominantly to the Buddhist *Monpa* tribe, in general do not eat primates. However, some hunting of primates for meat is carried out by other tribes posted.–Source: Mishra *et al*. (2004)

Photo courtesy: NEHU, Shillong

2.4.2.1 Status of Species Richness–Projects level

Species richness in TRB varied from 4 species (from 1 genus and family) at Jaswantgarh Stage–I area to a maximum of 13 species (13 genera and 9 families) in the Nykcharong chu area. Tawang–II and Zemithang were second most species rich areas recording 12 species each (Table VII. 2.10)

Table VII. 2.10: Status of species richness of mammals of different project areas

Sl. No .	Project name	Species	Genera	Families
1	Jaswantgarh Stage–I	4	4	4
2	Mago chu	10	10	8
3	New Melling	7	7	7
4	Nykcharong chu	13	13	9
5	Paikangrong chu	7	7	6
6	Rho	8	8	7
7	Tawang I	8	8	7
8	Tawang–II	12	12	10
9	Thingbu chu	10	9	7
10	Tsa chu–I	6	6	6
11	Tsa chu–II	7	7	6
12	Tsa chu–I Lower	6	6	5
13	Nyamjang chu	12	12	10

2.4.2.2 Overall Status of Species Richness

Irrespective of project areas, overall TRB reported a total of 18 mammalian fauna, each belonging to a separate genus from 13 families. The fauna consist of 2 species of primates, 3 ungulates, 5 rodents and 8 carnivore species. Thus abour 9% of all mammals reported in Arunachal Pradesh occur in the TRB.

2.4.2.3 Overall Abundance status in TRB

Overall presence of 18 species within TRBL was confirmed based on direct sightings of 296 animals and 253 indirect evidences. Nine species were sighted, while other species are reported based on tracks and signs to come up with relative abundance status. Seasonal variations are few with direct (86) and indirect sightings (202) sightings of animals during winter being higher than during summer and monsoon. This higher value during winters can be attributed to the facts that the species, in want of vegetations in winter due to snowfall, descend to river valley for food and water and are thus more visible along the riverine habitats both directly and through indirect evidences.

2.4.2.4 Species Specific Abundance in TRB

Among the species, 217 animals from 11 groups of Arunachal macaque (*Macaca munzala*), were recorded from 21 indirect evidences. A total of 13 individuals from 1 group of capped langur (*Trachypithecus pileatus)* were counted. Among the ungulates, 76 IE were collected for wild pig (*Sus scrofa)*, followed by 6 animals of barking deer (*Muntiacus muntjak)* with 22 IE. Since Himalayan goral inhabits higher reaches, it was sighted only once and 30 pellet groups were identified mostly along the riverside (Table VII.2.11).

Among the carnivore, jungle cat (*Felis chaus)* was recorded based on 48 scats followed by 4 animals of yellow throated martin (*Martes flavigula)* were sighted besides 21 droppings. Himaliyan palm civet was recorded through 15 IE mostly along the riverine habitat. Occurrence of other carnivores, namely, common leopard, leopard cat, Asiatic wild dog, Himalayan black bear were confirmed through less than five indirect evidences and showed low abundance status in the project areas. Presence of Red panda was reported based on two stuffed animals only from a village near Zemithang project area. The Rodents included three species of squirrels, one rat and porcupine. A total of 23 individuals were counted of all the three species of squirrels (hoary–bellied, orange–bellied and Himalayan stripped). Chesnut rat was sighted thrice while porcupine was recorded based on five indirect evidences (Table VII.2.11). Overall this species list of 18 species of TRB contributed 62.02% of 29 species of the Tawang region (Mishra *et al*., 2006).

Table VII. 2.11: Status of mammalian fauna of TRB

Sl. No.	Common name	Scientific name	Seasons			Overall	Conservation status	
			S	M	W		IUCN	IWPA
1	**Cercopithecidae**							
1	Arunachal Macaque	*Macaca munzala*	IE 5/A 12	IE11/A16	IE5A/189	IE 21 A 217 (11)	EN	–
2	Capped Langur	*Trachypithecus pileatus*	IE3/A13	IE1		IE4/A13	EN	I
II	**Ailuridae**							
3	Red panda	*Ailurus fulgens*	IE 2 **			IE 2 **	VU	I
III	**Bovidae**							
4	Himalayan goral	*Naemorhedus goral*	IE13/A1	IE7	IE10	IE 30/A1	NT	III
IV	**Cervidae**							
5	Barking Deer	*Muntiacus muntjak*	IE 10/A2	IE 4/A4	IE 8	IE22/A 6	LC	III
V	**Suidae**							
6	Wild pig	*Sus scrofa*	IE25	IE19	IE32	IE76	LC	III
VI	**Ursidae**							
7	Himalayan Black Bear	*Ursus thibetanus*	IE 2			IE 2	VU	II
VII	**Canidae**							
8	Asiatic wild dog or Dhole	*Cuon alpines*	IE 2		IE1	IE3	EN	II
VIII	**Felidae**							
9	Jungle cat	*Felis chaus*	IE13	IE11	IE24	IE 48	LC	II
10	Leopard Cat	*Prionailurus bengalensis*	IE 3			IE3	LC	–
11	Common Leopard	*Panthera pardus*	IE 1			IE 1	NT	I
IX	**Mustelidae**							
12	Yellow Throated Marten	*Martes flavigula*	IE 8/A2	IE9/A2	IE4	IE 21/A4	LC	II
X	**Viverridae**							
13	Himalayan Palm Civet	*Paguma larvata*	IE6	IE9		IE15	LC	II
XI	**Sciuridae**							
14	Orange–Bellied Himalayan Squirrel	*Dremomys lokriah*	A2	A7		A9	LC	
15	Hoary–bellied Himalayan Squirrel	*Callosciurus pygerythrus*	A13	A5	A 5	A23	LC	–
16	*Himalayan Stripped Squirrel*	*Tamipos macclellandi*	A1	A12	A7	A20	LC	–
XII	**Hystricidae**							
17	Indian Porcupine	*Hystrix indica*	IE 2	IE1	IE2	IE5	LC	IV
XIII	**Muridae**							
18	Chesnut rat	*Niviventer fluvescens*		A2	A1	A3	LC	V
	No of species		**17**	**13**	**11**	**18**		
	Total and types of records		**IE 97 A 46**	**IE 72 A 48**	**IE 86 A 202**	**IE 253 A 296**		

IE–Indirect Evidences A–animals sighted, W–Winter, S–Summer, M–Monsoon, IUCN–Red List, IWPA–Indian Wildlife Protection Act, EN–Endangered, Vu–Vulnerable, LC–Least Concern, NE–Not Evaluated , ** Stuffed animal of two Red panda was reported, Number in parenthesis denotes number of groups.

2.4.2.5 Status of Threatened mammal Species

Among the 18 mammalian fauna identified from the Tawang landscape, Arunachal Macaque *(M. munzala),* Capped Langur (*Trachypithecus pileatus),* Asiatic wild dog (*Cuon alpines)* were the three species categorised as endangered and Himalayan black bear (*Ursus thibetanus)* and red panda (*Ailurus fulgens)* as vulnerable under IUCN red list. Overall six species of mammals reported in TRBL fall under species of high conservation significance of IUCN and IWPA (Table VII.2.12).

2.4.2.6 Distribution of Threatened Mammal Species

Amongst highly threatened species, Arunachal macaque *(M. munzala)* was reported with 21 IE and 217 animals (Table VII.2.14) and showed wider distribution in nine project areas with minimum of 1 indirect evidence (Jaswantgarh Stage–I) to a maximum of 95 animals from 5 groups (Tawang–II). A total of 13 individuals from one group of capped langur were also reported from Tawang–II (Table VII.2.12). Remaining 4 threatened species were reported based on very few indirect evidences.

Table VII. 2.12: Status of Highly Threatened mammalian fauna of TRB

Threatened species		**JG**	**MG**	**NM**	**NY**	**PI**	**RH**	**TG I**	**TG II**	**TIB**	**TS I**	**TS II**	**TSL**	**ZG**
Cercopithecidae														
Arunachal Macaque	*Macaca munzala*	IE1	–	IE1 A32	IE1	IE1 A15	A 15	IE 5 92	IE7 A50	IE 3	–	–	–	IE3 A12
Capped Langur	*Trachypithecus pileatus*		–			–			IE2 A13		–	–	–	IE 2
Ailuridae														
Red panda	*Ailurus fulgens*		–			–					–	–	–	IE2 *
Ursidae														
Himalayan Black Bear	*Ursus thibetanus*		–			–			IE 2		–	–	–	
Canidae														
Asiatic wild dog or Dhole	*Cuon alpines*		–		IE 2	–			IE 1		–	–	–	
Felidae														
Common Leopard	*Panthera pardus*		–		IE 1	–					–	–	–	
No of species		1	0	1	3	1	1		4	1	0	0	0	1
Total and types of records		IE1		IE1 A32	IE4	IE1 A15	A15		IE12 A63	IE3				

IE–Indirect Evidences A–animals sighted, JG–Jaswantgarh Stage–I, MG–Mago chu, Nm–New Melling, NY–Nykcharong chu, PI–Paikangrong chu, RH–Rho, TGI–Tawang–I, TGII–Tawang–II,TIB–Thingbu chu, TSI–Tsa chu–I, TSII–Tsa chu–II, TL–Tsa chu–I Lower, ZG–Zemithang.

2.4.3 Herpetofauna

Being a high altitude area, Tawang district do not support high herpetofauna (the cold blooded animals) diversity and abundance. *Hemidactylus frenatus, Myctopholis austiana, Elaphecantoris, Xenochrophis piscator, Amphiesma platyceps* and *Boiga ochracea,* are few common species. Among the amphibian fauna, species like *Bufo melanostictus, Bufo himalayana, Amolops afghanus, Rana cyanophlyctis, Rana tigrina* and *Polypedates maculates* are reported. None of these herpetofaunal species are locally and globally threatened.

2.4.3.1 Status of Species Richness

Overall, in the entire TRL only 2 species of amphibians (bush frog, *Philautus* spp. with two individuals and 16 Indian Skipping/Skittering Frog, *Euphlyctis cyanophlyctis*) and 4 species of reptiles (5 individuals of Indian Garden Lizard, *Calotes versicolor*; 5 individuals of Many–lined Grass Skink, *Eutropis multifascita*; 1 individuals each of Common Wolf Snake, *Lycodon aulicus* and Monocled Cobra, *Naja kaouthia*) were recorded during this survey.

Ahmed *et al*. (2009) has recorded revealed presence of 8 species of amphibians (7 genera, 4 families) and 28 species of reptiles (21 genera, 8 families). This included 3 species each of agamids and gecko, 2 species of skinks, 1 of glass lizard, 18 species of snakes and 1 species of turtle (Table VII. 2.13).

2.4.3.2 Status of Threatened Species

The herpetofauna of conseration significance include, endangered short–nosed vine snake (*Ahaetulla prasina*) and keeled box turtle (*Cuora mouhotii*), vulnerable common mock viper (*Psammodynastes pulverulentus*) and red–necked keelback (*Rhabdophis subminiatus*) (Table VII. 2.13). Though, the entire Tawang River Landscape (TRL) was surveyed covering three seasons, none of these species were reported within 13 project areas and therefore, the herpetofauna of TRBL is of very low conservation significance.

Table VII. 2.13: List of Herpetofauna recorded and possible species occur in the TRB

S.No	Common (Scientific) Name	Altitude (m)	PS/SS	IUCN Red List	WPA 1972
A	**Amphibians**				
I	**Megophryidae**				
1	Mountain Horned Frog (*Xenophrys parva*)	150–2700	*	LC	
II	**Dicroglossidae**		*		
2	Indian Skipping/Skittering Frog (*Euphlyctis cyanophlyctis*)	40–2500	16	LC	IV
III	**Rhacophoridae**				
3	Two–striped Pigmy Tree Frog (*Chiromantis vittatus*)	50–1500	*	LC	
4	Common Tree Frog (*Polypedates teraiensis*)	40–1800	*	LC	
5	Twin–spotted Tree Frog (*Rhacophorus bipunctatus*)	80–2200	*	LC	
6	Large Tree Frog (*Rhacophorus maximus*)	80–2000	*	LC	
7	Bush frog–(*Philautus* spp.)		2		
IV	**Salamandridae**				
8	Himalayan Newt (*Tylototriton verrucosus*)	1300–2727	*		
B	**Reptiles**				
V	**Agamidae**				
9	Jerdon's Forest Lizard (*Calotes jerdoni*)	500–2500	*	DD	
10	Moustached Forest Lizard (*Calotes mystaceus*)	700–1500	*		
11	Indian Garden Lizard (*Calotes versicolor*)	Up to 2700	7	NT	
VI	**Geckkonidae**				
12	Brook's House Gecko (*Hemidactylus brookii*)		*	LC	
13	Asian House Gecko (*Hemidactylus frenatus*)		*	LC	
14	Flat–tailed Gecko (*Hemidactylus Platyurus*)	50–2500	*	LC	
VII	**Scincidae**				
15	Bronze Grass Skink (*Eutropis macularia*)	50–1500	*	LC	
16	Many–lined Grass Skink (*Eutropis multifascita*)	1065–1461	5		
VIII	**Anuguidae**				
17	Asian Glass Lizard (*Ophisaurus gracilis*)	500–2500	*	NT	
	Snakes				
IX	**Colubridae**				
18	Short–nosed Vine Snake (*Ahaetulla prasina*)	60–2000	*	EN	IV
19	Green Cat Snake (*Boiga cyanea*)	40–2000	*	NT	IV
20	Copper–headed Trinket (*Coelognathus radiatus*)	50–1500	*	LC	IV
21	Painted Bronzeback (*Dendrelaphis pictus*)	50–1500	*		IV
22	Common Wolf Snake (*Lycodon aulicus*)		1	NT	IV
23	White–barred Kukri Snake (*Oligodon albocinctus*)	60–1500	*	DD	IV
24	Common Mock Viper (*Psammodynastes pulverulentus*)	50–2000	*	VU	IV
25	Indo–Chinese Rat Snake (*Ptyas korros*)	Upto 2000	*		IV
26	Himalayan Keelback (*Rhabdophis himalayanus*)	70–2000	*	NT	IV
27	Red–necked Keelback (*Rhabdophis subminiatus*)	50–1200	*	VU	IV
X	**Elapidae**				
28	Banded Krait (*Bungarus fasciatus*)	40–2300	*	NT	IV
29	Greater Black Krait (*Bungarus niger*)	100–1500	*	DD	IV
30	Monocled Cobra (*Naja kaouthia*)	40–1500	1		II
31	King Cobra (*Ophiophagus hannah*)	60–2700	*	NT	II
32	MacClelland's Coral Snake (*Sinomicrurus macclellandi*)	Up to 1900	*		IV
XI	**Viperidae**				
33	White–lipped Pit Viper (*Crytelytrops albolabris*)	50–2000	*	NT	IV
34	Mountain Pit Viper (*Ovophis monticola*)	500–2000	*	DD	IV
35	Jerdon's Pit Viper (*Protobothrops jerdonii*)	1300–2700	*		IV
	Turtles and Tortoises				
XII	**Geoemydidae**				
36	Keeled Box Turtle (*Cuora mouhotii*)	200–2500	*	EN	

SS–Secondary Source: Ahmed *et al*., 2009. Project Area, : * possibility of occurrence, and number are actual animals recorded during the field survey, EN–Endangered, NT–Near Threatened, DD–Data Deficient, LC–Least Concern; WPA–Wildlife (Protection) Act–1972

2.4.4 Butterfly

Butterflies are very good indicator of environmental changes. No systematic inventory of butterfly species is reported from Tawang region. Survey results revealed presence of 42 species of butterflies (Table VII.2.14). The list include three species under Scheduled I and II of WPA (1972).

Table VII. 2.14: Butterfly diversity in TRB

Banded Tree brown *Lethe confuse*	Indian Purple Emperor, *Mimathyma ambica*
Blue Baron *Euthalia telchinia**	Indian Fritillary *Argyreus hyperbius*
Chestnut Tiger *Parantica sita*	Indian Tortoiseshell, *Aglais caschmirensis*
Chocolate Grass Yellow *Eurema sari*	Large Hedgeblue, *Celastrina hugeli oreana*
Chocolate Pansy *Junonia iphita iphita*	Large Silverstripe, *Argynnis children*
Common Blue Apollo *Parnassius hardwickii*	Large Threering, *Ypthima newara*
Common Bluebottle, *Graphium sarpedon sarpedon*	Longbanded silverline *Spindasis lohita himalayanus*
Common Flash *Rapala nissa ratna*	Lucas' Ace,*Sovia lucasii magna*
Common Hedge blue *Acytolepis puspa gisca*	Metallic Cerulean, *Jamides alecto eurysaces***
Common Mime *Chilasa clytia**	Mountain Tortoishell *Aglais urticae*
Common Peacock *Papilio polyctor ganesa*	Pale Hedgeblue *Udara dilecta*
Common Sailer *Neptis hylas varmona*	Paris Peacock *Papilio paris paris*
Dark Jezebel *Delias berinda*	Peablue, *Lampides boeticus*
Eastern Comma *Polygonia c–album agnicula*	Plain Sulphur, *Dercas lycorias*
Glassy Tiger *Graphium cloanthus*	Psyche *Leptosia nina nina*
Golden Birdwing *Troides aeacus aeacus*	Punchinello *Zemeros flegyas indicus*
Green Sapphire *Heliophorus moorei*	Purple sapphire *Heliophorus epicles indicus*
Green vein White *Pieris melete*	Small Grass Yellow *Eurema brigitta rubella*
Grey pansy *Precis atlites*	Spotless Grass Yellow *Eurema laeta*
Himalayan Fivering *Ypthima sacra*	Spotted Sawtooth, *Prioneris thestylis thestylis*
Indian Cabbage White *Pieris canidia indica*	Straight–banded *Treebrown Lethe verma*
* Schedule I ; ** Schedule II of WPA (1972)	

Among the 13 project areas surveyed within TRL, species richness varied from minimum of 12 species (11 genera, 3 families) reported from Tsa chu–I Lower project area and to a maximum of 28 species from Tawang–I and Zemithang (22 and 25 genera, 5 families, respectively) followed by 22 species (18 genera, 5 families) in Tawang–II project area (Table VII. 2.15).

Table VII. 2.15: Status of taxonomical diversity and species richness of butterfly of different project areas

Sl. No.	Project name	Species	Genera	Families
1	Jaswantgarh Stage–I	15	10	4
2	Mago chu	16	16	5
3	New Melling	19	16	5
4	Nykcharong chu	18	15	4
5	Paikangrong chu	21	18	5
6	Rho	20	16	4
7	Tawang I	28	22	5
8	Tawang–II	22	18	5
9	Thingbu chu	19	17	5
10	Tsa chu–I	15	14	4
11	Tsa chu–II	20	18	5
12	Tsa chu–I Lower	12	11	3
13	Nyamjang chu	28	25	5

2.4.4.1 Overall Status of Species Richness

Survey of butterflies covering three seasons in the entire TRL showed overall low species richness (33 species, 28 genera, 5 families). Among the five families, Nymphalidae dominated (10 species) while Hesperiidae represented only one species (*Sovia lucasii magna*). No species is under IUCN threatened category (Table VII. 2.16).

Table VII. 2.16: Butterflies recorded in TRB

Sl. No.	Family common name	Scientific name
A	**Hesperidae**	
1	Lucas' Ace	*Sovia lucasii magna*
B	**Papilionidae**	
2	Common Peacock	*Papilio polyctor ganesa*
3	Paris Peacock	*Papilio paris paris*
4	Golden Birdwing	*Troides aeacus aeacus*
5	Common Bluebottle	*Graphium sarpedon sarpedon*
6	Indian Purple Emperor	*Mimathyma ambica*
7	Red Helen	*Papilio helenus*
C	**Pieridae**	
8	Dark Jezebel	*Delias berinda*
9	Spotless Grass Yellow	*Eurema laeta*
10	Small Grass Yellow	*Eurema brigitta rubella*
11	Indian Cabbage White	*Pieris canidia indica*
12	Green–veined White	*Pieris napi montana*
13	Green vein White	*Pieris melete*
14	Plain Sulphur	*Dercas lycorias*

15	Spotted Sawtooth	*Prioneris thestylis thestylis*
D	**Lycaenidae**	
16	Peablue	*Lampides boeticus*
17	Green Sapphire	*Heliophorus moore*
18	Pale Hedgeblue	*Udara dilecta*
19	Large Hedgeblue	*Celastrina hugeli oreana*
20	Common Flash	*Rapala nissa ratna*
21	Common Hedgeblue	*Acytolepis puspa gisca*
22	Punchinello	*Zemeros flegyas indicus*
23	Chocolate Royal	*Remelana jangala*
E	**Nymphalidae**	
24	Chestnut Tiger	*Parantica sita*
25	Eastern Comma	*Polygonia egea*
26	Large Threering	*Ypthima nareda*
27	Large Silverstripe	*Argynnis children*
28	Glassy Tiger	*Graphium cloanthus*
29	Indian Tortoiseshell	*Aglais caschmirensis*
30	Chocolate Pansy	*Junonia iphita iphita*
31	Banded Treebrown	*Lethe confusa*
32	Straight–banded Treebrown	*Lethe verma*
33	Blue Admiral	*Kaniska canace*

2.5 STATUS OF SELECTED FAUNAL GROUPS IN PROJECT AFFECTED AREAS

2.5.1 Status of Bird Species at Barrage and Powerhouse Sites.

Assessment of avifaunal status within 0.5 km up and downstream of dam/barrage and powerhouse sites of different projects showed that, river bed of Zemithang area is the wintering ground. No other threatened bird species were reported in the close vicinity of any of the project sites (Table VII. 2.17).

2.5.2 Status of Mammalian Fauna at Barrage and Powerhouse Sites.

Nykcharong chu project area is having 8 species in close vicinity of 0.5 km up and down streams, which include six common species and two highly threatened species (Table VII. 2.19), followed by Rho and Tawang–I sites where 7 species (6 common and 1 threatened Arunachal macaque with 15 individuals) were reported. New Melling area had only 3 species in the close vicinity of the project including 2 common and 32 individuals of one threatened Arunachal macaque (Table VII. 2.17).

Arunachal macaque, as highly threatened species occurred only at six project sites when considering presence at barrage and powerhouse sites only (Table VII. 2.19). Even within these six project areas, only New Melling had 32 individuals while Rho, and Tawang–I had 15 individuals each and rest three project areas did not record direct sightings but only few indirect evidences. The project team encountered large troopes more than 40 individuals at Rho village and the villagers informed about the severe crop damage by the Macaque.

Table VII. 2.17: Status of mammalian fauna at barrage and powerhouse sites of different project areas.

Sl. No.	Project name	No of C Sp	Highly threatened species (CR, EN, VU–IUCN & Schedule I IWPA)					
			AM	CPL	RP	HBB	DH	CL
1	Jaswantgarh Stage–I	2 (IE 3)	–	–	–	–	–	–
2	Mago chu	5 (IE 7–4A)						
3	New Melling	2 (IE 3)	A 32					
4	Nykcharong chu	6 (IE 17 & A 4)	–				2 IE	1IE
5	Paikangrong chu	2 (IE 1 & A 1)	1 IE					
6	Rho	6 (IE 5 & A 6)	A 15					
7	Tawang I	6 (IE 5 & A 2)	A 15, 2 IE					
8	Tawang–II	4 (IE 9)	2 IE					
9	Thingbu chu	5 (IE 5 & A 2)	3 IE					
10	Tsa chu–I	5 (IE 7 & A 1)						
11	Tsa chu–II	3 (IE 6)						
12	Tsa chu–I Lower	4 (IE10)						
13	Nyamjang chu	6 (IE10)						

CR–Critically Endangered, EN–Endangered, VU–Vulnerable, AM–Arunachal Macaque, CPL–Capped Langur, RP–Red Panda, HBB–Himalayan Black Bear, DH–Dhole–Asiatic Wild dog, CL–Common Leopard. IE–Indirect Evidences, A–Animals

2.6 DOMESTICATED BIODIVERSITY

The region is considered very rich and diverse in terms of domesticated biodiversity and thus had strong affinity with the socio–economic–cultural system of the local communities.

Monpas are mostly agrarian in nature and their source of living depends on some staple crops nurtured in upland agricultural field including wheat, rice finger millet, maize, potato, barley, soyabean, moong etc. The rice varieties grown in Tawang area at an elevation of 3,000 m msl., exhibit Japonica characters of globose grain, narrow and dark green leaves, drooping flag leaves, thin culm and thermo–sensitivity. The Japonica characters become less prominent toward eastward. The pubescent husk types occur in western Arunachal Pradesh whereas eastern part contains many glabrous types.

There are three indigenous varieties of maize namely *Fenthina* (dwarf variety, duration 3 months), *Thinasheru* (tall variety, duration 5 months) and *Baklangboo* (medium tall variety, duration 4 months). These indigenous varieties are location specific and grown under varying micro–farming situations.

Importantly, Monpa women are the key players in conserving crop diversity. The women have a range of diversified gene banks of indigenous varieties of wheat, barley (*Bong*, with or without awns); *Phaphda* (buckwheat)–*teeta & meetha;* paddy (*Sungsungbara*); finger millet (*mandua*); Indian bean (Lab–lab purpureus); rajmabean (*Phaseolus vulgaris*); millet (*Bundagmo,* Panicum psilopodium var. psilopodium); millet (*Moo*, *Panicum psilopodium* var. *coloradum*); coriander (*Ush*); bottle gourd (*Lau*); cucumber (*Manthong*); soybean (*Lee*); pumpkin (Broomsa)–peela and safed; bitter gourd (*Kaibandu*); spinach (*Taktak*); mustard (*Lai Saag*)–*Leme* and *Penche*; garlic (*Lamm*); Mann (Allium spp) bada and chhota; onion (*Chong*); chilli (*Solu*) and varieties of maize (*Fenthina, Thinasheru* and *Baklangboo*) (Singh and Sureja, 2006).

Among horticultural crops, rich diversity occurs of chilies, yams, Colocasia, beans, cucurbita etc. Yams (Dioscorea) are good nutritional food supplements to the tribal. Among the fruit crops, farmers generally grow Apples, Cherry, Chestnut, Kiwi, Peach, Pear, Plum and Walnut.

The *Brokpa*, sub–tribe of Monpa lives in high altitude grassland and they are professional Yak graziers and thus their rearing and herding. Other than Yak, farmers also possess other domesticated animals like mithun, cattle, sheep, goats and horse/ponies (Table VII. 2.18). The 'Mithun' (*Bos frontalis*) a species of large cattle, which is found both in wild and semi–domesticated form, has great significance in the social and cultural life of the people of this region. Traditionally, the Mithun was the medium of exchange and was a store and indicator of the wealth of a person.

Table VII. 2.18: Livestock population in Tawang district

Yaks	Cattle/ Mithun	Sheep	Goats	Horses & Ponies	Pigs	Poultry	Others
4964	69663	7313	7809	2672	4656	11470	3966

Source: District Statistical Handbook, Tawang (2010–11)

2.7 INVASIVE ALIEN SPECIES (IAS)

Newly introduced plants, called alien plants have various effects on the environment and economy, including forest regeneration, livestock grazing, native vegetation, and ecosystems or human health. However, there has been no systematic inventory of IAS in the region. One of the key locations of invasive species colonization is roadside area. Kosaka *et al*. (2010) made an effort to record invasive plant species along roadsides of Arunachal Pradesh including part of Tawang district. Accordingly, they reported presence of 18 invasive plant species from roadside areas. Thus, species like *Parthenium hysterophorus, Ipomoea carnea, Crotalaria pallida, Mimosa pudica, Cuphea carthagenensis, Stachytarpheta dichotoma, Ageratum conyzoides, Ambrosia artemisiifolia, Bidens pilosa*, *Mikania micrantha* and *Solanum carolinense* were reported from sub–tropical to temperate zones. *Taraxacum officinale* was the only species recorded from above 4200 m altitude.

3.1 INTRODUCTION

The components of human well–being includes security, basic material for a good life, health, good social relations, and freedom of choice and action, all of which depend either directly or indirectly on ecosystems and the services they provide–and therefore on biodiversity (Millennium Ecosystem Assessment, 2005) (Figure VII. 3.1). Humans rely on food, clean air and water, timber and medicines for survival. Human livelihoods rely on ecological services that support global employment and economic activity e.g., food and timber production, marine fisheries and aquaculture, and recreation. The Millennium Ecosystem Assessment (MEA) characterised the relationship between biodiversity and human well–being, and described 4 major categories of services provided by ecosystems to society viz., provisioning, cultural, supporting, and regulating (Figure VII. 3.1).

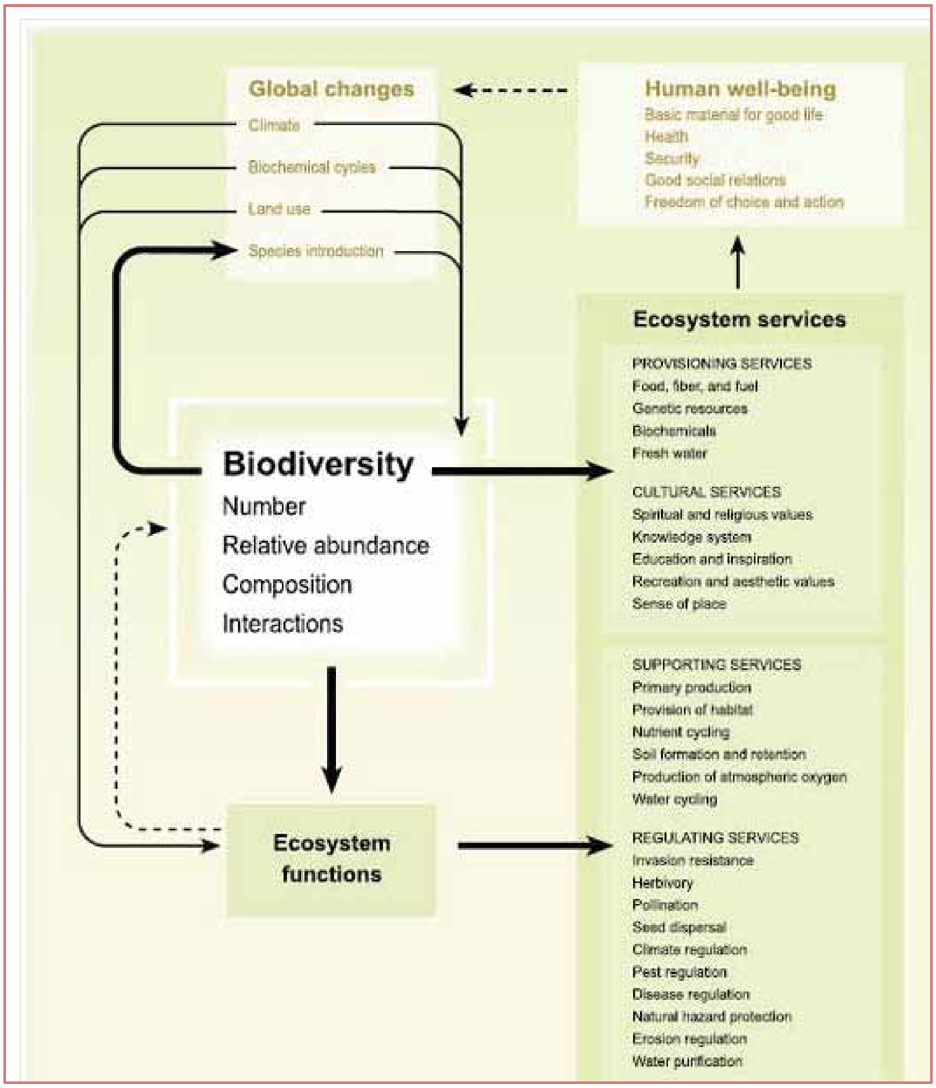


Figure VII. 3.1: Illustration of the relationships between biodiversity, ecosystem functioning, ecosystem services and people (Source: MEA, 2005)

3.2 NON–TIMBER FOREST PRODUCE

The ethnic communities including Monpas of the district have been using the economically important plants available in their forest areas since time immemorial. They have well–developed practices of utilization, where only natural products are used. The tribal societies are still engaged in utilizing the local plant resources for wide variety of purposes (in addition to fodder and fuel), viz. edible, handicrafts, coloring agents, beverages, adhesives etc. Most importantly, large numbers of plant species are used for medicinal purposes. Many species are directly used in their various religious ceremonies mainly in *Gompas*. An indicative list of plants and their various uses suggest the diversity and magnitude of such NTFP items in Tawang region. Saha and Sundriyal (2013) recorded that five tribal communities of Western Arunachal Pradesh, including Monpa of Tawang region, use as many as 343 plant species for various purpose. The Monpas reported 234 (i.e., 68%) of all the reported species (Table VII.3.1 and Annexure VII. 3.1). A total of 30 species were harvested during dry, 43 species during wet, and 270 species collected during extended (lean) season. A total of 76 species were sold in local markets.

Table VII. 3.1: Total number of NTFP species reported by Monpas

Purpose of use	Monpa
Medicinal plants	118
Wild fruits	52
Wild vegetables	37
Fodder	10
Dye and colour fixer	15
Edible mushroooms	14
Fuel wood	16
House construction, fencing	13
Aesthetic or ornamental	6
Agricultural tools	8
Spices and condiments	9
Gum, resin and tannin	6
Hunting and piscicide	7
Local drink and beverages	10
Incense and aroma	8
Furniture and handicraft	5
Thatching	2
Oil yielding	6
Edible pith/flowers	3
Paper, pulp and fibre	3
Masticator	1
Millets and seeds	3
Others	8

3.2.1 Edible and Beverage Making Plants

The Monpa community derives common vegetables either alone or in combination from under–exploited plant species like *Alocasia indica, Dioscorea alata, Ipomoea batatas, Manihot esculentum, Momordica charantia, Phaseolus vulgaris, Pouzolzia bennettiana, Diplazium esculentum, Centella asiatica, Houttuynia cordata, Thunb* (green salad), *Gynura crepedioides* (green salad), *Spilanthus oleraceae*, *Litsea cubeba* (spice), *Clerodendron viscosum, Solanum indicum* (green salad), *Solanum torvum* (Green salad), *Solanum etiopicum, Allium sativum* and *Allium hooleri* (green salad). These plant species are generally sold in the local market at reasonable price. The tender shoots of select bamboo species like *Dendrocalamus hamiltonii* collected in bulk was prepared by cutting it into strips or pieces and boiled (Namsa *et al*., 2011). Monpa also use *Prasiola crispa* (a protein rich algae) as vegetable (Saha and Sundriyal, 2013).

Tag *et al*. (2008) reported 40 wild edible plants, which are primarily consumed in raw form by Monpas of Tawang and adjoining West Kameng districts. A variety of traditional recipies are prepared out of these wild edible plants. Most of of the edible plant parts are available only during spring and summer season. However, local communities have rich traditional knowledge related to wise use of wild edible plants to ensure food security through traditional drying and storage methods. Six of these species were found to be commonly used, namely, *Diplazium esculentum* (shoot), *Elaeagnus umbellata* (fruit), *Maianthemum purpureum* (shoot), *Oenanthe javanica* (shoot), *Panax bipinnatifidus* (tuber) and *Pyrus pashia* (leaves). Artificial propagation system may be promoted for production of raw material in commercial scale which may ultimately improve the rural livelihood of the tribal population.

Popular traditional beer, locally known as '*Bhangchang'*, is prepared from rice (*Oryza sativa*), finger millet (*Eleusine coracana*), maize (*Zea mays*) and buck–wheat (*Fagopyrum esculentum*). Monpas use young leaves and twigs of certain species like piper beetle, *Solanum indicum*, *Buddleja asiatica* and *Hedyotis scandens*, as common growth supplements during the preparation of *bhangchang* (Namsa *et al*., 2011).

3.2.2 Dye Yielding Plants

Thirty–seven dye yielding species have been recorded from some parts of the State (Mahanta & Tiwari, 2005). The Monpas have traditionally been using *Woodfordia fruticosa* and *Daphne papyracea* for preparing natural dyes. Animal residues like hide, fat and secretion of insects like *Kerria lucca*, commonly known as the *lac* insect, are used in the preparation of natural dyes (Mahanta & Tiwari, 2005). Some of the documented dye yielding plants of Tawang region is presented below:

- Seed, bark and leaves of *Illicium griffithii* (Lissi) produce yellow bark colored dye
- Leaves and pods of *Indigofera tinctoria* (Zia–shing) produce Indigo colored dye
- Bark of *Pinus wallichiana* (Tongschi, Lamshing) produce black colored dye
- Entire plant of *Polygonum hydropiper* (Chhum–gon) produce blue–black colored dye
- Unripe fruits of *Juglans regia* (Kay) produce black colored dye
- Bark and fruits of *Daphne papyracea* (Shugu–Sheng) produce dark red colored dye
- Flower and fruits of *Punica granatum* (Dalim) produce deep blue–black colored dye
- Bark of *Engelhardtia spicata* (Corcorshing) produce dark brown colored dye
- Entire plant of *Rubia cordifolia* (Lining–Ru) produces red colored dye
- Flowers of *Woodfordia fruticosa* (Chot–tingba) produce reddish–yellowish dye

3.2.3 Medicinal Plants

The region is also having rich medicinal plant diversity. The flora of the district includes 114 species of medicinal plants having some active therapeutic use by the local ethnic communities and 42 species of some useful plants being used by the local people in their day to day life. Some of the commonly used medicinal plants include *Aconitum ferox, Acorus calamus, Artemisia nilagirica, Berberis aristata, Illicium griffithii, Lavendula vera, Nardostachys jatamansi, Panax pseudoginseng, Frittilaria cirrhosa, Pelargonium graveolens, Picrorrhiza kurrooa, Plantago major, Podophyllum hexanadrum, Polygonatum cirrhifolium, Potentilla fulgens, Rheum australe, Swertia chirata,Taxus wallichiana* etc. Namsa *et al*. (2011) also reported use of 50 plant species by Monpa tribe.

Collection of medicinal plants from the high altitude meadows, as well as forests, seems to be an important source of cash income for the villagers. The main species in trade are *Swertia* chirayita, *Taxus wallichiana*, *Dactylorhiza* sp., *Cordyceps* sp., *Rubia cordifolia* and *Picrorrhiza kurrooa Nardostachys jatamansi, Valariana wallichii*. Overall, there are rapid decline in the abundance of medicinal plants due to unregulated collection. In particular, *Taxus wallichiana*, an endangered tree, appears to have undergone drastic population decline. *Ilicium griffithi* fruits, used as a spice, also constitute an important source of income for the villagers.

The region is not only a rich repository of medicinal plants, but it also nurtured several distinct ethno–medicinal systems. Among them, the most prominent is the Tibetan system of medicine, relying mostly on the local plant resources.
Many medicinal plant species are traded in large quantities and they include Jatamansi (*Nardostachys jatamansi*), Kutki (*Hydnocarpus kurzii*), Bish (*Aconitum ferox*), Lissi (*Illicium griffithii*), Boch (*Acorus calamus*), Teyshing (*Taxus wallichiana*).

3.2.4 Paper Making

Many tribal and other forest dwelling societies of the world use inner fibrous bark of many tree species in preparing papers. Monpas used *Daphne papyracea* (Shugu–Sheng) for making hand–made paper. For the purpose, people use mature stems of 5–6 years age. The paper is strong wth its visible natural fibres and a unique texture. One traditional paper making unit is situated at Langatang of Mukto village in Tawang district. The prepared papers sheets (62 cm x 51 cm) are sold in the local market. These papers are used for writing Buddhist religious scripts, wind Horse Prayer flag and painting in the monasteries. *D. papyracea* could be an income source for the Monpas if they are engaged in growing of the trees and later in harvesting and manufacturing of paper making. So this type of indigenous green technology needs to be promoted (Paul *et al*., 2006).

3.2.5 Other Uses

Fresh leaves of *Munsheng* (*Illicium griffithii*) trees in combination with Juniper leaves are burnt for making smoke. The smoke is believed to be sacred and help purifying air. This is regularly used in most of the religious ceremonies in Gompas (monestries). The *munsheng* leaves are traded to as far as monestries in Dharamshala in Himachal Pradesh. Fruits are also used as incense. Leaves of *Pinus wallichiana* and *Thuja orientalis* are used in different daily rituals in monasteries. Also, rhizomes of *Zingiber officinale* and *Manihot esculentum* remain an integral component of daily rituals among the Monpas religious life.

3.3 WILDLIFE USE

Different animal products are used in different socio–cultural activities of the Monpas (Solanki and Chutia, 2004):

- Hide shield (*Khuk*) used as armour of defense made up of dry skin of bear or yak.
- Coat (*Pakcha*) made up of dry skin of sambhar and other wild animals.
- Cap (Yama) made from the tail hair of yak.
- Hats: '*Yangcha* 'made–up of monkey hair and skin; '*Over chamo'*, made up of skin of jungle cat.
- '*Dao'* or '*Dang'*: a jungle weapon made from iron, and decorated with skin and hair of wild goat.

Some of the larger wild animals are being utilized in various ways:

- Himalayan black bear (*Selenarctos thibetanus*)–Meat use for food, Gall bladder used as medicine for Malaria and Typhoid.
- Musk deer (*Moschus moschiferus*): Meat use as food; musk, a very high priced animal produt, used for malaria and diaorrhea.
- Yak (*Bos grunniens*): Multi utility animal whose hairs and skins use for making household items.

3.4 HUNTING PRACTICE

Aiyadurai (2007) surveyed Monpa tribes in 9 villages of Zemithang and Mukto circle of Tawang district to record the hunting patterns and practices in 2006. Amusingly, all the respondents reported that they are not active hunters now. They reported that some villagers used to hunt earlier but have stopped hunting since the visit of Dalai Lama, the spiritual leader of Buddhism. Villagers interviewed in Pangchen Valley of Zemithang circle of Tawang district claimed they never hunted and also mentioned that no one hunts in the valley because of religious reasons. Nevertheless, people often kill wild animals to protect their livestock and crops. Interestingly, survey revealed hunting evidences–skin and skulls–of 12 species of mammals from these villages.

However, an earlier survey in 2003–2004 reported hunting of 27 mammalian species from high altitude areas of Tawang district (Mishra *et al*., 2004 and 2006). Often the hunting was motivated to stop crop damage (Arunachal macaque, Assamese macaque,wild pig), local meat consumption (barking deer, Himalayan goral, sambar, serow, wild pig), retaliation for livestock depredation (dhole, leopard cat, yellow throated martin), skin (yellow throated martin, red panda, common leopard, barking deer, Himalyan goral). Interestingly, they reported that in lower Nyamjang chu valley, the villagers pool money to reward hunters for killing wild predators.

It is important to mention here that while Monpas, although Buddhists, were engaged in animal hunting from time immemorial, recently in last 3–4 years time, majority of them stop hunting the animals and birds because of no–hunting preaching of Dalai Lama. Although, it is reported widely that they strictly adhere to that dictate of Dalai Lama, it is yet to be confirmed from all parts of Tawang region.

3.5 HUMAN–WILDLIFE CONFLICT

Mishra (2004) reported human–wildlife conflicts in Tawang region. Later, Chaudhary *et al*. (2010) presented a report of various kind of conflicts between local Monpa community and different wild animals in Tsangyang Gyatso Biosphere Reserve in part of Tawang district. Accordingly, there were altogether 11 wild animal species which were in direct conflict with humans in the region. Conflicts were mainly in terms of crop raiding and livestock depredation. Himalayan black bear (*Ursus thibetanus*) was reported engaged in crop raiding and livestock killing. Snow leopard (*Uncia uncia*) and wild dog (*Cuon alpines*) were mainly blamed for maximum livestock depredation and were subject to retaliatory persecution. However, wild boar (*Sus scrofa*) and Arunachal macaque (*Macaca munzala*) were reported as major cause of concern for their crop raiding behaviour. Interestingly, Malayan porcupine (*Hystrix brachyura subcristata*) was reported to be feeding more on crop bulbs and tubers. Thus, according to people's perception causes for escalation in human–wildlife conflict in order of importance were increase in human population>excessive NTFP collection>road construction>increase in population of crop raiding and predator species.

Box VII. 3.1: Handicraft skill of yak pastoralist

The *Brokpa* community of the region is culturally and ethically distinct groupof semi–nomdic pastoralist people, belonging to the *Monpa* tribe, depending on yak herding as one of the major means of livelihood, by following transhumance system of yak management. The *Brokpas* are expert craftsmen making all the items of their daily utility, for processing and storing yak products, by themselves. Bamboo baskets (*Frokpa*), wooden tiffins (*Gorbu*), milking stools (*Zhotyak*), milking can (*Zho*), milk churners (Zopu), cheese (*Churpy*) separator (*Churchuk*), Drinking glass (*Ketong*), service spoon (*Zarba*) etc. are some of the common household items made by them. Crafting in the Brokpa society is exclusively done my male folk. The raw materials, bamboo, wood and cane, were always collected from the forest areas. The bamboo, called *sho,* used for crafting was mostly of the species *Dendrocalamus hamiltonii*, *Bambusa tulda*, *Bambusa pallida* etc. Similarly, wood from *Phrngpa* tree (*Quercus wallichiana*) is utilized for making the crafts. Generally, three types of crafting are done by Brokpas–(a). Cylindrical churn/can/box making (b) three dimensional basket weaving and (c) wood curving. Other than these, Brokapas use leaves of *Morlah* (a species of *Rhododendron*) for wrapping of wet cheese (*churpys*) for selling purpose.
Source: Bora *et al*. (2013).

4.1 INTRODUCTION

An understanding of various conservation and management systems, both formal and informal and customary and contemporary, those are in vogue is essential to develop an effective future conservation/management strategy. It is important because entire array of genetic, species and ecological diversity of the region are generated and sustained due to interactions of natural processes and human interferences including various modes and methods of its conservation and management. As a matter of fact, in areas like Tawang, the dynamics and complex rural livelihoods usually rely on diversity of plants, animals and ecosystems. The local people, therefore, evolved various management systems to ensure sustainable flow of ecosystem services and thus sustain their livelihood.

It is understood that management of natural resources in predominantly rural settings are based on two main aspects: the property rights of resources and institutional arrangements for conserving/protecting of, and accessing and sharing the benefits from, those resources. In the context of articulating biodiversity conservation plan at landscape level in Tawang region, these two aspects are critical and thus need little more elaboration as presented here.

4.2 PROPERTY RIGHTS OF KEY NATURAL RESOURCES

In most of the villages of Tawang region, dominated by Monpa tribes, property rights are defined under customary system.

4.2.1 Agriculture

In majority of the cases the ultimate ownership rights over agricultural land rested with the Gompa and the cultivators were considered to be tenants. Actually, quasi private property rights exist in most part of the region. Land rents are paid to either Gompa or village council. More than often, land rents given to village councils are not paid as such but is more in the nature of a household contribution to the village fund rather than land revenue. Land sale and leasing are allowed to certain extent (Harriss–White *et al*., 2009) but are necessarily subject to the consent of the *gaon burah* or village chief.

4.2.2 Forest

Majority of forest land categorized as ‘unclassed forest’ are in the hands of village communities and clans, but the effective control and management of these forests varies greatly across the communities. So property rights of these ‘unclassed’ forests vary from being entirely private to entirely collective. Interestingly, more than often villages have mixed ownership regimes i.e., some forests are privately owned and some are collectively. Interestingly, even in private forest, moral and political authority of *gaon burah* continues to exist. So, although the forest is privately owned, but still people can extract building materials, NTFP and firewood from there. Generally, there is no restriction on hunting on privately owned forests. However, no estimate of the extent of these different classes of forests is available.

4.2.3 Grazing Land

The ownership of grazing land varied across villages. The villages have different ownership system of grazing land. Thus, it ranged from being entirely privately owned to entirely collectively own to mix of both types.

4.2.4 High Altitude Wetlands

The ownership of most of the high altitude rested with village communities within the dictate of Tawang monastery.

Table VII. 4.1: Type of property rights of key land and water resources exist in village

Agriculture land	Privately owned but considered the property of Gompa on lease
	Privately owned but some land are owned by Tawang Gompa
	Private only
Grazing land	Partly private partly collective (mixed)
Forest	Entirely private
	Entirely collective
	Mixed
	Entirely government (reserved and protected forests)
	Joint (government & community collective)
High altitude wetlands	Entirely collective

Adopted from Harriss–White *et al*. (2009)

4.3 SYSTEM OF CONSERVATION AND MANAGEMENT OF NATURAL RESOURCES

Traditionally, the village–level institutions in *Monpas* dominated Tawang District follow a hierarchical structure under the Gompas (Buddhist monasteries) (Harriss–White *et al*., 2009). Singh (2013) described traditional village level institution for Natural Resource Management in Tawang region. Accordingly, at village level, a traditional informal rural social institution called *chhopa* (or village council), constituted of 12 male members headed by a *gaon burha*, exists that design and frame socio–culturally approved rules for people and their interactions with natural resources. It plays a significant role in governing, accessing and managing the natural resources. The village *gaon burha*/and or *Thummi* (village elder) is authorized by the villagers to take any decision regarding conflicts arising over natural resources at the village level.

At larger level, the Tawang Monastery collects and regulates the *khrai* (tax) in the region. This tax is imposed on two types of natural resources, one for forest use and the second for use of agricultural land resources. For private owner the amount of *khrai* depends upon the size and extent of forest land and agriculture land it owns. However, for community forest *khrai* may be taken in different forms: money, local crop seeds, and dry fuel wood. For one acre of forest land, the monastery charges around Rs. 15–20 per year or 2 lots (1 lot = 15 kg) of firewood. The collected revenue is used in Monastery's day to day activities and also for larger community development work.

4.3.1 Management of Riverine Resources

In general, Monpas do not fish. However, in some areas fishing is practiced under strict code of conduct where people are allowed to catch fish and other aquatic animals like shrimp, prawn, frog etc. This is particularly true for downstream areas of Nyamjang chu.

About other river resources, like sand and stone, the village council permits the collection and selling and in lieu of that they draw some royalty (in terms of cash or kind) which is then used for village or community welfare. Interestingly, the State Government Department (like revenue and mining) do not have any control over the resources. For the State's purpose also, they had to go through the village council's permission.

4.3.2 Management of Forest and its Resources

From the legal perspective, the forests of the Arunachal Pradesh State are classified under following categories: (i) Reserved Forest (RF), (ii) Protected Forest (PF) (iii) Unclassed Forests (UF) and (iv) Anchal Reserve Forest. However, in Tawang district, except PF of very small extent (5.98 sq km), all the forests are under UF category. Interestingly, these UFs are yet to be properly surveyed and demarcated. While *de jure* UF are under the dual control of State Revenue Department and State Forest Department (The Revenue Department issues land possession certificate and the Forest Department deals the matters related to transit and trade of forest produces), *de facto*, however, these Unclassified Forests are controlled by variously as private, clan or community forests and have remained traditionally under the control of communities or village councils. Thus, for all practical purposes, the UFs are treated as community forests where the people exercise their traditional rights of collection of fuel wood, small timbers, fodder, cultivation and ritual hunting as well as collection of medicinal plants.

4.3.2.1 Community Based Management

As discussed earlier, in each village the community controlled UFs may have private and/or community ownerships. Although large areas are under private ownership, for resource extraction, the owner needs to get at least verbal sanctions from *gaon burah* and village council. Singh (2013) described various village level institutional arrangements for forest management. In community forest area, villagers through village council, allowed access to forest resources throughout the year except in the month of November. They ban the entry of people because that is the time when most of the forest species are regenerating, fallen seeds are sprouting and vegetative growth is at its prime. For house construction and fencing purpose, however, bamboo is allowed to extract but in restricted quantity and also after having with prior permission from *gaon burah*.

In all the resource extraction cases, violations of any institutional norms are liable to substantial monetary fine (Rs. 500 to 2000). In addition to that, village council often collect some royalty from resource extractors. The village council meet regularly and decide use of collected amount. Generally, 75% of total eared money goes back to community based socio–cultural activities as well as various village development activities. Remaining 25% revenue is utilized in meeting various expenses incurred by the village council members while supervising and monitoring forest resource use.

Once a year, during the winter season, a common meeting of the villagers, called *sakorh*, is organized. Its objective is to assess the status and boundary of the community as well as private forests. If any violation are recorded and also any conflict arises over privately and community owned natural resources (including forest, river, lakes, grazing land etc.), this matter is referred to the *gaon burah*.

4.3.2.2 Joint Forest Management

As per the provisions of National Forest Policy (1988), Government of India, in June 1990, outlined and conveyed to State Governments, a framework for creating people's movement through the involvement of village level committees for the protection, regeneration and development of degraded forests situated in the vicinity of villages. This initiated a paradigm shift in forest management and thus a process called Joint Forest Management (JFM) evolved.

Government of Arunachal Pradesh formally adopted the JFM schemes from 1997 with broad objective to take up massive program for regeneration and protection of degraded UF with the help of communities through Village Forest Management Committees (VFMCs).

In Tawang region, the JFM is is not taking–off because *de facto*, all UF are under community ownership and thus follow the customary management systems. Nevertheless, Tawang district Forest Department, with their continuous persuasions, created 14 VFMCs (Table VII.4.2) and thus, assist village councils in regenerating the degraded forest lands through financial and technical support. Tawang Forest Development Agency, a district level body, is a confederation of all the constituted VFMCs.

Forest Department, on the other hand, with the help of Deputy Collector (Revenue Officer) and mutual agreement with village councils acquire some UF lands and legally mutate the entitlement to create 'Land Bank'. The area under land bank is then used for plantation under various Compensatory Afforestation schemes under CAMPA Scheme with the help of village councils. The usufruct benefits of these regenerated forests are shared between community and forest department.

Table VII. 4.2: List of existing VFMC in Tawang disrict

Sl. No.	Name of VFMC	Forest range
1	Lhou	Tawang
2	Shobur	Tawang
3	Rho	Tawang
4	Gomkelling	Jang
5	Mirba	Jang
6	Bongleng	Jang
7	Melonghar	Lumla
8	Mayu	Lumla
9	Gispu	Lumla
10	Shakti	Lumla
11	Suzo	Lumla
12	Kharteng	Lumla
13	Khobleleng	Lumla
14	Lumla	Lumla

Source: Tawang Forest Department

4.3.2.3 Grazing land Management

Rearing of Yaks and other cattle is important livelihood for many *Monpas*. The grazers (mainly the *Brokpa* sub–tribe of Monpa, also known as *Chowriwalla*), are experts in making and trading yak ghee, milk cheese (*Churpi*) and products from their animal skins. Generally, Brokpas took the Yak (locally known as *Chowrie*) to higher grazing grounds (i.e., sub–alpine and alpine meadows). Grazing season extend between May and October (i.e., Dawa Sumpa to *Dawa Gupa* in terms of local months).

For long, *Brokpa* have developed location specific holistic strategies of sustainable management of high altitude pasture land resources (Table VII.4.3). Periodic migration by *Brokpa* from one place to other ensures that natural resources are not used to the point of exhaustion and ultimate extinction. Generally, elder pastoralists regularly conduct ecological appraisal, which includes identifying and classifying plants and precisely assessing the water–holding capacity of distant pasture areas and draw up plan for the herd movement. Each year's livestock movements while provide them forage and water, it help in chalk out plan for subsequent year based on ecological situation of the area. Naturally, such planning needs a landscape level understanding of change in ecology and socio–cultural–political spectrum.

For grazing of yak, *Dzomo* (a female crossbred of Yak), cows and sheep, there is a private and common system. Every hamlet has its own communal grazing land. Along with this, many clusters of hamlets also select one common grazing land, which is managed by community initiatives. The grazing lands are selected near the available local water resources (Singh and Sureja, 2006). Every grazing land is named in local parlance based on the name of hills, rivers, lakes and forest.

There are different customary practices of grazing. Grazing grounds (locally know as *Bro*) generally owned and managed by *Mangma or Chhopa*–the village local body–or in some cases belongs to Tawang monastery. Sometime, with the permission of *Chhopa*, *Brokpas* create new grazing grounds after clearing the meadow. Generally three different types of grazing practices exist:

Table VII. 4.3: Grazing land management system in Tawang

Type	Description
Community grazing	All the *Brokpas* have equal rights and thus shared the grazing land resources and grazing huts.
Draw of Lots	Grazing land is allotted to a particular *Brokpa* family by random draw of lots. Other's are not allowed to graze there.
Mutual agreement	Grazing land was allotted to a particular *Brokpa* family after consent of other *Brokpa* families.

For the grazing of yak, sheep, goats and other animals, a particular date is decided by the people of a hamlet to avoid conflict and instead try to sustain the available forage and grass. The total number of grazing days are decided in advance, beyond which if someone is accessing the grazing land more, then he is fined by the *goan burah* (Singh and Sureja, 2006).

The Chowriwalla pay grazing tax to the *Mangma/Chhopa*. The tax amount is decided on the basis of number of yaks it took to the grazing land. More than often, the taxes are in the form of yak butter or cheese (*churpi*). During winter, yaks come down to lower altitude and graze in fixed allotted area. The land selected for community grazing are on slight slope to avoid soil erosion and sustain natural vegetation.

Box VII. 4.1: Brokpa pastoralist

Singh and Sureja (2006) recorded and analyzed various institutional issues related with pasture or rangeland. According to them ….”*For a long time, Brokpa (pastoralists) have developed location specific holistic strategies of sustainable management of natural resources and improved livelihoods at the high altitudes of Tawang region. Pastoral communities have always played an important role in sustaining the rangeland ecosystem by means of traditional norms and access strategies. Periodic migration by Brokpa from one place to other ensures that natural resources are not used to the point of exhaustion and ultimate extinction. In addition, their herds browse the vegetation, stomp the soil, transport seeds of wild species and fertilize the land, all of which benefit the rangeland and the maintenance of its biological diversity….* Despite existing economic difficulties, pastoral communities produce about 8–10 livestock products and 25–30 per cent ethnic foods”.

4.4 CULTURAL AND SPIRITUAL WAYS OF CONSERVATION

Spiritual values possessed by people plays significant roles in management of species and ecosystems and these values can sometimes be more important than monetary values in conserving some wild–lands.

Among the Monpas, it is vividly reflected in their life. They performed puja of a mountain, called shyala, during the last week of May to first week of June for better crop production. During an annual function of kanjur chhoskar, they re–emphasize the philosophy of conservation of not only economically and culturally important living organisms, but also of the non–living beings and even insect pests. Interestingly, during a 7–8 days long yanglen puja in October–November, they use 18–19 varieties of locally produced grains, 9–12 types of flowers and churpi.The puja is to please Ghepo Namsey–the god of animals, humans, plants, water and other natural resources and signifies the importance of both wild and agro–diversity in the spiritual life of Monpas (Singh, 2013). In most of the rituals, they use about 16 different tree and shrub species as *dhup*. Several monastery paintings also depicts the philosophy of interdependence and co–existence in nature.

For Monpas, all the high altitude lakes (*Tso*) and rivers are sacred places (*Lu*) and they don’t even cut the trees etc. from near these sites. There are several such *Lu* forest sites in the Tawang region. For example, many sacred groves exist in Sheru Basti and other villages of Lumla block. Another known Lu site is in Lhou Basti . Actually, there are two small (<100 ha) sacred forests near Tawang and Mukto, where no hunting or any other form of resource extraction is allowed. Thus, in these sites, while fallen fruits and other products can be used with the permission of the priests, direct harvesting of resources is considered unethical. These *Lu* sites are the therefore plays as centers for biodiversity conservation.

The Tawang monastery, second oldest and largest in the world, was found to serve as an important cultural institution in shaping the use and conservation of local biodiversity in nearby areas of Tawang. Nobody harvests the plants and hunts the wild animals from the valley surrounding this monastery. Hence, the diversity of plants and animals and their habitats are still rich in the vicinity of the Tawang monastery.

In places dominated by *Monpas*, who are practicing Buddhism, trees and bushes are tied with paper strips made from *Daphne papyracea* as a sacred mark. Such trees and bushes are not allowed to cut or be damaged. Similarly, certain plants like *Juglans regia* (*Kay*) traditionally used for extracting dyes are given protection and are conserved; their cutting is forbidden and a fine is imposed for violation.

Also, there are certain sacred areas locally called as *kela*. While, no efforts had been made in making comprehensive inventories of *kelas* or sacred groves in the District, as per Forest Department record, there are 6 known kelas or sacred groves in Tawang district (Table VII. 4.4). These areas are believed to be abode of their jungle deity *Singye lamo*. Each such *kela* has a temple (*bompa*) and the surrounding areas are considered to be the palace of the deity. Those who enter the *kela* observe certain refrains. Felling or cutting of trees or even its branches and hunting of any animal, are totally prohibited (Gupta, 2007).

Table VII. 4.4: List of known sacred groves in Tawang district

Sl. No.	Name of sacred grove	Coserved and managed by
1	Chngbu	Tawang Monastry
2	Sangelling	Sangelling Monastry
3	Urgelling	Tawang Maonastry
4	Bigha	Bomba–Bomteng Village
5	Seru–Phu (Temailok)	Seru village
6	Rigilling Gonpa	Rinpoche

Source: Tawang Forest Department

CHAPTER 5
LANDSCAPE LEVEL IMPACT ASSESSMENT ON BIODIVERSITY AND MITIGATION MEASURES

5.1 INTRODUCTION

Development programmes, policies, and projects can cause significant changes in the physical, biological, and social attributes of the environment. In some cases the changes may be beneficial while in others it may be detrimental. The occurrence and magnitude of these changes would depend on the project location, mode of operation, and technology involved. Hence, environmental impact studies must systematically identify, qualify, where possible and appropriately interpret the significance of these anticipated changes.

The major environmental problems associated with HEP activities are loss of habitat due to deforestation, soil erosion, disturbance to hydrological regime of the area, quality of water, air and noise pollution, loss of forest due to laying of approach roads to carry construction materials/machineries, overall habitat degradation and reduction of floral and faunal diversity. These impacts ultimately lead to degradation of land which affects the overall productivity and quality of human life in the vicinity of the project area.

Development projects in any given region must take care of the ecological integrity and biodiversity values of the region as these two attributes contribute substantially to the environment quality as well as the sustainability of the development interventions. The unwanted consequences of development can be reduced substantially through technical and managerial skills for preventing and/or mitigating them. This clearly necessiates for a well planned Environmental Impact Assessment.

In general, impact prediction methods argue that the foremost step in impact appraisal must consider and identify project actions that are likely to bring significant changes in the project environment. Environmental Impact Assessment is a tool and facilitates to assess the possible impact(s) which are; positive or negative, direct or indirect, short term or long term, local or strategic, reversible or irreversible that the proposed project may have on the surrounding physical, biological, and social environments in the vicinity.

Since all the 13 HEPs located in different altitudes and across different river systems which ultimately confluence into the main Tawang River and therefore project specific impacts in the upper reaches likely to have cumulative impact on the overall TRBL. Hence, the present study determined to predict the cumulative impacts of the proposed projects on TRBL with a focus on biological attributes such as diversity of floral and major faunal groups. With the understanding of the nature of the proposed projects and associated activities and existing biodiversity values assessed under baseline status survey of the project areas, the following possible cumulative impacts have been identified and evaluated for appropriate mitigation measures and management plans.

5.2. IMPACT ASSESSMENT

Impact assessment of the proposed project activities has been done at three levels, namely, (i) on the river, riverine and adjacent terrestrial ecosystems, (ii) on the biological elements (flora and fauna), and (iii) on threatened flora and faunal species.

With the understanding of the list of project activities and their location and correlating the estimated biodiversity values of ecosystems, faunal groups (butterfly, amphibians, reptiles, terrestrial and aquatic birds and mammals), plant species, and threatened flora and fauna, the level of impacts were predicted. The nature and magnitude (positive or negative, direct or indirect, short term or long term, local or strategic, reversible or irreversible) of impacts were evaluated based on the quantitative assessment of each faunal component which are: species richness, species diversity, species abundance, existence and distribution of species of conservation significance i.e., occurrence of threatened species. Similarly, the impacts of different project components on plant diversity including the threatened and economically important plant species were evaluated.

5.2.1 Possible impacts on ecosystems

5.2.1.1 Impact on river ecosystem and associated faunal diversity

Construction of barrage and regulating the normal water flow in the river system for power generation is one of the major activities of the proposed project. Therefore, the change in the quantity and quality of water flow across different season is predicted to have the following impacts on the faunal species of the project area:

Impact 1. *Regulating the normal water flow in the downstream may affect habitat and food regime of faunal species in the concerned river.*

In addition, it is expected that disposal of solid wastes, mainly spillage of concrete and other oil materials into the river system during construction phase may bring in additional impacts in following terms:

Impact 2. *Polluting of river system during the construction phase activities through disposing solid wastes and other concrete material into the river.*
Impact 3. *Pollution may cause possible reduction in abundance of other faunal species of river ecosystem.*

Evaluation: Due to the impending location of the proposed projects in the river valley with predominately steep hill slopes on the riversides, the activities planned along the river system (i.e., construction of barrage across the river, powerhouse and all other infrastructures), it is, but inevitable, to have impact in form of pollution of river systems. Presence of 2 frog species and presence of only one aquatic feeder and piscivore bird species, may render this as low magnitude impact. Added to this is meeting regular water needs of 18 mammals with six species of carnivore may raise overall impact of regulating water flow and polluting the rivers to moderate level.

Mitigation: Adopting strict management and regulation options for pollution and E–Flow are needed to counter moderate impact on faunal species during the construction phase.

5.2.1.2 Impact of muck generated through the construction of tunnels and the impact of muck disposal on land and water resources

The construction of head race tunnels would generate enormous quantity of muck, which would be stored within the designated land area earmarked as muck dump yards and often disposed along the river banks. Construction of such muck dump yards and muck disposal along the river banks is predicted to have the following impacts:

Impact 4. *Loss of habitats along the river systems including the alteration of hydraulics and hydrology of the river.*
Impact 5. *Construction of very long retaining wall to store the muck dumps along the river system will restrict the normal movement of mammal species, as well as access to the river water resources.*
Impact 6. *Runoff from the muck dumps will contaminate the land and water resource–river system.*
Impact 7. *Creation of muck dumping yards and disposal sites would damage the existing plant species.*

Evaluation: The areas identified for storing muck dumps are mainly the available flat areas on the riversides. The muck dumps will be stored within the dumping yard constructed with steep retaining wall in the river front which would affect the faunal species mainly due to loss of riverine habitats mainly inhabited by four species of squirrels, two species of primates and Himalayan palm civet and yellow throated martin. Addionally, few carnivores may be affected due to possible restrictions in access to water sources. The spilling over of muck to the river bed in extreme case could alter the river bed morphology affecting the hydraulics and hydrological properties of the river. Although most muck disposal sites are devoid of thick vegetation, some sites were found rich in medicinal herbs and shrubs e.g., *Gaultheria*, Citronella. Thus, the impact on the floral element through muck disposal is moderate.

Mitigation: In view of the moderate impact, proper technical and structural interventions are needed. While constructing the disposal and storing structures, the factors described above should be kept in mind and while using it has to be made mandatory to keep the disposal limit within the capacity of the site so that the muck does not spill to the river bed.

5.2.1.3 Effects of noise due to drilling, tunnelling, blasting and vehicular movements on the faunal groups

Drilling of blast holes, tunnelling, blasting activities during the construction phase and moving of heavy machineries and vehicles to transport construction materials are likely sources of noise pollution. The noise pollution may affect the faunal species in following manners:

Impact 8. *Changes in the normal behaviour due to restrictions in normal movement, feeding and resting activities of major faunal groups of the project area.*
Impact 9. *Possible permanent exodus of some affected larger territorial faunal species from the project area.*
Impact 10. *The impacts of noise and associated ground vibration would impact the lower vertebrates mainly ground dwelling, specifically burrowing and reptilian species.*

Evaluation: During construction phase, noise pollution would be generated mainly due to operation of blast hole drilling, blasting, tunnelling and plying heavy trucks for construction of all the project structures, which is inevitable in most of the developmental projects. Presence of 2 amphibian and 4 reptilian species through direct sighting and about 30 species through secondary sources, 18 and 241 species of mammals and birds, respectively, are likely to be affected by this moderate impact for a shorter period (during construction phase only).

Mitigation: This calls for use of high–tech equipments that would minimize noise levels and adoption of inevitable for managerial, ecological and technical interventions to minimize this moderate level impact through noise pollution.

5.2.1.4 Unregulated vehicular movement in the forest areas, and its impacts on faunal groups i.e., road mortality due to accidents, pollution load on the roadside plants and soil compaction

Frequent movement of heavy vehicles to transport construction materials, equipments and labour force are the activities that would impact selected faunal groups during construction phase in the project area in the following ways:

Impact 11. *Road killings: Mostly herpetofauna (amphibians and reptiles) smaller mammals are vulnerable to get killed by the vehicles while crossing the roads.*
Impact 12. *Frequent movement of vehicles leading to collision of bird species may reduce species richness and abundance in the habitats along the road side.*
Impact 13. *Compaction of soil:Movement of heavy vehicles would lead to soil compaction in the project areas leading to alteration of soil physico–chemical properties.*
Impact 14. *Movement of vehicles for construction works would increase the pollution load on roadside plants leading to loss of diversity and productivity.*

Evaluation: During construction phase, sudden and cumulative increase in vehicle movements from entire project area is predicted to have impacts mainly on herpetofauna and lesser mammals as road mortality and disturbance to avifauna of the project area. The compaction of soil would lead to alteration of soil ecosystem structure and function including reduction in density and diversity of soil fauna. The pollution load due to vehicular traffic on roadside plants would lead to the reduction in plant productivity, and in extreme cases mortality ultimately reducing the diversity. Thus, this impact is evaluated as moderate.

Mitigation: Taking appropriate measures to minimize this moderate impact would include strict management decisions on regulated vehicular movement to reduce the above said impacts.

5.2.1.5 Influx of population and pressure on the local natural resources

The proposed HEPs would necessitate presence of large labour force. These labourers may depend on the forest area for their stay (land) and fuel wood requirement and construction materials (small poles) for temporary sheds. Therefore, the large labour force likely to be brought to the project areas is predicted to have the following impacts:

Impact 15. *Clearing of land and vegetation cover for labour settlements.*
Impact 16. *Cutting of wooden poles from the forest area for the construction of temporary sheds.*
Impact 17. *Cutting of trees from the forest area to meet their fuel wood, risk of their involvement in illegal activities like poaching/hunting of animals.*

Evaluation: All the proposed HEPs would require labour force for non technical works. Therefore, large number of people (outsiders) would be brought to the project areas, who will need shelter facilities (labour colony) in the forest area. These labourers may depend on the forest for fuel wood, poles for temporary huts and some time they may involve in poaching of animals in the adjacent forest areas. These project related actions may bring in impact due to habitat degradation, polluting the forest environment by disposing solid waste material and killing of animals for food.

Mitigation: Very strict managerial role in mitigation measures is suggested to minimize the above predicted direct and primary impacts on forest and associated floral and faunal species of TRB.

5.2.1.6 Invasion of alien weed species

The construction of barrages would reduce the flow in the downstream area of the barrage where new terrestrial riverine areas would be created, that would be prone to invasion, the impact of which will be as follows:

Impact 18. *Reduced flow in the downstream areas would increase/initiate the areas under IAS.*

Evaluation: Reduced flow in the downstream area of all the projects would alter the river flow dynamics and reduce the net river flow area (perimeter). This reduction in turn would initiate a river bed succession of terrestrial plants that would be dominated by the invasive weed species (Table VII.5.1), which in turn would be detrimental to the local plant diversity and ecosystem structure and function. Thus, the overall impact can be rated as low during the construction phase and moderate during the operational phase.

Table VII. 5.1: Existing IAS in TRB

Existing IAS
Acanthospermum hispidum
Ageratum conyzoides
Artemisia nilagarica
Bidens pilosa
Crassocephalum crepidioides
Cuscuta reflexa
Eupatorium adenophorum
Eupatorium odoratum
Euphorbia hirta
Galinsoga parviflora
Imperata cylindrica
Mikania micrantha
Parthenium hysterophorus
Xanthium strumarium

Mitigation: The existing identified IAS should be weeded out and adequate measures should be taken to avoid import of new IAS through appropriate quarantine measures. An approproiate policy needs to be formulated by the Government of Arunachal Pradesh.

5.2.2 Possible impacts on flora and fauna

One of the foremost project activities is acquisition of land for setting up of various project structures, such as, construction of barrage structure, powerhouse, tunnel related structures, office premises, residential colonies/complex, labour camps, material storage yards, waste dumping areas, construction of new approach roads, etc.

5.2.2.1 Acquisition of forest land and changing the land use for the proposed project's development activities and impacts of loss of habitat

The proposed projects requires an area of 838 ha of land for the development of 7 project structures which includes 261 ha of forest land which is essentially community forest land and legally classified as unclassed forest. The conversion of forest land is likely to have the following direct/primary impacts:

Impact 19. *Loss of habitat: Due to diversion of forest land for the project activities including the construction of approach road, habitat conditions are altered resulting in deforestation, soil erosion and land degradation.*

Impact 20. *Changes in floral composition: Following removal of the forests for construction of various structures, the species composition of the altered habitat is bound to change due to modified micro–environmental conditions. The pioneer species are likely to dominate the regenerating forests replacing the primary forest species except coppice regeneration.*

Impact 21. *Changes in faunal composition: The smaller group of faunal species, which are potent indicators of changes in the habitat (butterflies, amphibians and reptiles), are likely to be more impacted. Though, impact will also be felt amongst avifaunal and mammalian species as well.*

Evaluation: The proposed HEPs in the TRBL requires a total of 261 ha of forest land for the construction of different project structures of 7 projects. For the remaining projects, data on land requirement were not available. Faunal diversity assessment reveals that this area has low species richness with presence of only 33 species (28 genera, 5 families). Mammalian fauna was assessed as moderate species richness with 18 species based on 253 indirect evidences and 296 sightings of animals (Table VII.5.2). Presence of only 2 amphibian and 4 reptilian species is an indication of this area having low herpetofaunal diversity. In case of avifauna, most (about 75%) of the total 241 species reported (high diversity at 4.5), are with very low abundance. Therefore, impact on avifauna shall also be moderate to low. Therefore, the overall impact on faunal diversity of the proposed project sites in TRB due to loss of forest habitats may stand at low to moderate levels.

Mitigation: The low to moderate level of impact is reversible and can be restored with concerted efforts. In this case, it is suggested to take up afforestation program using dominant native tree species and woody shrubs, to compensate both for the floral and faunal losses in the project areas.

Table VII. 5.2: Status of major faunal groups reported in TRBL (Sp–Species, Ge–Genus, Fl–Family)

S.No	Faunal groups	Species Richness	Species Diversity	Abundance
1	Butterflies	33 Sp, 28 Ge, 5 Fl	–	
2	Amphibian	8 Sp, 7Ge, 4 Fl * (2)	–	
3	Reptile	28Sp, 21Ge, 8Fl * (4)	–	
4	Terrestrial birds	241 Sp, 132 Ge, 48 Fl	H'4.3	Total of Birds–11,947 74.7 % of species (180 species) fall under very low to low categories of abundance status
5	Mammals	18 Sp, 18 Ge, 13 Fl		IE 253, A 296 (9 species)

*–possible species based on secondary sources, number given in parenthesis denotes number of species reported

Impact 22: *Construction activities related to the proposed projects would impact the terrestrial plant and aquatic plant and animal species having commercial importance and would have important livelihood implications.*

Evaluation: Although fish density and diversity is extremely low in the river stretches beginning from Tawang I project and all the projects in its upstream, their density and diversity in Tawang–II project and Nyamjang chu project are quite high. The algae *Prasiola crispa* growing in the large stretches of Tawang river would also be affected due to the construction activities during construction phase. Since this species has high commercial value and contributes substantially to the income of the local people, the damage to their population would have a significant impact. In addition, several plant species growing in the project affected areas such as Citronella, *Gaultheria*, orchids, mushrooms and a host of medicinal plants having high economic importance would be affected both in long and short term due to project implemetation. Therefore, the overall impact is rated as high.

Mitigation: In view of the high impact as identified above, the BMP has described in detail the development of these resources to mitigate the impact.

Impact 23. *Acquisition of forest land for the proposed project activities is expected to increase the resource dependency (timber, fire wood, fodder and grazing) on other available forest lands, thereby indirectly impacting the the overall floral and faunal diversity.*

Evaluation: A total of 261 ha of community forest land (CFL) is likely to be converted for the construction of different project structures for 7 projects in TRB. Given, that the local communities are in possession of large extent of forest lands, the conversion of CFL is not expected to put any additional pressure on the other forest lands. Therefore, the above said impact has been evaluated as low impact on the floral and faunal diversity of TRB.

Mitigation: Since the impact is extremely low, activities planned under compensatory afforestation and catchment area treatment should be adequate to mitigate this impact.

5.2.3 Possible impacts on threatened floral and faunal species

Threatened floral and faunal species in the proposed project area are also likely to get impacted due to the above said project related activities in the form of:

Impact 24. *Loss of specific habitats of the threatened floral and faunal species of the project area.*

Impact 25. *Habitat degradation and fragmentation will have significant impact on threatened floral and faunal populations.*

Evaluation: Though the status of threatened faunal species has been described up to near threatened species (fourth lowest category of IUCN red list) in base line chapter, the impact assessment has been done only for Critically Endangered (CR), Endangered (EN) and Vulnerable (VU) species of IUCN and Schedule I species of WPA, 1972 in respect of indicator faunal groups of butterfly, herpetofauna, avifauna and mammalian fauna.

No impact as none of the 42 butterfly speceis fall under threatened categories. Same is the case of herpetofauna having no direct sighting of threatened species. However, few threatened species, namely, keeled box turtle (*Cuora mouhotii*), common mock viper (*Psammodynastes pulverulentus*), short–nosed vine snake (*Ahaetulla prasina*) and red–necked keelback (*Rhabdophis subminiatus*), have been recorded based on secondary data without confirmed record to the TRB. Moreover, none of these species are listed under Schedule I of WLPA. Out of a total of 241 bird species reported in the project area, only one individual of species rufous–necked hornbill (*Aceros nipalensis*) qualify as vulnerable under IUCN Red List (Rahmani, 2012, IUCN, 2013), was recorded from this study landscape from the entire landscape. In addition, theWorld Wide Fund (WWF), Tezpur has recorded presence of 5 black–necked cranes (*Grus nigricollis*) in the Nyamjang chu basin near Zimithang barrage site during the winter of 2013. The population status of this species has been reocrded for the past five years indicating their regular visits to this area as wintering ground. Hence the project related activities would significantly impact up the wintering habitat of this vulnerable crane species. Overall in the TRBL, 6 out of a total of 18 mammal species have been identified as species of high conservation significance by IUCN and IWPA. These include 2 species of primates, red panda, himalayan black bear, common leopard and Asiatic wild dog. Overall, among the threatened mammals, the ecological and behavioural needs of wild dogs, requiring frequent use of drinking water sources, setting 'territoral' markings in form of 'laterine site', etc., may get impacted due to project related activities. However, presence of wildl dogs and also common leopard has been recorded only through infrequent indirect evidences during seasonal studies in the project area (Nykcharong chu and only wild dog and Himalayan Black Bear in Tawang–II). It is clearly evident that due to low abundance status of these three species and infrequent use of project area across TRBL may cause minimal and insignificant impact.

Impact on 11 groups of Arunachal macaque with 217 individuals and one group of Capped langur with 13 individuals is likely to be of moderate to high level, depending upon the local of their home range from the project area. Being a generalist feeder (using 40 food plant species) from wider range of habitats due to semi–arboreal nature (crop fields, broadleaved forest, open scrub, forest clearing, abies forest, dense oak forest and riverine forest), and tolerance to human pressure (Sinha *et al*., 2005 and 2006), lessen the impact on this species to moderate to low levels.

Red panda (*Ailurus fulgens*) was another threatened species reported based on the stuffed animals reported by a local villager (the villager said dead animal were collected from the riverside). This species was reported within the project area but not close to the barrage and powerhouse sites. Even though, being habitat specialist and in the view of the existing threats (sport hunting and killing for skin), it is very important to take management actions to protect and conserve this highly threatened species. As per Nayar and Sastry (1987, 1988, 1990) and CAMP evaluation, atleast 10 RET and/or endemic species were found in TRB (Table VII.5.3), although none of them was present in the project affected areas i.e., barrage, powerhouse, colony, and muck disposal sites, and adits. Because of this and since no IUCN classified threatened plant was present, the impact may be rated as low.

Table VII. 5.3: RET and/or endemic species in TRB

Sl. No.	Endemic and/or Threatened Plants	Description
1	*Acer hookeri*	*Acer hookeri* is listed in the Red Data Book of India as endangered species which is found in Sikkim and Arunachal Pradesh and in some parts of Darjeeling district inWest Bengal. Among all HEP sites in TRB this species was only found in Mago chu HEP site.
2	*Acer sikkimensis*	*Acer sikkimensis* is listed in the Red Data Book of India as endangered species which is found in Sikkim and Arunachal Pradesh and in some parts of Darjeeling district inWest Bengal. In the HEP sites of TRB at four places this species was located i.e., in Mago chu, Thingbu, Rho and Nykcharong chu HEP site.
3	*Aconitum ferox*	EN category according to CAMP, 2003. It is found above 2000 m elevation and because of its important medicinal property which helps in treatment of a number of ailments (cough, asthma, leprosy, fever, muscular rheumatism as well as against snake bite, neuralgia, skin disease, acute gout, etc.) it is getting extinct from the wild due to excessive collection by the people. In the TRB Project sites it was located in two sites i.e., from Tsa chu–I Lower and Thingbu chu Project sites.
4	*Aconitum heterophyllum*	Listed endangered by IUCN and kept in EN category according to CAMP, 2003. The dried root of this plant is used generally for fever and body pain.
5	*Albizia arunachalensis*	This is an endemic tree found in the state. During the floristic survey in TRB {Project sites this tree was located from two HEP sites, namely, Tawang I and Tawang–II. A good number of populations was observed.
6	*Panax bipinnatifidus*	Listed endangered according to CAMP, 2003. In TRB project area, in several places a good number of populations of this plant were found as in Thingbu chu, Mago chu, New Melling, Nykcharong chu, Tsa chu–I Lower and Tsa chu–II.
7	*Paris polyphylla*	Listed vulnerable both by IUCN and CAMP. During the floristic survey it was located in Tsa chu–I, Tsa chu–II and in Tsa chu–I Lower.
8	*Swertia chirayita*	Listed as endangered CAMP, 2003.The water extract of the plant is generally used during fever. Other uses are in bronchial asthma, dyspepsia and debility
9	*Taxus wallchiana*	Listed as endangered by (Thomas and Farjon, 2011). A very reputed tree exploited for traded leaves used to extract Taxol an anti cancer alkaloid. Also used by community.
10	*Torricellia tiliifolia*	This is an endemic tree found in the Eastern Himalyas, also found in china. During the floristic survey in TRB Project sites this tree was located from two HEP sites, namely, Tawang–I and Tawang–II. A good number of populations were observed. Some population was also located in other places.

EN=Endangered; Endm=Endemic; VU=Vulnerable

Mitigation: Based on the above evaluation on conservation status, it is important to follow some of the management strategies suggested which can minimise high to moderate level impact on the above identified floral and faunal species of TRBL.

5.3 MITIGATION PLAN

Mitigation refers to action that can be implemented to minimize the magnitude of the project related detrimental impacts on different physical, biological, and social environments of the project area. Mitigation of biological environment can be undertaken along three possible courses of actions with respect to the impacting factor i.e., by changing (1) at source, (2) path, and (3) at the receiving end. Mitigation plan is an appropriate follow–up process which involves management and monitoring & evaluation. It also provides opportunities for making future improvements in project related activities. Based on different types of impacts on biodiversity elements identified and evaluated in terms of their magnitude, the following mitigation plans have been suggested:

5.3.1 Development of natural resources

Natural resource development programme has been planned to mitigate and minimize impacts on the overall biodiversity of the TRB due to diversion of forest areas for project activities, that could lead to loss of habitat for faunal species of concern, loss of community forests and their over–exploitation due to increase dependency by project–related labour force and local villagers.

5.3.2 Managerial, technical and legal interventions

During the construction phase, few managerial and technical interventions are proposed to mitigate impacts on the overall biodiversity of the river basin, noise pollution, road mortalities due to increased vehicular movements, and severe biotic pressures on habitat from the labour force.

5.4 DEVELOPMENT OF NATURAL RESOURCES

5.4.1 Compensatory afforestation to mitigate the loss of forest land

A total of 261 ha of community forest land (CFL) is likely to be converted for the construction of different project structures for 7 projects in TRB. The impacts of forest loss on change in composition and abundance of floral and faunal species in TRBL has been assessed to be at moderate to low levels. To mitigate the impacts of forest loss and to enhance the floral and faunal diversity, it is suggested to take up compensatory afforestation programme with the dominant native and endemic tree and shrub species occurring in the river basin.

It is suggested that only native and endemic plant species are selected for the afforestation programme. The selected species should preferably have high important value index (IVI), which indicate their wider distribution and higher growth/size, thus better performance. Afforestation would provide habitat for butterflies (as host plant), herpetofauna (micro–habitat), birds (food, nesting and roosting sites) and terrestrial (barking deer, wild pig, jungle cat) and arboreal mammals (yellow throated martin, Himalayan palm civet and squirrel), and especially the endangered primate Arunachal Macaque which uses diverse habitats.

A majority of the forest area in TRB is under the traditional ownership and *de facto* control of the village councils, and families appear to have rights over most of the grazing land. Forests are also used for collecting fuel wood, timber, bamboo for house–building and leaf litter as manure (Mishra *et al*., 2006). Collection of medicinal plants is an important source of cash for the villagers. Considering the dependency on forest resources, it is suggested to support people create more forest resources on the existing community lands to minimise the impact on additional forest areas.

- The existing community land of the concerned villagers, that have been acquired for the project development, be further developed by planting bamboo (wherever appropriate), fodder and medicial plant species. This will reduce dependency on the interior forest areas to practically nil.

- *Bamboo and fodder species:* Villagers extensively collect bamboo from the nearby forest areas, use trees as construction material and gain access to forest areas for livestock grazing. Therefore, it is recommended to locate areas within village community land to raise bamboo and fodder species plantation.
- These plantations must be protected initially for a period of five years to attain the sustainable production and use them sustainably through the village natural resource committee.
- *Herbal garden:* It has been identified that, collection of medicinal plants is one of the income sources of the Tawang tribes/villagers, and they over–exploit these resources for trading. Hence developing herbal gardens can be an option to minimize the resource dependency of the villagers from the interior forest.
- The project proponents should interact with the herbal healers in the villages to identify the important (life supporting), most frequently used, rare and commercially used medicinal plants and their availability and distribution in different areas. Based on this it is suggested to develop at least four to five herbal gardens with the selected species in different areas of each covering 25 ha within the TRB.
- The project proponents to also identify market links and devise proper management systems through the village communities for sustainable use of the resources developed to completely check collections from the interior forest areas.
- A strong village level herbal garden network should be established and all the activities have to be executed and implemented through this Herbal Garden Committee under the compliance of the State Forest department and consultation with the experts from the state and national Medicinal Plant Boards.

5.5 MANAGERIAL, TECHNICAL AND LEGAL INTERVENTIONS

5.5.1 Mitigation to sustain the ecological processes of the river ecosystem

Barrage construction would affect the normal water flow in the river system during the operational phase. Consequently, the diversity and abundance of the flora and fauna in the project area/river would be affected. Hence, it is necessary to maintain the ecological flow of the river ecosystem to maintain the overall ecological integrity and sustainability of the TRB. Therefore, adopting strict management options and regulation are suggested to minimize the negative impacts. It is suggested to allow adequate water flow (E–Flow) into the downstream considering the riverine vegetation composition to maintain the ecosystem processes, which in turn shall ensure continuation of ecosystem services to the local communities, and also for protection and long term survival of overall floral and faunal diversity of the TRBL.

5.5.2 Mitigation to control pollution

The following precautionary measures and management options are suggested to all the project proponents to mitigate impact from pollution.

- Providing for a retaining wall at upstream of barrage site during the construction phase to avoid mixing of the runoff water into waste concrete materials.
- Daily cleaing and removal of entire waste concrete materials being generated during construction activities of different project structures.
- No dumping of waste materials especially oily material into the river be allowed. The contractors and other workers must be made strictly aware of this. .
- A separate waste storage yard need to be identified for storing and transporting waste materials regularly. Such site may be idenfitifed in consultations with the State and Central Pollution Control Boards..
- Washing of trucks/vehicles must be in the river system to control oil pollution. All concerned drivers/cleaners to be strictly instructed to this effect.
- The project proponent should strictly comply with the guidelines of the Central and State Pollution Control Boards under EIA notification on HEP.

5.5.3 Technical and biological interventions to minimise the impact of muck dump yards

Dumping and disposal of muck generated during the construction of tunnels would have the impacts such as loss of habitat, polluting the river system, and restriction of faunal movement and access to water sources. These impacts have been evaluated to be of moderate level, hence adopting the suggested technical and biological mitigations would minimise these impacts as insignificant.

- The open areas, far from river side and with not much of vegetation should be selected for this purpose. It will avoid the loss of riverine habitat and pollution problem
- It is suggested to collect and store the top soil of the area identified for the construction of muck dump yards
- Once filled, the muck dump yards should be covered with the stored top soil so that the seed bank of herbaceous vegetation (grass and herbs) can regenerate. It will also check rain washed runoff of waste from muck dump to the river system.
- Dump site should be planted with native woody shrubs and tree species to give it a narural look.
- The retaining wall planned to construct towards the waterfront of the muck dump yards should maintain 45^o slope to ensure accessibility of faunal species to the river meeting day to day water requirements.
- Construction of 2 to 3 dump yards separated about 1–2 km from each other be preferred over one long dump yard. It will facilitate animals to reach to river water for their use more conveniently without necessity of moving for long distances.

5.5.4 Technical and management plan to control the impact of noise pollution

Noise pollution due to drilling, tunnelling, blasting activities and intensive vehicle movements in the project areas has been identified as indirect and shot term impact that would affect the normal behaviour and locally disappearance of larger group species and impact on ground dwelling lower vertebrates. The impacts of noise pollution on the faunal group of the project area identified and evaluated as moderate to high of shorter period (construction phase) on herpetofauna, mammals and birds. The following technical and management methods may be adopted to reduce the noise pollution (Table VII. 5.4).

Table VII. 5.4: Details of technical and managerial mitigatory measures to minimize the impact of noise

Source of noise	Mitigatory Measures–Technical
Generation of Noise due to movement of vehicles and equipments.	• Ensuring all machines used for site clearing are well maintained and regularly serviced. • The vehicles used will be with the standard of limiting noise output.
Generation of noise during blast hole drilling	• The project proponent should adopt innovative approaches of using improvised plant and machinery design with in–built mechanism to reduce sound emissions like improved silencers, mufflers and closed noise generating parts. • Specifically, noise from compressors will be minimized by sound maintenance of the equipment and by providing enclosures.
Generation of noise due to blasting	• Adoption of suitable explosive charge and short delay detonators, adequate stemming of holes at collar zone and avoiding blasting on foggy days, at night times and at the time of high wind speeds. • Restricting blasting to a particular time of the day i.e., during lunch hours, so that humans (other than authorized persons) are away during the blasting. • Reducing ground vibrations by controlling charge per hole as well as charge per round of hole. • Adopting muffling (i.e., covering the blast holes by sand bags) when the distance from important features/ecologically sensitive area is less than 500 m.
Regulating activities	• Restricted blasting hour to specific time period, once in a day and ensure the movements of faunal groups rest of day and night hours • All the blasting related preparatory activities–drilling of blast holes and tunneling should not take place during the night hours • Restrict the heavy movement of vehicles during day hours and vehicle should not fly during night hours (from 06.00 pm to 06.00 am)

Strict follow up of above suggested technical and management plans shall ensure very low impact, which may become insignificant in due course to allow the faunal species behave normally and move freely without exodus.

5.5.5 Mitigation to avoid accidental road mortality due to vehicle pressures in the forest areas

The impact of construction of new approach roads in the remote areas and frequent heavy vehicle movements in the existing forest roads on faunal species of the project area has been identified as moderate road mortality on herpetofauna and six terrestrial mammals, while high on 241 species of avifauna. Strictly enforcing the below suggested management and conservation action plans is likely to bring down the evaluated impact on herpetofauna, small mammals and avifauna of the TRB.

Road mortality and bird collision

- Canals of 0.5 m x 0.5 m dimension on the hill slope side and culverts of 1x1 m dimensions may be constructed as safe passage for the herpetofauna for movement and crossing over to check road based mortalitites.
- These structures would also check road erosion of newly constructed roads; those will last long thus reducing the maintenance cost.
- Speed limit to be strictly observed at 20 km/hour on the forest roads to avoid bird collision.
- Poper signages be provided for slow driving and allowing animals to cross over first.

5.5.6 Mitigation measures to evade biotic pressures from labour force

The impact identified due to sudden influx of labour force are, loss of land and vegetation cover for labour settlements, dependency on forest resources for construction materials**,** collection of fuel wood and getting involved in poaching. Therefore, following mitigation measures are suggested to minimise the above said direct and primary impacts on forest and associated faunal species.

- Involvement of local people/villagers whose land has been acquired for the proposed projects in the project related activities. This will support them economically and would lead to minimise pressure on the natural forest and wildlife resources.
- Proper labor colonies be set up for outside labour force to avoid their dependence on the forest resources.
- Supply of LPG be provided to check fuel wood consumption. This will save cutting of trees for this purpose and hence the impact.
- Migrants should be kept under strict vigilance to not to indulge in killing and hunting of animals in and around the forest areas of the project site.
- The labour colony/settlement should be facilitated with waste disposal point to avoid dumping of unwanted waste materials into the river system
- The project proponents should create overall awareness education to keep the project environment neat and clean and also follow the above mentioned regulations strictly.

CHAPTER 6

SPECIES–SPECIFIC AND LANDSCAPE LEVEL BIODIVERSITY MANAGEMENT PLAN

6.1 INTRODUCTION

Considering the potential cumulative impacts of the proposed HEPs on ecology and biodiversity of TRB described in the preceeding chapter, the goal of this BMP is to ensure the long term sustainable management of biodiversity in TRB. The twin objectives under this goal are:

(1) species–specific conservation measures and
(2) landscape level BMP

6.2 GUIDING PRINCIPLES

The species–specific conservation measures are based on the following:

- The conservation measures for all the threatened and endemic species reported need to be covered.
- The conservation measure must include to mitigate other environmental drivers influencing the species populations in addition to the proposed power projects.
- Both *in situ* and *ex situ* approaches must be adopted wherever applicable.

Landscape level biodiversity conservation and management measures need to be:

- Based on traditional and contemporary knowledge systems and understanding on biodiversity and its varied elements.
- In tune with local socio–cultural practices and belief systems.
- Participatory in nature ensuring meaningful engagement of local communities and other stakeholders (mainly the monasteries) in decision making as well as implementation of various strategies and actions.
- Empowering local institutions and communities for adopting conservation friendly livelihood practices through enabling capacity building.
- Creating efficient and transparent organizational mechanisms to coordinate and implement different measures.

6.3 SPECIES–SPECIFIC CONSERVATION PLAN

6.3.1 Conservation of threatened faunal species

Species–specific management plans are suggested for threatened faunal species in the TRB, such as, Arunachal Macaque, Red Panda, and Black–necked crane. The strategy of the species–specific conservation plan is undertaking *in situ* conservation measures. These plans shall lead to overall enhancement of species richness and diversity of avifauna due to improvement of habitats across TRB. The management plan includes activities such as species–specific habitat development, protection measures, education and awareness, and monitoring and research programmes.

6.3.1.1 Conservation of Arunachal Macaque (*Macaca munzala*)

Though Arunachal macaque has been sighted only in 9 project areas, due to its wide distribution in Tawang region, the following mitigation and management plans as joint venture in term of sharing the implementing cost of all the mitigations and management plans have been proposed for all the 13 projects.

(a) Awareness education programme

The foremost mitigation measures need to be implemented is awareness programme among the local stakeholders who resort to hunting and killing of Arunachal macaque for medicinal values for their live stock and crop damaging respectively, causing direct impact on the population status of the endangered and newly detected primate species. The targeted stakeholders include mainly the local villagers (agro–postural community), government departments and the school kids so that change in their mindset against killing of macaques would ensure long term survival of the species.

(b) Crop protection

Cultivating buffer crops along/bordering the main cash crops in consultation with the local villagers could be other potential mitigation measure to reduce the losses of main crop. The project proponents should share the cultivation cost for buffer crops, specifically in the villages falling within the project area. In each village 4–5 youths can be engaged and trained as crop watchers to protect the crops in their traditional harmless ways during day and night hours. It may be noted that wild boar damages the crop mostly during night hours. The wages can be met from the Project cost. The project proponents should introduce crop compensation or insurance programmes in the highly affected villages with the joint venture of concerned forest department, insurance companies and agriculture departments.

(c) Habitat improvement

Habitat improvement programme is also an important mitigation measures which would help the macaque troops affected and moved out of their range due to the project activities. Hence it is suggested to develop macaque foraging habitats in and around the project area to compensate the loss of habitat/forest cover. It is recommended to develop 4 blocks of macaque forage habitat of 5 ha area each by developing/planting food plants used by Arunachal macaques. The land should be identified with the help of local villagers and forest department. Overall 200–250 ha area can be brought under macaque's forage habitat within TRB with the joint venture of all the project proponents, who will share the planting costs. With the help local villagers and plant taxonomists the species need to be identified and collected from the nearby forest areas and devise mode of planting to increase the growth and survival rate. Initially, these forage habitats should be protected with green fencing for a period of three years to attain the maturity and start producing fruits and to gain enough seed resources for long term sustainability through natural regeneration. These forage habitats should be monitored and evaluated by engaging experts for use by the macaque troops and also other species such as birds.

(d) Management Oriented Research Programmes

Since this macaque species is not much studied for its ecology and behavior, specially on the issue of man–monkey conflicts, it is proposed to initiate long–term scientific research programmes to understand the correlation between the altitudinal variation in macaque density against the magnitude of crop damage and its impact on retaliatory persecution of the macaques.
The project proponent can provide financial support to the local universities to carry out such management oriented research and development programmes in collaboration/consultation with the national level subject experts.

(e) Wildlife tourism

Arunachal macaque has the potential to become a tourist attraction as well as a flagship species for conservation (Alexander 2000, Hill, 2002). In recent years Tawang has been promoted as an important tourist destination and has considerable potential for community–based wildlife tourism. On other hand, means of offsetting livestock losses to wild carnivores and crop damage by macaques are also required (Mishra *et al*., 2006). Hence, a well planned community based wildlife tourism can be a good option to help and gain confidence among the local communities to protect and conserve this macaque species as well as the other threatened fauna of TRB.

Box VII. 6.1: Arunachal macaque (*Macaca munzala*)

Arunachal macaque *Macaca munzala,* a primate new to science which is a unique outcome of biological expeditions in 2003 and 2004 (Mishra *et al*., 2006). Arunachal macaque was earlier hypothesised to be closely related to *Macaca assamensis* and *M. thibetana* based on similarities in their appearance and distribution. Now, molecular study has established the distinct identity of *M. munzala* as an independent species and revealed its close affinities with the allopatric *M. radiata* rather than with the geographically closer *M. assamensis* or *M. thibetana*. Based on the only available information on conservation status assessment for Arunachal macaque in Tawang and West Kameng districts of Arunachal Pradesh, the following aspects have been synthesized for basic understanding on the biology of this new species:

Population/abundance: The survey of Arunachal macaque between April 2004 and August 2005 in Tawang and West Kameng districts of Arunachal Pradesh estimated a total of 569 individuals in 35 troops. Of that, from Tawang 540 individuals in 32 troops were reported. The remianing was from West Kameng district. The troop size varied from solitary to>60, with an average troop size of 16.3 ± 13.4 individuals and density of 22.01/km^2.

Habitat/vegetation: Arunachal macaque predominantly inhabits the human modified landscape and forest close to human habitation. They were seen during this field survey in crop fields, broadleaved forest, open scrub, forest clearing, Abies forest, dense oak forest and riverine forest.

Feeding: Study on two multimale multifemale troops for a period of 112 hours in Zemithang valley of Tawang district showed that they spent on an average, 48% of the observed time in moving and foraging, 36% in sitting and resting, and 16% in social interactions. Foraging alone accounted for 29% of the time–activity budget. They were observed feeding on fruits of *Elaeagnus parvifolia* for atleast 65.8% of the total foraging time during the study period and hence frugivorous diet is likely to be seasonal. A list of approximately 40 species of plants were identified as food plants with diverse food items and they feed only on plants and plant products (Mendiratta *et al*., 2009).

Ranging: A. macaque troops of 22 and 13 individuals had distinct territories with home ranges of 28 ha and 16 ha respectively and daily ranging distance measured of approximately 1.5 km for both the troops. Another study reported the home range varying in size of 7 to 55 ha (Kumar *et al*., 2008 and Mendiratta *et al*., 2009).

Human–Macaque relation: Though the agro–pastoral tribe Monpa of Tawang do not hunt primates for meat (Solanki and Chutia 2004, Mishra *et al*., 2006), a certain level of persecution of Arunachal macaque was reported in retaliation against crop damage (Sinha *et al*., 2005, Mishra *et al*., 2006) and also for medicinal use particularly for livestock (Solanki and Chutia, 2004). A survey on people's perception revealed that amongst the wildlife, macaques and wild pigs were the dominant species reported to cause highest crop losses and crop damage throughout the year. In the villages where persecution was confirmed, an average of 35 macaques were killed in five years. Killing of macaques related to crop damage is a serious problem which needs to be addressed with appropriate management plan.

6.3.1.2 Conservation of Red Panda (*Ailurus fulgens)*

Even though, no sighting of red panda occurred during the study period, its presence in and around the Zemithang project area was confirmed based on the 2 stuffed animals collected from the riverside. With understanding of its habitat requirements and existing threats, it is very crucial to adopt some mitigation measures through management plans as suggested below to protect this threatened species.

Red pandas are known to inhabit temperate forest with bamboo undergrowth (Pocock, 1976; Prater, 2005) at elevation between 1525 (Prater, 1980) and 3900 m (Allen, 1938). Red panda preferred broad leaved forest and subalpine forest between 2800 and 3600m, with species like *Abies densa*, *Acer* sp., *Mangnolia campbelli, Osmanthus sauvis, Quercus pachyphylla, Rododen campanulatum, Schefflera impressa, Sorbus cuspidata, S. microphylla* and *Vitex heterophylla* (Pradhan, 1999). Red panda occur in Singhalila National Park, Dibang Valley National Park, Mehao, Tawang, Palin, Pakhui and Lado Wildlife Sanctuary in Arunachal Pradesh (Rodgers and Panwar, 1988).

Though, it is classified under carnivora group, red panda subsists entirely on plant diet, predominately on higher altitude bamboo. They also feed on berries and fruits of *Sorbus cuspidata* and *Sorbus microphylla* (Yonzon, 1989). *Arundinaria maling* contributed major proportion in the diet of the red pandas (Pradhan *et al*., 2000).

Six areas surveyed in western Arunachal Pradesh for threat assessment and conservation status identified hunting of red panda in all the six areas for sport and skin (Mishra *et al*., 2006). Its survival outside the protected areas is highly threatened and needs to take appropriate conservation measures for long term survival.

(a) Population Status and Assessment
A well formatted questionnaire survey covering all the villages located within10 km radius from all the project sites should be carried out to know the possible locations/habitat of the red panda and resource dependency of the local people from the panda's habitat. Based on that, habitat specific field survey should be undertaken to estimate their abundance, habitat status in term of quantifying biotic pressures. In addition, all the known bamboo habiats/locally called *jhapra* existing within the project areas also surveyed for red panda. All the areas identified should be earmarked for further protection and habitat improvement programmes. The project proponents should also provide financial support to initiate the above notedhabitat and population status survey of red panda.

(b) Habitat Protection and Restoration.
Based on the above surveys and the availability of potential red panda habitat, as many as sites should be selected for further habitat improvement plans. The selected habitats should be protected and monitored from the biotic pressures along with the concerned village committees. Local youths can be appointed as red panda watchers mainly from the villages whose land has been acquired for the proposed projects, and therefore they get monetary benefit. These habitats should be restored by planting *ringal* bamboo with the help of local villagers and consultation with the concerned forest department. In addition to that, these habitats should be planted with some of the food plants like *Sorbus cuspidate, Sorbus microphylla* and bamboo species *Arundinaria maling* identified as food plant of red panda.

Around 100 ha of sacred forest near Taeang and Mukto is under protection from hunting and resource extraction by the forest department, where sightings of red pandas is reported. These need to be further conserved. In total at least 20 Red panda habitats should be protected and conserved within TRBL.

(c) Awareness Education Programme
Out of six areas surveyed, red panda is reported to be under hunting pressure in all the sites which also includes Nyamjang chu Valley. In addition, local people also collect bamboo for the house building. Taking into account of the above discussed issues on hunting and resource use by the local people, it is very important to create awareness among the villages and schools to protect the threatened red pandas and other threatened species (capped langur, Arunachal macaque and black–necked crane) of TRB. The project proponent must provide adequate financial support to implement the above suggested activities with technical support from concerned subject experts.

6.3.1.3 Conservation of black–necked crane
Black–necked crane is a vulnerable species as per IUCN red list and schedule I of WPA (Box 2.1). Considering the conservation importance of the species, the experts were unanimous to protect the habitat of the species, which might be affected by Nyamjang chu project.

6.3.1.4 Conservation of butterfly species
In TRB 42 species of butterflies were reported which is of low species richness and none of the species fall under threatened categories of IUCN and IWPA. Even then adequate care should be taken to conserve their host plants in the forests.

6.3.1.5 Conservation of herpetofauna
The reported presence of four threatened reptiles viz., keeled box turtle (*Cuora mouhotii)*, common mock viper (*Psammodynastes pulverulentus)*, short–nosed vine snake (*Ahaetulla prasina)* and red–necked keelback (*Rhabdophis subminiatus)* in TRB indicates the need of

taking conservation measures for this animal group. Although the impact of the proposed projects on herpetofauna has been evaluated as insignificant, the measures described in the preceeding chapter should be adopted to ensure their conservation (refer sub–section 7.3.5).

6.3.1.6 Conservation of avifauna

Since bird community of the TRB is represented by high diversity and foraging groups, it is not possible to develop species–specific conservation plans. However, two conservation options are suggested for the overall enhancement and conservation of bird species diversity of TRB viz., (1) providing nest boxes for the specific group of hole nesting birds and, (2) development of feeding habitats for the overall bird species.

Table VII. 6.1: List of hole nesting bird of TRBL

Sl. No.	Family & Species	Common name	MS	Overall	P/S Hole Nester	Size of Nest Box	Hole Size in Diameter–cm
1	**Aegithalidae**						
1	*Aegithalos concinnus*	Red–headed Tit	R	29	S	Small	3.5
2	*Aegithalos iouschistos*	Rufous–fronted Tit	R	24	S	Small	3.5
II	**Bucerotidae**						
3	*Aceros nipalensis*	Rufous–necked Hornbill	R	1	P	Large	14
III	**Certhiidae**						
4	*Certhia discolor*	Brown–throated Treecreeper	R	2	S	Small	3.5
5	*Certhia familiaris mandellii*	Eurasian Treecreeper	R	24	S	Small	3.5
6	*Certhia nepalensis*	Rusty–flanked Treecreeper	R	29	S	Small	3.5
IV	**Corvidae**						
7	*Urocissa flavirostris*	Yellow–bellied Blue Magpie	R	6	S	Small	5.0
8	*Copsychus saularis*	Oriental Magpie–robin	R	1	S	Small	5.0
9	*Myiomela leucura*	White–tailed Blue Robin	R	1	S	Small	5.0
V	**Falconidae**						
10	*Falco tinnunculus*	Common Kestrel	WV	4	S	Large	12
11	*Myiomela leucura*	White–tailed Blue Robin	R	11	S	Small	5.0
VI	**Megalaimidae**						
12	*Megalaima asiatica*	Blue–throated Barbet	R	7	P	Medium	6.0
13	*Megalaima franklinii*	Golden–throated Barbet	R	23	P	Medium	6.0
14	*Megalaima virens*	Great Barbet	R	51	P	Medium	6
VII	**Muscicapidae**						
15	*Tarsiger chrysaeus*	Golden Bush–robin	R	2	S	Small	5.0
16	*Tarsiger rufilatus*	Himalayan Red–flanked Bush Robin	R	3	S	Small	5.0
17	*Copsychus saularis*	Oriental Magpie–robin	R	21	S	Small	5.0
18	*Myiomela leucura*	White–tailed Blue Robin	R	3	S	Small	5.0
VIII	**Paridae**						
19	*Parus spilonotus*	Black–spotted Yellow Tit	R	19	S	Small	3.5
20	*Parus ater*	Coal Tit	R	74	S	Small	3.5
21	*Parus monticolus*	Green–backed Tit	R	210	S	Small	3.5
22	*Parus dichrous*	Grey–crested Tit	R	60	S	Small	3.5
23	*Parus rubidiventris*	Rufous–vented Tit	R	18	S	Small	3.5
24	*Melanochlora sultanea*	Sultan Tit	R	12	S	Small	3.5
25	*Sylviparus modestus*	Yellow–browed Tit	R	12	S	Small	3.5
IX	**Passeridae**						
26	*Passer rutilans*	Cinnamon Sparrow	R	39	S	Small	4.0
27	*Passer montanus*	Eurasian Tree Sparrow	R	107	S	Small	4.0
X	**Picidae**						
28	*Blythipicus pyrrhotis*	Bay Woodpecker	R	2	P	Medium	7
29	*Dryocopus martius*	Black Woodpecker	R	3	P	Large	14
30	*Dendrocopos cathpharius*	Crimson–breasted Pied Woodpecker	R	2	P	Medium	7.0
31	*Dendrocopos darjellensis*	Darjeeling Pied Woodpecker	R	2	P	Medium	7
32	*Picus flavinucha*	Greater Yellownape	R	17	P	Large	14
33	*Dendrocopos canicapillus*	Grey–capped Pygmy Woodpecker	R	6	P	Small	5.0
XI	**Sittidae**						
34	*Sitta himalayensis*	White–tailed Nuthatch	R	49	S	Small	3.5
35	*Upupa epops*	Common Hoopoe	WV	11	S	Medium	7.0

MS–Migratory Status–BV–Breeding Visitor, IR–Isolated Record, R–Resident, WV–Winter Visitor; P/S Hole Nester : P–Primary Hole Nester, S–Secondary Hole Nester; Size of Nest Box: Small–height/depth = 20 cm, Length & width = 13 cm, Medium–height/depth =40 cm. length & Width = 25 cm, Large–height/depth = 75 cm, Length & width = 50 cm

Facilitating nesting niche through installing nest boxes

Of the total 241 bird species in Tawanr river basin, 35 species are hole nesters (Table VII. 6.1). The most simple and appropriate measure for creation of alternate habitat for avifauna isinstallation of artificial nesting structures that can be used to increase wildlife reproductive success. While these nests are generally designed to meet the nesting requirements of certain species, yet, these may also be used by non–target species. Nest boxes, nesting platforms or shelves, and nesting baskets are some of the common types of artificial nesting structures.

Based on the bird size, it is recommended to fix at least, 200 nest boxes in and around all the 13 project areas with varying sizes of hole (nest entrance) and dimension (Small–height/depth = 20 cm, Length & width = 13 cm, Medium–height/depth =40 cm. length & Width = 25 cm, Large–height/depth = 75 cm, Length & width = 50 cm) so that some of the birds can be benefited. Even though some project areas reported very few hole nesters (Tsa chu–I, Tsa chu–II and Tsa chu–I Lower), there may be many more species missed out during the study can be benefited.

The most effective artificial nesting structures are installed in close proximity to brood–rearing habitats, adequate escape/concealment covers, a reliable source of food and water, and other elements of the habitat of target species. Predators, competitors, and territory sizes for individual species also influence the usefulness of nesting structures. Nest monitoring and maintenance actions can be taken to limit competing or undesirable species and assess reproductive success.

Primary cavity–nesting species such as members of the woodpecker family, excavate nesting cavities in live or standing dead trees (snags). Secondary cavity nesters (e.g., some passerine or perching birds, owls, flycatchers) use cavities abandoned by primary excavators and those formed by fungus, knots, and trees subject to decay. The presence of snags in forested areas is directly related to the quality and quantity of nesting habitat for many cavity–nesting species. The installation of artificial nest boxes in the influence zone and catchment area of the project may be done after consultation with an expert in the field. These nest boxes have been found to be quite beneficial for attracting hole nester birds. The size and capacity of boxes vary from one species to another.

Feature of a Nest Box

The characteristic features of nest box (Figure VII. 6.1) are listed below:

- Should be made of untreated wood of cypress, pine or other locally available timber yielding tree
- Walls of the box should be thick (at least ¾ inches)
- Box should open from the side or top for maintenance and cleaning.
- Sides of nest box should enclose the floorboard (recessed 1/4 inch) to prevent rain seepage
- Nails, woodscrews, and hinges should be rust–proof.
- Entrance hole dimensions should accommodate the desired bird species; hole should not be large enough to allow competitors and predators access.
- A double thick entrance and extended roof to deter predators like squirrels and raccoons.
- Ventilation holes or slits at the top of both sides, just beneath the roof of the box.
- Drainage holes (four or five) drilled into the bottom of the nest box to allow for drainage.
- Nest box should not be treated with green–preservative–it is poisonous to birds.
- Nest box should not be painted on the inside or painted bright, unnatural colours on the outside (may attract predators or exotic species).

The entrance hole should have a 2–inch diameter and 6 inch depth from entrance hole. Nest boxes are placed on trees at height from 10–12 feet. Such nest box designs have been used with success.

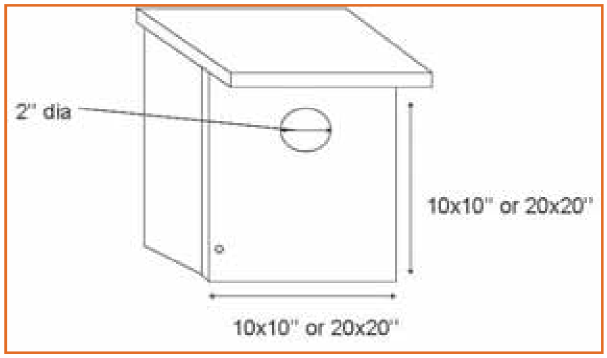


Figure VII. 6.1: Design of a nest Box to be installed in TRB area

Placement of Nesting Structures

Habitat requirements of target bird species and available habitats greatly influence nesting structure placement. Some species seek secluded nesting sites, while others prefer to nest in more open areas. Installing nesting structures is guided by the species–specific preferences and should be in place before commencement of the breeding season.

Installation of Nesting Structures

When installing nesting structures, several aspects like height above the ground, orientation, predator guards, and preferred natural nesting sites should be considered. Woodpeckers prefer nest boxes that face east, providing greater morning sun exposure. Most birds favour entrances that face away from prevailing winds.Nest structures can be attached to poles, posts, or pipes on land or in the water. Nest boxes can also be attached to trees. Supports should be sturdy enough to keep the structure from swaying or tipping over in high winds. Nest boxes can be attached to 4x4–or 4x6–inch treated wooden posts or trees by inserting a 4–to 6–inch lag bolt through a hole drilled in the back of the box, opposite the entrance hole. A large washer between the head of the lag bolt and the box should be used to secure the box to the support. The bolt should be checked each year and loosened as the tree grows. Wire should not be used to attach nest structures to live trees to avoid damaging the tree.

Predator Guards

Predators can limit the reproductive success of wildlife using natural nest sites and artificial nesting structures. The rough surface of wooden posts and trees makeclimbing easy for terrestrial predators such as snakes and domestic cats (Figure VII. 6.2). Artificial nesting structures, especially those close to water, should be fitted with predator guards to reduce the likelihood of nest predation. Heavy plastic, aluminium sheet metal, and other materials can be used to construct predator guards. In addition to installing predator guards to discourage ground–dwelling predators, overhanging or low branches near nesting structure should be removed to discourage access by arboreal predators.


Figure VII. 6.2: Predator guards help reduce loss of eggs and young to predation.

Monitoring and Maintenance
Nesting structures can be monitored throughout the nesting season to track use and nest success, remove undesirable exotic species, and to clean the structure after young are fledged to make it available for late and second nesting attempts. Some birds tolerate limited levels of human disturbance, such as occasional (once a week or once every ten days) nest checks, but others do not. Nest checks should be completed quickly to minimize stress on parent birds and young. Intrusive monitoring of sensitive species (e.g., owls) should be limited to prevent nest abandonment.

Development of Feeding Habitat
It is proposed to create special feeding habitats for birds in 4 to 5 different locations. Each such block shall be of 2 to 2.5 ha dimension and would provide different habitat types to cater to diverse avifauna. The existing herbaceous vegetation in all these blocks shall be kept intact and additional planting of 10–15 species of native plants for meeting diverse food needs (insects, fruits, seeds and other vegetable matters) and nesting sites of avifauna shall be done.

Awareness Programme
Very strong awareness programmes are necessary for the local villagers and schools in the nearby areas about the ecological role of bird community to enhance the ecosystem services and the benefits we gain from them. Since the locals were observed with bow and arrow in few villages it is very important to educate them towards the conservation of birds and other wildlife in general.

The awareness programmes should include designing and distribution of attractive posters of important and threatened bird species of TRB to the schools, shopping and religious centres. The posters should also carry information on the conservation importance of birds as they are environmental indicators and diverse ecosystem service providers. Small 'bird library' be encouraged in the schools where pictures of local bird species be kept to generate interests among the children.

The above suggested measures (deploying nest boxes and developing feeding habitat) are to be taken before the initiation of the project to minimse the predicted impacts on the avifauna across the TRB.

It is proposed that one qualified person be hired for a period of eight years. An amount of Rs. 49.00 lakh can be earmarked for habitat improvement of avifauna in the study area. The details are given in Table VII.6.2.

Table VII. 6.2: Cost of habitat improvement for avifauna in the study area

Sl. No.	Particulars	Amount (₹ lakh)
A	**Non–recurring Cost**	
1	Cost of nests of different sizes (10" x 10" to 20" x 20"; average cost ₹ 500 per wooden box) and installation in the area along with the green belt/1 km wide riverine buffer (1500 Nos.)	7.50
2	Repair and maintenance of the nests	2.50
B	**Recurring Cost (for 7 years)**	
1	Salary for one skilled person @ ₹ 25,000 per month for implementation and data collection including 10% escalation	28.46
2	Contingencies (including avifaunal biodiversity awareness programme for the local inhabitants)	5.00
3	Consultancy services	5.00
Total Cost (A+B)		**48.46 (Say, ₹ 49 lakh)**

6.3.1.7 Mammalian fauna

Mammalian fauna of the Tawang river valley identified six threatened species. Both direct and indirect evidences for Arunachal macaque have suggested presence of 217 individuals (11 groups) in six project areas. Capped langur is reported in one project area (Tawang–II) with 13 individuals. Species specific mitigation measures are suggested for these two endangered primate species listed in IUCN and WPA and also taking into account the current conservation status of Arunachal macaque in the Tawang region. Capped langur, being very common across north–eastern states as reported from 18 protected areas (Choudhury, 1989a, 1989b, 1996, 2013 and Gupta, 1994), and due to its capability to use diverse habitats and food plants, the impact of project activities would be very minimal. Therefore, capped langur is not chosen for special mitigation plan. However, the mitigation plan as suggested for Arunachal macaque would also take care of capped langur as well.

6.4 CONSERVATION OF THREATENED PLANTS

There are quite a few threatened species of plants in the landscape which also have high use values for local communities. These species need to be propagated in natural conditions through assisted natural regeneration efforts. However, in order to achieve the above, following needs to be done:

- Standardization for propagation protocols and techniques of different species
- Develop nurseries to raise quality planting materials
- Threatened Plant Species Distribution Mapping for Conservation
- Reintroduction of species in minimum 2 ha area of suitable natural habitats.
- Create *in–situ* germplasm bank

Out of the 10 threatened species identifed in the previous chapter, adequate distribution records for 4 species could be collected viz. *Acer hookeri*, *Panax bipinnatifidus*, *Taxus wallichiana*, *Toricellia tillifolia* etc. The potential area distribution mapping for 4 threatened species has been made using ecological niche modeling (Figure VII. 6.3–6.6). These areas are also suitable for reintroduction of the species for their recovery. In addition, 12 species have been identified that show conservation concern needing further studies concerning their populations, species biology and regeneration in nature (Table VII.6.3).

Table VII. 6.3: Species with conservation concern from TRB

Endemic, Useful and/or Threatened Plants	Description and field observation
Clethra delavayi	This species has been reported as a new family to india from West Kemeng dist and has a narrow distribution. There is evident pressure on the species. In the study site it is seen along the river side.
Fritillaria cirrhosa	Herb known for medicinal tuber and extracted
Picrorhiza kurroa	Population decling due to extraction
Rhododendron anthopogon	Extracted for fumigation
Bergenia ciliata	Medicinal herb collected. Population decline observed
Podophyllum hexandrum	Population declining due to extraction
Polygonum verticillatum	Herb exposed to threat due to habitat destruction and wild harvesting
Cornus capitata	Very small population exposed to cutting and habitat destruction
Botrychium sp. *(virginianum)*	Threatened due to habitat destruction and it is very rare in natural habitat
Pleione precox	Threatened due to habitat destruction and it is very rare in natural habitat
Fraxinus griffithii	A rare tree with reduced population and due to deforestation
Schizophragma heterophyllum	A rare species from the state which is much rare and exposed to threat due to forest destruction and tree felling

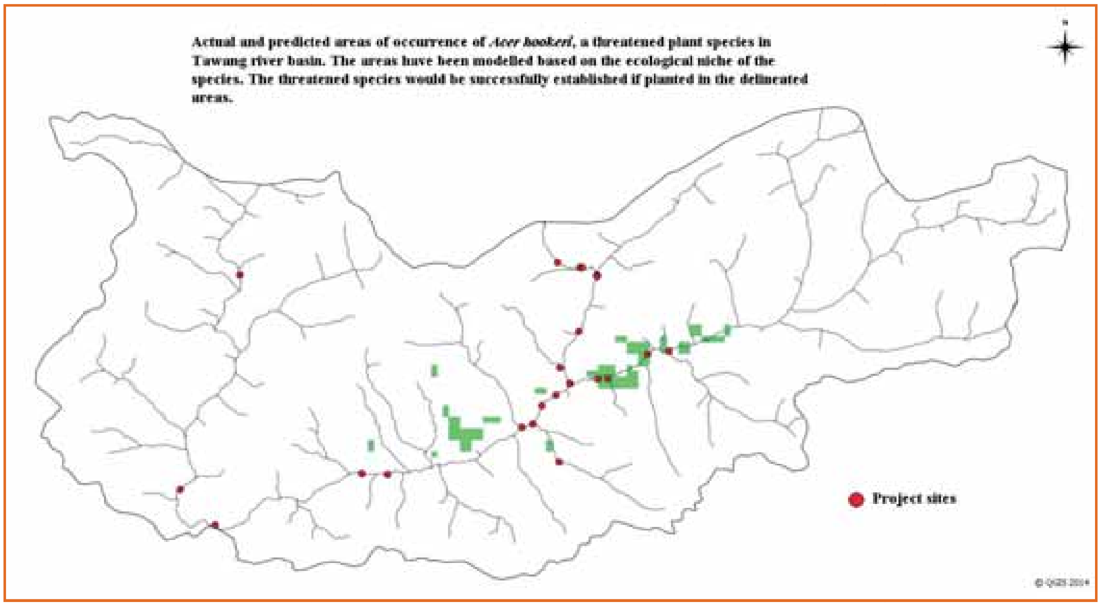


Figure VII. 6.3: Actual and predicted areas of occurrence of *Acer hookeri* in TRB

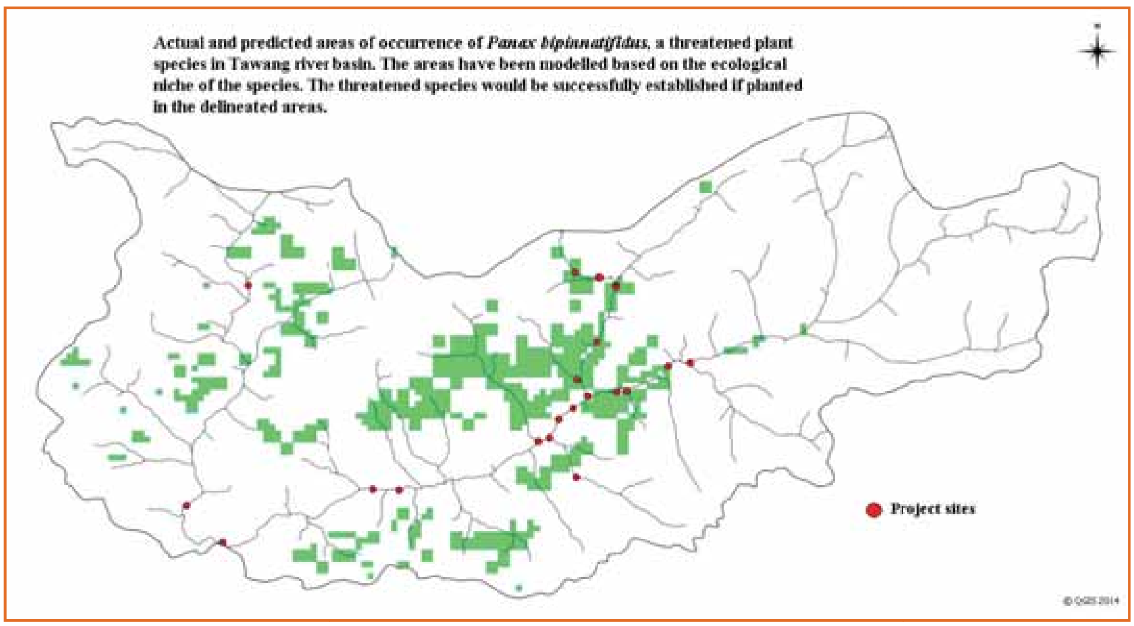


Figure VII. 6.4: Actual and predicted areas of occurrence of *Panax bipinnatifidus*

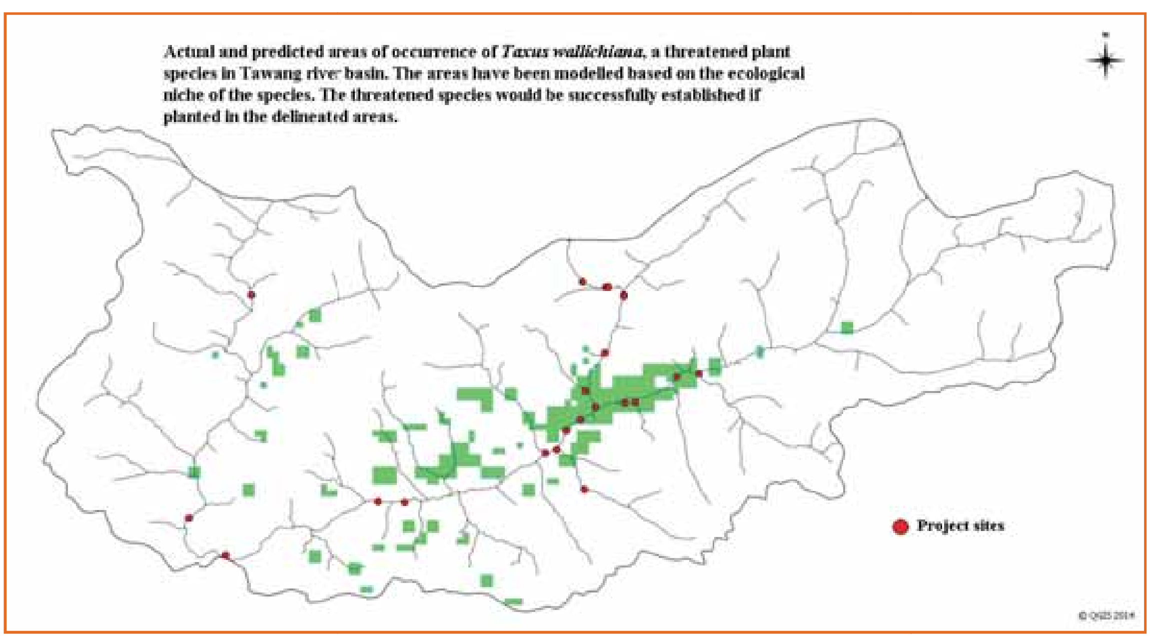


Figure VII. 6.5: Actual and predicted areas of occurrence of *Taxus wallichiana* in TRB

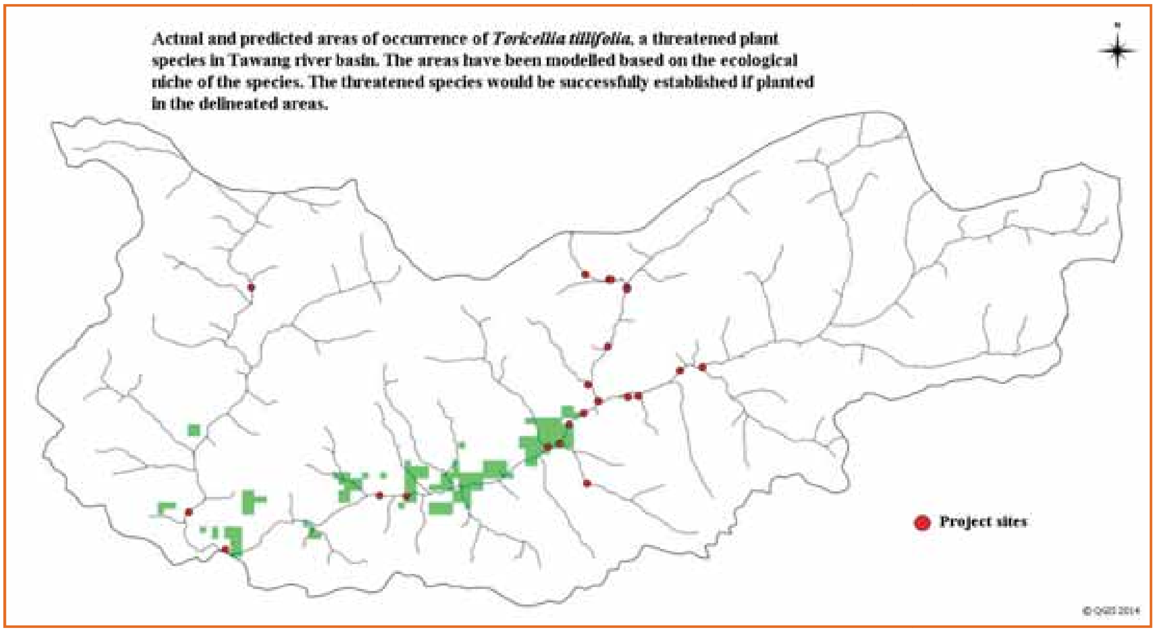


Figure VII. 6.6: Actual and predicted areas of occurrence of *Toricellia tillifolia* in TRB

6.5 LANDSCAPE LEVEL CONSERVATION STRATEGIES AND MEASURES

'Ecosystem approach' was considered as the strategy for developing the landscape level BMP for TRB. Therefore, constituent ecosystems were identified for each landscape element and ecosystems were used as unit of planning for developing landscape level BMP.

6.5.1 Tawang river basin landscape matrix

Given the (1) wide altitudinal variation in TRB, and (2) varied landscape elements, the landscape level BMP considered two layers of classification for developing the plan. TRB was classified into four climatic zones based on the elevation viz. montane sub–tropical (1000–1800 m), temperate (1800–3000 m), sub–alpine (3000–4000 m) and alpine (>4000 m) (Figure VII.). The dominant landscape elements at each climatic zone were represented by the combinations of different ecosystems such as forests, scrubland, cropland, wetlands, etc. based on the climatic zone (Figure VII. 6.7).

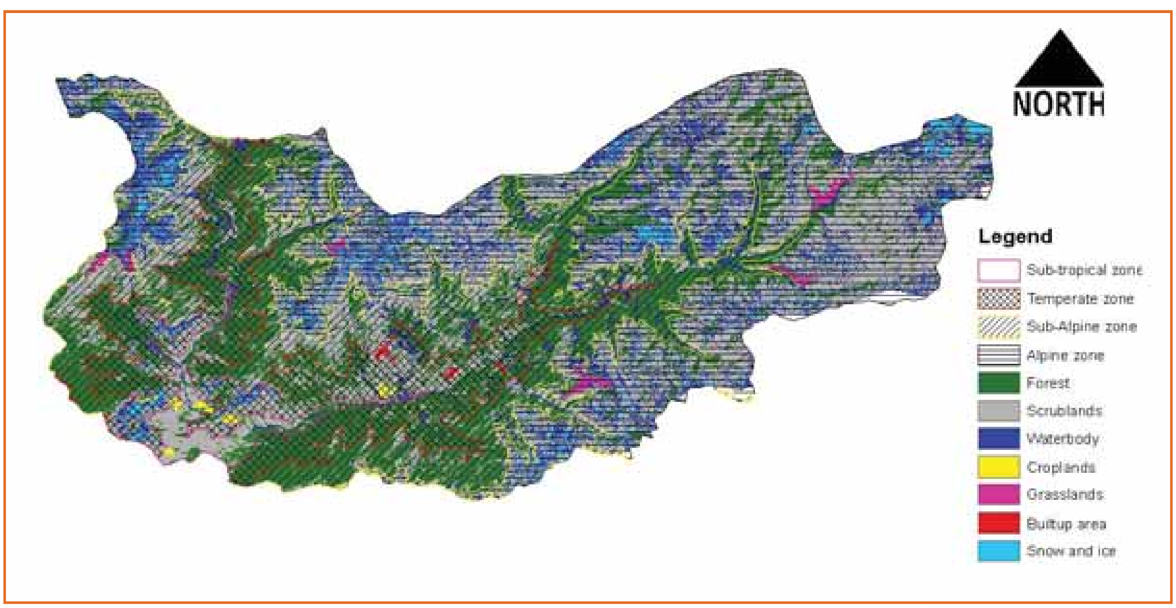


Figure VII. 6.7: Landscape matrix delineation based on climatic zone and ecosystems

The landscape elements in sub–tropical zone represented the interacting forest, cropland and riverine ecosystems. The temperate landscape elements were represented by the interacting forests, cropland, grasslands and wetlands. The sub–alpine landscape elements were represented by forests, Rhododendron scrubs, grasslands and wetlands. The alpine landscape had forest, Rhododendron scrub, alpine meadow, and wetland ecosystems. Such a delineation would help in developing climate appropriate management plan for biodiversity management with detailed prescriptions such as species to be used for specific management activities. The highest geographical area in sub–tropical landscape was under scrublands. In temperate and sub–alpine landscapes, forest and scrubland are the two most important ecosystems with highest geographical area. In alpine zone, Rhododendron scrubs and alpine grasslands occupied the highest geographical area after snow and ice cover (Table VII. 6.4). Thus, the present landscape level BMP laid special emphasis on the management of forest and scrublands.

Table VII. 6.4: Ecosystems/landscape elements under four landscape types classified on the basis of climatic zones

Sl. No.	Ecosystems/landscape elements	Area under different landscape types (ha)			
		Sub–tropical	Temperate	Sub–alpine	Alpine
1	Forest	2775.40	29448.72	41990.24	21550.55
2	Scrublands	4297.07	11926.49	23699.61	63344.95
3	Waterbody/wetlands	455.96	2690.12	4081.41	22678.18
4	Croplands	211.43	385.38	4.66	133.79
5	Grasslands	0.65	38.97	56.09	1562.92
6	Builtup area	2.75	377.39	52.20	367.54
7	Snow and ice	14.85	1196.17	564.86	9836.75

Following activities are suggested as a part of the landscape level BMP:

6.5.2 Filling the knowledge gap

Undertake research, inventories and monitoring programs to fill the knowledge gaps on various aspects of ecology and biodiversity. Also, it is important to record traditional knowledge of communities about biodiversity and its various uses.

***Undertake comprehensive inventory and status survey of key taxonomic groups*:** Need to undertake field explorations/surveys to prepare an up–to–date inventory of, lesser known but ecologically important, taxonomic groups across the landscape. Some of these taxa may include: Orchids, Herpetofauna, Fish, Small mammals, Raptors etc. Surveys also need to be done to record population and distribution of all the Rare, endangered and threatened (RET) and endemic species of the region. Some of these species are, Black necked crane, Tawang macaque, Himalayan goral, wild dog, clouded leopard, capped langur, hornbill, etc. need to be focused.

***Conduct research on structure, function, and interactions amongst and within ecosystems*:** This aspect is very poorly understood for different ecosystems of the landscape. Thus, it is important to undertake ecological research at few representative sites, keeping the altitudinal variations in mind. In the present context ecological research on forest, alpine meadows and high altitude wetland ecosystem systems need to be undertaken.

***Monitor the status of ecosystems in the District*:** Initiate periodical monitoring of key indicators of biodiversity values of important ecosystems of Tawang district, using rapid ecological and community based monitoring tools and methodologies. Focus need to be on Forest, Pastureland and High Altitude wetlands.

***Documenting traditional knowledge of community through preparation of People's Biodiversity Register (PBR)*:** As mandated in Biodiversity Act (2002), PBRs need to be documented for each elected bodies (e.g., village Panchayat, district Panchayat etc.). PBR should make a detailed inventory of people's traditional knowledge about floral and faunal species, their habitats and various uses. Both wild and domesticated (agriculture crops and livestock) diversity need to be recorded. Thus, efforts need to be initiated to prepare PBRs for all the project affected villages and also those who fall under influence zone. This shall help enhancing the understanding of community traditions, knowledge, practices, and livelihood related to biodiversity. Importantly, this will help recording various conservation and management practices including the inventories of sacred groves and other community conservation areas.

***Create a comprehensive, multi–layered biodiversity data base in GIS domain*:** For better comprehension and conservation planning at landscape level, it is important to create and maintain a publicly accessible and user interactive GIS database of all biodiversity related information.

6.5.3 Ecosystem–based conservation efforts

***Creation and support to biosphere reserve*:** As on today, the district, despite supporting a rich and unique assemblage of flora and fauna, there is no Protected Area (PA) in the region. It is, therefore, important to create a network of PAs in the area. In this context, a Biosphere Reserve has been proposed. The proposed biosphere reserve, known as Tsangyang Gyatso Biosphere Reserve, will have about 1190 sq km of Core area covering eastern part of Tawang district and part of West Kameng district (Figure VII. 6.8). Since the Biosphere Reserve is yet not officially notified and there are certain degree of apprehensions among the local Monpa communities, it is important to pursue the case at both Government and community level. Considering the fact that with the diversion of large chunk of forest under different HEP schemes, the proposed biosphere reserve should help provide much needed refuge to many RET species and threatened habitats. The HEP schemes should provide support in creation and conservation and management of the Biosphere Reserve.

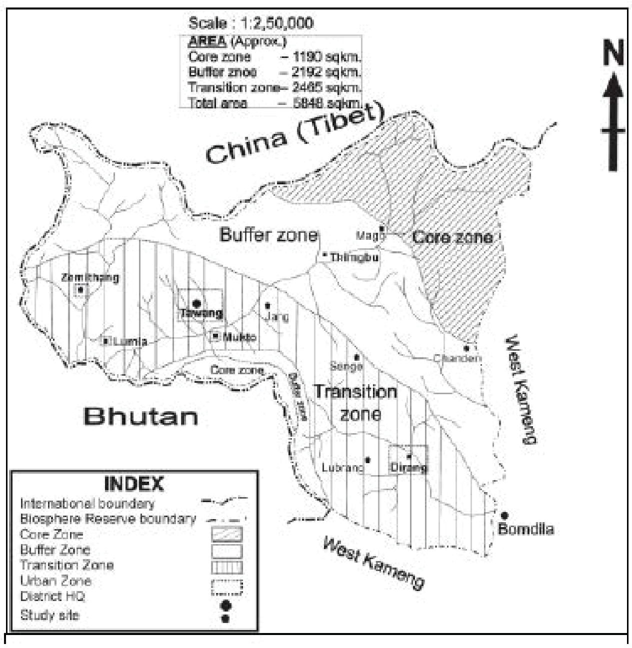


Figure VII. 6.8: Map showing proposed Tsangyang Gyatso Biosphere Reserve in Tawang and West Kameng districts (adopted from Chaudhry *et al*., 2010)

***Expand network of community conserved areas*:** Since majority of forest lands are owned by local communities, it is important to strengthen community–based conservation initiatives in these forest lands (Figure VII. 6.9–6.12). WWF–India under its Western Arunachal landscape program, successfully demonstrated the creation of CCAs in neighboring West Kameng district mainly to conserve red panda population. They convinced local communities to create CCAs in their land and as a result area under CCAs in the district hasgrown from merely 30 sq km in 2004 to 818 sq km in 2013. In Tawang district also, two CCAs in Nyamjang chu valley was promoted covering an area of roughly 200 sq km. In each case, a CCA Management Committee was set up comprising local villagers who would be responsible for the conservation of the forest land, as well as socio–economic development of the village. Such CCA models of conservation of wildlife values need to be promoted in consultation with local communities in project affected villages. For this, it is essential to examine the scope of creating few more such areas keeping in view the ecological, biodiversity, livelihood, and cultural values of sites. Also, it is important to analyze the experiences/lesson learning of WWF in creating and managing CCAs in above created CCAs. These Community Conservation Areas may be declared under the relevant provision of the WLPA to give legislative strength to the Conservation Committee. Moreover, this will also attract funds from the Central government.

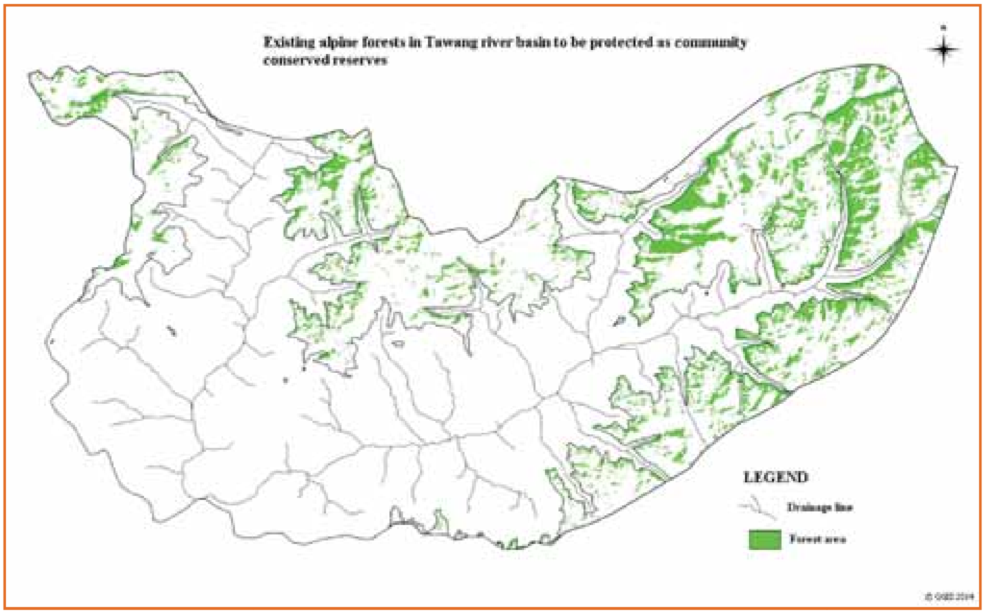


Figure VII. 6.9: Existing alpine forests in TRB to be protected as community conserved reserves

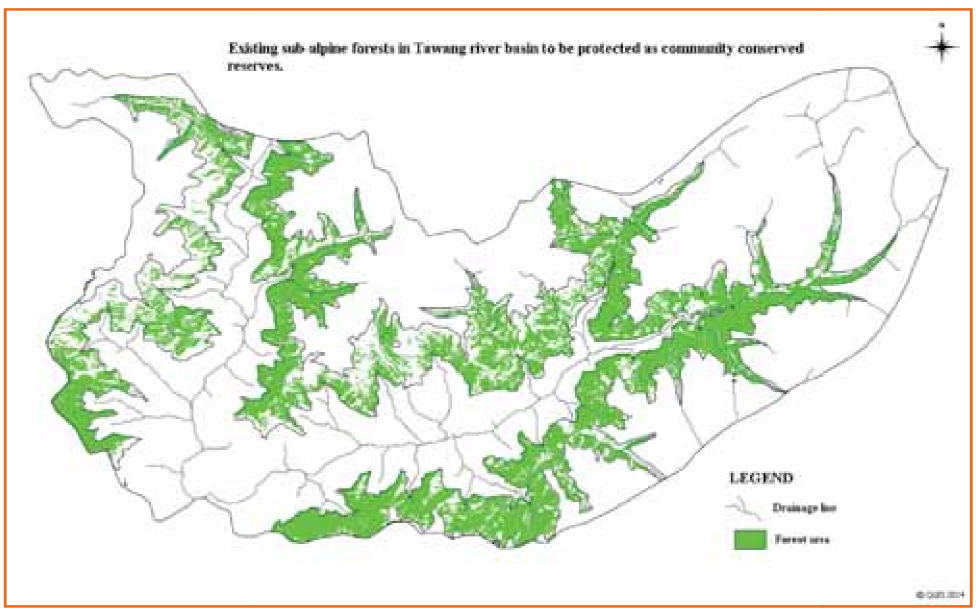


Figure VII. 6.10: Existing sub–alpine forests in TRB to be protected as community conserved reserves

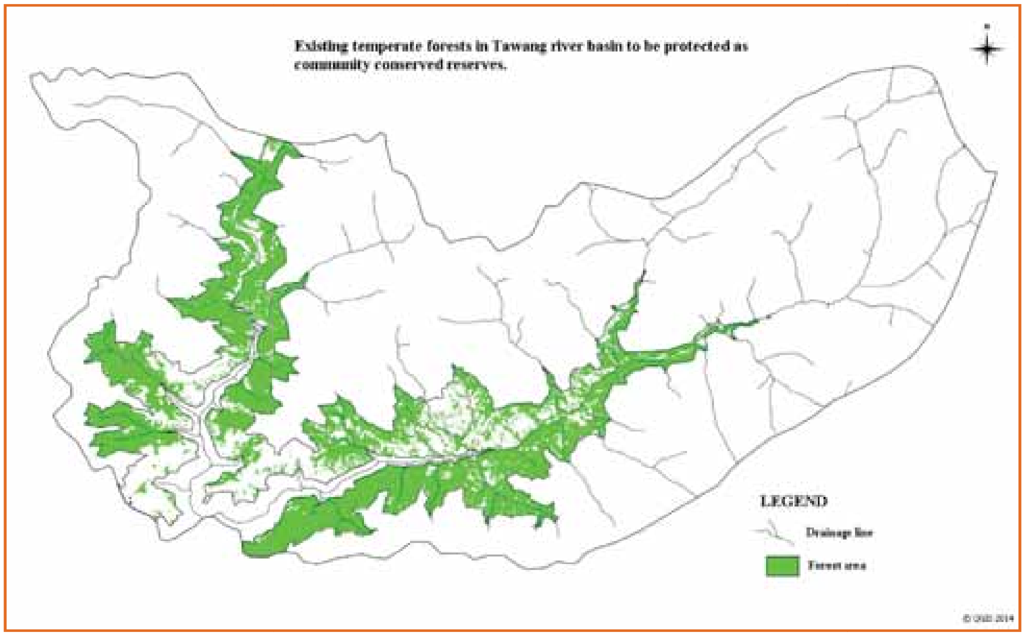


Figure VII. 6.11: Existing temperate forests in TRB to be protected as community conserved reserves

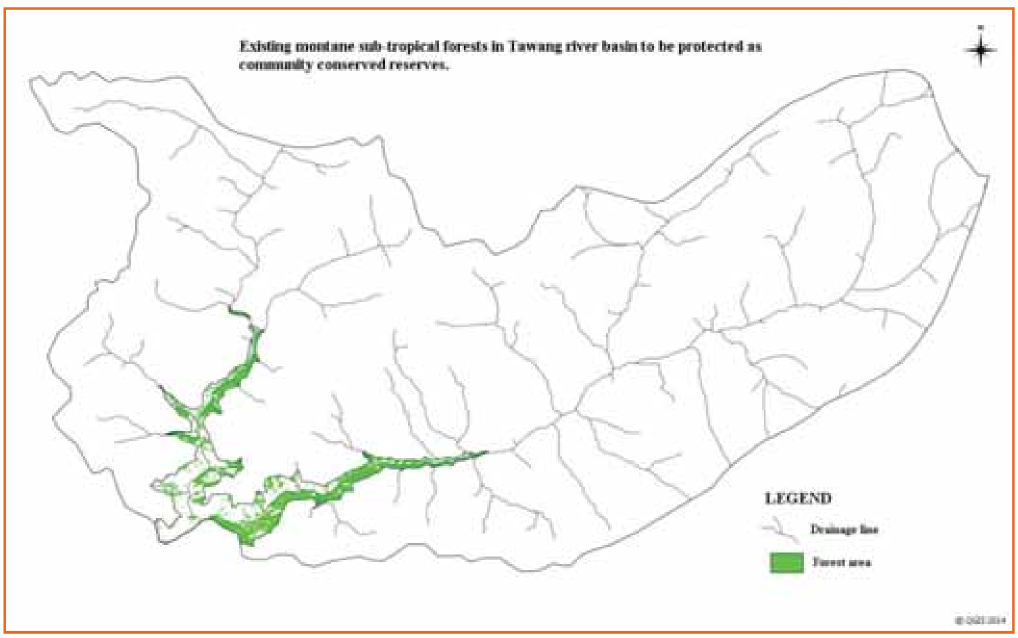


Figure VII. 6.12: Existing sub–tropical forests in TRB to be protected as community conserved reserves

***Protection measures to biodiversity rich areas in influence zones of different projects*:** The biodiversity rich areas within influence zones of different projects have been identified under this study (Figure VII. 6.13). In this context, those USF areas, which are close to village areas and people had traditional resource use rights, can be promoted as informal CCAs or, if mutually agreed, notify them under Conservation or Community Reserve categories of PAs. However, if the area does not enjoy any community rights, then the Forest Department needs to bring them under their protection through appropriate legal and administrative mechanism.

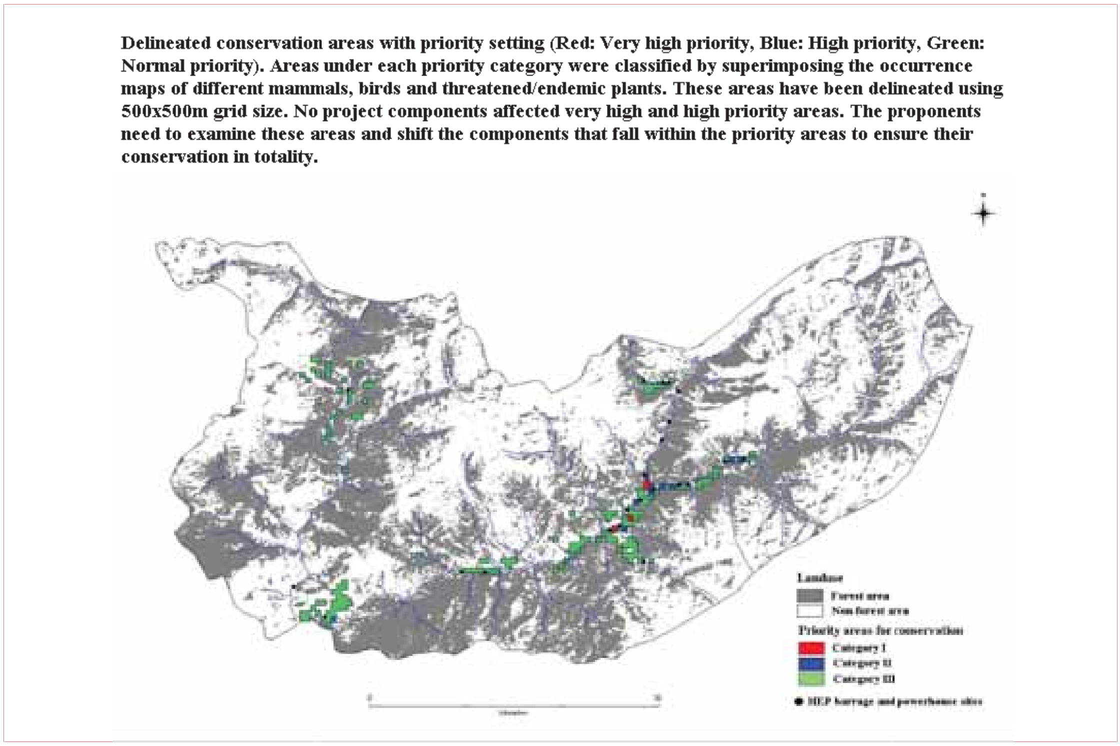


Figure VII. 6.13: Conservation areas delineated with priority setting in TRBL

Wildlife corridors have been identified to facilitate the migration and smooth movement/reproduction of the wild plants and animals. The identified corridors may be treated under compensatory afforestation or specialized plantation programmes uncluding the native and host species (Figure VII. 6.14).

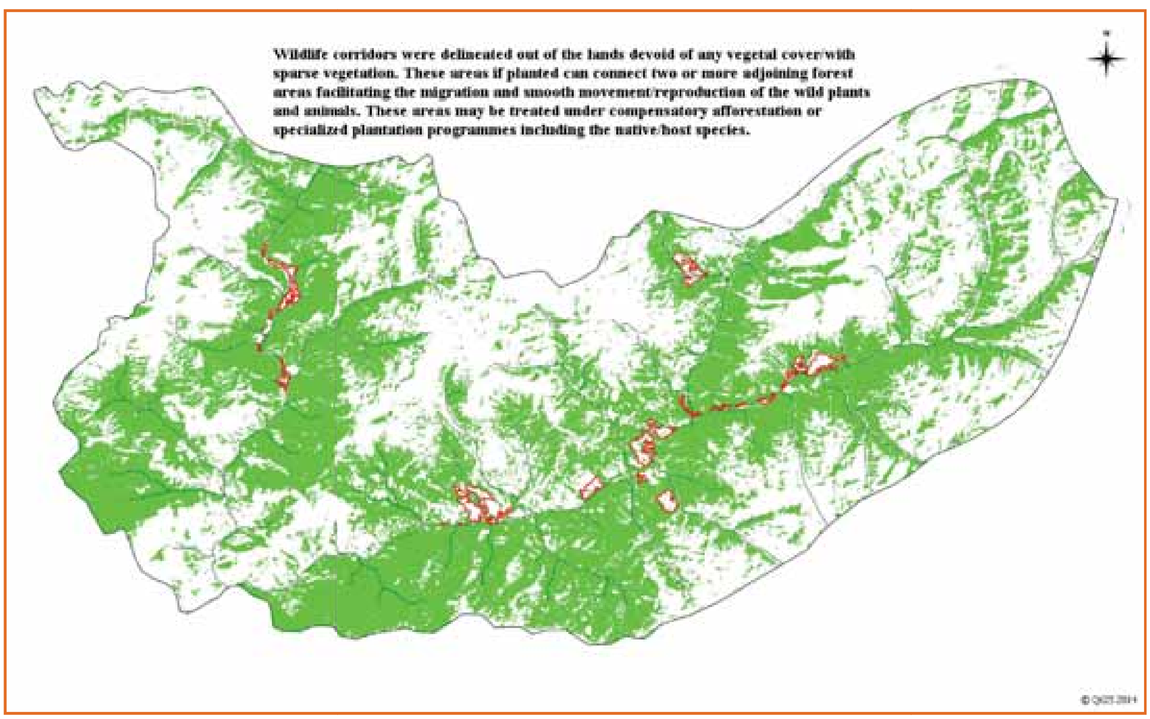


Figure VII. 6.14: Corridors delineated to facilitate migration/movement of wildlife in TRBL

***Conservation and protection of other biodiversity rich areas*:** At landscape level, there are quite a many sites rich in biodiversity. Chatterjee *et al*. (2006) identified two such areas: (1) *Nagula–PT Tso* support rich conifer forest, Rhododendron shrubs and alpine meadows. Interesting, plants include *Ponerorchis* spp., *Boeschniakia*, and *Sassaurea obvellata*. Many high–altitude medicinal plants such as *Frittillaria cirrhosa*, *Aconitum*, and *Rheum* are also reported from here. This unique location requires immediate attention for conservation. (2) *Mago–Thingbu*, which need immediate conservation focus due to high concentration of conifers and medicinal plants. Some of the largest conifer trees in the Tawang region are seen here. The temperate and alpine flora is largely undistrubed due to remoteness. However, biotic pressures from grazing, agriculture etc. are becoming visible. In addition to this, *Pangchen valley*, including the *Zimithang* area, is considered as biodiversity rich site of the district. The valley support rich mammalian and avifauna diversity, including many rare and endangered species like red panda and black necked crane (WWF report). The area need to be supported for its rich conservation values and heritage.

***Creation of Riverine Buffers on Both Side of the Stream/River/Drainage Line*:** Existing forest areas within 1 km riverine buffer of TRB is to be strictly conserved. Blank areas along the river course may be planted with suitable tree species depending on the climatic zone to create continuous buffer (Figure VII. 6.15–6.19).

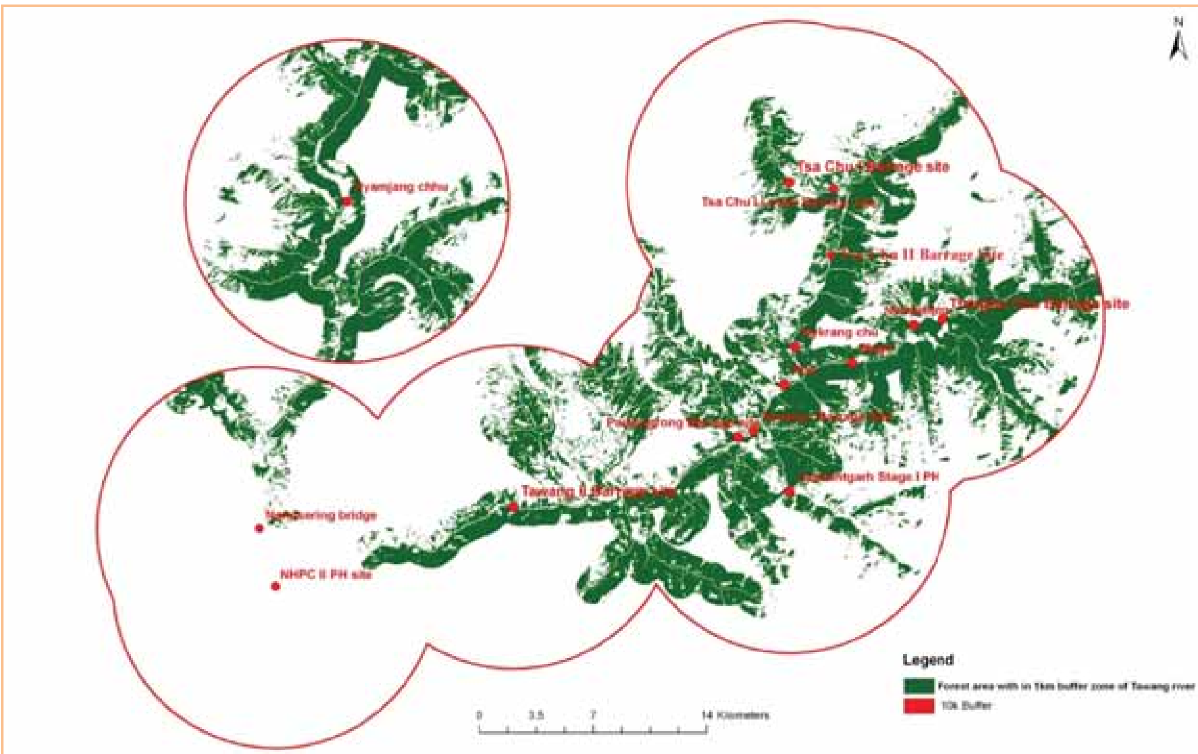


Figure VII. 6.15: Forest area within 1km riverine buffer in TRB. Blank areas along the river course may be planted with suitable tree species depending on the climatic zone to create continuous buffer.

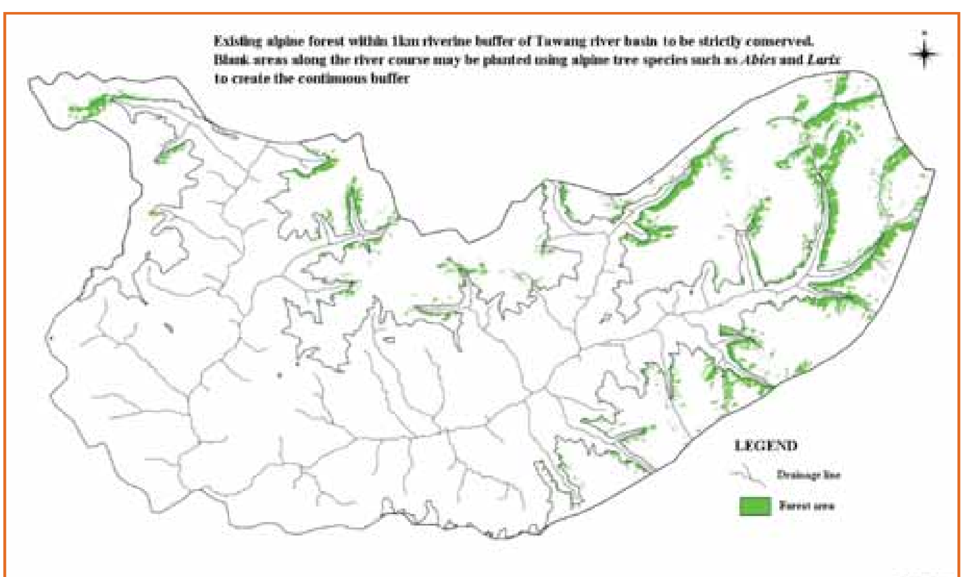


Figure VII. 6.16: Existing alpine forests within 1 km riverine buffer of TRB to be strictly conserved

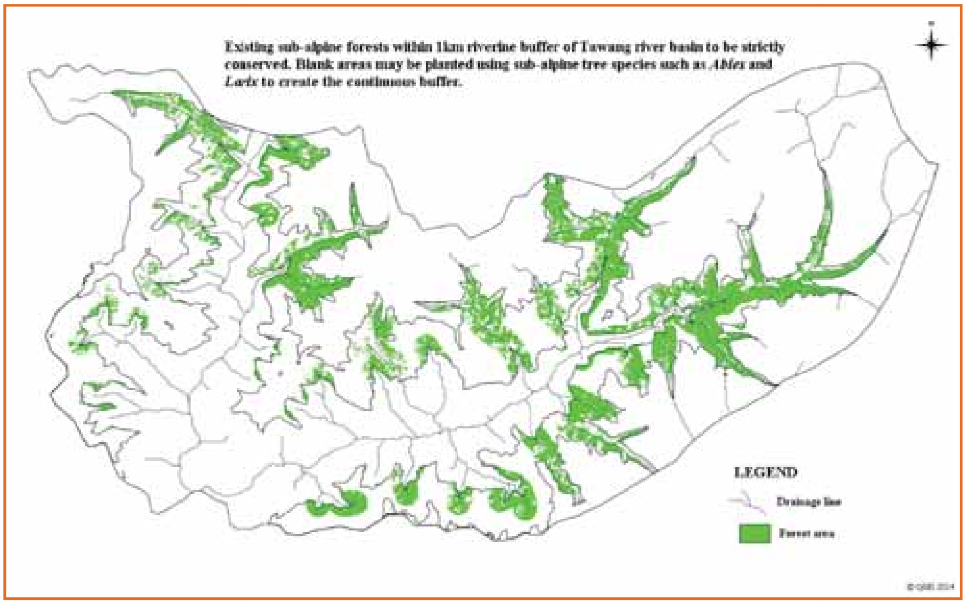


Figure VII. 6.17: Existing sub–alpine forests within 1 km riverine buffer of TRB to be strictly conserved

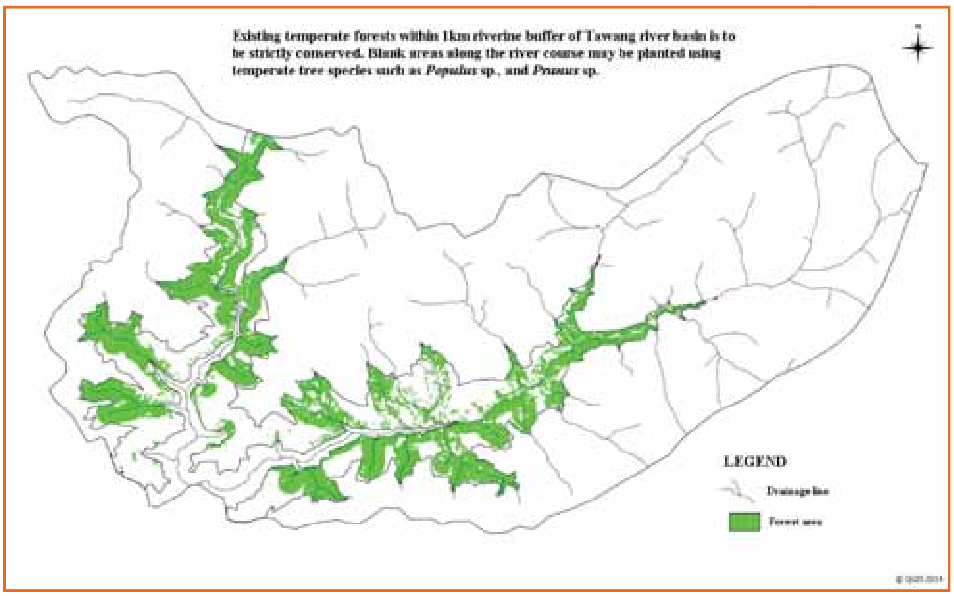


Figure VII. 6.18: Existing temperate forests within 1 km riverine buffer of TRB to be strictly conserved

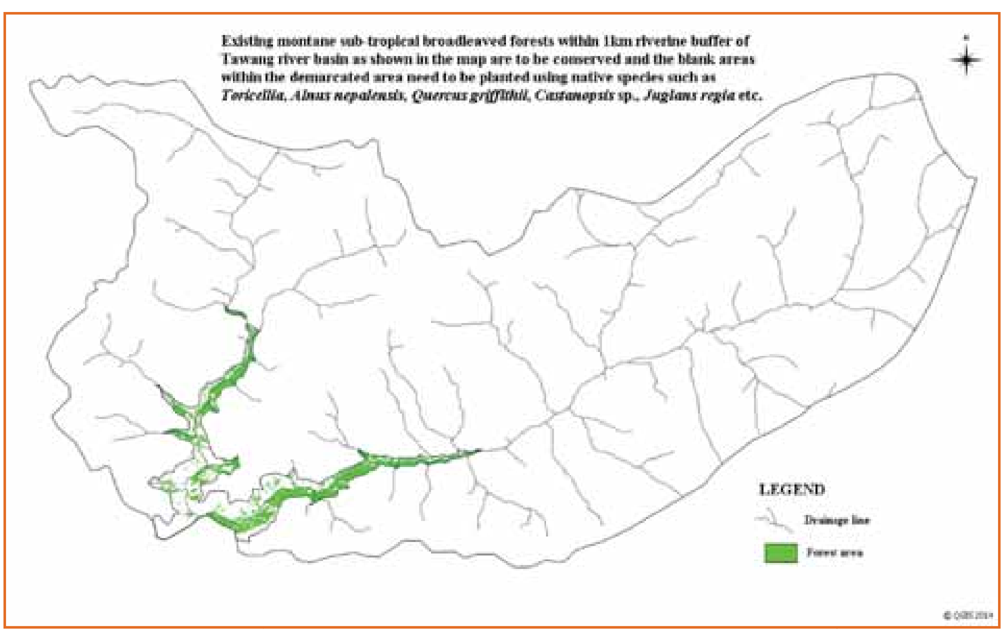


Figure VII. 6.19: Existing sub–tropical forests within 1 km riverine buffer of TRB to be strictly conserved

***Conservation and Protection of High Altitude Wetlands*: **Immediate catchment areas of most of the high altitude wetlands are used as traditional grazing grounds. These are under the ownership of the local indigenous communities (mainly the Mompas), and so it is necessary to understand the conservation values of wetlands and the grazing pressures being faced by them. As the breeding period of many of the migratory birds overlap with the grazing period of domestic livestock, it is however important to educate and initiate conservation initiatives involving these livestock grazers to conserve wetlands for breeding as well as wintering habitats of migratory birds. Chatterjee *et al*. (2006) identified PT Tso, Oriangdukpu, Sangetsar and Paradise lakes having high conservation significance. Concerted efforts are needed to inventorize values and threats. Efforts are also needed in initiating community based conservation plans for these wetlands.

Promote Conservation Friendly Agro–pastoral System

- Provide incentives to revive and promote seed banks of indigineous crop varieties in the farmer's field. Special focus will be on crop like maize, rice etc.
- Incentivise farmers for adopting organic farming and undertake mass training cum awareness program for farmers and concerned government department officials.
- Facilitate mechanisms for organic certification
- Provide sustainable market linkages for better price realization to farmers.
- Assist and facilitate scientific description of local Yak and other livestock breeds.

***Regenerate and Restore Degraded and Open Forest and Pasturelands*: **Indigenous fruit bearing plants, vital for wildlife, including the bird and mammals, need to be planted. The plantation should be complimented with adequate Soil Moisture Conservation (SMC) measures. Choice of species should consider altitudainal variations.

***Fire Prevention and Education*: **Fire is common problem threatening both ecological and economic values of biodiversity. This needs to be addressed through integrated and adaptive management strategies. Information generation, prevention and education are the three suggested measures which need to be supported. While spatio–temporal mapping of fire events are critical to identify fire prone areas, preventive mechanisms like creating fire–lines in those priority fire prione areas is the second order of solution. Finally, local communities, through BMCs and VFMCs, need to be educated regarding the fire ecology and its management in their localities.

***Reducing the spread of IAS*: **Spread of exotic species in natural and native ecosystem is one of the major threats to biodiversity values and thus associated ecosystem services. In the TRBL, invasive species reported presence of *Ageratina adenophora, Chromolaena odorata, Ageratum conyzoides, Ambrosia artemissiifolia, Lantana camara* etc. There are few more such exotic invasive species identified in the landscape. Ecological niche modelling study predicts that lower elevations viz. montane sub–tropical and lower temperate zones are prone to exotic weed invasion at moderate to high risk levels because of suitable climate (Figure VII. 6.20). Considering the rich biodiversity of TRB, their spread need to be checked, especially in view of anticiapated constructions of roads and influx of labors from various part of the country with the progressing stages of different HEP schemes. Thus, there is a need to prepare Invasive Species Control Eradication/Management Program for each project site. This can be done by first inventorying the invasive species and their distribution and extent near project sites and then adopt appropriate method of their control (e.g., chemical, biological and mechanical).

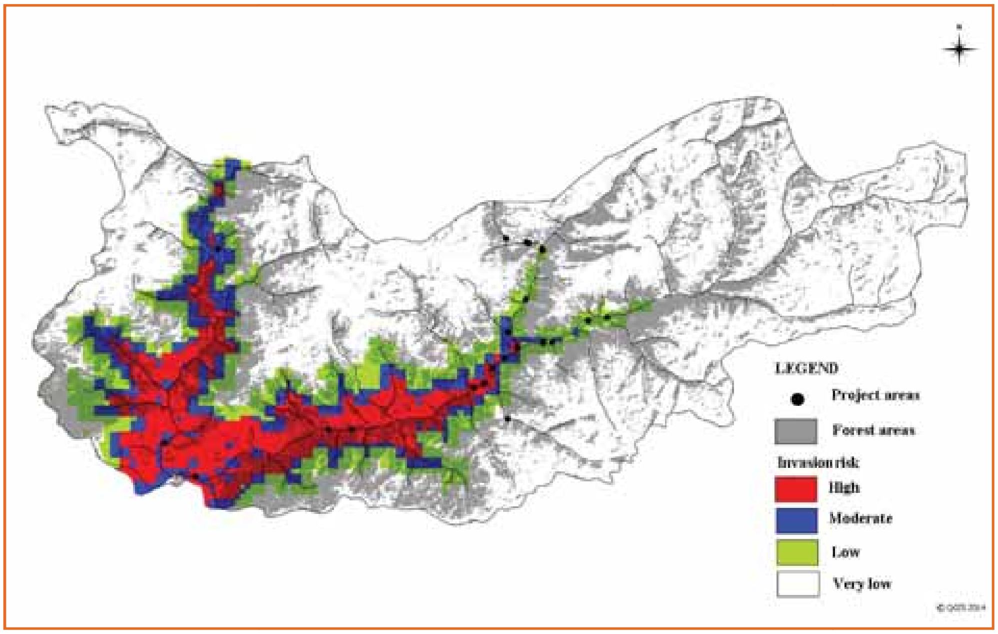


Figure VII. 6.20: Invasion risk map of exotic weeds in TRBL

Biodiversity conservation activities: The biodiversity conservation activities suggested for TRB and the land area under the respective activities are summarized in Tables 6.5 and 6.6.

Table VII. 6.5: Biodiversity conservation activities suggested for TRBL

Biodiversity conservation activities	Total area to be maintained (ha)	Existing cover (ha)	Net area to be established/ maintained (ha)
Protection of existing dense forests as community conserved reserves (66% of total geographical area)	143352	80257.68	63094.32
Creation of 1km buffer forest on both sides of river/stream	94280.32	49479.84	44800.48
Area under scrubland to be afforested under aided natural regeneration (below 2500 m asl)	24641.92	11443.32	13198.6
Creation of corridors for important wildlife	1630.72	435.84	1194.88
Conservation/rehabilitation of Rhododendron scrubs (ha) (above 2500 m asl)	158822.4	86124.96	72697.44
Creation of a sanctuary of 40 ha area sorrounding Tsa chu–I Lower project			40
Total			**195025.7**

Table VII. 6.6: Area prescribed for different biodiversity conservation activities in forest ecosystems across different climatic zones in TRBL

Managing the existing biodiversity	Montane sub–tropical	Temperate	Sub–alpine	Alpine
Protection of existing dense forests as community conserved reserves (ha)	2642.04	25694.64	35961.12	15598.8
Protection of 1km buffer forest on both sides of river/stream including the creation of a new sanctuary (ha)	2642.04	25694.64	35961.12	7430.76
Protection of existing scrublands on 1km buffer of river/stream (ha)	4027.68	12641.04	23602.32	57337.9
Creation of corridors for important wildlife (ha)	53.76	1040	519.04	27.52
Conservation/rehabilitation of Rhododendron scrubs (ha)	NA	12641.04	23602.32	57337.9

6.5.4 Constitution of BMCs in TRB and synergising the activities with State Biodiversity Board

It is suggested that the Government of Arunachal Pradesh and the project proponents facilitate creation of BMCs in each village panchayat. As described earlier, the key for biodiversity conservation is enagement of local communities.The communities in the Tawang landscape manage their resources through various informal traditional institutional arrangements where monasteries and village councils play major roles. However, Biodiversity Act (2002) provides for a formal, constitutionally authorized and decentralized institutional mechanism by creating BMC in each village panchayats.

6.5.5 Regeneration of species of NTFP values

The NTFPs management must be viewed as an important opportunity for increasing community livelihood options as well as biodiversity conservation, and such an approach need to have more community patronage. Following need to be done for conservation, sustainable use and commercial promotion of NTFP species:

- Promote and strenghthen local BMCs in adopting and developing 'access and benefit sharing (ABS)' mechanisms for NTFP items (as mandated under Biodiversity Act, 2002).
- Community mobilization for domestication of selected species can provide a better conservation of gene pool of species. Thus, plantations of prioritized species could be promoted through domestication trials and selected species can be accommodated in traditional agroforestry systems.
- There is a greater need to spread awareness about use and conservation of NTFPs among the communities. Capacity building (through training programs) on non–destructive methods of product harvesting is essential.
- Explore possibilities of value addition of products of a few species of commercial importance and thus tap newer markets. Appropriate technology need to be promoted for value addition purpose of different products, through elsewhere proposed Technology Park.
- For sustainable flow of economically important NTFP plants, approach like *in–situ*, *ex–situ* (i.e., nursery raising and plantation) and developing sustainable harvesting protocols, need to be explored. A tentative list of such plants and their possible conservation technicques is given under (Table VII.6.7).

Table VII. 6.7: List of economically and ethno–botanically important species found in TRB

Scientific name	Vernacular name	Traditional use	Conserv. technique
Amomumsubulatum Roxb.	Borong elaichi	Economic	b
Angiopteris evecta (Forst) Hoffm	Tabe	Traditional famine food	a, b, c
Cinnamomum caudatum Nees.	Chingcha	Spice, medicinal	b
Citrus medica L.	Tsaloo sheng	Traditional fruit	b
Clerodendrum colebrookianum Walp	Kangjila	Traditional food, medicine	b
Colocasia esculenta Schott	Niyang–leng	Famine food	b
Cordyceps sinensis	Yartsa gumbu	Medicine,Commercial	c
Cornus capitata Wall	Shyamrungma	Traditional fruit, commercial	a, c
Cymbidium aloifolium (L.) Sw.	Momdang	Cultural , aesthetic	b
Cyphomandra betacea (Cav)	Khalangji	Vegetable	b
Dendrobium densiflorum Lindl.	Momdang	Religio–cultural, medicinal	b
Diospyros peregrina (Gaertn.) Gurke	Legalomah	Traditional fruit, commercial	a, c
Dioscorea bulbifera Linn.	Khojeng jokthang	Food, commercial	b
Elaeagnus pyriformis Hk.f.	Kyameing shing	Traditional fruit	a
Perilla frutescens L	Nam	Spice, medicinal	b
Fagopyrum esculentum Moench	Fapar	Traditional food	b
Ficus hirta Vahl	Nuphru–gubo	Traditional fruit	a, b
Gymnocladus assamicus P.C. Kanjilal	Myangmanba se	Religio–cultural/detergent	a, b, c
Illicium griffithii Hk.. f. & Th	Lissi	Commercial	a, b, c
Juglans regia Linn.	Khe Shing	Traditional fruit	a
Litsea citrata Blume	Niyeng	Traditional spice	a, b, c
Manihot esculenta Crantz	Simal alu	Femine food	b
Myrica esculenta Buch.–Ham	Zen sheng	Traditional fruit; medicine	a, c
Oroxylum indicum Vent	Namkaling	Religio–cultural; medicine	a
Panax bipinnatifidus Seem	Gunamanchung	Commercial	b
Pinus roxburghii Serg.	Lensung, Roinang	Commercial	a, c
Prunus persica Benth. & Hk. f	Aru	Traditional fruit	b
Pyrus pashia Buch. Ham. *ex* D. Don	Lugrang	Traditional fruit	a, b
Rubia cordifolia L.	Lainee, Tsot	Commercial	b
Solanum torvum Swartz	Khalangjing	Vegetable, commercial	a, b
Spilanthes paniculata Wall	Sikia pan	Leafy vegetable, commercial	b
Spondias axillaris Roxb.	Lapsi	Traditional fruit	a
Swertia chirayita (Roxb. ex Fleming) Karsten	Pangduk man	Economic, medicine	b
Taxus wallichiana (Zucc.) Pilger	Kitangma	Economic purpose	b
Thalictrum foliolosum DC.	Rong Sheng	medicine	a
Valeriana jatamansii Jones	Pangposs	Commercial	a, c
Wallichia densiflora Mart	Niyuk	Famine food ; cultural	a, b, c
Zanthoxylum armatum DC	Khagi	Traditional spice, commercial	a, b, c
Zanthoxylum oxyphyllum Edge	Yer	Traditional spice, commercial	a, b, c

a–*in–situ* conservation; b–*ex–situ* conservation through cultivation/rearing; c–management through traditional sustainable harvest technique. Source: Saha and Sundriyal (2013)

6.5.6 Establishment of natural resource based value addition facilities for livelihood improvement: The following four value addition facilities are suggested:

- Rhododendron flower based jelly and squash preparation
- Citronella oil distillation plant
- Broom preparation from broom–grass
- Processing and storage facility for fruits such as plum, peach, pears, kiwi, pomegrenate, amla, and walnut

6.5.7 Orchid Species Conservation: Tawang landscape is rich in Orchid diversity. They have very high conservation as well as ornamental (economic) values. Following needs to be done:

- Develop one or two Orchidarium at suitable locations. Based on existing understanding of orchid habitats in Tawang landscape, tentatively followings sites can be explored for creation of Orchidarium at Zimithang, Lumla, Jang, and Rho.
- Develop protocol for propagation techniques of some of the economically important Orchid species to take it at the commercial level by involving local communities. This can be promoted as economic activity through community based organization (like SHGs).

6.5.8 Mitigate Human–Wildlife conflicts

Mitigate Human–Wildlife Conflicts

Following needs to be done:

- Simplify the existing compensation giving mechanism for crop damage and livestock depradation for immediate benefits reaching the sufferer.
- Standardize and promote crop protection measures (like electric fencing), against wild boars and monkeys.

6.5.9 Promote biodiversity and nature education/awareness program

For long term conservation of biodiversity in Tawang landscape, it is important to engage younger generations and make them aware about various issues related with environment, nature and wildlife of the region. Thus, there is an urgent need to create cadres of School/college going youths in project affected villages or in the influence zone, who are atleast aware of issues related with biodiversity heritage of the district and the need for their conservation. Imortantly, in most of the villages educational infrastructures poorly exist. Following need to be done:

- Support and strengthen program like National Green Corps (NGC) and formation of 'Eco–clubs' in recognized school in the districts to engage youths in the national mission of environmental management and nature conservation.
- Create and promote Nature Education Cell within District Forest Department.
- Support nature education program in Schools and colleges
- Create camping facilities for students and other nature enthusiast

Promote infrastructure for eco–tourism development

- Promote suitable trekking routes and other adventure tourism activities in different parts of the Tawang landscape
- Support communities in developing and improving 'Home Stay' infrastructure in important trekking routes
- Develop Nature Interpretation Centres (NIC)
- Develop Butterfly Park

Support to Existing VFMCs**:** In Tawang district, 14 VFMCs are created with a vision to engage local communities in regenerating degraded forests in their vicinity. However, at present not much is happening in the field. Thus, in order to push JFM approach through VFMCs, following need to be supported:

- Creation of more VFMCs and identify and support various entry point activities, especially for project affected villages.

- Provide technical and financial support for plantations like of Bamboo, fuel–wood, medicinal plant and species of economic importance like paper making plant (*Daphne papyracea*).

Program implementation mechanism: It needs an efficient institutional mechanism to plan, coordinate, and implement above suggested measures for biodiversity conservation and management at landscape level. We suggested three–tier institutional mechanism:

- Constitute a Biodiversity Conservation Monitoring Committee under the chairmanship of PCCF. The committee will provide policy and administrative related advices and periodically review the biodiversity conservation works in the landscape.

- An institutional and administrative mechanism is required for well–coordinated and cost effective implementation of various measures. For this, a 'Tawang Landscape Conservation Cell' (TLCC) needs to be created within 'Tawang chu Basin Environment and Development Authority'. The proposed cell will oversee all the biodiversity conservation related activities.

- At field level, community based participatory decision–making and decentralized program implementation mechanism need to be promoted. In the overall context of Tawang landscape, there already exists strong institutions like Monastries and Village Councils (Chhopas)havingstrong and time–tested methods of managing their natural resources including the biodiversity. In addition, customary roles of *gaonburha* (or *Thummi)* in resolving various inter–and intra–village conflicts need to be used for the implementation of programs and more importantly in equitable sharing of various benefits. Proposed Conservation Cell should work closely and intandem with these already existing village Institutions.

6.6 BUDGET FOR THE LANDSCAPE LEVEL BIODIVERSITY MANAGEMENT PLAN

A list of all the above suggested measures along with tentative budgetary implications is presented in Table VII. 6.8.

Table VII. 6.8: Budget for the landscape level BMP

Sl. No.	Suggested biodiversity conservation and management measures	Tentative budget (in lakh Rs.)
RESEARCH AND INVENORY TO IMPROVE KNOWLEDGE BASE		
1	Creation of BMCs and preparation of PBR	50.00
2	Inventory and status surveys of key taxonomic groups of plants and animals	50.00
3	Status survey of threatened species of plants and animals	50.00
4	Ecological assessment of key ecosystems (forest, grassland and high altitude lakes)	60.00
5	Creation of biodiversity database in GIS domain	30.00
PROMOTE IN–SITU CONSERVATION MEASURES		
6	Create and support biosphere reseves	50.00
7	Create and support community conserved areas	30.00
8	Protection measures to biodiversity rich areas in influence zone	50.00
9	Support conservation activities in *Nagula–PTSO, Mago Thimbu* and*Pangchan Valley*	100.00
10	Support conservation activities high altitude wetlands including PT Tso, Oriangdukpu, Sangetsar and paradise lakes	100.00
WILDLIFE HABITAT IMPROVEMENT		
11	Regenerate and restore degraded and open forest	50.00
12	Regenerate and restore degraded pasturelands	50.00
13	Control of invasive and control	30.00
14	Develop and promote integrated fire management system (like information generation, fire line creation and education/awareness)	60.00
RECOVERY OF THREATENED PLANT SPECIES		
15	Protocol development for propagation techniques of different species	30.00

16	Nursery creation	30.00
17	Reintroduction of species and create in–situ germplasm	50.00
REGENERATION OF SPECIES OF NTFP VLAUES		
18	Plantation of NTFP species through agroforestry models	50.00
19	Capacity building–training and awareness on sustainable harvesting	40.00
20	Technology introduction for value addition in selected products	50.00
ECOTOURISM CUM NATURE EDUCATION PROMOTION		
21	Create eco–parks in select areas and grow important plant species of the region	100.00
22	Support eco–club program in 25 schools in project areas	50.00
23	Create infrastructure for eco–tourism and nature education (camping sites, trekking routes)	200.00
24	Support for promotion of home stay facilities	50.00
25	Develop nature interpreationcentres	50.00
26	Develop butterfly park	40.00
27	Develop orchidarium in at least two suitable locations	60.00
28	Develop bambusetum for bamboo and cane germ plasms	40.00
MITIGATE HUMAN WILDLIFE CONFLICTS		
29	Strenghten and support existing compensation mechanism for crop damage and livestock depredation for affected and influenc villages	30.00
30	Standardize and promote crop protection technologies	30.00
PROMOTE CONSERVTION FRIENDLY AGRO–PASTORALISM		
31	In–situ conservation of local crop varieties in farmer's field	25.00
32	Capacity builing of farmer's for adoption of organic farming–training and awareness	30.00
33	Facilitate and support organic certification process	30.00
34	Facilitate scientific description of local yak and other livestock breeds	50.00
CREATE PROGRAM IMPLEMENTATION MECHANISM		
35	Create and support Tawang biodiverity conservation cell for 5 years	300.00
HABITAT IMPROVEMENT FOR AVIFAUNA		
37	Bird nest installation, repair and maintenence, consultancy services	49.00
HUMAN RESOURCE DEVELOPMENT		
38	Capacity building, biodiversity–based enterpreunership development and HRD	156.00
	TOTAL	**2300.00**

SECTION VIII

CONCLUSION AND RECOMMENDATIONS

The draft report submitted to Government of Arunachal Pradesh on 25th September, 2014 was discussed with several stakeholders, and the report was finalized taking following points into consideration:

- Many developers have redesigned the project, and also have changed the location of the project sites. When the study was started, these developers did not finalize their DPR. The data were collected from the sites as shown by the developers at the beginning of the study. The new sites/changed location of the project components were revisited, and the data were modified accordingly.
- The data on dead body disposal, and dependency on natural resources including river were verified. Necessary corrections were made.
- The developer of Nyamjang chu joined the study late. The sites could be visited only for one season i.e. pre-monsoon season. In absence of the data for three seasons, it was not possible to conclude and recommend on all the aspects of the project. This was particularly important in determination of E-flow. The expert team felt that the protection of the wintering habitat of the threatened black-necked crane could be a major deciding factor in determining the E-flow for Nyamjang Chu project. However, during the present study the team could not directly observe or camera-trap the bird as winter season was already over by the time the developer joined the study. Therefore, E-flow for Nyamjang Chu project could not be recommended. It is recommended that a national level institution having adequate expertise on black-necked crane such as WII, BNHS or SACON should be involved to recommend the E-flow for Nyamjang Chu project vis-a-vis the habitat protection of black-necked crane. The E-flow recommended by the EIA committee of MoEF & CC for Nyamjang Chu project was used for calculating cumulative index at basin level.
- Because of latitudinal difference between Eastern and Western Himalayas, the climatic and vegetation features at 2,500 m in the Western Himalaya are similar to those found at about 3,200 m elevation in the Eastern Himalayan mountains.
- Based on the available imagery evidences duly supported by adequate ground truthing, it was concluded that paraglacial deposits (Ballantyne, 2002) are present in Tawang district above the elevation of 3,500 m a.s.l. Although winter snowline is at about 2,700-2,800 m a.s.l., the Himalaya in Tawang harbors considerable vegetation cover at this elevation and is relatively stable. Therefore, the snow cover at this elevation should not cause any disaster like paraglacial sediment outburst. Current glacial line in Tawang district is at an elevation of 5,000 m and above. A recent study in Sikkim Himalaya i.e., the glacial study available for the nearest area shows that the retreat rate of glaciers during 1976-2005 period was on an average 13.02 m per year (Raina, 2010).Thus, the glacial retreat in the last century should not be more than 1300 m. Since no glacier retreat data for Eastern Himalaya in Tawang is available, we considered the above mentioned rate of glacier retreat in Tawang district, and concluded that the glaciers were at least 3,700 m a.s.l. before 100 years. Therefore, the paraglacial deposit in no case was visible at or below3,200 m asl.
- Based on the above facts, it is recommended that no HEP should be constructed above 3,200 m. However, project-specific strict environmental safeguards/mitigation measures must be undertaken for the projects above 2,500 m elevation.
- Considering the agreed mitigation measures as stated by the developers and public leaders, such as electric crematorium instead of dead body disposal in the river, creation of riverine green belt to reduce IAS invasion, reassessment of ecosystem structure and function vis-a-vis flow dynamics in different seasons, E-flows for three seasons were recalculated.

Based on several rounds of brainstorming among the experts, and all the stakeholders as mentioned above, the following recommendations were made:

1. The projects above standardized cumulative impact assessment (SCIA) index value 1.0 i.e., 95 percent confidence band of the CIA index value of 0.84 would not be implemented. Under these criteria, Tsa chu-I and Thingbu chu should not be implemented.

2. The projects proposed above 3200 m asl should not be implemented in the river basin. Further, the projects above 2,500 m have to follow strict environmental safeguards and adopt specific mitigation measures, subject to fulfilling of other conditions.
3. The E-flow as recommended in Table IV. 5.1 should be maintained by all the projects recommended viz., Nykcharong chu, Tawang-I, Tawang-II, Rho, Mago chu, New Melling, Tsa chu-I Lower and Tsa chu-II.
4. The recommended 9 projects and the 2 micro-hydels viz., Nykcharong chu, Tawang-I, Tawang-II, Nyamjang chu, Rho, Mago chu, New Melling, Tsa chu-I Lower, Tsa chu-II, Jaswantgarh Stage-I and Paikangrong chu should be implemented in two phases as follows: Phase-I (0-5 years): Nykcharong chu, Tawang-I, Tawang-II, Nyamjang chu, Jaswantgarh Stage-I and Paikangrong chu; and Phase-II (5-10 years): Rho, New Melling, Mago chu, Tsa chu-I Lower, and Tsa chu-II.
5. The following mitigation measures should be implemented to minimize the adverse impacts of the projects.

5.1 Adopting strict management and regulation options for pollution. E-flow is needed to be adjusted to moderate the impact on faunal species during the construction phase.
5.2 While constructing the muck disposal and storing structures, the existing vegetation and the accessibility of wildlife to river water should be kept in mind and while using, it has to be made mandatory to keep the disposal limit within the capacity of the site so that the muck does not spill into the river bed.
5.3 High-tech equipments should be used to minimize noise levels. Suitable managerial, ecological and technical interventions should be adopted to minimize the impact of noise pollution.
5.4 Taking appropriate measures to minimize the death of wild animals due to increased vehicular traffic. Strict management decisions on regulated vehicular movement would reduce the accidental deaths.
5.5 Very strict managerial role in mitigation measures is suggested to minimize the impact of influx of population and pressure on local natural resources.
5.6 The existing identified IAS should be weeded out and adequate measures should be taken to avoid import of new IAS through appropriate quarantine measures. An appropriate policy needs to be formulated by the Government of Arunachal Pradesh.
5.7 Afforestation program using dominant native tree species and woody shrubs should be taken up to compensate for the floral losses in the project areas.
5.8 In view of the high impact on the terrestrial plant and aquatic plant and animal species having commercial importance, the development of these resources as described in the biodiversity management plan should be undertaken to mitigate the impact.
5.9 Activities recommended under compensatory afforestation and catchment area treatment should be adequate to mitigate the impact of resource dependency i.e. timber, fire wood, fodder and grazing, on other available forest lands.
5.10 Safety criteria are to be followed in design of the barrages to mitigate the possible impacts due to seismicity.
5.11 For fish migration, fish ladder at all the project sites should be a part of barrage design. Adequate E-flow must be ensured at all project sites and regulatory steps to minimise the pollution close to zero discharge level should be taken.
5.12 Incorporation of the interventions suggested for mitigation, and prescriptions made in biodiversity and development plan at landscape/district levels, respectively should be made mandatory while according approval to individual projects. The specific activities recommended in the landscape level plan those fall within the 10 km radius of the respective projects should be taken up by the proponents.

6. The project-specific mitigation measures as detailed below should be implemented:

Tsa Chu-I Lower and Tsa Chu-II

- Minimum destruction to the terrestrial and aquatic ecosystems should be ensured during construction phase. Existing roads should be used for material transport with limited load, and new road construction is to be avoided.
- Cutting of trees is to be avoided and a sanctuary of 40 ha is to be created surrounding the project area (Tsa chu-I Lower barrage site) through tree planting to mitigate the diversion of forest land.

New Melling

- Adequate measures to be taken to prevent landslide hazards.
- Adequate care must be taken to minimise the disturbance to the river habitat of the edible aquatic algae (*Prisciola crispa*) and E-flow recommended should be maintained to sustain the species.

Mago Chu

- Adequate care must be taken to minimise the disturbance to the river habitat of the edible aquatic algae (*Prisciola crispa*) and E-flow recommended should be maintained to sustain the species.

Nykcharong Chu and Rho

- The construction activities should be planned in such a way that no existing forests and habitats of the biodiversity are destroyed. If required, the ancillary construction activities may be relocated to save the old growth forests (e.g., colony site of Rho project).

Tawang-I

- Care must be taken to save the tourist place i.e., Nuranang Falls from the adverse impacts of dam construction and also during operational phase.
- Drinking water sources for all the influenced villages must be ensured.
- Advanced and appropriate machineries should be used to minimize ground vibrations during construction phase.

Tawang-II

- The habitats for birds must be protected. The host plant species should be planted under various afforestation programmes, and artificial nest boxes must be installed in sufficient numbers. Although these measures are common to all the projects, Tawang-II project must make extra efforts in this regard in view of high abundance of birds.

Nyamjang Chu

- The information furnished by WWF and local people as well as secondary literature indicates that the barrage site is a wintering habitat of Black necked crane (BNC). However, there is difference of opinion about the actual location of the habitat of BNC vis-à-vis the barrage site/axis. Some experts claim that the entire river stretch adjacent to Zimithang town is the habitat of BNC. During the site visit of the present expert team during May, 2014, the developers of Nyamjang chu project and WWF personnel jointly showed the wintering habitat. Subsequently the Power department of Government of Arunachal Pradesh expressed its reservation about the location of wintering habitat of BNC shown during the aforesaid site visit. Since the developers joined the study only for one season i.e. pre- monsoon period, the team did not get an opportunity to observe the black necked crane wintering habitat directly or to camera trap it as winter season was already over by the time the developer joined the study. In absence of direct conclusive evidence, this study therefore, is not in a position to recommend the E-flow as well as appropriate conservation measure for the threatened species. In view of this, we feel that there is a need to conduct an in-depth study on the black necked crane habitat vis-a-vis Nyamjang chu project by an independent institution having adequate expertise on black necked crane, such as WII, BNHS, or SACON.

The 20-year perspective development plan with a vision of 'Sustainable development of TRB' recommends the following actions under 4 basin strategies:

Basin Strategies	Activities recommended
Institutional	The autonomous body named as TRBDA is proposed to be constituted that will work closely with HEP developers in collaboration with the various existing TRB institutions for implementing the development plan.
Development	Articulate plans/schemes/grants for each infrastructural and socio-economic sector was formulated taking into account the current scenario and requirements of the communities. The following R&R scheme and CSR activities were proposed: • Land compensation for acquisition of private land. • Compensation towards customary rights over community and UFs • School infrastructure development schemes • Merit scholarship scheme for different education levels • Salary support for teachers and staff to ensure qualified and adequate teaching manpower • Training grant for teachers and support staff • Exposure tours/visits for school students to technical institutions outside TRB • Initiate Worker health program (WHP) and Public health delivery plan (PHDP) • Road construction and network expansion scheme • Adopt sustainable transport system during construction phase to minimize adverse impacts on forests, environment and landscape. • Power supply scheme and power subsidies • Water supply and irrigation schemes • Sanitation and solid waste management plan • Agricultural land compensation • Agriculture development package • Veterinary assistance • Livestock development • Grant for craft centres and skill development scheme • Compensation for horticultural land and horticulture development scheme • Tourism development grant • Income generation scheme, subsistence grant and control of influx • Electric crematorium • Value addition of NTFPs growing naturally such as *Citronella* • Large scale plantation of horticultural crops such as *Juglans regia* (Walnut) and *Punica granatum* (Pomegranate)
Protection	Protection of environment has been suggested, conservation of biodiversity was emphasized, and specific habitat improvement and conservation plans was made. The following protection measures are proposed and recommended: • Public awareness programmes • Adoption of strict rules and regulation during construction phase for protection of local environment including air, water and soil. • Soil and catchment area protection • Catchment Area Treatment Plan (CAT Plan) • Other environment management plans viz., muck management /disposal plan, water, air quality and noise environment management, water pollution control plans, environmental management in labour camp, environmental management in road construction, control of pollution from labour camps, reservoir rim treatment and soil erosion control, maintenance of air and water quality and noise level. • Forest and biodiversity conservation
Disaster risk	Potential disaster risk associated with TRB landscape was identified and appropriate mitigation measures and management for each was proposed. The following actions were proposed: • Dam breakage: Preventive measure, surveillance and evacuation plan • Regulation of barrage water discharge • Seismic disaster management • GLoF: Monitoring, early warning systems, mitigation and preparedness

With the above recommendations, TRB would have the following scenario:

1. The river basin would have at least 66% of its total geographical area under forest cover. Only 519.54 ha forest area will be diverted for construction of different project components.
2. At least 40 percent of the main river length should be free-flowing i.e., free from any projects.

3. A minimum distance of 1 km free-flowing river length between the two successive projects will be maintained.
4. Being thinly populated, with a total population of 49,977, the influx of population in TRB at any given point of time would not exceed 15% of the original local population i.e. 57,474.
5. Minimum level of water would flow in the river round the year required to maintain the river ecosystem structure, function and services, including flora and fauna in river, and the riverine and the adjacent terrestrial ecosystem structure and function.
6. The seasonal flow dynamics of the river would be maintained, although at a much lower scale, to maintain the river ecosystem function and the adjoining riverine and terrestrial ecosystem functions. This would ensure the flow of existing ecosystem services, although in much reduced scale.
7. All the existing forest/scrub areas should be managed and no more forests should be converted for other uses.
8. The biodiversity present will be conserved in totality and not a single element of biodiversity would be lost.
9. The air, water, and noise quality would be maintained well-below the permissible limit as notified by CPCB.
10. Given the sensitivity and ecological fragility of the ecosystems above 3,200 m elevation in the Eastern Himalaya, no power projects would be undertaken beyond this elevation.
11. Religious places or the stretches directly related to the sacred belief of the people will not be disturbed.
12. No lateral flow or the adjoining ecosystems contributing to the lateral flow in the downstream region of the barrages would be disturbed.
13. There will be a 1-km wide green corridor on the both sides of the river in the entire stretch of Tawang river beginning from the first barrage in the upstream region upto Bhutan border in the downstream area.
14. All the well-vegetated forest areas are connected through wildlife corridors for their smooth migration.
15. Establishment of well-designed HEPs i.e. design discharge based on actual water availability in a realistic manner, and allowing minimum level of E-flow for the downstream river stretch for the sustenance of the river ecosystem. This would also ensure the continued dependency of people and wildlife on the river in the downstream area.
16. Forest diversion per capita of power generation would be optimized.
17. Substantial contribution by the power developers towards the socio-economic development of the river basin, particularly for those people whose lands would be acquired.
18. Soil erosion and other hazards including future uncertainties due to climate change, earthquake and GLoF must be taken care of.
19. Significant increase in employment opportunities and livelihood diversification.
20. Improved quality of life through need-based intervention in education, health, road network, sanitation, and water supply.

All this would contribute towards sustainable development of TRB.

Ahmed, H.F., Das, A. and Dutta, S.K. 2009. *Amphibians and Reptiles of Northeast India: A Photographic Guide.* Aaranyak, Guwahati, India, 168 p.

Aiyadurai, A. 2007. Hunting in a biodiversity hotspot: a survey on hunting practices by indigenous communities in Arunachal Pradesh, North-east India. Technical Report. Rufford Small Grant Foundation, UK.

Alexander, L., Auerbach, M.R., Czajak, S.C., Hohnson, W.E. and Desrosiers, R.C. 2000. Species specificity of Macaque rhadinovirus glycoprotein B sequences. *Journal of Virology* 74: 584–590.

Ali, S. 2002. *Book of Indian Birds.* Bombay Natural History Society and Oxford University Press. 13th Edition, 326 p.

Allen, G.M. 1938. *The Mammals of China and Mongolia*. Volume 1. Natural History of Central Asia 11. American Museum of Natural History, New York, 620 p.

Allen, L., Engeman, R. and Krupa, H. 1996. Evaluation of three relative abundance indices for assessing dingo population. *Wildlife Research* 23: 197-206.

Allen, S.E., Grimshaw, H.M., Parkinson, J.A. and Quarmby, C. 1974. *Chemical Analysis of Ecological Materials*. Blackwell Scientific Publications, Oxford.

Allison, A. and Englund, R. 1995. *Terrestrial Animals and Aquatic Invertebrates*. In: Mueller-Dombois, D., Bridges, K.W. and Daehler, C.C. (Eds.), *Biodiversity Assessment of Tropical Island Ecosystems. Pabitra Manual for Interactive Ecology and Management*, Bishop Museum Press, pp. 49-70.

Anderson, J.M. and Ingram, J.S.I. 1993. *Tropical Soil Biology and Fertility*: *A Handbook of Methods*.2ndEdition, C.A.B. International, Wallingford, UK.

Angadi, S.B., Shiddamallayya, N. and Patil, P.C. 2005. Limnological studies of Papnash pond, Bidar (Karnataka). *Journal of Environmental Biology* 26: 213-216.

APHA, 1995. *Standard Methods*. 19th Edition. American Public Health Association, Washington, DC.

APHA, 2012. *Standard Methods for the Examination of Water and Wastewater.* 22nd Edition. American Public Health Association, Washington, DC.

Baker, M.J. 2014. The Socio–Ecological Impacts of Small Hydropower Projects in Himachal Pradesh (Part–2). South Asia Network on Dams, Rivers and People. <http://sandrp.wordpress.com>.

Ballantyne, C.K. 2002. Paraglacial geomorphology. *Quaternary Science Review* 21: 1935-2017.

Battish, S.K. 1992. *Freshwater Zooplankton of India*. Oxford and IBH Publishing Company, 233 pp.

Bergey, E.A. and Resh, V.H. 2006. Differential response of algae on small streambed substrates to floods. *American Midland Naturalist* 155: 270–277.

Bettis, F.N. 1954. Occurrence of the black-necked crane in Indian Limits. *Journal of Bombay Natural History Society* 52: 605-606.

Bhatt, L.R., Lacoul, P., Lekhal, H.D. and Jha, P.K. 1999. Physico-chemical characteristic and phytoplanktons for Taudha lake, Kathmandu. *Pollution Research* 18 (4): 353-358.

Bhupathy, S. 1991. *Population and Resource Utilisation of Waterfowl in Keoladeo National Park, Bharatpur*. Ph.D. Thesis, Rajasthan University, Jaipur.

Bhutiani, R. and Khanna, D.R. 2007. Ecological study of river Suswa: modeling DO and BOD. *Environmental Monitoring Assessment* 125: 183-195.

Bibby, C.J., Burgerss, N.D. and Hill, D.A. 1992. *Bird Census Techniques*. Academic Press, London.

Bloxham, M.J., Richards, J.P., Glegg, G.A., Cooper, P., Caballero, P. and Mee, L.D. 2005. Training Course on the TDA/SAP Approach in the GEF International Waters Programme, 1st edition. University of Plymouth. training materials in 6 modules (Train-Sea-Coast Programme).

Boggs, J. 1991. EIA within democrative politics: contradiction in terms or emerging paradigm. *Impact Assessment Bulletin* 9: 1–11.

Bor, N.L. 1938. A sketch of the vegetation of the Aka hills, Assam synecological study. *Indian Forest Records* (*Botany)* 1 (4): 103-222.

Borang, A. and Thapliyal, G.S. 1993. Natural distribution and ecological status of nonhuman primates in Arunachal Pradesh. *Indian Forester* 119: 834–844.

Borror, D.J. and Delong, D.M. 1971. *An Introduction to the Study of Insects*. Holt, Rinehart and Winston, New York, 812 p.

Bray, R.H. and Kurtz, L.T. 1945. Determination of total, organic and available forms of phosphorus in soils. *Soil Science* 59: 39–45.

Brisbane Declaration, 2007. Recommendations of the 10th International River symposium and International Environmental Flows Conference, held in Brisbane, Australia, on 3-6th September, 2007; <www.riversymposium.com/ 2006/index.php?element=2007Brisbanbane Declaration241007>.

Brookes, P.C., Landman, A., Pruden, G. and Jenkinson, D.S. 1985. Chloroform fumigation and the release of soil nitrogen: A rapid direct extraction method for measuring microbial biomass nitrogen in soil. *Soil Biology and Biochemistry* 17: 837–842.

Burnham, K.P., Andreson, D.R. and Laake, J.L. 1980. Estimation of density from line transect sampling of biological population. *Wildlife Monograph* No. 72. The Wildlife Society, Washington DC. 202 p.

Calijuri, M.C., Dos Santos, A.C and Jati, S. 2002. Temporal changes in the phytoplankton community structure in a tropical and eutrophic Reservoir (Barra Bonita, S.P.-Brazil). *Journal of Plankton Research* 24: 617-634.

CAMP, 2003. Medicinal Plants of Arunachal Pradesh, Assam, Meghalaya and Sikkim. FRLHT, Bangalore, India.

Canadian Environmental Assessment Agency, 1998. *Cumulative Effects Assessment Practitioners Guide*. Canadian Environmental Assessment Agency.

Census of India, 2006. The Registrar General and Census Commissioner, New Delhi, Ministry of Home Affairs, Government of India.

Census of India, 2011. The Registrar General and Census Commissioner, New Delhi, Ministry of Home Affairs, Government of India.

Champion, H.G. and Seth, S.K. 1968. *A Revised Survey of the Forest Types of India*. Government of India Publication, New Delhi.

Chatterjee, S., Saikia, A., Dutta, P., Ghosh, D., Pangging, G. and Goswami, A.K. 2006. *Biodiversity Significance of Northeast India*. Background Paper 13. WWF–India, New Delhi.

Chaudhry, S., Veeraswami, G.G., Mazumdar, K. and Samal, P.K. 2010. Conflict identification and prioritization in proposed Tsangyang Gyatso Biosphere Reserve, Eastern Himalaya, India. *Journal of the Bombay Natural History Society* 107: 189–197.

Chitale. M.A. 1992. Development of India's river basin. *Water Resources Development* 8 (1): 30-44.

Choudhury, A. 2002. Status and conservation of Cranes in northeast India. In: Rahmani, A.R. and Ugra, G. (Eds.), Birds of Wetlands and Grasslands: *Proceedings of Salim Ali Centenary Seminar on Conservation of Avifauna of Wetlands and Grasslands. Bombay Natural History Society*, Mumbai: 41.

Choudhury, A. 2006. A pocket guide to the birds of Arunachal Pradesh. Gibbon Pocket Guides, Gibbon Books and The Rhino Foundation for Nature in NE India, 91 p.

Choudhury, A.U. 1989a. *Primates of Assam: Their Distribution, Habitat and Status*. Ph.D. Thesis, Gauhati University, Guwahati, Assam, India.

Choudhury, A.U. 1989b. Ecology of the capped langur in Assam, India. *Folia Primatology* 52: 88–92.

Choudhury, A.U. 1996. Primates in Assam—status and conservation. *Tigerpaper* 23 (3): 14–17.

Choudhury, A.U. 2013. *The Mammals of North East India*. Gibbon Books and The Rhino Foundation for Nature in Northeast India. Guwahati, India.

Choudhury, N. and Ghosh, A. 2013. Responsible hydropower development in India, Challenges for the future. Council of Energy, Environment and Water (CEEW), New Delhi.

Chow, V.T. 1959. Open Channel Hydraulics. McGraw-Hill, New York, 680 pp.

Collar, N.J. and Andrew, P. 1988. *Birds to Watch: The ICBP World Checklist of Threatened Birds*. ICBP and IUCN, Cambridge, UK.

Collar, N.J., Andreev, AV., Chan S., Crosby, M.J., Subramanya S. and Tobias, J.A. 2001. Threatened Birds of Asia. Bird Life International, pp. 1198-1225.

Council on Environmental Quality. 1997. Considering Cumulative Effects Under the National Environmental Policy Act. Council on Environmental Quality, Executive Office of the President, Washington, DC, USA, January, 122 p.

Crossley, D.A. Jr. and Blair, J.M. 1991. A high efficiency “low technology' Tullgren-type extractor for soil microarthropods. *Agriculture, Ecosystems and Environment* 34: 182-187.

Dutta, A., Naniwadekar, R. and Anand, M.O. 2008. Occurrence and conservation status of small carnivores in two protected areas in Arunachal Pradesh, north-east India. *Small Carnivore Conservation* 39: 1–10.

Desikachary, T.V. 1985. Cyanophyta. Indian Council of Agricultural Research: New Delhi, 686 p.

Dixit, S.S., Smol, J.P., Kingston, J.C. and Charles, D.F. 1992. Diatoms: powerful indicators of environmental change. *Environmental Science and Technology* 26: 21-33.

Dobriyal, A.K. and Singh, H.R. 1989. Observation on temporal trends of phytoplankton diversity in the river Nayar of Garhwal Himalaya. *Journal of Fresh Water Biology* 1: 1-6.

Edmonson, W.T. 1992. *Freshwater Biology.* 2nd Edition. Periodicals supply services, New Delhi, 1248 p.

Environment Agency, 2003. *The stability of landfill lining systems*. R&D Technical Reports P1-385/TR1 & 2. <https://www.gov.uk/government/uploads/system/.../sp1-385-tr1-e-e.pdf>.

European Commission, 1999. Guidelines for the Assessment of Indirect and Cumulative Impacts as well as Impact Interactions. Luxembourg, 172pp.

Forman, T.T.R. and Gordon, M. 1986. *Landscape Ecology*. John Wiley and Sons Publications, New York, 619 p.

Forest Survey of India, 2009. India State of Forest Report. Ministry of Environment, Forests and Climate Change. Government of India.

Gandhi, H.P. 1998. Freshwater Diatoms of central Gujarat–With a Review and Some others: Shiva offset Press: Dehradun: India.

GRBEMP, 2011. Ganga River Basin Environment Management Plan. Report Code: 012_GBP_IIT_ EFL_SOA_01_ Ver1_June 2011.

Garg, J.K., Narayan, A. and Basu, A. 1988. Monitoring environmental changes over Kudremukh iron ore mining area, India, using remote sensing technique. Proceedings: *Indo-British workshop on Remote Sensing of Environment in Mining field. Indian School Mines,* Dhanbad, 41-47.

Government of India, 1988. National Forest Policy. No.3A/86-FP, Department of Environment, Forests and Wildlife, Ministry of Environment and Forests, Government of India. <http://envfor.nic.in/legis/forest /forest1. html>.

Government of India, 1992. National Conservation Strategy and Policy Statement on Environment and Development. Ministry of Environment and Forests, Government of India. moef.gov.in/sites/default/files/ introduction-csps.pdf**.**

Government of India, 1992. Policy Statement on Abatement of Pollution, No. H.11013(2)/90-CPW, Government of India, Ministry of Environment and Forests. moef.gov.in/sites/default/files/introduction-psap.pdf.

Government of India, 2000. National Agriculture Policy, Ministry of Agriculture and Consumer Affairs, Food and Public Distribution, Government of India.

Government of India, 2000. National Population Policy. Ministry of Health and Family Welfare, Department of Family Welfare, New Delhi, p. 4.

Government of Arunachal Pradesh, 2005. Human Development Report. Arunachal Pradesh, 310 p.

Government of India, 2005. The Disaster Management Act. National Disaster Management Authority, Ministry of Law and Justice, Government of India, 29 p.

Government of India, 2006. National Environment Policy. Department of Environment, Forests and Wildlife, Ministry of Environment and Forests, Government of India. moef.gov.in/sites/default/files/introduction-nep2006e.pdf.

Government of India, 2007. National Rehabilitation and Resettlement Policy (NRRP). F. No. 26011/4/2007-LRD. Ministry of Rural Development, Department of Land Resources, Land Reforms Division, New Delhi.

Government of India, 2008. Hydropower Policy- 2008. Ministry of Power, Government of India, 84 p.

Government of Arunachal Pradesh, 2008. The Arunachal Pradesh Gazette. Department of Power, Government of Arunachal Pradesh Vol XV (104). 14 p.

Government of India, 2012. National Water Policy. Ministry of Water Resources. Government of India.

Government of India, 2013. The Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Act. The Gazette of India, Ministry of Law and Justice, Government of India.

Guiry, M.D. and Guiry, G.M. 2012. Algaebase. World-wide Electronic publication, National University of Ireland, Galway. <http: //www.algaebase.org>.

Gupta, A.K. 1994. "Status and Conservation of Non-Human Primates in Tripura, India." In: Thierry, B., Anderson, J.R., Roeder, J.J. and Herrenschmidt, N. (Eds.), *Current Primatology*. Vol. 1: *Ecology and Evolution.* University of Louis Pasteur, Strasbourg.

Gupta, A.K. 2007. Biodiversity and wildlife research in northeast India: new initiatives by the wildlife institute of India. <http//www.wii.gov.in/envis/rain_forest/chapter18>.

Harding, W.R., Archibald, C.G.M. and Taylor, J.C. 2005. The relevance of diatoms for water quality assessment in South Africa: a position paper. Water SA 31, 41–46.

Harriss-White, B., Rohra, S., and Singh, N. 2009. *Political architecture of India's technology system for solar energy.* Economic and Political Weekly, Vol. XLIV, No. 47, pp. 49-60.

Henke, S.E. and Knowlton, F.F. 1995. Techniques for estimating Coyote abundance. In: Proceedings of the symposium: Coyotes in the southwest. Parks and wildlife Department: Austin, Texas, 71-78.

Henry, M., Bombelli, A. *et al*. 2013. GlobAllomeTree: International platform for tree allometric equations to support volume, biomass and carbon assessment. iForest - Biogeosciences and Forestry e1-e5.

Heywood, V.H. and Baste, I. 1995. *Global Biodiversity Assessment*. Cambridge University Press, Cambridge. 1140 p.

Hill, C.M. 2002. Primate conservation and local communities–ethical issues and debates. *American Anthropologist* 104: 1184–1194.

Hutto, R.L., Pletsechel, S.M. and Hendrick, P. 1986. A fixed radius point count method for non breeding season use. *The Auk* 103: 593-602.

Hynes, H.B. 1970. *The Ecology of Running Waters*: Liverpool, Liverpool University Press, 555 p.

IBEF, 2010. India Brand Equity Foundation, Arunachal Pradesh. <http: //www.ibef.org/ download/>.

ICIMOD, 2011. Glacial lakes and Glacial lake outburst flood in Nepal. Kathmandu: ICIMOD.

Imtiaj, A. and Lee, T. 2007. Screening of Antibacterial and Antifungal Activities from Korean Wild Mushrooms. *World Journal of Agricultural Science* 3 (3): 316-321.

Industrial Policy, 2008. Department of Industries, Government of Arunachal Pradesh, Udyog Sadan, ltanagar.

ISRO, 2009. National Wetland Atlas: Arunachal Pradesh, SAC/RESA/AFEG/NWIA/ ATLAS/06/2009, Space Applications Centre (ISRO), Ahmedabad, India, 98 p.

IUCN, 2003. Flow: the Essentials of the Environmental Flows. IUCN, Gland, Switzerland and Cambridge, UK.

IUCN, 2013. IUCN Red List of Threatened Species. Version 2013.2. <www.iucnredlist.org>. Downloaded on 7th May 2014.

Jackson, M.K. 1973. *Soil Chemical Analysis*. Prentice Hall Inc., Englewood Cliffs, New Jersey.

John, D.M., Whitton, B.A. and Brook, A.J. 2002. The Freshwater Algal Flora of the British Isles: An Identification Guide to Freshwater and Terrestrial Algae: Cambridge University Press: Cambridge.

Kaul, R.N. and Haridasan, K. 1987. Forest types of Arunachal Pradesh–A preliminary study. *Journal of Economic and Taxonomic Botany* 9 (2): 379-388.

Kelly, M. and Whitton, B.A. 1995. The trophic diatom index: a new index for monitoring eutrophication in rivers. *Journal of Applied Ecology* 7, 433–44.

Killham, K. 1994. *Soil ecology*. Cambridge University Press, Cambridge, 231 p.

Kingsley, L. 1997. *A guide to Environmental Assessments: Assessing Cumulative Effects*. Parks Canada, Department of Canadian Heritage, March 1997.

Kitner, M. and Poulickova, A. 2003. Littoral diatoms as indicators for the eutrophication of Shallow lakes. *Hydrobiologia* 506-509: 519-524.

Kosaka, Y., Saikia, B., Mingki, T., Tag, H., Riba, T. and Ando, K. 2010. Roadside distribution patterns of invasive alien plants along an altitudinal gradient in Arunachal Himalaya, India. *Mountain Research and Development* 30: 252–258.

Krammer, K. and Lange-Bertalot, H. 1986-1991. Bacillariophyceae, Parts 1-4. Volume 2 of "Süsswasserflora von Mitteleuropa". Ettl, H., Heynig, H. and Mollenhauer, D. (Eds.), Gustav Fischer Verlag: Stuttgart: Germany.

Kumar, A., Singh, M. and Molur, S. 2008. *Macaca silenus*. IUCN Red List of Threatened Species. Version 2011.1. <www.iucnredlist.org>. Accessed: 20 September 2011.

Kumar, G. 1997. *Geology of Arunachal Pradesh*. Geological Society of India publication, 217 p.

Lillesand, T.M. and Kiefer, R.W. 1987. *Remote Sensing and Image Interpretation*. John Wiley, New York. Ltd.

Ludlow, F. 1920. Notes on the Nidification of certain birds in Ladakh. *Journal of Bombay Natural History Society* 27: 141-146.

Ma, Z., Becker, D.R. and Kilgore, M.A. 2009. Assessing cumulative impacts within state environmental review frameworks in the United States. *Environmental Impact Assessment Review* 29: 390–398.

Mahanta, D. and Tiwari, S.C. 2005: Natural dyes yielding plants and indigenous knowledge on dye preparation in Arunachal Pradesh, North East India, *Current Science* 88: 1474-1480.

Mahapatra, H.S. 2010. A contribution to the flora of Tawang district, Arunachal Pradesh. *Bulletin of Arunachal Forest Research* 26 (1 & 2): 44-51.

Maheswaran, G. 2012. *Fauna of Protected Areas of Arunachal Pradesh*. Publ. Director, Zoological Survey of India, Kolkata, pp. 1-14.

Majer, J.D. and Beeston, G. 1996. The biodiversity integrity index: an illustration using ants in western Australia. *Conservation Biology* 10 (1): 65-73.

Malik, D.S. and Bharti, U. 2012. Status of plankton diversity and biological productivity of Sahastradhara stream at Uttarakhand, India. Journal of Applied and Natural Science 4: 1: 96-103.

May, R.M. 1988. How many species are there on earth? *Science* 241: 1441-1449.

Mendiratta, U., Kumar, A., Mishra, C., and Sinha, A. 2009. Winter ecology of the Arunachal macaque Macaca munzala in Pangchen Valley, western Arunachal Pradesh, north-eastern India. American *Journal of Primatology* 71: 939–947.

Menon, V. 2003. A field guide to Indian Mammals. Dorling Kindersley (India) Ltd. New Delhi, 201 p.

Millennium Ecosystem Assessment, 2005. Ecosystems and Human Well-being: Synthesis. Island Press, Washington, DC, pp. 155.

Mishra, C., Datta, A. and Madhusudan, M.D. 2004. The high altitude wildlife of Western Arunachal Pradesh: a survey report. CERC Technical Report No. 8. Nature Conservation Foundation, International Snow Leopard Trust, and Wildlife Conservation Society (India Program), Mysore, India.

Mishra, C., Madhusudan, M.D. and Datta, A. 2006. Mammals of the high altitudes of Western Arunachal Pradesh, Eastern Himalayas: an assessment of threats and conservation needs. *Oryx* 40 (1): 1-7.

Misra, R. 1968. *Ecology Work Book*. Oxford Publishing Company, Calcutta, India.

Mooney, H.A., Lubchenco, J. Dirzo, R. and Sala O.E. 1995a. Biodiversity and ecosystem functioning: basic principles, pp. 279-325. In: Heywood, V.H. and Watson, R.T. (Eds.), *Global Biodiversity Assessment*, Cambridge University Press, Cambridge, 1140 p.

Moore, J.C. de Ruiter, P.C and Hunt, H.W. 1993. Influence of productivity on the stability of real and model ecosystems. *Science* 261: 906-908.

Moore, J.C., Walter, D.E. and Hunt, H.W. 1988. Arthropod regulation of micro- and meso-biota in below-ground detrital food webs. *Annual Review of Entomology* 33: 419-439.

Myers, N., Mittermier, R.A., Mittermier, C.G., da Fonseca, G.A.B. and Kent, J. 2000. Biodiversity Hotspots for Conservation Priorities. *Nature* 403: 853–858.

Namsa, N.D., Mandal, M., Tangjang, S. and Mandal, S.C. 2011. Ethnobotany of the Monpa ethnic group of Arunachal Pradesh. *Journal of Ethnobiology and Ethnomedicine* 7: 31. DOI: 10.1186/1746-4269-7-31.

Nannipieri, P., Ascher, J., Ceccherini, M.T., Landi, L., Pietramellara, G. and Renella, G. 2003. Microbial diversity and soil functions. *European Journal of Soil Science* 54: 655-670.

Narula, R.L., Acharyya, S.K. and Banerjee, J. 2000. Seismotectonic atlas of India and its environs. Vol. 43, Geological Survey of India, Kolkata.

Nautiyal, P. 1986. Studies on the riverine ecology of the torrential waters in Indian uplands of Garhwal region-Floristic faunistic survey. *Tropical Ecology* 27: 157-165.

Naveh, Z. and Lieberman, A.S. 1990. *Landscape Ecology: Theory and Applications*. Springer-Verlag, New York.

Nayar, M.P. and Sastry, A.R.K. 1987. *Red Data Book of Indian Plants.* Volume I. Botanical Survey of India.

Nayar, M.P. and Sastry, A.R.K. 1988. *Red Data Book of Indian Plants.* Volume II. Botanical Survey of India.

Nayar, M.P. and Sastry, A.R.K. 1990. *Red Data Book of Indian Plants.* Volume III. Botanical Survey of India.

Ndiritu, G.G., Gichuki, N.N., Kaur, P. and Triest, L. 2003. Characterization of environmental gradients using physicochemical measurements and diatom densities in Nairobi River, Kenya. *Aquatic Ecosystem and Health Management* 6 (3): 343–354.

Noss, R.F. 1990. Indicators for monitoring biodiversity: a hierarchical approach. *Conservation Biology* 4: 355-364.

Noss, R.F. and Harris, L.D. 1986. Notes, networks and MUMs: preserving diversity at all scales. *Environmental Management* 10: 299-309.

ODPM, 2002. Local Authority Housing Finance (document on-line) Housing Factsheet No.10. London, UK: ODPM, accessed 16 January 2003. <http://www.housing.odpm.gov.uk/factsheet/lahfinance/index. htm>.

Ormerod, S.J., Baral, H.S., Brewin, P.A., Buckton, S.T., Juttner, I., Rothfritz, H and Suren, A.M. 1997. River habitat surveys and biodiversity in the Nepal Himalaya. In: Boon, P.J. and Howell, D.L. (Eds.), Freshwater Quality: Defining the Indefinable, HMSO, Edinburgh, 640 p.

Passy, S.I. and Bode, R.W. 2004. Diatom model affinity (DMA), a new index for water quality assessment. *Hydrobiologia* 524: 241–51.

Pathani, S.S. and Mahar, S. 2006. A study of population of plankton in the river Suyal of Uttaranchal, India. *Flora and Fauna* 11: 2: 250-256.

Paul, A., Arunachalam, A., Khan, M.L. and Arunachalam, K. 2006. *Daphne papyracea* Wall. ex Steud.-A traditional source of paper making in Arunachal Pradesh. *Indian Journal of Natural Products and Resources* 5 (2): 133-138.

Paul, A., Khan, M.L. and Das, A.K. 2010. Utilization of rhododendrons by Monpas in western Arunachal Pradesh, India. *Journal American Rhododendron Society* 64 (2): 81-84.

Pegram, G., Li, Y., Quesne, T. Le., Speed, R., Li, J. and Shen, F. 2013. *River Basin Planning: Principles, procedures and approaches for strategic basin planning.* UNESCO, Paris.

Phillips, R. 1981. *Mushrooms and other Fungi of Great Britain and Europe*. London, Pan Books.

Pielou, E.C. 1969. *An Introduction to Mathematical Ecology*. Wiley, New York.

Piper, C.S. 1942. *Soil and Plant Analysis*. University of Adelaide, Adelaide, 368 p.

Pocock, R.I. 1976. *The Fauna of British India. (including Ceylon and Burma).* Mammalia Vol I. Primates and Carnivores. Dr. W. Junkov B.V. Publishers, The Hague.

Pradhan, S, Saha, G.K., and Khan, J.A., 2000. Food habits of the red panda, *Ailurus fulgens* in the Singhalila National Park, Darjeeling, India. *Journal of the Bombay Natural History Society* 98: 224–230.

Pradhan, S. 1999. Observations of the Red Panda (*Ailurus fulgens*) in the Singalila Park, Darjeeling, India. *Small Carnivore Conservation* 21: 6-8.

Prater, S.H. 1980. *The Book of Indian animals*. Third edition. Bombay Natural History Society. Bombay, 428 p.

Prater, S.H. 2005. *The Book of Indian Animals*. Bombay Natural History Society and Oxford University press 12th Edition, 316 p.

Praveen, K.G., Agarwal, P. and Hegde, P. 2012. A Review of Xylo-oligosaccharides, *International Research Journal of Pharmacy.*

Presscott, G.W. 1982. *Algae of the Western Great Lakes Area*: WMC Brown Publishers: Dubuque: Lowa.

Puri, G.S., Meher-Homji, Gupta, V.M. and Puri, S. 1983. *Forest Ecology*. Vol. I & II. Oford and IBH Publishing Co. New Delhi.

Rahmani, A.R. 2012. Important Bird Areas in India: Priority sites for conservation.

Raina, V.K. 2010. *Himalayan Glaciers A State-of-Art Review of Glacial Studies, Glacial Retreat and Climate Change*. Geological Survey of India.

Rajvanshi, A., Mathus, V.B., Teleki, G.C. and Mukherjee S.K. 2001. Roads, Sensitive Habitat and Wildlife: Environmental Guideline for India and South Asia. Wildlife Institute of Indian, Dehra Dun and Canadian Environmental Collaborative Ltd., Toronto, 215 p.

Rasmussan, P.C. and Anderton, J.C. 2005. *Birds of South Asia. The Ripley Guide.* Vols. 1 and 2. Smithsonian Institution and Lynx Edicions, Washington, D.C. and Barcelona, 378 p.

Rodgers, W.A. 1991. *Technique for Wildlife Census in India: A field Manual*. Technical Manual. TM2. Wildlife Institute of India, Dehradun. India, 81 p.

Rodgers, W.A. and Panwar, H.S. 1988. *Planning a Wildlife Protected Area Network in India*. 2 Vols. Project FO: IND/82/003. FAO, Dehra Dun, 606 p.

Rosenstock, S.S., Anderson, D., Giesen, R., Kenneth, M., Leukering, T. and Carter, M.F. 2002. Landbird Counting Techniques: Current Practices and an Alternative. *The Auk* 119 (1): 46–53.

Rusanov, A.G., Stanislavskaya, E.V and Acs, E. 2012. Periphytic algal assemblages along environmental gradients in the rivers of the Lake Ladoga basin, Northwestern Russia: Implication for the water quality assessment. *Hydrobiologia* 695: 305–327.

Saha, D. and Sundriyal, R.C. 2013. Perspectives of tribal communities on NTFP resource use in a global hotspot: implications for adaptive management. *Journal of Natural Sciences Research* 3 (4): 125-169.

Saha, S.B., Bhattacharya, S.B. and Choudhary, A. 2000. Diversity of phytoplankton of a sewage pollution brackish water tidal ecosystem. *Journal of Environmental Biology* 21: 1: 9-14.

Sale, J.B. and Berkmuller, K. 1988. Manual of Wildlife Techniques for India. FAO, United Nation's India Establishment of Wildlife Institute of India Dehradun.

Sarma, K., Sarma, R.K. and Barik, S.K. 2012. Soil erosion vulnerability mapping of Nokrek Biosphere Reserve, Meghalaya using geographic information system. *Disaster and Development* 6 (1 & 2): 19-32.

SBSAP. 2005. State Biodiversity Strategy and Action Plan Reports for Arunachal Pradesh, Assam, Manipur Meghalaya, Mizoram, Nagaland and Sikkim.

Schneider, D.M., Godschalk, D.R. and Axler, N. 1978. The Carrying Capacity Concept as a Planning Tool. American Planning Association, Planning Advisory Service Report 338, Chicago.

Shannon, C.E. and Wiener, W. 1963. *The Mathematical Theory of Communities*. University of Illinois Press, Urbana, Illinois, 117 p.

Sharma, B.K. and Sharma, S. 1987. On species of genus *Lepadella* (Eurotatoria: Monogononta: Colurellidae) from north-eastern India, with remarks on Indian taxa. *Hydrobiologia* 147: 15-22.

Sharma, G., Kamalakannan, M. and Venkataraman, K. 2014. A checklist of mammals of India with their distribution and conservation status. The Director, *Zoological Survey of India,* Kolkata-700 053, India. *ZSI e-publication,* 123 p.

Siangbood, H. and Ramanujam, P. 2014. Effect of anthropogenic activities on algal assemblages in Umiew River, Meghalaya. *Phykos* 44 (1): 41-51.

Simpson, E.H. 1949. Measurement of diversity. *Nature* 163: 688.

Singh, D.N. 2001. Status and distribution of primates in Arunachal Pradesh. *ENVIS Bulletin: Wildlife and Protected Areas* 1: 113–119.

Singh, P. 1994. Recent bird records from Arunachal Pradesh. *Forktail* 10: 65–104.

Singh, R.K. 2013. Ecoculture and subsistence living of Monpa community in the eastern Himalayas: An ethnoecological study in Arunachal Pradesh. *Indian Journal of Traditional Knowledge* 12 (3): 441-453.

Singh, R.K. and Sureja, A.K. 2006. Community knowledge and sustainable natural resources management: Learning from Monpa tribe of Arunachal Pradesh, TD: *The Journal for Transdisciplinary Research in Southern Africa*, Northwest University, Norway, 2 (1): 73-102.

Sinha, A., Datta, A., Madhusudan, M.D. and Mishra, C. 2005. *Macaca munzala*: A new species from western Arunachal Pradesh, North-eastern India. *International Journal of Primatology* 26: 977–989.

Sinha, A., Kumar, R.S., Gama, N., Madhusudan, M.D. and Mishra, C. 2006. Distribution and conservation status of the Arunachal Macaque, *Macaca munzala*, in western Arunachal Pradesh, north-eastern India. *Primate Conservation* 21: 145–148.

Solanki, G.S. and Chutia, P. 2004. Ethno-zoological and socio-cultural aspects of Monpas of Arunachal Pradesh. *Journal of Human Ecology* 15: 251–254.

Sridharan, U. 1989. *Comparative Ecology of Resident Ducks in Keoladeo National Park, Bharatpur*. Ph.D. Dissertation, University of Bombay, Bombay.

Statistical Abstract of Arunachal Pradesh, 2006. Director Directorate of Economics and Statistics. Government of Arunachal Pradesh, Itanagar.

Statistical Abstract of Arunachal Pradesh, 2011. Director Directorate of Economics and Statistics. Government of Arunachal Pradesh, Itanagar.

Steinkamp, M., Peterjohn., Bryd, H.V., Carter, H. and Lowe, R. 2003. Breeding season survey techniques for sea birds and colonial water birds throughout North America. <www.im.nbs.gov/cwb/manual/>.

Stevenson, R.J. 1990. Benthic algal community dynamics in a stream during and after a spate. *Journal of the North American Benthological Society* 9: 277-288.

Stevenson, R.J. and Pan, Y. 1999. *Assessing environmental conditions in rivers and streams with diatoms*. In: Stoermer, E.F. and Smol, J.P. (Eds.), *The Diatoms: Applications for the Environmental and Earth Sciences*. Cambridge University Press, New York, pp. 11-40.

Tag, H., Murtem, G., Das, A.K. and Singh, R.K. 2008. Diversity and distribution of ethno-medicinal plants used by the Adi Tribe in East Siang District of Arunachal Pradesh, India. *Pleione* 2: 123–136.

Talwar, P.K. and Jhingran, A.G. 1991. *Inland Fishes of India and Adjacent Countries*. Vol. 1, Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi-Calcutta, pp. 263-264.

Thomas, P. and Farjon, A. 2011. *Taxus wallichiana*. The IUCN Red List of Threatened Species. Version 2014.3. <www.iucnredlist.org>.

Thompson, I.D., Davidson, I.J., O'Donnell, S. and Brazeau, F. 1989. Use of track transect to measure the relative occurrence of some boreal mammals in uncut forest and regeneration stands. *Canadian Journal of Zoology* 67: 1816-1823.

Thompson, W.L. 2002. Towards reliable bird surveys: accounting for individuals present but not deleted. *The Auk* 119: 18-25.

Tiffany, L.H. and Britton, M.E. 1952. *The Algae of Illinois*: University of Chicago Press, Chicago, 407 p.

Tilman, D., Wedin, D. and Knops, J. 1996.Productivity and sustainability influenced by biodiversity in grassland ecosystems. Nature 379: 718-720

Turner, I.M., Chia, K.S. Ong, J.S.Y., Soong, B.C. and Tan, H.T.W. 1996. A century of plant species loss from an isolated fragment of lowland tropical rain forest. *Conservation Biology* 10: 1229-1244.

United Nations, 1976. *River Basin Development: Policies and Planning, Vol. I.* Proceedings of a UN Interregional Seminar on River Basin and Interbasin Development September 16-26, 1975, Budapest. UNDP/National Water Authority of Hungary, Washington, DC.

United Nations, 2006. Global Survey of Early Warning Systems. A Report Prepared By UNISDR at the Request of the Secretary–General of the United Nations. Geneva: UNISDR–<www.unisdr.org/ppew/info-resources/ewc3/Global–Survey–of–Early–Warning–Systems.pdf>.

Vance, E.D., Brookes, P.C. and Jenkinson, D.S. 1987. An extraction method for measuring soil microbial biomass–C. *Soil Biology and Biochemistry* 19: 703–707.

Van der Drift, J. 1951. Analysis of the animal community in a beech forest floor. *Tijdschrift voor entomologie* 94: 1-168.

Vollenweider, R.A. 1969. *A manual on methods for measuring primary production in aquatic environments.* IBP handbook 12. Burgess and Son, Abingdon, UK.

Wallwork, J.A. 1970. *Ecology of Soil Animals*. McGraw-Hill, London, 283 p.

Walter, K.S. and Gillett, H.J. 1998. IUCN Red List of Threatened Plants. World Conservation Monitoring Centre. IUCN, Gland, Switzerland.

Welsh, H.H. Jr. 1987. Monitoring herpetofauna in woodlands of north western California and south west Oregon: a comparative strategy. In: *Multiple–Use Management of California's hardwood resources*. T.R. Plumb, N.H. Pillisbury Gen. Tech. Regional Environmental Planning. PSW–100) US Department of Agriculture, Forest Service, pp. 203-213.

Wetzel, R.G. and Likens, G.E. 2000. *Limnological Analysis*. 3rd Edition. Springer-Verlag, New York, NY.

Wilcox, B.A. 1980. *Insular ecology and conservation*. In: M.A. Saunders, (Ed.), *An evolutionary–ecological perspective*. Sinauer, pp. 95-117.

Wilcox, B.A. and Murphy, D.D. 1985. Conservation strategy: the effect of fragmentation on extinction. *American Naturalist* 125: 879-887.

Wood, C., Barker, A.J. and Jones C.E. 1997. Cumulative effects and EIA, *EIA Newsletter* 14. University of Manchester, UK.

World Commission on Dams, 2000. Dams and Development, a New Framework for Decision–Making. The Report of the World Commission on Dams. Earthscan Publications Ltd., London/Sterling, VA.

Yap, N. 1989. Round the Peg or Square the Hole? Populist, Technocrats and Environmental Assessment in Third World Countries. *Impact Assessment Bulletin* 8: 69–84.

Yonzon, P.B., 1989. *Ecology and Conservation of the Red Panda in the Nepal-Himalayas*. Ph.D. Dissertation, University of Maine.

Zafar-ul Islam, M. and Rahmani, A.R. 2005. *Important Bird Areas in India: Priority Sites for Conservation*. IBCN, *Bombay Natural History Society*, Mumbai.

SECTION IX

APPENDICES

Appendix II. 3.1: List of plant species recorded from Tsa chu–I HEP site

Sl. No.	Species name	Family
TREES		
1	*Abies densa*	Pinaceae
2	*Acer* sp.	Aceraceae
3	*Betula alnoides*	Betulaceae
4	*Junipers* sp.	Cupressaceae
5	*Quercus* sp.	Fagaceae
6	*Rhododendron* sp.	Ericaceae
SHRUBS		
7	*Berberis* sp.	Berberidaceae
8	*Daphne papyracea*	Thymelaeaceae
9	*Elaeagnus parviflora*	Elaegnaceae
10	*Pogostemon* sp.	Lamiaceae
11	*Rosa* sp.	Rosaceae
12	*Rubus ellipticus*	Rosaceae
13	*Salix* sp.	Salicaceae
HERBS		
14	*Aconogonum alpinum*	Polygonaceae
15	*Ainsliaea* sp.	Asteraceae
16	*Arisaema nepenthoides*	Araceae
17	*Elsholtzia* sp.	Lamiaceae
18	*Elsholtzia strobilifera*	Lamiaceae
19	*Fragaria* sp.	Rosaceae
20	*Galinsoga parviflora*	Asteraceae
21	*Galium* sp.	Rubiaceae
22	*Gentiana capitata*	Gentianaceae
23	*Geranium nepalense*	Geraniaceae
24	*Hemiphragma heterophyllum*	scrophulariaceae
25	*Impatiens* sp.	Balsaminaceae
26	*Leontopodium stracheyi*	Asteraceae
27	*Meconopsis* sp.	*Papaveraceae*
28	*Panax* sp.	Araliaceae
29	*Persicaria* sp.	Polygonaceae
30	*Pilea umbrosa*	Urticaceae
31	*Pogostemon* sp.	Lamiaceae
32	*Polygonum hydropiper*	Polygonaceae
33	*Potentilla cuneata*	Rosaceae
34	*Pouzolzia* sp.	Urticaceae
35	*Primula denticulata*	Primulaceae
36	*Primula* sp.	Primulaceae
37	*Prunella vulgaris*	Lamiaceae
38	*Ranunculus* sp.	Ranunculaceae
39	*Rumex nepalensis*	Polygonaceae
40	*Sambucus adnata*	Caprifoliaceae
41	*Senecio cappa*	Asteraceae
42	*Stellaria* sp.	Caryophyllaceae
43	*Swertia* sp.	Gentianaceae
44	*Viola sikkimensis*	Violaceae
CLIMBERS		
45	*Clematis montana*	Ranunculaceae
46	*Clematis* sp.	Ranunculaceae
47	*Hedera nepalensis*	Araliaceae
ORCHIDS		
48	*Bulbophyllum* sp.	Orchidaceae
PTERIDOPHYTES		
49	*Adiantum* sp.	Adiantaceae
50	*Dryopteris serrato–dentata*	Dryopteridaceae
51	*Equisetum diffusum*	Equisetaceae
52	*Equisetum* sp.	Equisetaceae
53	*Lycopodium japonicum*	Lycopodiaceae
54	*Mecodium badium*	Hymenophyllaceae
55	*Selaginella tenuifolia*	Selaginellaceae
56	*Selaginella indica*	Selaginellaceae
57	*Vittaria flexuosa*	Vittariaceae
BRYOPHYTES		
58	*Brachymenium* sp.	Bryaceae

Sl. No.	Species name	Family
59	*Bryum billardieri*	Bryaceae
60	*Funaria* sp.	Funariaceae
61	*Marchantia* sp.	Marchantiaceae
LICHENS		
62	*Aspicilia* sp.	Megasporaceae
63	*Cladia aggregata*	Cladoniaceae
64	*Cladonia coccifera*	Cladoniaceae
65	*Stereocaulon* sp.	Stereocaulaceae
66	*Usnea dasaea*	Parmeliaceae
FUNGI		
67	*Boletus reticulatus*	Boletaceae
68	*Clathrus rubra*	Phallaceae
69	*Daldinia concentrica*	Xylariaceae
70	*Gloeophyllum sepiarium*	Gloeophyllaceae
71	*Hericium erinaceus*	Hericiaceae
72	*Laccaria laccata*	Hydnangiaceae
73	*Lactarius rubidus*	Russulaceae
74	*Polyporus arcularius*	Polyporaceae
75	*Poria monticola*	Polyporaceae
76	*Pycnoporellus fibrillosus*	Formitopscidaceae
77	*Strobilomyces strobilaceus*	Boletaceae
78	*Thelephora penicillata*	Thelephoraceae
79	*Tremella mesenterica*	Tremellaceae
80	*Xylaria polymorpha*	Xylariaceae
81	*Coprinus disseminatus*	Agaricaceae
82	*Hydnum repandum*	Hydnaceae
83	*Schizophyllum commune*	Schizophyllaceae

Appendix II. 3.2: Different groups of plant species present at Tsa chu–I HEP site

Sl. No.	Species name Barrage and Powerhouse	Family	Sl. No.	Species name Catchment area	Family
CLIMBERS					
1	*Clematis montana*	Ranunculaceae	1	*Clematis montana*	Ranunculaceae
2	*Clematis* sp.	Ranunculaceae	2	*Hedera nepalensis*	Araliaceae
3	*Hedera nepalensis*	Araliaceae			
ORCHIDS					
1	*Bulbophyllum* sp.	Orchidaceae	1	*Bulbophyllum* sp.	Orchidaceae
PTERIDOPHYTES					
1	*Adiantum* sp.	Adiantaceae	1	*Adiantum* sp.	Adiantaceae
2	*Dryopteris serrato–dentata*	Dryopteridaceae	2	*Dryopteris serrato–dentata*	Dryopteridaceae
3	*Equisetum diffusum*	Equisetaceae	3	*Lycopodium japonicum*	Lycopodiaceae
4	*Equisetum* sp.	Equisetaceae	4	*Selaginella indica*	Selaginellaceae
5	*Lycopodium japonicum*	Lycopodiaceae	5	*Vittaria flexuosa*	Vittariaceae
6	*Mecodium badium*	Hymenophyllaceae			
7	*Selaginella tenuifolia*	Selaginellaceae			
8	*Selaginella indica*	Selaginellaceae			
9	*Vittaria flexuosa*	Vittariaceae			
BRYOPHYTES					
1	*Brachymenium* sp.	Bryaceae	1	*Brachymenium* sp.	Bryaceae
2	*Bryum billardieri*	Bryaceae	2	*Bryum billardieri*	Bryaceae
3	*Funaria* sp.	Funariaceae	3	*Funaria* sp.	Funariaceae
4	*Marchantia* sp.	Marchantiaceae	4	*Marchantia* sp.	Marchantiaceae
LICHENS					
1	*Aspicilia* sp.	Megasporaceae	1	*Aspicilia* sp.	Megasporaceae
2	*Cladia aggregata*	Cladoniaceae	2	*Cladia aggregata*	Cladoniaceae
3	*Cladonia coccifera*	Cladoniaceae	3	*Stereocaulon* sp.	Stereocaulaceae
4	*Stereocaulon* sp.	Stereocaulaceae	4	*Usnea dasaea*	Parmeliaceae
5	*Usnea dasaea*	Parmeliaceae			

Appendix II. 3.3: Species list of macro–fungi recorded from barrage and powerhouse sites of Tsa chu–I

Species	Family	Species	Family
Barrage		**Powerhouse**	
Boletus reticulatus	Boletaceae	*Boletus reticulatus*	Boletaceae
Clathrus rubra	Phallaceae	*Clathrus rubra*	Phallaceae
Daldinia concentrica	Xylariaceae	*Coprinus disseminatus*	Agaricaceae
Gloeophyllum sepiarium	Gloeophyllaceae	*Gloeophyllum sepiarium*	Gloeophyllaceae
Hericium erinaceus	Hericiaceae	*Hydnum repandum*	Hydnaceae
Laccaria laccata	Hydnangiaceae	*Lactarius rubidus*	Russulaceae
Lactarius rubidus	Russulaceae	*Polyporus arcularius*	Polyporaceae
Polyporus arcularius	Polyporaceae	*Schizophyllum commune*	Schizophyllaceae
Poria monticola	Polyporaceae	*Strobilomyces strobilaceus*	Boletaceae
Pycnoporellus fibrillosus	Formitopscidaceae	*Tremella mesenterica*	Tremellaceae
Strobilomyces strobilaceus	Boletaceae		
Thelephora penicillata	Thelephoraceae		
Tremella mesenterica	Tremellaceae		
Xylaria polymorpha	Xylariaceae		
Catchment area			
Boletus reticulatus	Boletaceae		
Clathrus rubra	Phallaceae		
Coprinus disseminatus	Agaricaceae		
Daldinia concentrica	Xylariaceae		
Gloeophyllum sepiarium	Gloeophyllaceae		
Hericium erinaceus	Hericiaceae		
Hydnum repandum	Hydnaceae		
Laccaria laccata	Hydnangiaceae		
Lactarius rubidus	Russulaceae		
Polyporus arcularius	Polyporaceae		
Poria monticola	Polyporaceae		
Pycnoporellus fibrillosus	Formitopscidaceae		
Schizophyllum commune	Schizophyllaceae		
Strobilomyces strobilaceus	Boletaceae		
Tremella mesenterica	Tremellaceae		
Xylaria polymorpha	Xylariaceae		

Appendix II. 3.4: Frequency, density, basal area and IVI for tree species in Tsa chu–I barrage site

Sl. No.	Species name	Post–monsoon				Monsoon				Winter			
		Fr.	**Dn.**	**BA**	**IVI**	**Fr.**	**Dn.**	**BA**	**IVI**	**Fr.**	**Dn.**	**BA**	**IVI**
1	*Abies densa*	70	170	2.94	111.32	70	170	2.94	111.32	70	170	2.94	111.32
2	*Acer* sp.	30	60	1.10	42.70	30	60	1.10	42.70	30	60	1.10	42.70
3	*Betula alnoides*	40	80	1.32	54.89	40	80	1.32	54.89	40	80	1.32	54.89
4	*Junipers* sp.	20	40	0.35	22.95	20	40	0.35	22.95	20	40	0.35	22.95
5	*Quercus* sp.	20	50	0.57	28.24	20	50	0.57	28.24	20	50	0.57	28.24
6	*Rhododendron* sp.	30	70	0.76	39.94	30	70	0.76	39.94	30	70	0.76	39.94
Total		**210**	**470**	**7.02**	**300**	**210**	**470**	**7.02**	**300**	**210**	**470**	**7.02**	**300**

Fr.–Frequency percentage, Dn.–Density (ha^{-1}), BA–Basal area ($m^2\ ha^{-1}$), IVI–Importance value index

Appendix II. 3.5: Frequency, density and IVI of shrubs in Tsa chu–I barrage site

Sl. No.	Species name	Post–monsoon			Monsoon			Winter		
		Fr.	**Dn.**	**IVI**	**Fr.**	**Dn.**	**IVI**	**Fr.**	**Dn.**	**IVI**
1	*Berberis* sp.	12	112	20.49	12	112	20.49	12	112	20.49
2	*Daphne papyracea*	24	128	31.45	24	128	31.45	24	128	31.45
3	*Elaeagnus parviflora*	16	96	22.02	16	96	22.02	16	96	22.02
4	*Pogostemon* sp.	8	64	12.60	8	64	12.60	8	64	12.60
5	*Rosa* sp.	24	304	48.91	24	304	48.91	24	304	48.91
6	*Rubus ellipticus*	12	64	15.72	12	64	15.72	12	64	15.72
7	*Salix* sp.	32	240	48.81	32	240	48.81	32	240	48.81
Total		**128**	**1008**	**200**	**128**	**1008**	**200**	**128**	**1008**	**200**

Fr.–Frequency percentage, Dn.–Density (ha^{-1}), IVI–Importance value index

Appendix II. 3.6: Frequency, density and IVI of herbs in Tsa chu–I barrage site

Sl. No.	Species name	Post–monsoon			Monsoon			Winter		
		Fr.	**Dn.**	**IVI**	**Fr.**	**Dn.**	**IVI**	**Fr.**	**Dn.**	**IVI**
1	*Aconogonum alpinum*				24	8400	7.57	20	4400	18.89
2	*Ainsliaea* sp.	28	11200	20.08	48	12400	12.77	44	9200	40.58
3	*Arisaema nepenthoides*				28	6000	6.79			
4	*Elsholtzia* sp.	32	8400	18.18	20	4400	4.91			
5	*Fragaria* sp.	28	9200	17.91	36	12800	11.46			
6	*Galinsoga parviflora*	20	4800	10.88	16	4400	4.40			
7	*Galium* sp.	24	5600	12.88	28	5200	6.36			
8	*Gentiana capitata*				20	4400	4.91	20	3200	16.42
9	*Geranium nepalensis*				28	6000	6.79			
10	*Hemiphragma heterophyllum*	24	5200	12.45	60	14800	15.59	48	18000	60.72
11	*Impatiens* sp.	24	4800	12.01	48	7600	10.20			
12	*Leontopodium stracheyi*	8	1600	4.00	16	3600	3.97	16	3600	15.28
13	*Meconopsis* sp.				12	2800	3.03			
14	*Panax* sp.				76	18800	19.78			
15	*Persicaria* sp.	16	2800	7.58	28	5200	6.36			
16	*Pilea umbrosa*	28	10800	19.64	28	10000	8.94			
17	*Pogostemon* sp.	12	2800	6.44	28	4800	6.15	24	3600	19.20
18	*Polygonum hydropiper*	16	3600	8.44	12	3600	3.46			
19	*Potentilla cuneata*	28	6400	14.88	8	2000	2.09			
20	*Pouzolzia* sp.				28	4800	6.15			
21	*Primula denticulata*				16	2800	3.54			
22	*Primula* sp.				8	2000	2.09	12	2800	11.67
23	*Prunella vulgaris*	16	4800	9.74	24	6000	6.28	20	3600	17.24
24	*Ranunculus* sp.	12	2800	6.44	20	5200	5.34			
25	*Rumex nepalensis*	24	4400	11.58	36	6400	8.03			
26	*Sambucus adnata*				24	4800	5.64			
27	*Senecio cappa*				12	2800	3.03			
28	*Stellaria* sp.				28	8400	8.08			
29	*Swertia* sp.				12	3200	3.25			
30	*Viola sikkimensis*	12	3200	6.87	12	2800	3.03			
Total		**352**	**92400**	**200**	**784**	**186400**	**200**	**204**	**48400**	**200**

Fr.–Frequency percentage, Dn.–Density (ha^{-1}), IVI–Importance value index

Appendix II. 3.7: Frequency, density, basal area and IVI for tree species in Tsa chu–I powerhouse site

Sl. No.	Species name	Post–monsoon				Monsoon				Winter			
		Fr.	**Dn.**	**BA**	**IVI**	**Fr.**	**Dn.**	**BA**	**IVI**	**Fr.**	**Dn.**	**BA**	**IVI**
1	*Abies densa*	70	160	1.92	91.56	70	160	1.92	91.56	70	160	1.92	91.56
2	*Acer* sp.	50	90	1.52	62.62	50	90	1.52	62.62	50	90	1.52	62.62
3	*Betula alnoides*	30	40	1.11	37.72	30	40	1.11	37.72	30	40	1.11	37.72
4	*Junipers* sp.	50	80	0.49	44.04	50	80	0.49	44.04	50	80	0.49	44.04
5	*Quercus* sp.	20	30	0.23	17.81	20	30	0.23	17.81	20	30	0.23	17.81
6	*Rhododendron* sp.	40	70	1.01	46.33	40	70	1.01	46.33	40	70	1.01	46.33
Total		**260**	**470**	**6.29**	**300**	**260**	**470**	**6.29**	**300**	**260**	**470**	**6.29**	**300**

Fr.–Frequency percentage, Dn.–Density (ha^{-1}), BA–Basal area (m^2 ha^{-1}), IVI–Importance value index

Appendix II. 3.8: Frequency, density and IVI of shrubs in Tsa chu–I powerhouse site

Sl. No.	Species name	Post–monsoon			Monsoon			Winter		
		Fr.	**Dn.**	**IVI**	**Fr.**	**Dn.**	**IVI**	**Fr.**	**Dn.**	**IVI**
1	*Berberis* sp.	16	112	23.11	16	112	23.11	16	112	23.11
2	*Daphne papyracea*	24	128	30.87	24	128	30.87	24	128	30.87
3	*Elaeagnus parviflora*	12	112	19.98	12	112	19.98	12	112	19.98
4	*Pogostemon* sp.	12	80	16.95	12	80	16.95	12	80	16.95
5	*Rosa* sp.	20	288	42.90	20	288	42.90	20	288	42.90
6	*Rubus ellipticus*	12	80	16.95	12	80	16.95	12	80	16.95
7	*Salix* sp.	32	256	49.24	32	256	49.24	32	256	49.24
Total		**128**	**1056**	**200**	**128**	**1056**	**200**	**128**	**1056**	**200**

Fr.–Frequency percentage, Dn.–Density (ha^{-1}), IVI–Importance value index

Appendix II. 3.9: Frequency, density and IVI of herbs in Tsa chu–I powerhouse site

Sl. No.	Species name	Post–monsoon			Monsoon			Winter		
		Fr.	**Dn.**	**IVI**	**Fr.**	**Dn.**	**IVI**	**Fr.**	**Dn.**	**IVI**
1	*Aconogonum alpinum*							16	5200	17.62
2	*Ainsliaea* sp.	24	11200	23.17	44	12800	15.61	52	10800	45.46
3	*Arisaema nepenthoides*				24	6400	8.16			
4	*Elsholtzia strobilifera*	28	8400	21.28	16	4800	5.77			
5	*Fragaria* sp.	24	9200	20.71	32	13200	13.74			
6	*Galinsoga parviflora*	16	4800	12.16	12	4800	5.06			
7	*Galium* sp.	20	5600	14.71						
8	*Gentiana capitata*				16	4800	5.77	12	2000	9.54
9	*Geranium nepalensis*				24	6400	8.16			
10	*Hemiphragma heterophyllum*	20	5200	14.22	56	15200	19.20	56	19600	64.40
11	*Impatiens* sp.	20	4800	13.72	44	8000	12.66			
12	*Leontopodium stracheyi*	8	1600	5.10	12	4000	4.57	16	3600	14.52
13	*Meconopsis* sp.				8	3200	3.37			
14	*Panax* sp.				72	19200	24.47			
15	*Persicaria* sp.				24	5600	7.67			
16	*Pilea umbrosa*	24	10800	22.68	24	10000	10.37			
17	*Polygonum hydropiper*				8	3600	3.62			
18	*Pogostemon* sp.	8	2800	6.57				24	3600	18.30
19	*Potentilla cuneata*	24	6400	17.26	4	2000	1.93			
20	*Pouzolzia* sp.				24	4800	7.17			
21	*Primula denticulata*				12	2800	3.83			
22	*Primula* sp.							16	3200	13.75
23	*Prunella vulgaris*				20	6000	7.21	20	3600	16.41
24	*Ranunculus* sp.	8	2800	6.57	16	5200	6.01			
25	*Rumex nepalensis*	20	4400	13.23	32	6400	9.57			
26	*Sambucus adnata*				20	4800	6.47			
27	*Senecio cappa*				8	2800	3.13			
28	*Swertia* sp.				8	3200	3.37			
29	*Viola sikkimensis*	12	3200	8.63	8	2800	3.13			
Total		**256**	**81200**	**200**	**568**	**162800**	**200**	**212**	**51600**	**200**

Fr.–Frequency percentage, Dn.–Density (ha^{-1}), IVI–Importance value index

Appendix II. 3.10: Frequency, density, basal area and IVI for tree species in Tsa chu–I catchment area

Sl. No.	Species name	Post–monsoon				Monsoon				Winter			
		Fr.	**Dn.**	**BA**	**IVI**	**Fr.**	**Dn.**	**BA**	**IVI**	**Fr.**	**Dn.**	**BA**	**IVI**
1	*Abies densa*	70	210	3.33	96.06	70	210	3.33	96.06	70	210	3.33	96.06
2	*Acer* sp.	50	90	1.24	46.68	50	90	1.24	46.68	50	90	1.24	46.68
3	*Betula alnoides*	30	50	1.51	35.23	30	50	1.51	35.23	30	50	1.51	35.23
4	*Junipers* sp.	60	110	0.88	50.02	60	110	0.88	50.02	60	110	0.88	50.02
5	*Quercus* sp.	30	50	2.00	40.35	30	50	2.00	40.35	30	50	2.00	40.35
6	*Rhododendron* sp.	30	80	0.67	31.67	30	80	0.67	31.67	30	80	0.67	31.67
Total		**270**	**590**	**9.63**	**300**	**270**	**590**	**9.63**	**300**	**270**	**590**	**9.63**	**300**

Fr.–Frequency percentage, Dn.–Density (ha^{-1}), BA–Basal area (m^2 ha^{-1}), IVI–Importance value index

Appendix II. 3.11: Frequency, density and IVI of shrubs in Tsa chu–I catchment area

Sl. No.	Species name	Post–monsoon			Monsoon			Winter		
		Fr.	**Dn.**	**IVI**	**Fr.**	**Dn.**	**IVI**	**Fr.**	**Dn.**	**IVI**
1	*Berberis* sp.	8	112	20.57	8	112	20.57	8	112	20.57
2	*Daphne papyracea*	20	128	35.84	20	128	35.84	20	128	35.84
3	*Elaeagnus parviflora*	8	112	20.57	8	112	20.57	8	112	20.57
4	*Rosa* sp.	16	304	49.33	16	304	49.33	16	304	49.33
5	*Rubus ellipticus*	8	80	17.29	8	80	17.29	8	80	17.29
6	*Salix* sp.	28	240	56.41	28	240	56.41	28	240	56.41
Total		**88**	**976**	**200**	**88**	**976**	**200**	**88**	**976**	**200**

Fr.–Frequency percentage, Dn.–Density (ha^{-1}), IVI–Importance value index

Appendix II. 3.12: Frequency, density and IVI of herbs in Tsa chu–I catchment area

Sl. No.	Species name	Post–monsoon			Monsoon			Winter		
		Fr.	Dn.	IVI	Fr.	Dn.	IVI	Fr.	Dn.	IVI
1	*Aconogonum alpinum*				20	8800	7.34	28	4800	22.73
2	*Ainsliaea* sp.	32	11600	20.25	44	12800	12.85	44	9600	40.00
3	*Arisaema nepenthoides*				24	6400	6.71			
4	*Elsholtzia* sp.	36	8800	18.18	16	4800	4.74			
5	*Fragaria* sp.	32	9600	18.08	32	13200	11.30			
6	*Galinsoga parviflora*	24	5200	11.40	16	4800	4.74			
7	*Galium* sp.	28	6000	13.22	24	5600	6.31			
8	*Gentiana capitata*				16	4800	4.74	24	3600	18.41
9	*Geranium nepalensis*				24	6400	6.71			
10	*Hemiphragma heterophyllum*	28	5600	12.79	56	15200	15.80	48	16400	55.98
11	*Impatiens* sp.	28	5200	12.36	44	8000	10.43			
12	*Leontopodium stracheyi*	8	1200	3.22	12	4000	3.76	20	3600	16.59
13	*Meconopsis* sp.				8	3200	2.78			
14	*Panax* sp.				72	19200	20.14			
15	*Persicaria* sp.	20	2400	7.41	24	5600	6.31			
16	*Pilea umbrosa*	32	10400	18.95	24	10400	8.73			
17	*Pogostemon* sp.	16	2400	6.44	24	5200	6.11	24	3600	18.41
18	*Polygonum hydropiper*	20	3200	8.27	8	4000	3.18			
19	*Potentilla cuneata*	32	6000	14.19	12	2400	2.95			
20	*Pouzolzia* sp.				24	5200	6.11			
21	*Primula denticulata*				12	3200	3.36	16	2800	13.11
22	*Primula* sp.				8	2400	2.37	16	3600	14.77
23	*Prunella vulgaris*	20	4400	9.57	20	6400	6.13			
24	*Ranunculus* sp.	16	2800	6.88	16	5600	5.15			
25	*Rumex nepalensis*	28	4400	11.49	32	6800	8.08			
26	*Sambucus adnata*				20	5200	5.53			
27	*Senecio cappa*				8	3200	2.78			
28	*Stellaria* sp.				24	8800	7.92			
29	*Swertia* sp.				16	3600	4.14			
30	*Viola sikkimensis*	16	3200	7.31	8	3200	2.78			
Total		**416**	**92400**	**200.00**	**688**	**198400**	**200.00**	**220**	**48000**	**200.00**

Fr.–Frequency percentage, Dn.–Density (ha^{-1}), IVI–Importance value index

Appendix II. 3.13: Dominant and Co–dominant species determined on the basis of IVI/density values of species in the plant community at Tsa chu–I

Community components	Barrage	Powerhouse	Catchment area
Tree species: *			
Dominant	*Abies densa*	*Abies densa*	*Abies densa*
Co–Dominant	*Larix griffithiana*	*Acer* sp.	*Junipers* sp.
Shrub species: **			
Dominant	*Rosa* sp.	*Rosa* sp.	*Rosa* sp.
Co–Dominant	*Salix* sp.	*Salix* sp.	*Salix* sp.
Herb species: **			
i. Post monsoon season			
Dominant	*Ainsliaea* sp.	*Hemiphragma heterophyllum*	*Hemiphragma heterophyllum*
Co–Dominant	*Hemiphragma heterophyllum*	*Ainsliaea* sp.	*Ainsliaea* sp.
ii. Monsoon season			
Dominant	*Hemiphragma heterophyllum*	*Panax bipinnatifidus*	*Panax bipinnatifidus*
Co–Dominant	*Panax bipinnatifidus*	*Hemiphragma heterophyllum*	*Hemiphragma heterophyllum*
iii. Winter season			
Dominant	*Ainsliaea* sp.	*Ainsliaea* sp.	*Ainsliaea* sp.
Co–Dominant	*Pilea umbrosa*	*Pilea umbrosa*	*Pilea umbrosa*
* Dominance is based on density values			

* Dominance based on IVI; ** Dominance based on density

Appendix II. 3.14: List of plant species recorded from Tsa chu–I Lower sites

Sl. No.	Species name	Family
TREES		
1	*Abies densa*	Pinaceae
2	*Acer* sp.	Aceraceae
3	*Betula utilis*	Betulaceae
4	*Junipers* sp.	Cupressaceae
5	*Quercus* sp.	Fagaceae
6	*Rhododendron* sp.	Ericaceae
SHRUBS		
7	*Berberis* sp.	Berberidaceae
8	*Daphne papyracea*	Thymelaeaceae
9	*Eleagnus parviflora*	Elaegnaceae
10	*Pogostemon* sp.	Lamiaceae
11	*Rosa* sp.	Rosaceae
12	*Rubus ellipticus*	Rosaceae
13	*Salix* sp.	Salicaceae
HERBS		
14	*Aconogonum alpinum*	Polygonaceae
15	*Aconitum ferox*	Ranunculaceae
16	*Aconitum heterophyllum*	Ranunculaceae
17	*Ainsliaea* sp.	Asteraceae
18	*Arisaema nepenthoides*	Araceae
19	*Elsholtzia strobilifera*	Lamiaceae
20	*Fragaria* sp.	Rosaceae
21	*Galinsoga parviflora*	Asteraceae
22	*Galium* sp.	Rubiaceae
23	*Gentiana capitata*	Gentianaceae
24	*Geranium nepalensis*	Geraniaceae
25	*Hemiphragma heterophyllum*	Scrophulariaceae
26	*Impatiens* sp.	Balsaminaceae
27	*Leontopodium stracheyi*	Asteraceae
28	*Meconopsis* sp.	Papaveraceae
29	*Panax bipinnatifidus*	Araliaceae
30	*Paris polyphylla*	Trilliaceae
31	*Persicaria* sp.	Polygonaceae
32	*Pilea umbrosa*	Urticaceae
33	*Pogostemon* sp.	Lamiaceae
34	*Polygonum hydropiper*	Polygonaceae
35	*Potentilla cuneata*	Rosaceae
36	*Primula denticulata*	Primulaceae
37	*Primula* sp.	Primulaceae
38	*Prunella vulgaris*	Lamiaceae
39	*Ranunculus* sp.	Ranunculaceae
40	*Rumex nepalensis*	Polygonaceae
41	*Sambucus adnata*	Polygonaceae
42	*Senecio cappa*	Caprifoliaceae
43	*Stellaria* sp.	Caryophyllaceae
44	*Swertia* sp.	Gentianaceae
45	*Viola sikkimensis*	Violaceae
CLIMBERS		
46	*Clematis montana*	Ranunculaceae
47	*Clematis* sp.	Ranunculaceae
48	*Hedera nepalensis*	Araliaceae
ORCHIDS		
49	*Bulbophyllum* sp.	Orchidaceae
PTERIDOPHYTES		
50	*Adiantum venustum*	Adiantaceae
51	*Dryopteris serrato–dentata*	Dryopteridaceae
52	*Equisetum diffusum*	Equisetaceae
53	*Equisetum ramosissimum*	Equisetaceae
54	*Lycopodium japonicum*	Lycopodiaceae
55	*Mecodium badium*	Hymenophyllaceae
56	*Selaginella indica*	Selaginellaceae
57	*Selaginella tenuifolia*	Selaginellaceae
58	*Vittaria flexuosa*	Vittariaceae
59	*Dryopteris wallichiana*	Dryopteridaceae

BRYOPHYTES		
60	*Brachymenium* sp.	Bryaceae

Sl. No.	Species name	Family
61	*Bryum billardieri*	Bryaceae
62	*Funaria* sp.	Funariaceae
63	*Marchantia* sp.	Marchantiaceae
LICHENS		
64	*Aspicilia* sp.	Megasporaceae
65	*Cladia aggregata*	Cladoniaceae
66	*Cladonia coccifera*	Cladoniaceae
67	*Lobaria retigera*	Lobariaceae
68	*Stereocaulon* sp.	Stereocaulaceae
69	*Usnea dasaea*	Parmeliaceae
FUNGI		
70	*Boletus reticulatus*	Boletaceae
71	*Clathrus rubra*	Phallaceae
72	*Coprinus disseminatus*	Agaricaceae
73	*Daldinia concentrica*	Xylariaceae
74	*Gloeophyllum sepiarium*	Gloeophyllaceae
75	*Hericium erinaceus*	Hericiaceae
76	*Hydnum repandum*	Hydnaceae
77	*Phellinus schweintizii*	Hymenochaetaceae
78	*Poria monticola*	Polyporaceae
79	*Pycnoporellus fibrillosus*	Formitopscidaceae
80	*Thelephora penicillata*	Thelephoraceae
81	*Hygrocybe miniata*	Hygrophoraceae

Appendix II. 3.15: Different groups of plant species present at Tsa chu–I Lower HEP site

Sl. No.	Species name Barrage and Powerhouse	Family	Sl. No.	Species name Catchment area	Family
CLIMBERS					
1	*Clematis montana*	Ranunculaceae	1	*Clematis montana*	Ranunculaceae
2	*Clematis* sp.	Ranunculaceae	2	*Clematis* sp.	Ranunculaceae
3	*Hedera nepalensis*	Araliaceae	3	*Hedera nepalensis*	Araliaceae
ORCHIDS					
1	*Bulbophyllum* sp.	Orchidaceae	1	*Bulbophyllum* sp.	Orchidaceae
PTERIDOPHYTES					
1	*Adiantum venustum*	Adiantaceae	1	*Adiantum venustum*	Adiantaceae
2	*Dryopteris serrato–dentata*	Dryopteridaceae	2	*Dryopteris serrato–dentata*	Dryopteridaceae
3	*Equisetum diffusum*	Equisetaceae	3	*Equisetum ramosissimum*	Equisetaceae
4	*Equisetum ramosissimum*	Equisetaceae	4	*Mecodium badium*	Hymenophyllaceae
5	*Lycopodium japonicum*	Lycopodiaceae	5	*Selaginella indica*	Selaginellaceae
6	*Mecodium badium*	Hymenophyllaceae	6	*Selaginella tenuifolia*	Selaginellaceae
7	*Selaginella indica*	Selaginellaceae	7	*Vittaria flexuosa*	Vittariaceae
8	*Selaginella tenuifolia*	Selaginellaceae	8	*Dryopteris wallichiana*	Dryopteridaceae
9	*Vittaria flexuosa*	Vittariaceae			
10	*Dryopteris wallichiana*	Dryopteridaceae			
BRYOPHYTES					
1	*Brachymenium* sp.	Bryaceae	1	*Brachymenium* sp.	Bryaceae
2	*Bryum billardieri*	Bryaceae	2	*Bryum billardieri*	Bryaceae
3	*Funaria* sp.	Funariaceae	3	*Marchantia* sp.	Marchantiaceae
4	*Marchantia* sp.	Marchantiaceae			
LICHENS					
1	*Aspicilia* sp.	Megasporaceae	1	*Aspicilia* sp.	Megasporaceae
2	*Cladia aggregata*	Cladoniaceae	2	*Cladia aggregata*	Cladoniaceae
3	*Cladonia coccifera*	Cladoniaceae	3	*Lobaria retigera*	Lobariaceae
4	*Lobaria retigera*	Lobariaceae	4	*Stereocaulon* sp.	Stereocaulaceae
5	*Stereocaulon* sp.	Stereocaulaceae	5	*Usnea dasaea*	Parmeliaceae
6	*Usnea dasaea*	Parmeliaceae			

Appendix II. 3.16: Species list of macro–fungi recorded from barrage and powerhouse sites of Tsa chu–I Lower

Species	Family	Species	Family
Barrage		**Powerhouse**	
Boletus reticulatus	Boletaceae	*Boletus reticulatus*	Boletaceae
Clathrus rubra	Phallaceae	*Clathrus rubra*	Phallaceae
Coprinus disseminatus	Agaricaceae	*Coprinus disseminatus*	Agaricaceae
Daldinia concentrica	Xylariaceae	*Daldinia concentrica*	Xylariaceae
Gloeophyllum sepiarium	Gloeophyllaceae	*Hericium erinaceus*	Hericiaceae

Species	Family	Species	Family
Hericium erinaceus	Hericiaceae	*Hygrocybe miniata*	Hygrophoraceae
Hydnum repandum	Hydnaceae	*Phellinus schweintizii*	Hymenochaetaceae
Phellinus schweintizii	Hymenochaetaceae		
Poria monticola	Polyporaceae		
Pycnoporellus fibrillosus	Formitopscidaceae		
Thelephora penicillata	Thelephoraceae		
Catchment area			
Boletus reticulatus	Boletaceae		
Clathrus rubra	Phallaceae		
Coprinus disseminatus	Agaricaceae		
Daldinia concentrica	Xylariaceae		
Gloeophyllum sepiarium	Gloeophyllaceae		
Hericium erinaceus	Hericiaceae		
Hydnum repandum	Hydnaceae		
Hygrocybe miniata	Hygrophoraceae		
Phellinus schweintizii	Hymenochaetaceae		
Poria monticola	Polyporaceae		
Pycnoporellus fibrillosus	Formitopscidaceae		
Thelephora penicillata	Thelephoraceae		

Appendix II. 3.17: Frequency, density, basal area and IVI for tree species in Tsa chu–I Lower barrage site

Sl. No.	Species name	Post–monsoon				Monsoon				Winter			
		Fr.	Dn.	BA	IVI	Fr.	Dn.	BA	IVI	Fr.	Dn.	BA	IVI
1	*Abies densa*	80	170	3.56	116.82	80	170	3.56	116.82	80	170	3.56	116.82
2	*Acer* sp.	40	80	1.27	50.71	40	80	1.27	50.71	40	80	1.27	50.71
3	*Betula utilis*	30	50	0.98	36.26	30	50	0.98	36.26	30	50	0.98	36.26
4	*Junipers* sp.	20	60	1.13	36.04	20	60	1.13	36.04	20	60	1.13	36.04
5	*Rhododendron* sp.	60	120	0.69	60.17	60	120	0.69	60.17	60	120	0.69	60.17
Total		230	480	7.65	300	230	480	7.65	300	230	480	7.65	300

Fr.–Frequency percentage, Dn.–Density (ha^{-1}), BA–Basal area (m^2 ha^{-1}), IVI–Importance value index

Appendix II. 3.18: Frequency, density and IVI of shrubs in Tsa chu–I Lower barrage site

Sl. No.	Species name	Post–monsoon			Monsoon			Winter		
		Fr.	Dn.	IVI	Fr.	Dn.	IVI	Fr.	Dn.	IVI
1	*Berberis* sp.	8	64	13.81	8	64	13.81	8	64	15.14
2	*Daphne papyracea*	24	128	34.76	24	128	34.76	28	176	47.64
3	*Eleagnus parviflora*	12	96	20.71	12	96	20.71	12	96	22.71
4	*Rosa* sp.	20	288	47.86	20	288	47.86	20	288	52.14
5	*Rubus ellipticus*	12	80	19.05	12	80	19.05	16	112	28.50
6	*Salix* sp.	28	224	48.33	28	224	48.33	16	160	33.86
		112	960	200	112	960	200	100	896	200

Fr.–Frequency percentage, Dn.–Density (ha^{-1}), IVI–Importance value index

Appendi II.3.19: Frequency, density and IVI of herbs in Tsa chu–I Lower barrage site

Sl. No.	Species name	Post–monsoon			Monsoon			Winter		
		Fr.	Dn.	IVI	Fr.	Dn.	IVI	Fr.	Dn.	IVI
1	*Ainsliaea* sp.	28	11600	23.83	24	8800	8.14	40	9200	48.71
2	*Aconitum Heterophyllum*				48	15600	15.21			
3	*Arisaema nepenthoides*				28	6400	7.42			
4	*Elsholtzia strobilifera*	32	8800	21.67	20	4800	5.42			
5	*Fragaria* sp.	28	10800	22.83	36	15200	13.29			
6	*Galinsoga parviflora*	20	5200	13.17	20	4800	5.42			
7	*Galium* sp.	24	6000	15.50	28	5600	6.99			
8	*Gentiana capitata*							12	3600	16.78
9	*Geranium nepalensis*				28	6400	7.42			
10	*Hemiphragma heterophyllum*	24	5600	15.00	60	15200	16.69	52	15200	
11	*Impatiens* sp.				48	8000	11.12			
12	*Leontopodium stracheyi*	8	1600	4.67	16	4000	4.42	20	4800	24.87
13	*Panax bipinnatifidus*				76	19200	21.12			
14	*Persicaria* sp.	16	2400	8.33	28	5600	6.99			
15	*Pilea umbrosa*	32	9200	22.17	28	10400	9.57			
16	*Polygonum hydropiper*				12	4000	3.86			

17	*Potentilla cuneata*	32	6000	18.17	16	2400	3.56			
18	*Paris polyphylla*				24	5200	6.20			
19	*Primula denticulata*				12	3200	3.42			
20	*Primula* sp.				12	2800	3.21	20	3200	20.75
21	*Prunella vulgaris*	20	4400	12.17	20	6400	6.28	16	2800	17.22
22	*Rumex nepalensis*	16	4800	11.33	16	5600	5.28			
23	*Rumex nepalensis*				32	6800	8.20			
24	*Sambucus adnata*				16	4400	4.64			
25	*Stellaria* sp.				24	8800	8.14			
26	*Swertia* sp.				20	3600	4.78			
27	*Viola sikkimensis*	20	3600	11.17	12	2800	3.21			
Total		**300**	**80000**	**200**	**704**	**186000**	**200**	**160**	**38800**	**200**

Fr.–Frequency percentage, Dn.–Density (ha^{-1}), IVI–Importance value index

Appendix II. 3.20: Frequency, density, basal area and IVI for tree species in Tsa chu–I Lower powerhouse site

Sl. No.	Species name	Post–monsoon				Monsoon				Winter			
		Fr.	Dn.	BA	IVI	Fr.	Dn.	BA	IVI	Fr.	Dn.	BA	IVI
1	*Abies densa*	90	200	3.17	110.95	90	200	3.17	110.95	90	200	3.17	110.95
2	*Acer* sp.	60	80	1.12	40.89	60	80	1.12	40.89	60	80	1.12	40.89
3	*Betula utilis*	30	70	0.90	33.67	30	70	0.90	33.67	30	70	0.90	33.67
4	*Quercus* sp.	40	80	0.88	35.06	40	80	0.88	35.06	40	80	0.88	35.06
5	*Junipers* sp.	40	70	1.46	47.20	40	70	1.46	47.20	40	70	1.46	47.20
6	*Rhododendron* sp.	40	80	0.77	32.26	40	80	0.77	32.26	40	80	0.77	32.26
Total		**300**	**580**	**8.29**	**300**	**300**	**580**	**8.29**	**300**	**300**	**580**	**8.29**	**300**

Fr.–Frequency percentage, Dn.–Density (ha^{-1}), BA–Basal area (m^2 ha^{-1}), IVI–Importance value index

Appendix II. 3.21: Frequency, density and IVI of shrubs in Tsa chu–I Lower powerhouse site

Sl. No.	Species name	Post–monsoon			Monsoon			Winter		
		Fr.	Dn.	IVI	Fr.	Dn.	IVI	Fr.	Dn.	IVI
1	*Berberis* sp.	8	80	16.50	8	80	16.50	8	80	16.50
2	*Daphne papyracea*	28	144	42.29	28	144	42.29	28	144	42.29
3	*Elaeagnus parviflora*	12	64	18.38	12	64	18.38	12	64	18.38
4	*Pogostemon* sp.	12	80	20.20	12	80	20.20	12	80	20.20
5	*Rosa* sp.	24	304	56.77	24	304	56.77	24	304	56.77
6	*Salix* sp.	24	208	45.86	24	208	45.86	24	208	45.86
Total		**108**	**880**	**200**	**108**	**880**	**200**	**108**	**880**	**200**

Fr.–Frequency percentage, Dn.–Density (ha^{-1}), IVI–Importance value index

Appendix II. 3.22: Frequency, density and IVI of herbs in Tsa chu–I Lower powerhouse site

Sl. No.	Species name	Post–monsoon			Monsoon			Winter		
		Fr.	Dn.	IVI	Fr.	Dn.	IVI	Fr.	Dn.	IVI
1	*Aconogonum alpinum*				28	8400	8.81	12	2800	13.00
2	*Ainsliaea* sp.	24	11200	21.48	52	12400	14.47	44	9200	45.21
3	*Arisaema nepenthoides*				32	6000	7.93			
4	*Elsholtzia strobilifera*	28	8000	19.28	24	4400	5.89			
5	*Fragaria* sp.	24	9200	19.20	40	12800	13.07			
6	*Galinsoga parviflora*	16	4800	11.28	20	4400	5.35			
7	*Galium* sp.	20	5600	13.64	32	5200	7.46			
8	*Gentiana capitata*				24	4400	5.89	16	3200	16.10
9	*Geranium nepalensis*				32	6000	7.93			
10	*Hemiphragma heterophyllum*	20	6000	14.10	64	14800	17.53	48	18000	67.75
11	*Leontopodium stracheyi*	8	2400	5.64	20	3600	4.87			
12	*Meconopsis* sp.				12	2800	3.30			
13	*Panax bipinnatifidus*				76	18800	21.55			
14	*Pilea umbrosa*	28	11600	23.39	28	10000	9.76			
15	*Pogostemon* sp.	12	3600	8.46	28	4800	6.68	24	3600	21.38
16	*Polygonum hydropiper*	16	4400	10.82	12	3600	3.78			
17	*Potentilla cuneata*	28	7200	18.36	8	2000	2.28			
18	*Pouzolzia* sp.				28	4800	6.68			
19	*Primula denticulata*				16	2800	3.85			
20	*Primula* sp.							16	2800	15.18
21	*Prunella vulgaris*	16	6000	12.65	24	6000	6.84	24	3600	21.38
22	*Rannunculus* sp.				20	5200	5.82			
23	*Rumex nepalensis*	24	4400	13.72	36	6400	8.72			

Sl. No.	Species name	Post–monsoon			Monsoon			Winter		
24	*Sambucus adnata*				24	4800	6.13			
25	*Senecio cappa*				12	2800	3.30			
26	*Stellaria* sp.				28	8400	8.81			
27	*Viola sikkimensis*	12	3200	8.00	12	2800	3.30			
Total		**276**	**87600**	**200**	**732**	**168400**	**200**	**184**	**43200**	**200**

Fr.–Frequency percentage, Dn.–Density (ha^{-1}), IVI–Importance value index

Appendix II. 3.23: Frequency, density, basal area and IVI for tree species in Tsa chu–I Lower catchment area

Sl. No.	Species name	Post–monsoon				Monsoon				Winter			
		Fr.	Dn.	BA	IVI	Fr.	Dn.	BA	IVI	Fr.	Dn.	BA	IVI
1	*Abies densa*	70	210	3.54	97.74	70	210	3.54	97.74	70	210	3.54	97.74
2	*Acer* sp.	50	90	1.54	49.06	50	90	1.54	49.06	50	90	1.54	49.06
3	*Betula utilis*	30	50	0.79	27.27	30	50	0.79	27.27	30	50	0.79	27.27
4	*Junipers* sp.	80	140	1.24	64.11	80	140	1.24	64.11	80	140	1.24	64.11
5	*Quercus* sp.	30	50	1.11	30.85	30	50	1.11	30.85	30	50	1.11	30.85
6	*Rhododendron* sp.	30	80	0.69	30.98	30	80	0.69	30.98	30	80	0.69	30.98
Total		**290**	**620**	**8.92**	**300**	**290**	**620**	**8.92**	**300**	**290**	**620**	**8.92**	**300**

Fr.–Frequency percentage, Dn.–Density (ha^{-1}), BA–Basal area (m^2 ha^{-1}), IVI–Importance value index

Appendix II. 3.24: Frequency, density and IVI of shrubs in Tsa chu–I Lower catchment area

Sl. No.	Species name	Post–monsoon			Monsoon			Winter		
		Fr.	Dn.	IVI	Fr.	Dn.	IVI	Fr.	Dn.	IVI
1	*Daphne papyracea*	24	128	41.33	24	128	41.33	24	128	41.33
2	*Elaeagnus parviflora*	12	96	24.74	12	96	24.74	12	96	24.74
3	*Rosa* sp.	20	256	53.49	20	256	53.49	20	256	53.49
4	*Rubus ellipticus*	12	112	26.79	12	112	26.79	12	112	26.79
5	*Salix* sp.	28	192	53.66	28	192	53.66	28	192	53.66
Total		**96**	**784**	**200**	**96**	**784**	**200**	**96**	**784**	**200**

Fr.–Frequency percentage, Dn.–Density (ha^{-1}), IVI–Importance value index

Appendix II. 3.25: Frequency, density and IVI of herbs in Tsa chu–I Lower catchment area

Sl. No.	Species name	Post–monsoon			Monsoon			Winter		
		Fr.	Dn.	IVI	Fr.	Dn.	IVI	Fr.	Dn.	IVI
1	*Aconogonum alpinum*				20	8800	8.21	24	4800	19.94
2	*Ainsliaea* sp.	20	11200	19.15	44	12400	13.78	48	10000	40.69
3	*Aconitum heterophyllum*				24	6400	7.29			
4	*Elsholtzia strobilifera*	24	8400	17.40	16	4400	4.94			
5	*Fragaria* sp.	20	9200	16.93	32	12800	12.35			
6	*Galinsoga parviflora*	12	4800	9.36	12	4800	4.63			
7	*Galium* sp.	16	5600	11.60	32	5200	7.67			
8	*Gentiana capitata*				24	4400	6.06	24	3600	17.54
9	*Geranium nepalensis*				32	5200	7.67			
10	*Hemiphragma heterophyllum*	16	5200	11.16	64	12800	16.82	48	18000	56.69
11	*Impatiens* sp.	16	4800	10.72	52	6400	11.20			
12	*Leontopodium stracheyi*	8	1600	4.47						
13	*Panax bipinnatifidus*				80	18800	22.75			
14	*Persicaria* sp.	16	2800	8.50	32	5200	7.67			
15	*Leontopodium stracheyi*							20	3600	15.82
16	*Pilea umbrosa*	28	9600	20.08	28	10000	10.07			
17	*Pogostemon* sp.	12	2000	6.27				28	3600	19.27
18	*Polygonum hydropiper*	16	2800	8.50	16	3600	4.45			
19	*Potentilla cuneata*	28	6400	16.54	12	1600	2.66			
20	*Primula denticulata*				20	2800	4.52			
21	*Primula* sp.				12	2400	3.15	16	2800	12.50
22	*Prunella vulgaris*	16	4800	10.72	28	6000	7.61	24	3600	17.54
23	*Ranunculus* sp.	12	3200	7.59						
24	*Rumex nepalensis*	24	4400	12.98	40	6400	9.53			
25	*Sambucus adnata*				28	4800	6.87			
26	*Senecio cappa*				16	2800	3.96			
27	*Stellaria* sp.				28	8400	9.08			
28	*Swertia* sp.				12	3200	3.65			
29	*Viola sikkimensis*	12	3600	8.04	12	2800	3.40			
Total		**296**	**90400**	**200**	**716**	**162400**	**200**	**232**	**50000**	**200**

Fr.–Frequency percentage, Dn.–Density (ha^{-1}), IVI–Importance value index

Appendix II. 3.26: Dominant and Co–dominant species in the plant communities at Tsa chu–I Lower determined on the basis of IVI/density values

Community components	Barrage	Powerhouse	Catchment area
Tree species: *			
Dominant	*Abies densa*	*Abies densa*	*Abies densa*
Co–Dominant	*Junipers* sp.	*Junipers* sp.	*Junipers* sp.
Shrub species: **			
Dominant	*Salix* sp.	*Rosa* sp.	*Rosa* sp.
Co–Dominant	*Rosa* sp.	*Salix* sp.	*Salix* sp.
Herb species: **			
i. Post monsoon season			
Dominant	*Panax bipinnatifidus*	*Panax bipinnatifidus*	*Panax bipinnatifidus*
Co–Dominant	*Hemiphragma heterophyllum*	*Hemiphragma heterophyllum*	*Hemiphragma heterophyllum*
ii. Monsoon season			
Dominant	*Ainsliaea* sp.	*Pilea umbrosa*	*Pilea umbrosa*
Co–Dominant	*Fragaria* sp.	*Ainsliaea* sp.	*Ainsliaea* sp.
iii. Winter season			
Dominant	*Hemiphragma heterophyllum*	*Hemiphragma heterophyllum*	*Hemiphragma heterophyllum*
Co–Dominant	*Ainsliaea* sp.	*Ainsliaea* sp.	*Ainsliaea* sp.
* Dominance is based on density values			

* Dominance based on IVI; ** Dominance based on density

Appendix II. 3.27: List of plant species recorded from Tsa chu–II HEP site

Sl. No.	Species name	Family
TREES		
1	*Abies densa*	Pinaceae
2	*Acer* sp.	Aceraceae
3	*Alnus nepalensis*	Betulaceae
4	*Betula utilis*	Betulaceae
5	*Junipers* sp.	Cupressaceae
6	*Lyonia ovalifolia*	Ericaceae
7	*Quercus* sp.	Fagaceae
8	*Rhododendron* sp.	Ericaceae
9	*Tsuga dumosa*	Pinaceae
SHRUBS		
10	*Berberis* sp.	Berberidaceae
11	*Daphnae papyracea*	Thymelaeaceae
12	*Eleagnus parviflora*	Elaegnaceae
13	*Pogostemon* sp.	Lamiaceae
14	*Rosa* sp.	Rosaceae
15	*Rubus ellipticus*	Rosaceae
16	*Salix* sp.	Salicaceae
HERBS		
17	*Aconogonum alpinum*	Polygonaceae
18	*Aconitum heterophyllum*	Ranunculaceae
19	*Ainsliaea* sp.	Asteraceae
20	*Arisaema nepenthoides*	Araceae
21	*Elsholtzia strolifera*	Lamiaceae
22	*Fragaria* sp.	Rosaceae
23	*Galinsoga parviflora*	Asteraceae
24	*Galium* sp.	Rubiaceae
25	*Gentiana capitata*	Gentianaceae
26	*Geranium nepalensis*	Geraniaceae
27	*Hemiphragma heterophyllum*	scrophulariaceae
28	*Impatients* sp.	Balsaminaceae
29	*Leontopodium Stracheyi*	Asteraceae
30	*Meconopsis* sp.	Papaveraceae
31	*Oxalis corniculata*	Oxalidacea
32	*Panax bipinnatifidus*	Araliaceae
33	*Paris polyphylla*	
34	*Persicaria* sp.	Polygonaceae
35	*Pilea umbrosa*	Urticaceae
36	*Pogostemon* sp.	Lamiaceae
37	*Polygonum hydropiper*	Polygonaceae
38	*Potentilla cuneata*	Rosaceae
39	*Pouzolzia* sp.	Urticaceae

Sl. No.	Species name	Family
40	*Primula denticulata*	Primulaceae
41	*Primula* sp.	Primulaceae
42	*Prunella vulgaris*	Lamiaceae
43	*Rannunculus* sp.	Ranunculaceae
44	*Rumex nepalensis*	Polygonaceae
45	*Rumex* sp.	Polygonaceae
46	*Sambacus adnata*	Caprifoliaceae
47	*Senecio cappa*	Asteraceae
48	*Stellaria* sp.	Caryophyllaceae
49	*Swertia* sp.	Gentianaceae
50	*Viola sikkimensis*	Violaceae
CLIMBERS		
51	*Clematis montana*	Ranunculaceae
52	*Clematis* sp.	Ranunculaceae
53	*Hedera nepalensis*	Araliaceae
ORCHIDS		
54	*Bulbophyllum* sp.	Orchidaceae
PTERIDOPHYTES		
55	*Adiantum venustum*	Adiantaceae
56	*Dryopteris serrato–dentata*	Dryopteridaceae
57	*Equisetum diffusum*	Equisetaceae
58	*Equisetum ramosissimum*	Equisetaceae
59	*Lycopodium japonicum*	Lycopodiaceae
60	*Mecodium badium*	Hymenophyllaceae
61	*Selaginella tenuifolia*	Selaginellaceae
62	*Selaginella indica*	Selaginellaceae
63	*Vittaria flexuosa*	Vittariaceae
BRYOPHYTES		
64	*Brachymenium* sp.	Bryaceae
65	*Bryum billardieri*	Bryaceae
66	*Funaria* sp.	Funariaceae
67	*Marchantia* sp.	Marchantiaceae
LICHENS		
68	*Aspicilia* sp.	Megasporaceae
69	*Cladia aggregata*	Cladoniaceae
70	*Cladonia coccifera*	Cladoniaceae
71	*Stereocaulon* sp.	Stereocaulaceae
72	*Usnea dasaea*	Parmeliaceae
FUNGI		
73	*Laccaria laccata*	Hydnangiaceae
74	*Lactarius rubidus*	Russulaceae
75	*Phellinus schweintizii*	Hymenochaetaceae
76	*Polyporus arcularius*	Polyporaceae
77	*Poria monticola*	Polyporaceae
78	*Pycnoporellus fibrillosus*	Formitopscidaceae
79	*Schizophyllum commune*	Schizophyllaceae
80	*Strobilomyces strobilaceus*	Boletaceae
81	*Thelephora penicillata*	Thelephoraceae
82	*Tremella mesenterica*	Tremellaceae
83	*Boletus reticulatus*	Boletaceae
84	*Clathrus rubra*	Phallaceae

Appendix II. 3.28: Different groups of plant species present at Tsa chu–II HEP site

Sl. No.	Species name Barrage and Powerhouse	Family	Sl. No.	Species name Catchment area	Family
CLIMBERS					
1	*Clematis montana*	Ranunculaceae	1	*Clematis montana*	Ranunculaceae
2	*Clematis* sp.	Ranunculaceae	2	*Hedera nepalensis*	Araliaceae
3	*Hedera nepalensis*	Araliaceae			
ORCHIDS					
1	*Bulbophyllum* sp.	Orchidaceae	1	*Bulbophyllum* sp.	Orchidaceae
PTERIDOPHYTES					
1	*Adiantum venustum*	Adiantaceae	1	*Adiantum* sp.	Adiantaceae
2	*Dryopteris serrato–dentata*	Dryopteridaceae	2	*Dryopteris serrato–dentata*	Dryopteridaceae
3	*Equisetum diffusum*	Equisetaceae	3	*Lycopodium japonicum*	Lycopodiaceae

Sl. No.	Species name Barrage and Powerhouse	Family	Sl. No.	Species name Catchment area	Family
4	*Equisetum ramosissimum*	Equisetaceae	4	*Selaginella indica*	Selaginellaceae
5	*Lycopodium japonicum*	Lycopodiaceae	5	*Vittaria flexuosa*	Vittariaceae
6	*Mecodium badium*	Hymenophyllaceae			
7	*Selaginella tenuifolia*	Selaginellaceae			
8	*Selaginella indica*	Selaginellaceae			
9	*Vittaria flexuosa*	Vittariaceae			
BRYOPHYTES					
1	*Brachymenium* sp.	Bryaceae	1	*Brachymenium* sp.	Bryaceae
2	*Bryum billardieri*	Bryaceae	2	*Funaria* sp.	Funariaceae
3	*Funaria* sp.	Funariaceae	3	*Marchantia* sp.	Marchantiaceae
4	*Marchantia* sp.	Marchantiaceae			
LICHENS					
1	*Aspicilia* sp.	Megasporaceae	1	*Aspicilia* sp.	Megasporaceae
2	*Cladia aggregata*	Cladoniaceae	2	*Cladia aggregata*	Cladoniaceae
3	*Cladonia coccifera*	Cladoniaceae	3	*Stereocaulon* sp.	Stereocaulaceae
4	*Stereocaulon* sp.	Stereocaulaceae	4	*Usnea dasaea*	Parmeliaceae
5	*Usnea dasaea*	Parmeliaceae			

Appendix II. 3.29: Species list of macro–fungi recorded from barrage and powerhouse sites of Tsa chu–II

Species	Family	Species	Family
Barrage		**Powerhouse**	
Laccaria laccata	Hydnangiaceae	*Boletus reticulatus*	Boletaceae
Lactarius rubidus	Russulaceae	*Clathrus rubra*	Phallaceae
Phellinus schweintizii	Hymenochaetaceae	*Lactarius rubidus*	Russulaceae
Polyporus arcularius	Polyporaceae	*Phellinus schweintizii*	Hymenochaetaceae
Poria monticola	Polyporaceae	*Polyporus arcularius*	Polyporaceae
Pycnoporellus fibrillosus	Formitopscidaceae	*Pycnoporellus fibrillosus*	Formitopscidaceae
Schizophyllum commune	Schizophyllaceae	*Schizophyllum commune*	Schizophyllaceae
Strobilomyces strobilaceus	Boletaceae		
Thelephora penicillata	Thelephoraceae		
Tremella mesenterica	Tremellaceae		
Catchment area			
Boletus reticulatus	Boletaceae		
Clathrus rubra	Phallaceae		
Laccaria laccata	Hydnangiaceae		
Lactarius rubidus	Russulaceae		
Phellinus schweintizii	Hymenochaetaceae		
Polyporus arcularius	Polyporaceae		
Poria monticola	Polyporaceae		
Pycnoporellus fibrillosus	Formitopscidaceae		
Schizophyllum commune	Schizophyllaceae		
Strobilomyces strobilaceus	Boletaceae		
Thelephora penicillata	Thelephoraceae		
Tremella mesenterica	Tremellaceae		

Appendix II. 3.30: Frequency, density, basal area and IVI for tree species in Tsa chu–II barrage site

Sl. No.	Species name	Post–monsoon				Monsoon				Winter			
		Fr.	**Dn.**	**BA**	**IVI**	**Fr.**	**Dn.**	**BA**	**IVI**	**Fr.**	**Dn.**	**BA**	**IVI**
1	*Abies densa*	70	160	1.92	67.3	70	160	1.92	67.3	70	160	1.92	67.3
2	*Alnus nepalensis*	50	90	1.52	45.8	50	90	1.52	45.8	50	90	1.52	45.8
3	*Betula utilis*	30	40	1.11	27.5	30	40	1.11	27.5	30	40	1.11	27.5
4	*Junipers* sp.	50	80	0.49	32.4	50	80	0.49	32.4	50	80	0.49	32.4
5	*Quercus* sp.	20	30	0.23	13.1	20	30	0.23	13.1	20	30	0.23	13.1
6	*Rhododendron* sp.	40	70	1.01	34.0	40	70	1.01	34.0	40	70	1.01	34.0
7	*Acer* sp.	70	110	1.79	57.6	70	110	1.79	57.6	70	110	1.79	57.6
8	*Lyonia ovalifolia*	30	40	0.66	22.3	30	40	0.66	22.3	30	40	0.66	22.3
Total		**360**	**620**	**8.73**	**300**	**360**	**620**	**8.73**	**300**	**360**	**620**	**8.73**	**300**

Fr.–Frequency percentage, Dn.–Density (ha^{-1}), BA–Basal area (m^2 ha^{-1}), IVI–Importance value index

Appendix II. 3.31: Frequency, density and IVI of shrubs in Tsa chu–II barrage site

Sl. No.	Species name	Post–monsoon			Monsoon			Winter		
		Fr.	**Dn.**	**IVI**	**Fr.**	**Dn.**	**IVI**	**Fr.**	**Dn.**	**IVI**
1	*Berberis* sp.	16	80	21.12	16	80	21.12	16	80	21.12
2	*Daphnae papyracea*	28	144	37.39	28	144	37.39	28	144	37.39
3	*Pogostemon* sp.	16	80	21.12	16	80	21.12	16	80	21.12
4	*Rosa* sp.	16	288	43.53	16	288	43.53	16	288	43.53
5	*Rubus ellipticus*	20	112	27.69	20	112	27.69	20	112	27.69
6	*Salix* sp.	32	224	49.14	32	224	49.14	32	224	49.14
Total		**128**	**928**	**200**	**128**	**928**	**200**	**128**	**928**	**200**

Fr.–Frequency percentage, Dn.–Density (ha^{-1}), IVI–Importance value index

Appendix II. 3.32: Frequency, density and IVI of herbs in Tsa chu–II barrage site

Sl. No.	Species name	Post–monsoon			Monsoon			Winter		
		Fr.	**Dn.**	**IVI**	**Fr.**	**Dn.**	**IVI**	**Fr.**	**Dn.**	**IVI**
1	*Aconogonum alpinum*	28	5600	18.23	32	8400	8.32			
2	*Ainsliaea* sp.	48	12400	35.57	56	14800	14.61	24	11200	19.05
3	*Aconitum heterophyllum*				36	6000	7.50			
4	*Elsholtzia strolifera*				28	4400	5.69	28	8400	17.19
5	*Fragaria* sp.				44	15200	13.40	24	9200	16.89
6	*Galinsoga parviflora*				24	5200	5.65	16	4800	9.82
7	*Galium* sp.				36	5200	7.07	20	5600	11.85
8	*Gentiana capitata*	12	2000	7.20	28	4800	5.90			
9	*Geranium nepalensis*				36	6000	7.50			
10	*Hemiphragma heterophyllum*	44	16800	40.99	68	14800	16.03	20	5200	11.42
11	*Impatients* sp.				56	7600	10.73	20	4800	10.99
12	*Leontopodium Stracheyi*	20	3600	12.40	24	3600	4.78	8	2000	4.48
13	*Meconopsis* sp.				20	3200	4.09			
14	*Panax bipinnatifidus*				72	18400	18.44			
15	*Persicaria* sp.				24	5200	5.65	16	2800	7.67
16	*Pilea umbrosa*				24	10000	8.23	28	10800	19.78
17	*Pogostemon* sp.	20	3600	12.40	24	4800	5.43	20	3200	9.26
18	*Polygonum hydropiper*				8	3600	2.89	12	2800	6.51
19	*Potentilla cuneata*				12	2000	2.50	28	6400	15.04
20	*Paris polyphylla*				24	4800	5.43			
21	*Primula denticulata*				12	2800	2.93			
22	*Prunella vulgaris*	24	3600	13.77	20	6000	5.60	16	4800	9.82
23	*Rannunculus* sp.				16	5200	4.70	24	3600	10.86
24	*Rumex nepalensis*	36	6400	22.21	32	4400	6.16	24	4400	11.72
25	*Sambacus adnata*	24	4800	15.63	32	4800	6.38			
26	*Stellaria* sp.				20	8400	6.90			
27	*Swertia* sp.	20	3200	11.79	16	3200	3.62			
28	*Viola sikkimensis*	16	2800	9.80	20	2800	3.88	16	2800	7.67
Total		**292**	**64800**	**200**	**844**	**185600**	**200**	**344**	**92800**	**200**

Fr.–Frequency percentage, Dn.–Density (ha^{-1}), IVI–Importance value index

Appendix II. 3.33: Frequency, density, basal area and IVI for tree species in Tsa chu–II powerhouse site

Sl. No.	Species name	Post–monsoon				Monsoon				Winter			
		Fr.	**Dn.**	**BA**	**IVI**	**Fr.**	**Dn.**	**BA**	**IVI**	**Fr.**	**Dn.**	**BA**	**IVI**
1	*Abies densa*	70	160	1.9	54.4	70	160	1.9	54.4	70	160	1.9	54.4
2	*Acer* sp.	50	90	1.5	37.0	50	90	1.5	37.0	50	90	1.5	37.0
3	*Betula utilis*	30	40	1.1	22.1	30	40	1.1	22.1	30	40	1.1	22.1
4	*Junipers* sp.	50	80	0.5	26.3	50	80	0.5	26.3	50	80	0.5	26.3
5	*Quercus* sp.	20	30	0.2	10.6	20	30	0.2	10.6	20	30	0.2	10.6
6	*Rhododendron* sp.	40	70	1.0	27.4	40	70	1.0	27.4	40	70	1.0	27.4
7	*Alnus nepalensis*	60	120	2.0	47.4	60	120	2.0	47.4	60	120	2.0	47.4
8	*Lyonia ovalifolia*	50	60	0.8	26.4	50	60	0.8	26.4	50	60	0.8	26.4
9	*Tsuga dumosa*	70	110	2.0	48.4	70	110	2.0	48.4	70	110	2.0	48.4
Total		**440**	**760**	**11.0**	**300**	**440**	**760**	**11.0**	**300**	**440**	**760**	**11.0**	**300**

Fr.–Frequency percentage, Dn.–Density (ha^{-1}), BA–Basal area ($m^2\ ha^{-1}$), IVI–Importance value index

Appendix II. 3.34: Frequency, density and IVI of shrubs in Tsa chu–II powerhouse site

Sl. No.	Species name	Post–monsoon			Monsoon			Winter		
		Fr.	**Dn.**	**IVI**	**Fr.**	**Dn.**	**IVI**	**Fr.**	**Dn.**	**IVI**
1	*Berberis* sp.	8	64	14.2	8	64	14.2	8	64	14.2
2	*Daphnae papyracea*	32	240	55.0	32	240	55.0	32	240	55.0
3	*Pogostemon* sp.	20	112	29.9	20	112	29.9	20	112	29.9
4	*Rubus ellipticus*	36	224	56.4	36	224	56.4	36	224	56.4
5	*Salix* sp.	24	208	44.5	24	208	44.5	24	208	44.5
Total		**120**	**848**	**200**	**120**	**848**	**200**	**120**	**848**	**200**

Fr.–Frequency percentage, Dn.–Density (ha^{-1}), IVI–Importance value index

Appendix II. 3.35: Frequency, density and IVI of herbs in Tsa chu–II powerhouse site

Sl. No.	Species name	Post–monsoon			Monsoon			Winter		
		Fr.	**Dn.**	**IVI**	**Fr.**	**Dn.**	**IVI**	**Fr.**	**Dn.**	**IVI**
1	*Aconogonum alpinum*	32	4800	17.1	36	9200	7.95			
2	*Ainsliaea* sp.	48	12400	33.0	60	15600	13.38	32	12400	23.03
3	*Arisaema nepenthoides*				40	6800	7.19			
4	*Elsholtzia strolifera*				32	5200	5.64	36	9600	21.06
5	*Fragaria* sp.				48	16000	12.40	32	10400	20.80
6	*Galinsoga parviflora*				28	6000	5.63			
7	*Galium* sp.				40	6000	6.81	28	6800	15.64
8	*Gentiana capitata*	16	2800	9.1	32	5600	5.83			
9	*Geranium nepalensis*				40	6800	7.19			
10	*Hemiphragma heterophyllum*	48	19200	42.7	72	15600	14.56	28	6400	15.19
11	*Impatients* sp.				60	8400	9.92	28	6000	14.74
12	*Leontopodium Stracheyi*	20	4400	12.7	28	4400	4.86	16	3200	8.17
13	*Meconopsis* sp.				24	4000	4.28			
14	*Panax bipinnatifidus*				76	19200	16.68			
15	*Persicaria* sp.				36	6000	6.41	24	4000	11.36
16	*Pilea umbrosa*				36	10800	8.72	28	10800	20.10
17	*Pogostemon* sp.	20	4800	13.2	32	5600	5.83	20	3200	9.32
18	*Polygonum hydropiper*				16	4400	3.68			
19	*Potentilla cuneata*				20	2800	3.31	28	6400	15.19
20	*Paris polyphylla*				32	5600	5.83			
21	*Primula denticulata*				20	3600	3.69			
22	*Prunella vulgaris*	24	5200	15.1	28	6800	6.01	20	4400	10.66
23	*Rannunculus* sp.				24	6000	5.24			
24	*Rumex nepalensis*	36	6400	20.6	40	5200	6.42	16	3200	8.17
25	*Sambacus adnata*	28	4400	15.2	40	5600	6.61			
26	*Stellaria* sp.				28	9200	7.17			
27	*Swertia* sp.	24	3600	12.8	24	4000	4.28			
28	*Viola sikkimensis*	16	2400	8.5	28	3600	4.48	12	2800	6.57
Total		**312**	**70400**	**200**	**1020**	**208000**	**200**	**348**	**89600**	**200**

Fr.–Frequency percentage, Dn.–Density (ha^{-1}), IVI–Importance value index

Appendix II. 3.36: Frequency, density, basal area and IVI for tree species in Tsa chu–II catchment area

Sl. No.	Species name	Post–monsoon				Monsoon				Winter			
		Fr.	**Dn.**	**BA**	**IVI**	**Fr.**	**Dn.**	**BA**	**IVI**	**Fr.**	**Dn.**	**BA**	**IVI**
1	*Abies densa*	70	160	1.92	65.73	70	160	1.92	65.73	70	160	1.92	65.73
2	*Acer* sp.	50	90	1.52	44.84	50	90	1.52	44.84	50	90	1.52	44.84
3	*Betula utilis*	30	40	1.11	26.94	30	40	1.11	26.94	30	40	1.11	26.94
4	*Junipers* sp.	50	80	0.49	31.56	50	80	0.49	31.56	50	80	0.49	31.56
5	*Quercus* sp.	20	30	0.23	12.75	20	30	0.23	12.75	20	30	0.23	12.75
6	*Rhododendron* sp.	40	70	1.01	33.18	40	70	1.01	33.18	40	70	1.01	33.18
7	*Alnus nepalensis*	70	100	1.59	52.53	70	100	1.59	52.53	70	100	1.59	52.53
8	*Lyonia ovalifolia*	40	70	0.95	32.47	40	70	0.95	32.47	40	70	0.95	32.47
Total		**370**	**640**	**8.82**	**300**	**370**	**640**	**8.82**	**300**	**370**	**640**	**8.82**	**300**

Fr.–Frequency percentage, Dn.–Density (ha^{-1}), BA–Basal area ($m^2 ha^{-1}$), IVI–Importance value index

Appendix II. 3.37: Frequency, density and IVI of shrubs in Tsa chu–II catchment area

Sl. No.	Species name	Post–monsoon			Monsoon			Winter		
		Fr.	**Dn.**	**IVI**	**Fr.**	**Dn.**	**IVI**	**Fr.**	**Dn.**	**IVI**
1	*Berberis* sp.	12	112	21.82	12	112	21.82	12	112	21.82
2	*Daphnae papyracea*	24	128	33.80	24	128	33.80	24	128	33.80
3	*Eleagnus parviflora*	12	96	20.18	12	96	20.18	12	96	20.18

Sl. No.	Species name	Post–monsoon			Monsoon			Winter		
4	*Pogostemon* sp.	8	64	13.45	8	64	13.45	8	64	13.45
5	*Rosa* sp.	20	288	46.75	20	288	46.75	20	288	46.75
6	*Rubus ellipticus*	12	64	16.90	12	64	16.90	12	64	16.90
7	*Salix* sp.	28	224	47.09	28	224	47.09	28	224	47.09
Total		**116**	**976**	**200**	**116**	**976**	**200**	**116**	**976**	**200**

Fr.–Frequency percentage, Dn.–Density (ha^{-1}), IVI–Importance value index

Appendix II. 3.38: Frequency, density and IVI of herbs in Tsa chu–II catchment area

Sl. No.	Species name	Post–monsoon			Monsoon			Winter		
		Fr.	Dn.	IVI	Fr.	Dn.	IVI	Fr.	Dn.	IVI
1	*Aconogonum alpinum*	20	4800	17.72	24	8400	8.15			
2	*Ainsliaea* sp.	44	9600	37.27	48	12400	13.77	32	12400	18.05
3	*Arisaema nepenthoides*				28	6000	7.32			
4	*Elsholtzia strolifera*				20	4400	5.30	36	9600	16.50
5	*Fragaria* sp.				36	12800	12.35	32	10400	16.30
6	*Galinsoga parviflora*				16	4400	4.74	24	6800	11.35
7	*Galium* sp.				28	5200	6.86	28	6400	11.90
8	*Gentiana capitata*	20	3600	15.57	20	4400	5.30			
9	*Geranium nepalensis*				28	6000	7.32			
10	*Hemiphragma heterophyllum*	48	18400	54.91	60	14800	16.81	28	6000	11.55
11	*Impatients* sp.				48	7600	11.01	28	5600	11.20
12	*Leontopodium Stracheyi*	16	4000	14.47	16	3600	4.28	12	2000	4.45
13	*Panax bipinnatifidus*				76	18800	21.33			
14	*Persicaria* sp.				28	5200	6.86	20	3200	7.30
15	*Pilea umbrosa*				28	10000	9.63	32	11200	17.00
16	*Pogostemon*	24	4000	18.10				16	3200	6.40
17	*Polygonum hydropiper*				12	3600	3.73			
18	*Potentilla cuneata*				8	2000	2.26			
19	*Pouzolzia* sp.				28	4800	6.63	20	4000	8.00
20	*Primula denticulata*				16	2800	3.82	32	6800	13.15
21	*Primula* sp.	12	3200	11.21	8	2000	2.26	20	5200	9.05
22	*Prunella vulgaris*	20	4000	16.29	24	6000	6.77			
23	*Oxalis corniculata*	16	4000	14.47						
24	*Rumex* sp.							28	4800	10.50
25	*Rumex nepalensis*				36	6400	8.66	28	9200	14.35
26	*Sambacus adnata*				24	4800	6.08			
27	*Senecio cappa*				12	2800	3.27			
28	*Stellaria* sp.				28	8400	8.71			
29	*Swertia* sp.				12	3200	3.50			
30	*Viola sikkimensis*				12	2800	3.27	12	4000	6.20
31	**Viola sp.**							16	3600	6.75
Total		**220**	**55600**	**200.00**	**724**	**173600**	**200.00**	**444**	**114400**	**200.00**

Fr.–Frequency percentage, Dn.–Density (ha^{-1}), IVI–Importance value index

Appendix II. 3.39: Dominant and Co–dominant species determined on the basis of IVI/density values of species in the plant communities at Tsa chu–II

Community components	Barrage site	Powerhouse	Catchment area
Tree species: *			
Dominant	*Abies densa*	*Abies densa*	*Abies densa*
Co–Dominant	*Acer* sp.	*Tsuga dumosa*	*Alnus nepalensis*
Shrub species: **			
Dominant	*Salix* sp.	*Daphnae papyracea*	*Salix* sp.
Co–Dominant	*Rosa* sp.	*Rubus ellipticus*	*Rosa* sp.
Herb species: **			
i. Post monsoon season			
Dominant	*Pilea umbrosa*	*Ainsliaea* sp.	*Ainsliaea* sp.
Co–Dominant	*Ainsliaea* sp.	*Elsholtzia strolifera*	*Pilea umbrosa*
ii. Monsoon season			
Dominant	*Panax bipinnatifidus*	*Hemiphragma heterophyllum*	*Panax bipinnatifidus*
Co–Dominant	*Panax bipinnatifidus* → *Hemiphragma heterophyllum*	*Panax bipinnatifidus*	*Hemiphragma heterophyllum*
iii. Winter season			
Dominant	*Hemiphragma heterophyllum*	*Hemiphragma heterophyllum*	*Hemiphragma heterophyllum*
Co–Dominant	*Ainsliaea* sp.	*Ainsliaea* sp.	*Ainsliaea* sp.
* Dominance is based on density values			

* Dominance based on IVI; ** Dominance based on density

Appendix II. 3.40: List of plant species recorded from Thingbu chu

Sl. No.	Species name	Family
TREES		
1	*Abies densa*	Pinaceae
2	*Acer sikkimensis*	Aceraceae
3	*Betula alnoides*	Betulaceae
4	*Corylus heterophylla*	Betulaceae
5	*Larix griffithii*	Pinaceae
6	*Leucosceptrum canum*	Lamiaceae
7	*Lindera neesiana*	Lauraceae
8	*Picea* spinulosa	Pinaceae
9	*Pinus wallichiana*	Pinaceae
10	*Taxus wallichiana*	Taxaceae
11	*Tsuga dumosa*	Pinaceae
SHRUBS		
12	*Aconogonum molle*	Poaceae
13	*Artemisia nilagirica*	Asteraceae
14	*Arundinaria maling*	Poaceae
15	*Arundinaria* sp.	Poaceae
16	*Berberis* sp.	Berberidaceae
17	*Coriaria nepalensis*	Coriariaceae
18	*Daphne papyracea*	Thymelaeaceae
19	*Eleagnus parviflora*	Elaeagnaceae
20	*Girardinia grandiflora*	Urticaceae
21	*Heracleum* sp.	Apiaceae
22	*Hypericum choisianum*	Hypericaceae
23	*Ilex dipyrena*	Aquifoliaceae
24	*Neillia thyrsiflora*	Rosaceae
25	*Philadelphus tomentosus*	Hydrangeaceae
26	*Piptanthus nepalensis*	Papilionaceae
27	*Rosa* sp.	Rosaceae
28	*Rubus ellipticus*	Rosaceae
29	*Rubus niveus*	Rosaceae
30	*Sarcococca* sp.	Buxaceae
31	*Seigesbeckia orientalis*	Asteraceae
32	Spirea sp.	Rosaceae
HERBS		
33	*Aconitum elswii*	Ranunculaceae
34	*Aconitum ferox*	Ranunculaceae
35	*Ainsliaea* sp.	Asteraceae
36	*Anaphalis margaritacea*	Asteraceae
37	*Aster* sp.	Asteraceae
38	*Astilbe rivularis*	Saxifragaceae
39	*Cyathula capitata*	Amaranthaceae
40	*Dipsacus asper*	Dipsacaceae
41	*Dracocephalum* sp.	Lamiaceae
42	*Elatostemma sessile*	Urticaceae
43	*Elsholtzia strobilifera*	Lamiaceae
44	*Fragaria* sp.	Rosaceae
45	*Galium* sp.	Rubiaceae
46	*Geranium pretense*	Geraniaceae
47	*Halenia elliptica*	Gentianaceae
48	*Herpetospermum pedunculosum*	Cucurbitaceae
49	*Lecanthus peduncularis*	Urticaceae
50	*Nepeta* sp.	Lamiaceae
51	*Ophiopogon intermedius*	Liliaceae
52	*Oplisminus compositus*	Poaceae
53	*Parasenecio quinquelobus*	Asteraceae
54	*Panax bipinnatifidus*	Araliaceae
55	*Paris polyphylla*	Triliaceae
56	*Parochaetus communis*	Papilionaceae
57	*Persicaria ruminata*	Polygonaceae
58	*Phlomis* sp.	Lamiaceae
59	*Pilea umbrosa*	Urticaceae
60	*Pogostemon* sp.	Lamiaceae
61	*Potentilla cuneata*	Rosaceae
62	*Salvia* sp.	Lamiaceae

Sl. No.	Species name	Family
63	*Sambucus adnata*	Adoxaceae
64	*Senecio cappa*	Asteraceae
65	*Swertia paniculata*	Gentianaceae
66	*Swertia chirayita*	
67	*Thalictrum foliolosum*	Ranunculaceae
68	*Thladiantha cordifolia*	Cucurbitaceae
69	*Urtica dioica*	Urticaceae
70	*Viola sikkimensis*	Violaceae
CLIMBERS		
71	*Clematis Bucchaniana*	Ranunculaceae
72	*Cissampelos* sp.	Menispermaceae
73	*Clematis* sp.	Ranunculaceae
74	*Ficus* sp.	Dioscoreaceae
75	*Hedera nepalensis*	Araliaceae
76	*Herpetospermun pedunculosum*	Araliaceae
77	*Holboellia latifolia*	Lardizabalaceae
78	*Periploca* sp.	Periplocaceae
79	*Philadephus tomentosus*	Hydrangeaceae
80	*Rubia cordifolia*	Rubiaceae
81	*Smilax aspera*	Smilacaceae
82	*Stephania glandulifera*	Menispermaceae
83	*Thladiantha cordifolia*	Cucubitaceae
ORCHIDS		
84	*Bulbophyllum* sp.	Orchidaceae
85	*Calanthe tricarinata*	Orchidaceae
86	*Coelogynae* sp.	Orchidaceae
87	*Cymbidium* sp.	Orchidaceae
88	*Dendrobium* sp.	Orchidaceae
89	*Oberonia* sp.	Orchidaceae
PTERIDOPHYTES		
90	*Botrychium* sp.	Ophioglossaceae
91	*Dicranopteris linearis*	Dicranopteridaceae
92	*Dryopteris wallichiana*	Dryopteridaceae
93	*Lepisorus* sp.	Polypodiaceae
94	*Polypodium* sp.	Polypodiaceae
95	*Pteris* sp.	Pteridiaceae
96	*Pteris vittata*	Pteridaceae
97	*Pyrrosia nuda*	Polypodiaceae
98	*Selaginella* sp.	Selaginellaceae
BRYOPHYTES		
99	*Desmotheca* sp.	Orthotrichaceae
100	*Diphyscium* sp.	Buxbaumiaceae
101	*Funaria* sp.	Funariaceae
102	*Lyellia* sp.	Polytrichaceae
103	*Marchantia* sp.	Marchantiaceae
104	*Plagiobryum* sp.	Bryaceae
LICHENS		
105	*Alectoria* sp.	Alectoriaceae
106	*Cladonia* sp.	Cladoniaceae
107	*Graphis* sp.	Graphidaceae
108	*Lobaria* sp.	Lobariaceae
109	*Parmelia* sp.	Parmeliaceae
110	*Parmotrema* sp.	Parmeliaceae
111	*Pseudocyphellaria* sp.	Lobariaceae
112	*Stereocaulon* sp.	Stereocaulaceae
113	*Sticta* sp.	Lobariaceae
114	*Teloschistes* sp.	Teloschistaceae
115	*Usnea* sp.	Parmeliaceae
FUNGI		
115	*Auricularia auriculiformis*	Auriculariaceae
116	*Clathrus rubra*	Phallaceae
117	*Coprinus disseminatus*	Agaricaceae
118	*Daldinia concentrica*	Xylariaceae
119	*Fomes pinicola*	Fomitopsidaceae
120	*Hygrocybe miniata*	Hygrophoraceae
121	*Laccaria laccata*	Hydnangiaceae

Sl. No.	Species name	Family
122	*Lactarius rubidus*	Russulaceae
123	*Phellinus schweintizii*	Hymenochaetaceae
124	*Poria monticola*	Polyporaceae
125	*Schizophyllum commune*	Schizophyllaceae
126	*Tremella mesenterica*	Tremellaceae
127	*Xylaria polymorpha*	Xylariaceae
128	*Hericium erinaceus*	Hericiaceae

Appendix II. 3.41: Species list of macro–fungi recorded from barrage and powerhouse sites of Thingbu chu

Species	Family	Species	Family
Barrage		**Powerhouse**	
Auricularia auriculiformis	Auriculariaceae	*Auricularia auriculiformis*	Auriculariaceae
Clathrus rubra	Phallaceae	*Clathrus rubra*	Phallaceae
Coprinus disseminatus	Agaricaceae	*Coprinus disseminatus*	Agaricaceae
Daldinia concentrica	Xylariaceae	*Fomes pinicola*	Fomitopsidaceae
Fomes pinicola	Fomitopsidaceae	*Hericium erinaceus*	Hericiaceae
Hygrocybe miniata	Hygrophoraceae	*Hygrocybe miniata*	Hygrophoraceae
Laccaria laccata	Hydnangiaceae	*Laccaria laccata*	Hydnangiaceae
Lactarius rubidus	Russulaceae	*Poria monticola*	Polyporaceae
Phellinus schweintizii	Hymenochaetaceae	*Tremella mesenterica*	Tremellaceae
Poria monticola	Polyporaceae	*Xylaria polymorpha*	Xylariaceae
Schizophyllum commune	Schizophyllaceae		
Tremella mesenterica	Tremellaceae		
Xylaria polymorpha	Xylariaceae		
Catchment area			
Species	**Family**		
Auricularia auriculiformis	Auriculariaceae		
Clathrus rubra	Phallaceae		
Coprinus disseminatus	Agaricaceae		
Daldinia concentrica	Xylariaceae		
Fomes pinicola	Fomitopsidaceae		
Hericium erinaceus	Hericiaceae		
Hygrocybe miniata	Hygrophoraceae		
Laccaria laccata	Hydnangiaceae		
Lactarius rubidus	Russulaceae		
Phellinus schweintizii	Hymenochaetaceae		
Poria monticola	Polyporaceae		
Schizophyllum commune	Schizophyllaceae		
Tremella mesenterica	Tremellaceae		
Xylaria polymorpha	Xylariaceae		

Appendix II. 3.42: Frequency, density, basal area and IVI for tree species in Thingbu chu barrage site

Sl. No.	Species name	Post–monsoon				Monsoon				Winter			
		Fr.	**Dn.**	**BA**	**IVI**	**Fr.**	**Dn.**	**BA**	**IVI**	**Fr.**	**Dn.**	**BA**	**IVI**
1	*Abies densa*	30	30	1.08	16.69	30	30	1.08	16.69	30	30	1.08	16.69
2	*Acer* sikkimensis	50	90	1.37	33.47	50	90	1.37	33.47	50	90	1.37	33.47
3	*Betula alnoides*	30	40	1.90	20.84	30	40	1.90	20.84	30	40	1.90	20.84
4	*Corylus heterophylla*	30	40	0.65	17.16	30	40	0.65	17.16	30	40	0.65	17.16
5	*Leucosceptrum canum*	60	100	2.44	41.11	60	100	2.44	41.11	60	100	2.44	41.11
6	*Lindera neesiana*	20	30	0.14	11.15	20	30	0.14	11.15	20	30	0.14	11.15
7	*Picea spinulosa*	20	20	2.94	17.68	20	20	2.94	17.68	20	20	2.94	17.68
8	*Pinus wallichiana*	30	50	5.76	33.97	30	50	5.76	33.97	30	50	5.76	33.97
9	*Taxus wallichiana*	20	30	0.40	11.91	20	30	0.40	11.91	20	30	0.40	11.91
10	*Tsuga dumosa*	70	150	17.16	96.03	70	150	17.16	96.03	70	150	17.16	96.03
Total		**360**	**580**	**33.83**	**300**	**360**	**580**	**33.83**	**300**	**360**	**580**	**33.83**	**300**

Fr.–Frequency percentage, Dn.–Density (ha^{-1}), BA–Basal area ($m^2\ ha^{-1}$), IVI–Importance value index

Appendix II. 3.43: Frequency, density and IVI of shrubs in Thingbu chu barrage site

Sl. No.	Species name	Post–monsoon			Monsoon			Winter		
		Fr.	**Dn.**	**IVI**	**Fr.**	**Dn.**	**IVI**	**Fr.**	**Dn.**	**IVI**
1	*Arundinaria maling*	44	96	8.91	44	96	8.91	44	96	8.91
2	*Aconogonum molle*	28	224	7.55	28	224	7.55	28	224	7.55
3	*Artemesia nilagarica*	60	1568	28.75	60	1568	28.75	60	1568	28.75
4	*Berberis* sp.	44	720	16.12	44	720	16.12	44	720	16.12

Sl. No.	Species name	Post–monsoon			Monsoon			Winter		
5	*Coriaria nepalensis*	40	544	13.38	40	544	13.38	40	544	13.38
6	*Daphne papyracea*	64	1968	34.08	64	1968	34.08	64	1968	34.08
7	*Eleagnus parviflora*	28	128	6.44	28	128	6.44	28	128	6.44
8	*Girardinia grandiflora*	36	368	10.63	36	368	10.63	36	368	10.63
9	*Heracleum*	8	128	2.90	8	128	2.90	8	128	2.90
10	*Hypericum choisianum*	8	48	1.97	8	48	1.97	8	48	1.97
11	*Ilex dipyrena*	12	144	3.79	12	144	3.79	12	144	3.79
12	*Neillia thyrsiflora*	8	80	2.34	8	80	2.34	8	80	2.34
13	*Philadelphus tomentosus*	8	48	1.97	8	48	1.97	8	48	1.97
14	*Piptanthus nepalensis*	56	464	15.29	56	464	15.29	56	464	15.29
15	*Rosa* sp.	12	128	3.61	12	128	3.61	12	128	3.61
16	*Rubus ellipticus*	24	208	6.66	24	208	6.66	24	208	6.66
17	*Rubus niveus*	8	48	1.97	8	48	1.97	8	48	1.97
18	*Sarcococca*	56	1568	28.04	56	1568	28.04	56	1568	28.04
19	*Seigesbeckia orientalis*	12	96	3.24	12	96	3.24	12	96	3.24
20	*Spirea* sp.	8	80	2.34	8	80	2.34	8	80	2.34
Total		**564**	**8656**	**200**	**564**	**8656**	**200**	**564**	**8656**	**200**

Appendix II. 3.44: Frequency, density and IVI of herbs in Thingbu chu barrage site

Sl. No.	Species name	Post–monsoon			Monsoon			Winter		
		Fr.	**Dn.**	**IVI**	**Fr.**	**Dn.**	**IVI**	**Fr.**	**Dn.**	**IVI**
1	*Aconitum elswii*				28	3600	4.11			
2	*Ainsliaea* sp.	20	3600	4.32	24	4800	3.94	16	3600	5.60
3	*Anaphalis margaritacea*	60	35600	22.01	60	49200	18.89	48	11200	17.01
4	*Aster* sp.	28	6800	6.70	16	3600	2.73			
5	*Astilbe rivularis*	24	7200	6.24	24	8400	4.82	20	5200	7.38
6	*Aconitum ferox*				28	6000	4.70	28	6000	9.63
7	*Cyathula capitata*	32	12800	9.48	36	13600	7.47	36	9600	13.41
8	*Dipsacus asper*	44	18000	13.19	20	9200	4.55			
9	*Dracocephalum* sp.	16	3600	3.72	16	3200	2.63			
10	*Elatostemma sessile*	32	9200	8.17	36	18000	8.54	44	18000	19.80
11	*Fragaria* sp.	60	44800	25.36	44	22400	10.53	40	22400	21.29
12	*Elsholtzia stobilifera*							48	35600	30.30
13	*Galium* sp.	20	9200	6.36	36	12800	7.27	32	12400	14.03
14	*Geranium pretense*	24	6800	6.09	16	3200	2.63	16	8400	8.21
15	*Herpetospermum pedunculosum*				20	3200	3.09			
16	*Leucanthus peduncularis*				48	55600	19.05			
17	*Nepeta* sp.	16	3200	3.58	16	3200	2.63			
18	*Ophiopogon intermedius*	24	4800	5.36	24	9200	5.01			
19	*Oplisminus compositus*	48	34800	19.91	56	49200	18.42	56	36400	32.55
20	*Parasenecio quinquelobus*				16	3600	2.73			
21	*Parochaetus communis*	36	13600	10.38						
22	*Persicaria ruminata*				28	9200	5.47			
23	*Paris polyphylla*	16	3200	3.58	16	3200	2.63			
24	*Pilea umbrosa*	36	15600	11.11	44	35600	13.73			
25	*Pogostemon* sp.	20	3200	4.18	16	3200	2.63	20	3200	6.29
26	*Potentilla cuneata*	32	7200	7.44	20	9200	4.55	24	6800	9.16
27	*Panax bipinnatifidus*				12	2800	2.07			
28	*Sambucus adnata*	36	17200	11.69	52	31200	13.59			
29	*Senecio cappa*	12	3200	2.97	16	3200	2.63			
30	*Swertia chiriyata*				40	18400	9.10			
31	*Thalictrum foliolosum*				16	4800	3.02			
32	*Thladiantha cordifolia*				12	3200	2.17			
33	*Urtica dioica*	28	10800	8.15	16	2800	2.53	12	4800	5.34
34	*Viola sikkimensis*				12	3200	2.17			
Total		**664**	**274400**	**200.00**	**864**	**412000**	**200.00**	**440**	**183600**	**200.00**

Appendix II. 3.45: Frequency, density, basal area and IVI for tree species in Thingbu chu powerhouse site

Sl. No.	Species name	Post–monsoon				Monsoon				Winter			
		Fr.	**Dn.**	**BA**	**IVI**	**Fr.**	**Dn.**	**BA**	**IVI**	**Fr.**	**Dn.**	**BA**	**IVI**
1	*Abies densa*	30	50	3.33	36.02	30	50	3.33	36.02	30	50	3.33	36.02
2	*Acer* sp.	50	70	1.24	38.97	50	70	1.24	38.97	50	70	1.24	38.97
3	*Betula alnoides*	30	50	2.51	32.58	30	50	2.51	32.58	30	50	2.51	32.58
4	*Corylus heterophylla*	60	110	1.88	54.31	60	110	1.88	54.31	60	110	1.88	54.31
5	*Pinus wallichiana*	30	40	3.00	32.38	30	40	3.00	32.38	30	40	3.00	32.38

6	*Taxus wallichiana*	30	50	0.67	24.90	30	50	0.67	24.90	30	50	0.67	24.90
7	*Tsuga dumosa*	50	70	11.23	80.83	50	70	11.23	80.83	50	70	11.23	80.83
Total		**280**	**440**	**23.87**	**300**	**280**	**440**	**23.87**	**300**	**280**	**440**	**23.87**	**300.00**

Fr.–Frequency percentage, Dn.–Density (ha^{-1}), BA–Basal area (m^2 ha^{-1}), IVI–Importance value index

Appendix II. 3.46: Frequency, density and IVI of shrubs in Thingbu chu powerhouse site

Sl. No.	Species name	Post–monsoon			Monsoon			Winter		
		Fr.	**Dn.**	**IVI**	**Fr.**	**Dn.**	**IVI**	**Fr.**	**Dn.**	**IVI**
1	*Arundinella* sp.	48	544	13.53	48	544	13.53	48	544	13.53
2	*Aconogonum molle*	60	368	13.27	60	368	13.27	60	368	13.27
3	*Artemesia nilagirica*	68	1248	24.73	68	1248	24.73	68	1248	24.73
4	*Berberis* sp.	72	896	21.23	72	896	21.23	72	896	21.23
5	*Coriaria nepalensis*	36	368	9.68	36	368	9.68	36	368	9.68
6	*Daphne paparacea*	72	1776	31.49	72	1776	31.49	72	1776	31.49
7	*Eleagnus parviflora*	36	272	8.56	36	272	8.56	36	272	8.56
8	*Girardinia grandiflora*	28	400	8.86	28	400	8.86	28	400	8.86
9	*Heracleum*	16	144	4.07	16	144	4.07	16	144	4.07
10	*Hypericum choisianum*	20	112	4.30	20	112	4.30	20	112	4.30
11	*Neillia thrysiflora*	12	96	2.92	12	96	2.92	12	96	2.92
12	*Philadelphus tomentosus*	12	64	2.54	12	64	2.54	12	64	2.54
13	*Piptanthus nepalensis*	48	768	16.14	48	768	16.14	48	768	16.14
14	*Rosa* sp.	32	80	5.72	32	80	5.72	32	80	5.72
15	*Rubus ellipticus*	36	288	8.75	36	288	8.75	36	288	8.75
16	*Rubus niveus*	8	64	1.94	8	64	1.94	8	64	1.94
17	*Sarcococca*	44	896	17.03	44	896	17.03	44	896	17.03
18	*Seigesbeckia orientalis*	20	192	5.23	20	192	5.23	20	192	5.23
Total		**668**	**8576**	**200**	**668**	**8576**	**200**	**668**	**8576**	**200**

Fr.–Frequency percentage, Dn.–Density (ha^{-1}), IVI–Importance value index

Appendix II. 3.47: Frequency, density and IVI of herbs in Thingbu chu powerhouse site

Sl. No.	Species name	Post–monsoon			Monsoon			Winter		
		Fr.	**Dn.**	**IVI**	**Fr.**	**Dn.**	**IVI**	**Fr.**	**Dn.**	**IVI**
1	*Aconitum elswii*				20	3600	3.74			
2	*Ainsliaea* sp.	16	3600	3.91	20	4800	4.13	16	3600	5.37
3	*Anaphalis margaritacea*	48	42800	21.57	44	31200	15.76	20	7600	8.37
4	*Aster* sp.	16	3600	3.91	20	3600	3.74			
5	*Astilbe rivularis*	24	8400	6.78	24	6800	5.29	28	4800	8.60
6	*Aconitum ferox*				20	5200	4.26	32	5600	9.89
7	*Cyathula capitata*	28	11600	8.47	32	12400	8.13	36	8400	12.25
8	*Dipsacus asper*	24	9200	7.03	28	13600	8.01	36	8800	12.46
9	*Dracocephalum* sp.	12	2400	2.84	12	2000	2.19			
10	*Elatostemma sessile*				40	26800	13.82	28	20800	17.15
11	*Elsholtzia strobilifera*	44	35200	18.53	36	16800	10.07			
12	*Fragaria* sp.	36	18000	11.84	28	8400	6.32	40	25600	22.30
13	*Galium* sp.	36	22400	13.19	16	3200	3.10	32	12800	13.73
14	*Geranium pretense*	28	12800	8.84	16	3200	3.10	20	4800	6.87
15	*Herpetospermum pedunculosum*				12	2800	2.45			
16	*Leucanthus peduncularis*				20	3200	3.61	44	31200	26.15
17	*Nepeta* sp.	16	3200	3.78	28	9200	6.58			
18	*Ophiopogon intermedius*	16	3200	3.78	36	11200	8.26	52	36400	30.65
19	*Oplisminus compositus*	60	55600	27.61	56	44400	21.58			
20	*Parasenecio quinquelobus*				12	2800	2.45			
21	*Parochaetus communis*	16	3200	3.78						
22	*Persicaria ruminata*				36	26800	13.31			
23	*Panax bipinnatifidus*	20	9200	6.33	24	3200	4.13			
24	*Pilea umbrosa*	36	49200	21.44	40	26800	13.82			
25	*Pogostemon* sp.	12	3600	3.21	16	3600	3.23	20	3600	6.23
26	*Potentilla cuneata*	20	9200	6.33	16	3600	3.23	28	6400	9.45
27	*Paris polyphylla*				8	1600	1.55			
28	*Sambucus adnata*	20	9200	6.33	36	12400	8.65			
29	*Senecio cappa*	16	3200	3.78	12	2800	2.45			
30	*Thalictrum foliolosum*				28	4800	5.16			
31	*Thladiantha cordifolia*	16	3200	3.78	16	3200	3.10			
32	*Urtica dioica*	12	2800	2.96	12	2800	2.45	32	6800	10.53
33	*Viola sikkimensis*				12	2400	2.32			
Total		**572**	**324800**	**200**	**776**	**309200**	**200**	**464**	**187200**	**200**

Fr.–Frequency percentage, Dn.–Density (ha^{-1}), IVI–Importance value index

Appendix II. 3.48: Frequency, density, basal area and IVI for tree species in Thingbu chu catchment area

Sl. No.	Species name	Post–monsoon				Monsoon				Winter			
		Fr.	**Dn.**	**BA**	**IVI**	**Fr.**	**Dn.**	**BA**	**IVI**	**Fr.**	**Dn.**	**BA**	**IVI**
1	*Abies densa*	20	30	1.51	31.36	20	30	1.51	31.36	20	30	1.51	31.36
2	*Acer* sp.	50	90	1.52	61.36	50	90	1.52	61.36	50	90	1.52	61.36
3	*Betula alnoides*	20	40	2.14	39.98	20	40	2.14	39.98	20	40	2.14	39.98
4	*Corylus heterophylla*	30	70	0.23	34.74	30	70	0.23	34.74	30	70	0.23	34.74
5	*Larix griffithii*	10	20	0.09	10.77	10	20	0.09	10.77	10	20	0.09	10.77
6	*Picea spinulosa*	10	10	1.11	17.72	10	10	1.11	17.72	10	10	1.11	17.72
7	*Pinus wallichiana*	20	30	2.18	37.72	20	30	2.18	37.72	20	30	2.18	37.72
8	*Taxus wallichiana*	20	20	1.60	29.58	20	20	1.60	29.58	20	20	1.60	29.58
9	*Tsuga dumosa*	40	60	0.25	36.78	40	60	0.25	36.78	40	60	0.25	36.78
Total		**220**	**370**	**10.64**	**300**	**220**	**370**	**10.64**	**300**	**220**	**370**	**10.64**	**300**

Fr.–Frequency percentage, Dn.–Density (ha^{-1}), BA–Basal area (m^2 ha^{-1}), IVI–Importance value index

Appendix II. 3.49: Frequency, density and IVI of shrubs in Thingbu chu catchment area

Sl. No.	Species name	Post–monsoon			Monsoon			Winter		
		Fr.	**Dn.**	**IVI**	**Fr.**	**Dn.**	**IVI**	**Fr.**	**Dn.**	**IVI**
1	*Arundinella malling*	28	368	8.97	28	368	8.97	28	368	8.97
2	*Aconogonum molle*	28	176	6.86	28	176	6.86	28	176	6.86
3	*Artemesia nilagirica*	60	1680	29.02	60	1680	29.02	60	1680	29.02
4	*Berberis* sp.	44	368	11.79	44	368	11.79	44	368	11.79
5	*Coriaria nepalensis*	40	448	11.96	40	448	11.96	40	448	11.96
6	*Daphne papyracea*	56	1872	30.42	56	1872	30.42	56	1872	30.42
7	*Eleagnus parviflora*	16	128	4.22	16	128	4.22	16	128	4.22
8	*Girardinia grandiflora*	36	336	10.03	36	336	10.03	36	336	10.03
9	*Heracleum* sp.	8	48	1.94	8	48	1.94	8	48	1.94
10	*Hypericum choisianum*	8	64	2.11	8	64	2.11	8	64	2.11
11	*Ilex dipyrena*	12	112	3.34	12	112	3.34	12	112	3.34
12	*Neillia thyrsiflora*	16	144	4.40	16	144	4.40	16	144	4.40
13	*Philadelphus tomentosus*	8	112	2.64	8	112	2.64	8	112	2.64
14	*Piptanthus nepalensis*	68	784	20.58	68	784	20.58	68	784	20.58
15	*Rosa* sp.	12	64	2.82	12	64	2.82	12	64	2.82
16	*Rubus ellipticus*	36	544	12.31	36	544	12.31	36	544	12.31
17	*Rubus niveus*	8	128	2.81	8	128	2.81	8	128	2.81
18	*Sarcococca*	56	1424	25.50	56	1424	25.50	56	1424	25.50
19	*Seigesbeckia orientalis*	20	240	6.16	20	240	6.16	20	240	6.16
20	*Spirea* sp.	8	64	2.11	8	64	2.11	8	64	2.11
Total		**568**	**9104**	**200**	**568**	**9104**	**200**	**568**	**9104**	**200**

Fr.–Frequency percentage, Dn.–Density (ha^{-1}), IVI–Importance value index

Appendix II. 3.50: Frequency, density and IVI of herbs in Thingbu chu catchment area

Sl. No.	Species name	Post–monsoon			Monsoon			Winter		
		Fr.	**Dn.**	**IVI**	**Fr.**	**Dn.**	**IVI**	**Fr.**	**Dn.**	**IVI**
1	*Ainsliaea* sp.	16	3600	3.15	20	7600	4.91	20	4400	8.43
2	*Anaphalis margaritacea*	36	26800	11.82	60	44800	21.06	36	10400	16.82
3	*Aconitum ferox*	12	2800	2.39	16	3200	3.10			
4	*Astilbi rivularis*	16	3600	3.15	16	3600	3.21	12	3200	5.43
5	*Cyathula capitata*	40	31200	13.50	24	6800	5.22	28	4800	10.89
6	*Dipsacus aspera*	44	18000	10.71	36	23200	11.57	24	9200	12.73
7	*Elatostemma sessile*	28	12400	7.05	44	12400	9.55			
8	*Elsholtzia strobilifera*	48	13600	10.15				48	35600	36.92
9	*Fragaria* sp.	12	2000	2.18	36	13600	8.81	36	26400	27.49
10	*Galium* sp.	40	22400	11.27	28	10800	6.91	28	7600	12.76
11	*Geranium pretense*	24	8400	5.48	12	2800	2.44	20	4800	8.69
12	*Halenia elliptica*	32	22400	10.15						
13	*Leucanthus penduncularis*	56	54800	21.72	48	58000	23.23			
14	*Nepeta* sp.	20	3200	3.60	24	8400	5.68	12	2800	
15	*Ophiopogon intermedius*	32	12400	7.61	24	8400	5.68			5.16
16	*Oplisminus compositus*	52	49200	19.74	48	35200	16.66	56	31200	36.18
17	*Parochaetus communis*	36	22400	10.71						
18	*Parasenecio quinquelobus*				12	2800	2.44			
19	*Persicaria ruminata*				36	22400	11.34			
20	*Phlomis* sp.	12	2800	2.39	16	4400	3.44			
21	*Pilea umbrosa*	48	44400	17.96	28	11200	7.03			

Sl.	Species name	Post–monsoon			Monsoon			Winter		
22	*Pogostemon* sp.	12	2800	2.39	20	4400	3.98	12	3200	5.43
23	*Potentilla cuneata*	20	4800	4.01	28	9200	6.45	20	3600	7.89
24	*Paris polyphylla*				20	3200	3.64			
25	*Sambucus adnata*	40	22400	11.27	48	26800	14.24			
26	*Senecio cappa*	12	2800	2.39	16	3600	3.21			
27	*Thalictrium foliosum*				24	3600	4.30			
28	*Thladiantha cordifolia*	16	3600	3.15	8	1600	1.55			
29	*Urtica dioica*	12	1600	2.08	28	12400	7.38	12	2800	5.16
30	*Viola sikkimensis*				16	2800	2.98			
Total		**716**	**394400**	**200.00**	**736**	**347200**	**200**	**364**	**150000**	**200**

Fr.–Frequency percentage, Dn.–Density (ha^{-1}), IVI–Importance value index

Appendix II. 3.51: Dominant and co–dominant species determined on the basis of IVI/density values of species in the plant communities at Thingbu chu site

Community components	Barrage	Powerhouse	Catchment area
Tree species*			
Dominant	*Tsuga dumosa*	*Tsuga dumosa*	*Acer* sp.
Co–Dominant	*Leucosceptrum canum*	*Corylus heterophylla*	*Betula alnoides*
Shrub species*			
Dominant	*Daphne papyracea*	*Daphne papyracea*	*Daphne papyracea*
Co–Dominant	*Sarcococca* sp.	*Artemesia nilagarica*	*Artemesia nilagarica*
Herb species**			
i. Pre–monsoon season			
Dominant	*Fragaria* sp.	*Opliomenus compositus*	*Lecanthus penduncularis*
Co–Dominant	*Anaphalis margaritacea*	*Anaphalis margaritacea*	*Opliomenus compositus*
ii. Monsoon season			
Dominant	*Anaphalis margaritacea*	*Opliomenus compositus*	*Lecanthus penduncularis*
Co–Dominant	*Opliomenus compositus*	*Anaphalis margaritacea*	*Anaphalis margaritacea*
iii. Winter			
Dominant	*Opliomenus compositus*	*Opliomenus compositus*	*Elsholtzia stobilifera*
Co–Dominant	*Fragaria* sp.	*Elsholtzia stobilifera*	*Opliomenus compositus*

* Dominance based on IVI; ** Dominance based on density

Appendix II. 3.52: List of plant species recorded from New Melling HEP site

Sl. No.	Species name	Family
TREES		
1	*Acer* sp.	*Aceraceae*
2	*Alnus nepalensis*	*Betulaceae*
3	*Betula alnoides*	*Betulaceae*
4	*Brassaiopsis glomerulata*	*Araliaceae*
5	*Corylus heterophylla*	*Betulaceae*
6	*Larix griffithiana*	*Pinaceae*
7	*Leucosceptrum canum*	*Lamiaceae*
8	*Persea* sp.	*Lauraceae*
9	*Picea spinulosa*	*Pinaceae*
10	*Pinus wallichiana*	*Pinaceae*
11	*Populus ciliata*	Salicaceae
12	*Quercus semicarpifolia*	*Fagaceae*
13	*Rhododendron campanulatum*	*Ericaceae*
14	*Rhododendron* sp.	*Ericaceae*
15	*Sorbus* sp.	*Rosaceae*
16	*Taxus wallichiana*	*Taxaceae*
17	*Tsuga dumosa*	*Pinaceae*
SHRUBS		
18	*Aconogonum molle*	*Polygonaceae*
19	*Artemisia nilagirica*	*Asteraceae*
20	*Arundinaria maling*	*Poaceae*
21	*Berberis* sp.	*Berberidaceae*
22	*Boenninghausenia albiflora*	*Rutaceae*
23	*Coriaria cylindrica*	*Coriariaceae*
24	*Coriaria nepalensis*	*Coriariaceae*
25	*Daphne papyracea*	*Thymelaeaceae*
26	*Elaeagnus parviflora*	*Elaegnaceae*
27	*Girardinia diversifolia*	*Urticaceae*
28	*Hypericum choisianum*	*Hypericaceae*

Sl. No.	Species name	Family
29	*Hypericum* sp.	*Hypericaceae*
30	*Ilex dipyrena*	*Aquifoliaceae*
31	*Neillia thyrsiflora*	*Rosaceae*
32	*Piptanthus nepalensis*	*Papilionaceae*
33	*Plectranthus* sp.	*Lamiaceaea*
34	*Rosa* sp.	*Rosaceae*
35	*Rubus ellipticus*	*Rosaceae*
36	*Rubus niveus*	*Rosaceae*
37	*Sarcococca* sp.	Buxaceae
38	*Seigesbeckia orientalis*	*Asteraceae*
39	*Spirea* sp.	*Rosaceae*
HERBS		
40	*Ainsliaea* sp.	Asteraceae
41	*Anaphalis margaritacea*	Asteraceae
42	*Aster* sp.	Asteraceae
43	*Aster trinervius*	Asteraceae
44	*Astilbe rivularis*	Saxifragaceae
45	*Campanula* sp.	Campanulaceae
46	*Cyathula capitata*	Amaranthaceae
47	*Cynoglossum*	Boraginaceae
48	*Dipsacus asper*	Dipsacaceae
49	*Dracocephalum* sp.	Lamiaceae
50	*Drymaria cordata*	Caryophyllaceae
51	*Elatostemma sessile*	Urticaceae
52	*Elsholtzia strobilifera*	Lamiaceae
53	*Equisetum* sp.	Equisetaceae
54	*Fragaria nubicola*	Rosaceae
55	*Fragaria* sp.	Rosaceae
56	*Galium rotundifolium*	Rubiaceae
57	*Galium* sp.	Rubiaceae
58	*Geranium pretense*	Geraniaceae
59	*Heracleum* sp.	Apiaceae
60	*Herpetospermum pedunculosum*	Cucurbitaceae
61	*Lecanthus peduncularis*	Urticaceae
62	*Nepeta* sp.	Lamiaceae
63	*Ophiopogon intermedius*	Liliaceae
64	*Oplisminus compositus*	Poaceae
65	*Panax bipinnatifidus*	Araliaceae
66	*Parasenecio quinquelobus*	Asteraceae
67	*Paris polyphylla*	Triliaceae
68	*Parochaetus communis*	Papilionaceae
69	*Persicaria runcinata*	Polygonaceae
70	*Phlomis* sp.	Lamiaceae
71	*Pilea umbrosa*	Urticaceae
72	*Pogostemon* sp.	Lamiaceae
73	*Potentilla cuneata*	Rosaceae
74	*Rumex acetosella*	Polygonaceae
75	*Rumex nepalensis*	Polygonaceae
76	*Salvia* sp.	Lamiaceae
77	*Sambucus adnata*	Adoxaceae
78	*Senecio cappa*	Asteraceae
79	*Swertia chirayita*	
80	*Swertia paniculata*	Gentianaceae
81	*Thalictrium foliolosum*	Ranunculaceae
82	*Thladiantha cordifolia*	Ranunculaceae
83	*Urtica dioica*	Urticaceae
84	*Viola sikkimensis*	Violaceae
CLIMBERS		
85	*Aristolochia griffithii*	Aristolochiaceae
86	*Celastrus paniculata*	Celastraceae
87	*Cissampelos* sp.	Menispermaceae
88	*Clematis* sp.	Ranunculaceae
89	*Dioscorea* sp.	Dioscoreaceae
90	*Ficus* sp.	Moraceae
91	*Hedera nepalensis*	Araliaceae
92	*Herpetospermun pedunculosum*	Cucurbitaceae

Sl. No.	Species name	Family
93	*Holboellia latifolia*	Lardizabalaceae
94	*Periploca* sp.	Periplocaceae
95	*Philadephus tomentosus*	Hydrangeaceae
96	*Rubia cordifolia*	Rubiaceae
97	*Smilax* sp.	Smilacaceae
98	*Stephania glandulifera*	Menispermaceae
99	*Thladiantha cordifolia*	Cucurbitaceae
ORCHIDS		
100	*Bulbophyllum* sp.	Orchidaceae
101	*Calanthe tricarinata*	Orchidaceae
102	*Coelogynae* sp.	Orchidaceae
103	*Cymbidium* sp.	Orchidaceae
104	*Dendrobium* sp.	Orchidaceae
105	*Oberonia* sp.	Orchidaceae
106	*Pleione praecox*	Orchidaceae
PTERIDOPHYTES		
107	*Adiantum* sp.	Adiantaceae
108	*Athyrium* sp.	Athyraceae
109	*Botrychium* sp.	Ophioglossaceae
110	*Dicranopteris linearis*	Dicranopteridaceae
111	*Dryopteris wallichiana*	Dryopteridaceae
112	*Dynaria quercifolia*	Drynariaceae
113	*Lepisorus* sp.	Polypodiaceae
114	*Polypodium* sp.	Polypodiaceae
115	*Pteris* sp.	Pteridiaceae
116	*Pteris vittata*	Pteridaceae
117	*Pyrrosia nuda*	Crptogrammaceae
118	*Selaginella* sp.	Selaginellaceae
119	*Vittaria elongata*	Vittariaceae
BRYOPHYTES		
120	*Aerobryum* sp.	Meteoriaceae
121	*Desmotheca* sp.	Orthotrichaceae
122	*Diphyscium* sp.	Buxbaumiaceae
123	*Funaria* sp.	Funariaceae
124	*Lyellia* sp.	Polytrichaceae
125	*Marchantia* sp.	Marchantiaceae
126	*Plagiobryum* sp.	Bryaceae
LICHENS		
127	*Alectoria* sp.	Alectoriaceae
128	*Cladonia* sp.	Cladoniaceae
129	*Graphis* sp.	Graphidaceae
130	*Lobaria* sp.	Lobariaceae
131	*Parmelia* sp.	Parmeliaceae
132	*Parmotrema* sp.	Parmeliaceae
133	*Pseudocyphellaria* sp.	Lobariaceae
134	*Stereocaulon* sp.	Stereocaulaceae
135	*Sticta* sp.	Lobariaceae
136	*Teloschistes* sp.	Teloschistaceae
137	*Usnea* sp.	Parmeliaceae
FUNGI		
138	*Auricularia auriculiformis*	Auriculariaceae
139	*Clathrus rubra*	Phallaceae
140	*Coprinus disseminatus*	Agaricaceae
141	*Daldinia concentrica*	Xylariaceae
142	*Fomes pinicola*	Fomitopsidaceae
143	*Hericium erinaceus*	Hericiaceae
144	*Hygrocybe miniata*	Hygrophoraceae
145	*Laccaria laccata*	Hydnangiaceae
146	*Lactarius rubidus*	Russulaceae
147	*Phellinus schweintizii*	Hymenochaetaceae
148	*Poria monticola*	Polyporaceae
149	*Pycnoporellus fibrillosus*	Formitopscidaceae
150	*Schizophyllum commune*	Schizophyllaceae
151	*Tremella mesenterica*	Tremellaceae
152	*Xylaria polymorpha*	Xylariaceae

Appendix II. 3.53: Different groups of plant species present at New Melling HEP site

Sl. No.	Species name Barrage and Powerhouse	Family	Sl. No.	Species name Catchment area	Family
CLIMBERS					
1	*Aristolochia griffithii*	Aristolochiaceae	1	*Aristolochia griffithii*	Aristolochiaceae
2	*Celastrus paniculata*	Celastraceae	2	*Celastrus paniculata*	Celastraceae
3	*Cissampelos* sp.	Menispermaceae	3	*Hedera nepalensis*	Araliaceae
4	*Clematis* sp.	Ranunculaceae	4	*Herpetospermun pedunculosum*	Cucurbitaceae
5	*Dioscorea* sp.	Dioscoreaceae	5	*Holboellia latifolia*	Lardizabalaceae
6	*Ficus* sp.	Moraceae	6	*Periploca* sp.	Periplocaceae
7	*Hedera nepalensis*	Araliaceae	7	*Philadephus tomentosus*	Hydrangeaceae
8	*Herpetospermun pedunculosum*	Cucurbitaceae	8	*Rubia cordifolia*	Rubiaceae
9	*Holboellia latifolia*	Lardizabalaceae	9	*Stephania glandulifera*	Menispermaceae
10	*Periploca* sp.	Periplocaceae	10	*Thladiantha cordifolia*	Cucurbitaceae
11	*Philadephus tomentosus*	Hydrangeaceae			
12	*Rubia cordifolia*	Rubiaceae			
13	*Smilax* sp.	Smilacaceae			
14	*Stephania glandulifera*	Menispermaceae			
15	*Thladiantha cordifolia*	Cucurbitaceae			
ORCHIDS					
1	*Bulbophyllum* sp.	Orchidaceae	1	*Bulbophyllum* sp.	Orchidaceae
2	*Calanthe tricarinata*	Orchidaceae	2	*Calanthe tricarinata*	Orchidaceae
3	*Coelogynae* sp.	Orchidaceae	3	*Cymbidium* sp.	Orchidaceae
4	*Cymbidium* sp.	Orchidaceae	4	*Dendrobium* sp.	Orchidaceae
5	*Dendrobium* sp.	Orchidaceae	5	*Oberonia* sp.	Orchidaceae
6	*Oberonia* sp.	Orchidaceae			
7	*Pleione praecox*	Orchidaceae			
PTERIDOPHYTES					
1	*Adiantum* sp.	Adiantaceae	1	*Adiantum* sp.	Adiantaceae
2	*Athyrium* sp.	Athyraceae	2	*Dicranopteris linearis*	Dicranopteridaceae
3	*Botrychium* sp.	Ophioglossaceae	3	*Dryopteris wallichiana*	Dryopteridaceae
4	*Dicranopteris linearis*	Dicranopteridaceae	4	*Lepisorus* sp.	Polypodiaceae
5	*Dryopteris wallichiana*	Dryopteridaceae	5	*Polypodium* sp.	Polypodiaceae
6	*Dynaria quercifolia*	Drynariaceae	6	*Pteris vittata*	Pteridaceae
7	*Lepisorus* sp.	Polypodiaceae	7	*Pyrrosia nuda*	Crptogrammaceae
8	*Polypodium* sp.	Polypodiaceae	8	*Selaginella* sp.	Selaginellaceae
9	*Pteris* sp.	Pteridiaceae	9	*Vittaria elongata*	Vittariaceae
10	*Pteris vittata*	Pteridaceae			
11	*Pyrrosia nuda*	Crptogrammaceae			
12	*Selaginella* sp.	Selaginellaceae			
13	*Vittaria elongata*	Vittariaceae			
BRYOPHYTES					
1	*Aerobryum* sp.	Meteoriaceae	1	*Aerobryum* sp.	Meteoriaceae
2	*Desmotheca* sp.	Orthotrichaceae	2	*Desmotheca* sp.	Orthotrichaceae
3	*Diphyscium* sp.	Buxbaumiaceae	3	*Funaria* sp.	Funariaceae
4	*Funaria* sp.	Funariaceae	4	*Plagiobryum* sp.	Bryaceae
5	*Lyellia* sp.	Polytrichaceae			
6	*Marchantia* sp.	Marchantiaceae			
7	*Plagiobryum* sp.	Bryaceae			
LICHENS					
1	*Alectoria* sp.	Alectoriaceae	1	*Alectoria* sp.	Alectoriaceae
2	*Cladonia* sp.	Cladoniaceae	2	*Cladonia* sp.	Cladoniaceae
3	*Graphis* sp.	Graphidaceae	3	*Graphis* sp.	Graphidaceae
4	*Lobaria* sp.	Lobariaceae	4	*Parmotrema* sp.	Parmeliaceae
5	*Parmelia* sp.	Parmeliaceae	5	*Pseudocyphellaria* sp.	Lobariaceae
6	*Parmotrema* sp.	Parmeliaceae	6	*Stereocaulon* sp.	Stereocaulaceae
7	*Pseudocyphellaria* sp.	Lobariaceae	7	*Usnea* sp.	Parmeliaceae
8	*Stereocaulon* sp.	Stereocaulaceae			
9	*Sticta* sp.	Lobariaceae			
10	*Teloschistes* sp.	Teloschistaceae			
11	*Usnea* sp.	Parmeliaceae			

Appendix II. 3.54: Species list of macro–fungi recorded from barrage and powerhouse sites of New Melling

Species	**Family**	**Species**	**Family**
Barrage		**Powerhouse**	
Auricularia auriculiformis	Auriculariaceae	*Auricularia auriculiformis*	Auriculariaceae
Clathrus rubra	Phallaceae	*Clathrus rubra*	Phallaceae
Coprinus disseminatus	Agaricaceae	*Coprinus disseminatus*	Agaricaceae
Daldinia concentrica	Xylariaceae	*Daldinia concentrica*	Xylariaceae
Fomes pinicola	Fomitopsidaceae	*Fomes pinicola*	Fomitopsidaceae
Hericium erinaceus	Hericiaceae	*Hericium erinaceus*	Hericiaceae
Hygrocybe miniata	Hygrophoraceae	*Hygrocybe miniata*	Hygrophoraceae
Laccaria laccata	Hydnangiaceae	*Laccaria laccata*	Hydnangiaceae
Lactarius rubidus	Russulaceae	*Poria monticola*	Polyporaceae
Phellinus schweintizii	Hymenochaetaceae	*Pycnoporellus fibrillosus*	Formitopscidaceae
Poria monticola	Polyporaceae	*Tremella mesenterica*	Tremellaceae
Pycnoporellus fibrillosus	Formitopscidaceae	*Xylaria polymorpha*	Xylariaceae
Schizophyllum commune	Schizophyllaceae		
Tremella mesenterica	Tremellaceae		
Xylaria polymorpha	Xylariaceae		
Catchment area			
Species	**Family**		
Auricularia auriculiformis	Auriculariaceae		
Clathrus rubra	Phallaceae		
Coprinus disseminatus	Agaricaceae		
Daldinia concentrica	Xylariaceae		
Fomes pinicola	Fomitopsidaceae		
Hericium erinaceus	Hericiaceae		
Laccaria laccata	Hydnangiaceae		
Lactarius rubidus	Russulaceae		
Poria monticola	Polyporaceae		
Pycnoporellus fibrillosus	Formitopscidaceae		
Schizophyllum commune	Schizophyllaceae		
Tremella mesenterica	Tremellaceae		
Xylaria polymorpha	Xylariaceae		

Appendix II. 3.55: Frequency, density, basal area and IVI for tree species in New Melling barrage site

Sl. No.	**Species name**	**Post–monsoon**				**Monsoon**				**Winter**			
		Fr.	**Dn.**	**BA**	**IVI**	**Fr.**	**Dn.**	**BA**	**IVI**	**Fr.**	**Dn.**	**BA**	**IVI**
1	Acer sp.	50	110	7.90	38.67	50	110	7.90	38.67	50	110	7.90	38.67
2	*Alnus nepalensis*	30	60	2.88	20.40	30	60	2.88	20.40	30	60	2.88	20.40
3	*Betula alnoides*	20	20	1.81	10.63	20	20	1.81	10.63	20	20	1.81	10.63
4	*Brassaiopsis glomerulata*	20	50	0.71	13.77	20	50	0.71	13.77	20	50	0.71	13.77
5	*Corylus heterophylla*	20	40	0.71	12.34	20	40	0.71	12.34	20	40	0.71	12.34
6	*Leucosceptrum canum*	30	70	0.96	19.82	30	70	0.96	19.82	30	70	0.96	19.82
7	*Picea spinulosa*	10	10	1.67	6.12	10	10	1.67	6.12	10	10	1.67	6.12
8	*Pinus wallichiana*	20	20	2.03	10.86	20	20	2.03	10.86	20	20	2.03	10.86
9	*Populus ciliata*	30	60	17.22	35.38	30	60	17.22	35.38	30	60	17.22	35.38
10	*Quercus semicarpifolia*	20	30	1.34	11.56	20	30	1.34	11.56	20	30	1.34	11.56
11	*Rhododendron campanulatum*	10	10	0.25	4.63	10	10	0.25	4.63	10	10	0.25	4.63
12	*Tsuga dumosa*	80	220	58.26	115.81	80	220	58.26	115.81	80	220	58.26	115.81
Total		**340**	**700**	**95.75**	**300**	**340**	**700**	**95.7**	**300**	**340**	**700**	**96**	**300**

Fr.–Frequency percentage, Dn.–Density (ha^{-1}), BA–Basal area ($m^2 ha^{-1}$), IVI–Importance value index

Appendix II. 3.56: Frequency, density and IVI of shrubs in New Melling barrage site

Sl. No.	**Species name**	**Post–monsoon**			**Monsoon**			**Winter**		
		Fr.	**Dn.**	**IVI**	**Fr.**	**Dn.**	**IVI**	**Fr.**	**Dn.**	**IVI**
1	*Artemesia nilagirica*	36	1168	16.15	36	1168	16.15	36	1168	16.15
2	*Arundinella manii*	56	2784	33.46	56	2784	33.46	56	2784	33.46
3	*Aconogonum molle*	28	272	7.07	28	272	7.07	28	272	7.07
4	*Berberis* sp.	36	416	9.67	36	416	9.67	36	416	9.67
5	*Coriaria nepalensis*	32	416	8.99	32	416	8.99	32	416	8.99
6	*Daphne paparacea*	44	1968	24.40	44	1968	24.40	44	1968	24.40
7	*Elaeagnus parviflora*	48	272	10.45	48	272	10.45	48	272	10.45
8	*Girardiniadiversifolia*	28	592	9.83	28	592	9.83	28	592	9.83
9	*Hypericum choisianum*	28	192	6.38	28	192	6.38	28	192	6.38
10	*Ilex dipyrena*	32	272	7.75	32	272	7.75	32	272	7.75

Sl. No.	Species name	Post–monsoon			Monsoon			Winter		
11	*Neillia thyrsiflora*	28	288	7.21	28	288	7.21	28	288	7.21
12	*Piptanthus nepalensis*	48	736	14.45	48	736	14.45	48	736	14.45
13	*Rosa* sp.	24	144	5.30	24	144	5.30	24	144	5.30
14	*Rubus ellipticus*	28	448	8.59	28	448	8.59	28	448	8.59
15	*Rubus niveus*	24	128	5.16	24	128	5.16	24	128	5.16
16	*Sarcococca*	44	1248	18.19	44	1248	18.19	44	1248	18.19
17	*Seigesbeckia orientalis*	28	256	6.94	28	256	6.94	28	256	6.94
Total		**592**	**11600**	**200**	**592**	**11600**	**200**	**592**	**11600**	**200**

Fr.–Frequency percentage, Dn.–Density (ha^{-1}), IVI–Importance value index

Appendix II. 3.57: Frequency, density and IVI of herbs in New Melling barrage site

Sl. No.	Species name	Post–monsoon			Monsoon			Winter		
		Fr.	Dn.	IVI	Fr.	Dn.	IVI	Fr.	Dn.	IVI
1	*Ainsliaea* sp.	24	5200	5.14	32	9200	5.05	20	1.51	5.08
2	*Anaphalis margaritacea*	48	26800	15.51	56	62400	18.05	44	7.06	14.92
3	*Aster* sp.	32	8400	7.33	32	9200	5.05			
4	*Aster trinervius*				28	6800	4.17			
5	*Astilbe rivularis*	28	6800	6.24	36	6800	4.97	28	2.35	7.35
6	*Campanula* sp.				32	4800	4.17			
7	*Cyathula capitata*	40	13600	10.15	52	26800	10.56	40	5.88	13.03
8	*Drymaria cordata*							56	14.96	24.96
9	*Dipsacus asper*	40	15200	10.65	44	13600	7.13			
10	*Dracocephalum* sp.	16	3200	3.34	28	4800	3.77			
11	*Elatostemma sessile*	40	26800	14.35	64	66800	19.73	52	9.41	18.70
12	*Elsholtzia strobilifera*	44	35600	17.73				60	15.97	26.68
13	*Equisetum*							24	3.36	7.65
14	*Fragaria* sp.							36	5.21	11.64
15	*Fragaria nubicola*	36	31200	15.17	28	22400	7.27			
16	*Galium* sp.	28	9200	7.00						
17	*Galium rotundifolium*				16	4800	2.56	24	3.36	7.65
18	*Geranium pretense*	16	6000	4.24	32	9200	5.05	28	3.03	8.03
19	*Leucanthus penduncularis*	24	7600	5.91	60	62400	18.45			
20	*Herachleum*				20	4800	2.96			
21	*Herpetospermum pedunculosum*				20	4800	2.96			
22	*Nepeta* sp.	20	3200	3.93	20	4400	2.88			
23	*Ophiopogon intermedius*	12	2800	2.64	12	12800	3.75			
24	*Oplisminus compositus*	44	53600	23.47	56	58000	17.18	48	17.31	25.88
25	*Panax bipinnatifidus*	24	3600	4.63	12	2000	1.60			
26	*Persicaria runcinata*				36	31200	9.83			
27	*Pilea umbrosa*	28	22400	11.20	92	30800	15.37			
28	*Pogostemon* sp.	20	3200	3.93	24	3200	3.05	20	1.18	4.75
29	*Potentilla cuneata*	40	5600	7.60	36	9200	5.45	24	2.35	6.64
30	*Rumex acetosella*							32	5.55	11.26
31	*Sambucus adnata*	44	14800	11.11						
32	*Senecio cappa*	20	3600	4.05	20	3200	2.65			
33	*Swertia chirayita*				16	3600	2.32			
34	*Thalictrium foliolosum*				32	9200	5.05			
35	*Thladiantha cordifolia*				16	3200	2.24			
36	*Urtica dioica*	20	5600	4.69	28	8400	4.48	24	1.51	5.80
37	*Viola sikkimensis*				16	3200	2.24			
Total		**688**	**314000**	**200**	**996**	**502000**	**200**	**560**	**100.00**	**200**

Fr.–Frequency percentage, Dn.–Density (ha^{-1}), IVI–Importance value index

Appendix II. 3.58: Frequency, density, basal area and IVI for tree species in New Melling powerhouse site

Sl. No.	Species name	Post–monsoon				Monsoon				Winter			
		Fr.	Dn.	BA	IVI	Fr.	Dn.	BA	IVI	Fr.	Dn.	BA	IVI
1	*Acer* sp.	20	20	0.71	24.40	20	20	0.71	24.40	20	20	0.71	24.40
2	*Alnus nepalensis*	20	30	0.67	27.35	20	30	0.67	27.35	20	30	0.67	27.35
3	*Brassaiopsis glomerulata*	40	60	0.74	47.63	40	60	0.74	47.63	40	60	0.74	47.63
4	*Persea* sp.	20	20	0.39	20.65	20	20	0.39	20.65	20	20	0.39	20.65
5	*Populus ciliata*	20	30	2.51	49.28	20	30	2.51	49.28	20	30	2.51	49.28
6	*Quercus semicarpifolia*	10	20	0.84	21.42	10	20	0.84	21.42	10	20	0.84	21.42
7	*Rhododendron* sp.	10	10	0.25	10.95	10	10	0.25	10.95	10	10	0.25	10.95
8	*Sorbus* sp.	10	10	0.04	8.49	10	10	0.04	8.49	10	10	0.04	8.49

Sl.	Species name	Post–monsoon				Monsoon				Winter			
9	*Tsuga dumosa*	20	20	1.44	33.09	20	20	1.44	33.09	20	20	1.44	33.09
10	*Corylus heterophylla*	20	20	0.31	19.64	20	20	0.31	19.64	20	20	0.31	19.64
11	*Leucosceptrum canum*	30	50	0.52	37.09	30	50	0.52	37.09	30	50	0.52	37.09
Total		**220**	**290**	**8.43**	**300**	**220**	**290**	**8.43**	**300**	**220**	**290**	**8.43**	**300.00**

Fr.–Frequency percentage, Dn.–Density (ha^{-1}), BA–Basal area ($m^2\ ha^{-1}$), IVI–Importance value index

Appendix II. 3.59: Frequency, density and IVI of shrubs in New Melling powerhouse site

Sl. No.	Species name	Post–monsoon			Monsoon			Winter		
		Fr.	**Dn.**	**IVI**	**Fr.**	**Dn.**	**IVI**	**Fr.**	**Dn.**	**IVI**
1	*Artemesia nilagarica*	48	1424	21.01	48	1424	21.01	48	1424	21.01
2	*Arundinella manii*	36	2672	28.69	36	2672	28.69	36	2672	28.69
3	*Aconogonum molle*	24	368	7.73	24	368	7.73	24	368	7.73
4	*Berberis* sp.	28	368	8.52	28	368	8.52	28	368	8.52
5	*Coriaria cylindrica*	12	112	3.28	12	112	3.28	12	112	3.28
6	*Coriaria nepalensis*	36	528	11.40	36	528	11.40	36	528	11.40
7	*Daphne papyracea*	56	2496	31.24	56	2496	31.24	56	2496	31.24
8	*Elaeagnus parviflora*	24	272	6.96	24	272	6.96	24	272	6.96
9	*Girardinia diversifolia*	28	464	9.30	28	464	9.30	28	464	9.30
10	*Hypericum choisianum*	24	336	7.47	24	336	7.47	24	336	7.47
11	*Ilex dipyrena*	32	416	9.70	32	416	9.70	32	416	9.70
12	*Piptanthus nepalensis*	44	864	15.70	44	864	15.70	44	864	15.70
13	*Rosa* sp.	16	112	4.08	16	112	4.08	16	112	4.08
14	*Rubus ellipticus*	32	368	9.32	32	368	9.32	32	368	9.32
15	*Rubus niveus*	12	112	3.28	12	112	3.28	12	112	3.28
16	*Sarcococca*	44	1424	20.21	44	1424	20.21	44	1424	20.21
17	*Spirea* sp.	8	64	2.10	8	64	2.10	8	64	2.10
Total		**504**	**12400**	**200**	**504**	**12400**	**200**	**504**	**12400**	**200**

Fr.–Frequency percentage, Dn.–Density (ha^{-1}), IVI–Importance value index

Appendix II. 3.60: Frequency, density and IVI of herbs in New Melling powerhouse site

Sl. No.	Species name	Post–monsoon			Monsoon			Winter		
		Fr.	**Dn.**	**IVI**	**Fr.**	**Dn.**	**IVI**	**Fr.**	**Dn.**	**IVI**
1	*Ainsliaea* sp.	16	5200	4.01	32	9200	5.83			
2	*Anaphalis margaritacea*	36	21200	12.01	56	49200	17.80	16	4000	4.39
3	*Aster* sp.	16	8000	4.89	16	4400	2.87			
4	*Aster trinervius*				20	4800	3.43	20	3600	5.01
5	*Astilbe rivularis*	16	5200	4.01	16	3200	2.59	24	5200	6.31
6	*Campanula* sp.				32	13600	6.84			
7	*Cynoglossum*	20	16800	8.25	36	18000	8.31	28	11200	9.10
8	*Cyathula capitata*	36	12400	9.25	48	22000	10.63	36	15200	11.97
9	*Dipsacus asper*	44	14000	10.94	44	12800	8.05			
10	*Drymaria cordata*							44	29600	18.36
11	*Dracocephalum* sp.	12	1600	2.29	20	3200	3.06			
12	*Elatostemma sessile*	32	22400	11.79	48	30400	12.55	40	47600	23.70
13	*Elsholtzia strobilifera*	48	39200	19.44				44	60800	28.93
14	*Fragaria* sp.	40	30000	15.36	36	22400	9.32	28	12000	9.37
15	*Equisetum*							28	12000	9.37
16	*Galium* sp.	24	16800	8.84						
17	*Galium* sp.				20	9200	4.44	32	7600	8.64
18	*Geranium pretense*	28	7200	6.43	24	4800	3.89	16	5200	4.79
19	*Herachleum*				28	4800	4.36			
20	*Herpetospermum pedunculosum*				24	4800	3.89			
21	*Nepeta* sp.	16	2000	3.01	12	2800	2.04			
22	*Ophiopogon intermedius*	32	7200	7.02	28	12800	6.19			
23	*Leucanthus peduncularis*	56	50000	24.02	48	58000	18.88	40	42800	22.07
24	*Parochaetus communis*				36	31200	11.34			
25	*Persicaria ruminata*				16	6800	3.42			
26	*Phlomis* sp.	12	2000	2.41	44	30800	12.18			
27	*Pilea umbrosa*	44	30000	15.96	48	49200	16.87			
28	*Pogostemon* sp.	24	2800	4.45	20	5600	3.61	12	1600	2.81
29	*Potentilla cuneata*	32	5600	6.52	16	3600	2.69	32	5600	7.96
30	*Rumex nepalensis*							40	12000	11.64
31	*Sambucus adnata*	44	13600	10.81				28	14800	10.32
32	*Salvia* sp.				16	3200	2.59			

Sl.	Species name	Post–monsoon			Monsoon			Winter		
33	*Oplisminus compositus*	20	2000	3.60	20	3200	3.06			
34	*Thalictrium foliolosum*				16	3200	2.59			
35	*Thladiantha cordifolia*				16	2800	2.50			
36	*Urtica dioica*	24	3600	4.70	12	3200	2.13	20	4400	5.28
37	*Viola sikkimensis*				12	2800	2.04			
Total		**672**	**318800**	**200**	**860**	**436000**	**200**	**528**	**295200**	**200**

Fr.–Frequency percentage, Dn.–Density (ha^{-1}), IVI–Importance value index

Appendix II. 3.61: Frequency, density, basal area and IVI for tree species in New Melling catchment area

Sl. No.	Species name	Post–monsoon				Monsoon				Winter			
		Fr.	**Dn.**	**BA**	**IVI**	**Fr.**	**Dn.**	**BA**	**IVI**	**Fr.**	**Dn.**	**BA**	**IVI**
1	*Larix griffithiana*	20	30	1.04	14.43	20	30	1.04	14.43	20	30	1.04	14.43
2	*Acer* sp.	10	20	1.46	9.83	10	20	1.46	9.83	10	20	1.46	9.83
3	*Alnus nepalensis*	20	40	1.19	16.48	20	40	1.19	16.48	20	40	1.19	16.48
4	*Betula alnoides*	30	20	1.09	16.29	30	20	1.09	16.29	30	20	1.09	16.29
5	*Leucosceptrum canum*	20	20	0.25	11.18	20	20	0.25	11.18	20	20	0.25	11.18
6	*Pinus wallichiana*	10	10	0.83	6.88	10	10	0.83	6.88	10	10	0.83	6.88
7	*Populus ciliata*	80	250	22.68	115.05	80	250	22.68	115.05	80	250	22.68	115.05
8	*Rhododendron* sp.	10	20	0.25	7.61	10	20	0.25	7.61	10	20	0.25	7.61
9	*Taxus wallichiana*	10	20	0.39	7.87	10	20	0.39	7.87	10	20	0.39	7.87
10	*Tsuga dumosa*	70	130	25.03	94.37	70	130	25.03	94.37	70	130	25.03	94.37
Total		**280**	**560**	**54.22**	**300**	**280**	**560**	**54.22**	**300**	**280**	**560**	**54.22**	**300**

Fr.–Frequency percentage, Dn.–Density (ha^{-1}), BA–Basal area (m^2 ha^{-1}), IVI–Importance value index

Appendix II. 3.62: Frequency, density and IVI of shrubs in New Melling catchment area

Sl. No.	Species name	Post–monsoon			Monsoon			Winter		
		Fr.	**Dn.**	**IVI**	**Fr.**	**Dn.**	**IVI**	**Fr.**	**Dn.**	**IVI**
1	*Artemesia nilagarica*	44	1152	16.96	44	1152	16.96	44	1152	16.96
2	*Arundinella manii*	56	2464	30.13	56	2464	30.13	56	2464	30.13
3	*Aconogonum molle*	28	368	7.67	28	368	7.67	28	368	7.67
4	*Berberis* sp.	36	608	11.01	36	608	11.01	36	608	11.01
5	*Coriaria nepalensis*	32	336	8.04	32	336	8.04	32	336	8.04
6	*Daphne papyracea*	52	2128	26.61	52	2128	26.61	52	2128	26.61
7	*Girardinia diversifolia*	36	304	8.41	36	304	8.41	36	304	8.41
8	*Hypericum* sp.	16	112	3.54	16	112	3.54	16	112	3.54
9	*Ilex dipyrena*	28	368	7.67	28	368	7.67	28	368	7.67
10	*Neillia thyrsiflora*	20	208	5.01	20	208	5.01	20	208	5.01
11	*Piptanthus nepalensis*	36	720	11.97	36	720	11.97	36	720	11.97
12	*Plectranthus* sp.	16	112	3.54	16	112	3.54	16	112	3.54
13	*Rosa* sp.	44	272	9.43	44	272	9.43	44	272	9.43
14	*Rubus ellipticus*	44	544	11.75	44	544	11.75	44	544	11.75
15	*Rubus nivies*	28	208	6.30	28	208	6.30	28	208	6.30
16	*Sarcococca*	52	1392	20.30	52	1392	20.30	52	1392	20.30
17	*Seigesbeckia orientalis*	32	272	7.49	32	272	7.49	32	272	7.49
18	*Boenninghausenia albiflora*	20	112	4.18	20	112	4.18	20	112	4.18
Total		**620**	**11680**	**200**	**620**	**11680**	**200**	**620**	**11680**	**200**

Fr.–Frequency percentage, Dn.–Density (ha^{-1}), IVI–Importance value index

Appendix II. 3.63: Frequency, density and IVI of herbs in New Melling catchment area

Sl. No.	Species name	Post–monsoon			Monsoon			Winter		
		Fr.	**Dn.**	**IVI**	**Fr.**	**Dn.**	**IVI**	**Fr.**	**Dn.**	**IVI**
1	*Ainsliaea* sp.	28	6400	5.82	28	7200	4.34	20	3600	5.31
2	*Anaphalis margaritacea*	44	34800	16.37	56	53600	16.58	44	12400	13.94
3	*Aster* sp.	20	4000	3.99	12	5600	2.37			
4	*Aster trinervius*				24	10000	4.49	36	8000	10.33
5	*Astilbe rivularis*	24	8400	5.84	28	4400	3.78	28	6000	7.92
6	*Campanula* sp.				36	9200	5.57			
7	*Cyathula capitata*	44	17200	11.23	52	30800	11.58	32	4800	8.01
8	*Drymaria cordata*							44	27200	21.40
9	*Dipsacus asper*	28	8400	6.41	44	19200	8.41			
10	*Dracocephalum* sp.	12	1600	2.16	16	2800	2.22			
11	*Elatostemma sessile*	32	18400	9.89	52	50800	15.61	36	18000	15.37
12	*Elsholtzia strobilifera*	48	50000	21.37				48	31600	24.32
13	*Equisetum*							24	9600	9.03

Sl.	Species name	Post–monsoon			Monsoon			Winter		
14	*Fragaria* sp.	32	21600	10.82	32	13600	6.05	44	18400	16.97
15	*Galium* sp.	28	12800	7.69	36	22400	8.23	36	14000	13.35
16	*Geranium pretense*	36	21600	11.39	44	18000	8.17	32	8400	9.83
17	*Heracleum*				32	9200	5.16			
18	*Herpetospermum pedunculosum*				12	2800	1.80			
19	*Ophiopogon intermedius*	48	17200	11.80	20	4400	2.95			
20	*Oplisminus compositus*	52	44000	20.18	56	52800	16.42	32	14000	12.65
21	*Parochaetus communis*	28	12800	7.69						
22	*Panax bipinnatifidus*				28	8400	4.58			
23	*Paris polyphylla*				20	5600	3.19			
24	*Parasenecio quinquelobus*				24	4800	3.45			
25	*Persicaria ruminata*				20	9200	3.92			
26	*Phlomis* sp.	24	3600	4.44	12	2800	1.80			
27	*Pilea umbrosa*	32	21600	10.82	36	31200	10.00			
28	*Pogostemon* sp.	20	4000	3.99	12	2400	1.72	16	2400	4.01
29	*Potentilla cuneata*	48	9200	9.46	44	13600	7.29	36	5200	8.91
30	*Rumex acetosella*							36	9600	11.13
31	*Salvia* sp.				20	4800	3.03			
32	*Sambucus adnata*	32	8400	6.97	52	53600	16.17			
33	*Senecio cappa*	24	4000	4.56	24	6400	3.77			
34	*Swertia paniculata*				36	20800	7.91			
35	*Thalictrum foliolosum*				20	4800	3.03			
36	*Thladiantha cordifolia*				12	2800	1.80			
37	*Urtica dioica*	24	12800	7.12	28	8400	4.58	28	5200	7.52
Total		**708**	**342800**	**200**	**968**	**496400**	**200.00**	**572**	**198400**	**200.00**

Fr.–Frequency percentage, Dn.–Density (ha^{-1}), IVI–Importance value index

Appendix II. 3.64: Dominant and Co–dominant species determined on the basis of IVI/density values of species in the plant communities at New Melling site

Community components	Barrage	Powerhouse	Catchment area
Tree species*			
Dominant	*Tsuga dumosa*	*Populus ciliata*	*Populus ciliata*
Co–Dominant	*Acer* sp.	*Brassiopsis glomerulata*	*Tsuga dumosa*
Shrub species**			
Dominant	*Arundinaria maling*	*Daphne papyracea*	*Arundinaria maling*
Co–Dominant	*Daphne papyracea*	*Arundinaria maling*	*Daphne papyracea*
Herb species**			
i. Post monsoon season			
Dominant	*Opliomenus compositus*	*Lecanthus peduncularis*	*Elsholtzia stobilifera*
Co–Dominant	*Elsholtzia stobilifera*	*Elsholtzia stobilifera*	*Opliomenus compositus*
ii. Monsoon season			
Dominant	*Elatostemma sessile*	*Lecanthus peduncularis*	*Anaphalis margaritacea*
Co–Dominant	*Lecanthus penduncularis*	*Anaphalis margaritacea*	*Opliomenus compositus*
iii. Winter			
Dominant	*Elsholtzia stobilifera*	*Elsholtzia stobilifera*	*Elsholtzia stobilifera*
Co–Dominant	*Opliomenus compositus*	*Elatostemma sessile*	*Drymaria cordata*

* Dominance based on IVI; ** Dominance based on density

Appendix II. 3.65: List of plant species recorded from Mago chu HEP site

Sl. No.	Species name	Family
TREES		
1	*Acer hookerii*	Aceraceae
2	*Acer sikkimensis*	Aceraceae
3	*Acer* sp.	Aceraceae
4	*Alangium alpinum.*	Alangiaceae
5	*Alnus nepalensis*	Betulaceae
6	*Brassaiopsis glomerulata*	Araliaceae
7	*Corylus hetrophylla*	Betulaceae
8	*Leucosceptrum canum*	Lamiaceae
9	*Lindera neesiana*	Lauraceae
10	*Pinus wallichiana*	Pinaceae
11	*Populus ciliata*	Salicaceae
12	*Quercus lamellosa*	Fagaceae
13	*Quercus semecarpifolia*	Fagaceae
14	*Rhododendron* sp.	Ericaceae

Sl. No.	Species name	Family
15	*Rhus chinensis*	Anacardiaceae
16	*Taxus wallichiana*	Taxaceae
17	*Tsuga dumosa*	Pinaceae
SHRUBS		
18	*Artemesia nilagirica*	Asteraceae
19	*Arundinaria maling*	Poaceae
20	*Berberis aristata*	Berberidaceae
21	*Coraria napalensis*	Coriariaceae
22	*Daphne papyracea*	Thymelaeaceae
23	*Elaeagnus parviflora*	Elaegnaceae
24	*Euphorbia sikkimensis*	Euphorbiaceae
25	*Girardinia diversifolia*	Urticaceae
26	*Hypericum choisianum*	Hypericaceae
27	*Ilex dipyrena*	Aquifoliaceae
28	*Neillia thyrsiflora*	Rosaceae
29	*Philadelphus tomentosus*	Hydrangeaceae
30	*Piptanthus nepalensis*	Papilionaceae
31	*Plectranthus* sp.	Lamiaceae
32	*Rosa* sp.	Rosaceae
33	*Rubus ellipticus*	Rosaceae
34	*Zanthoxylum armatum*	Rutaceae
35	*Zanthoxylum oxyphyllum*	Rutaceae
HERBS		
36	*Achyranthes aspera*	Amaranthaceae
37	*Ainsliaea* sp.	Asteraceae
38	*Anaphalis margaritacea*	Asteraceae
39	*Arisaema erubescens*	Araceae
40	*Arisaema nepenthoides*	Araceae
41	*Aster* sp.	Asteraceae
42	*Aster trinervius*	Asteraceae
43	*Astilbe rivularis*	Saxifragaceae
44	*Cirsium falconeri*	Asteraceae
45	*Crawfurdia speciosa*	Gentianaceae
46	*Cyathula capitata*	Amaranthaceae
47	*Didymocarpus* sp.	Gesneriaceae
48	*Dipsacus asper*	Dipsacaceae
49	*Dracocephalum* sp.	Lamiaceae
50	*Drymaria cordata*	Caryophyllaceae
51	*Elatostemma sessile*	Urticaceae
52	*Elsholtzia strobilifera*	Lamiaceae
53	*Fragaria nubicola*	Rosaceae
54	*Fragaria* sp.	Rosaceae
55	*Galinsoga parviflora*	Asteraceae
56	*Galium* sp.	Rubiaceae
57	*Gebbera* sp.	Asteraceae
58	*Geranium pretense*	Geraniaceae
59	*Goldfusia nutans*	Orchidaceae
60	*Gonatanthus pumilus*	Araceae
61	*Hepetospermum pendunculosum*	Cucurbitaceae
62	*Imperata cylindrica*	Poaceae
63	*Iris lactea*	Iridaceae
64	*Nepata* sp.	Lamiaceae
65	*Ophiopogon intermedius*	Liliaceae
66	*Oplisminus compositus*	Poaceae
67	*Oxalis corniculata*	oxalidaceae
68	*Parasenecio quinquelobus*	Asteraceae
69	*Paspallum* sp.	Poaceae
70	*Persicaria runcinata*	Polygonaceae
71	*Panax bipinnatifidus*	Araliaceae
72	*Phlomis* sp.	Lamiaceae
73	*Pilea umbrosa*	Urticaceae
74	*Plantago major*	Plantaginaceae
75	*Pogostemon* sp.	Lamiaceae
76	*Polygonum capitata*	Polygonaceae
77	*Potentilla cuneata*	Rosaceae
78	*Roscoea alpina*	Zingiberaceae

Sl. No.	Species name	Family
79	*Rumex acetosella*	Polygonaceae
80	*Swertia chirayita*	Gentianaceae
81	*Salvia* sp.	Lamiaceae
82	*Sambucus adnata*	Adoxaceae
83	*Senecio cappa*	Asteraceae
84	*Thaladiantha cordifolia*	Cucurbitaceae
85	*Thalictrum foliolosum*	Ranunculaceae
86	*Urtica dioica*	Urticaceae
87	*Viola sikkimensis*	Violaceae
CLIMBERS		
88	*Celastrus paniculata*	Celastraceae
89	*Cissampelos* sp.	Menispermaceae
90	*Clematis* sp.	Ranunculaceae
91	*Dioscorea* sp.	Dioscoreaceae
92	*Ficus* sp.	Moraceae
93	*Hedera helix*	Araliaceae
94	*Hedera nepalensis*	Araliaceae
95	*Herpetospermun pedunculosum*	Cucurbitaceae
96	*Holboellia latifolia*	Lardizabalaceae
97	*Periploca* sp.	Periplocaceae
98	*Philadephus tomentosus*	Hydrangeaceae
99	*Rubia cordifolia*	Rubiaceae
100	*Scziophgma* sp.	Hydrangeaceae
101	*Smilax* sp.	Smilacaceae
102	*Stephania glandulifera*	Menispermaceae
103	*Thladiantha cordifolia*	Cucurbitaceae
ORCHIDS		
104	*Cymbidium* sp.	Orchidaceae
105	*Bulbophyllum* sp.	Orchidaceae
106	*Calanthe tricarinata*	Orchidaceae
107	*Coelogynae* sp.	Orchidaceae
108	*Dendrobium* sp.	Orchidaceae
109	*Oberonia* sp.	Orchidaceae
110	*Pleione praecox*	Orchidaceae
111	*Vanda*	Orchidaceae
PTERIDOPHYTES		
112	*Botrychium* sp.	Ophioglossaceae
113	*Adiantum* sp.	Adiantaceae
114	*Dryopteris wallichiana*	Dryopteridaceae
115	*Lepisorus* sp.	Polypodiaceae
116	*Polypodium* sp.	Polypodiaceae
117	*Pteris* sp.	Pteridiaceae
118	*Pteris vittata*	Pteridaceae
119	*Pyrrosia nuda*	Crptogrammaceae
120	*Selaginella* sp.	Selaginellaceae
121	*Vittaria elongata*	Vittariaceae
BRYOPHYTES		
122	*Aerobryum* sp.	Meteoriaceae
123	*Desmotheca* sp.	Orthotrichaceae
124	*Diphyscium* sp.	Buxbaumiaceae
125	*Funaria* sp.	Funariaceae
126	*Lyellia* sp.	Polytrichaceae
127	*Marchantia* sp.	Marchantiaceae
128	*Plagiobryum* sp.	Bryaceae
LICHENS		
129	*Alectoria* sp.	Alectoriaceae
130	*Cladonia* sp.	Cladoniaceae
131	*Graphis* sp.	Graphidaceae
132	*Lobaria* sp.	Lobariaceae
133	*Parmelina* sp.	Parmeliaceae
134	*Parmotrema* sp.	Parmeliaceae
135	*Pseudocyphellaria* sp.	Lobariaceae
136	*Stereocaulon* sp.	Stereocaulaceae
137	*Sticta* sp.	Lobariaceae
138	*Usnea* sp.	Parmeliaceae
FUNGI		

Sl. No.	Species name	Family
139	*Auricularia auriculiformis*	Auriculariaceae
140	*Boletus reticulatus*	Boletaceae
141	*Clathrus rubra*	Phallaceae
142	*Coprinus disseminatus*	Agaricaceae
143	*Daldinia concentrica*	Xylariaceae
144	*Fomes pinicola*	Fomitopsidaceae
145	*Hericium erinaceus*	Hericiaceae
146	*Hydnum repandum*	Hydnaceae
147	*Hygrocybe miniata*	Hygrophoraceae
148	*Laccaria laccata*	Hydnangiaceae
149	*Phellinus schweintizii*	Hymenochaetaceae
150	*Polyporus arcularius*	Polyporaceae
151	*Poria monticola*	Polyporaceae
152	*Schizophyllum commune*	Schizophyllaceae
153	*Strobilomyces strobilaceus*	Boletaceae
154	*Thelephora penicillata*	Thelephoraceae
155	*Gloeophyllum sepiarium*	Gloeophyllaceae
156	*Lactarius rubidus*	Russulaceae
157	*Pycnoporellus fibrillosus*	Formitopscidaceae

Appendix II. 3.66: Different groups of plant species present at Mago chu HEP site

Sl. No.	Species name	Family	Sl. No.	Species name	Family
CLIMBERS					
1	*Celastrus paniculata*	Celastraceae	1	*Celastrus paniculata*	Celastraceae
2	*Cissampelos* sp.	Menispermaceae	2	*Hedera helix*	Araliaceae
3	*Clematis* sp.	Ranunculaceae	3	*Hedera nepalensis*	Araliaceae
4	*Dioscorea* sp.	Dioscoreaceae	4	*Herpetospermun pedunculosum*	Cucurbitaceae
5	*Ficus* sp.	Moraceae	5	*Holboellia latifolia*	Lardizabalaceae
6	*Hedera helix*	Araliaceae	6	*Periploca* sp.	Periplocaceae
7	*Hedera nepalensis*	Araliaceae	7	*Philadephus tomentosus*	Hydrangeaceae
8	*Herpetospermun pedunculosum*	Cucurbitaceae	8	*Rubia cordifolia*	Rubiaceae
9	*Holboellia latifolia*	Lardizabalaceae	9	*Smilax* sp.	Smilacaceae
10	*Periploca* sp.	Periplocaceae	10	*Stephania glandulifera*	Menispermaceae
11	*Philadephus tomentosus*	Hydrangeaceae	11	*Thladiantha cordifolia*	Cucurbitaceae
12	*Rubia cordifolia*	Rubiaceae			
13	*Scziophgma* sp.	Hydrangeaceae			
14	*Smilax* sp.	Smilacaceae			
15	*Stephania glandulifera*	Menispermaceae			
16	*Thladiantha cordifolia*	Cucurbitaceae			
ORCHIDS					
1	*Cymbidium* sp.	Orchidaceae	1	*Cymbidium* sp.	Orchidaceae
2	*Bulbophyllum* sp.	Orchidaceae	2	*Bulbophyllum* sp.	Orchidaceae
3	*Calanthe tricarinata*	Orchidaceae	3	*Calanthe tricarinata*	Orchidaceae
4	*Coelogynae* sp.	Orchidaceae	4	*Oberonia* sp.	Orchidaceae
5	*Dendrobium* sp.	Orchidaceae	5	*Pleione praecox*	Orchidaceae
6	*Oberonia* sp.	Orchidaceae			
7	*Pleione praecox*	Orchidaceae			
8	*Vanda* sp.	Orchidaceae			
PTERIDOPHYTES					
1	*Botrychium* sp.	Ophioglossaceae	1	*Adiantum* sp.	Adiantaceae
2	*Adiantum* sp.	Adiantaceae	2	*Dryopteris wallichiana*	Dryopteridaceae
3	*Dryopteris wallichiana*	Dryopteridaceae	3	*Lepisorus* sp.	Polypodiaceae
4	*Lepisorus* sp.	Polypodiaceae	4	*Pteris vittata*	Pteridaceae
5	*Polypodium* sp.	Polypodiaceae	5	*Selaginella* sp.	Selaginellaceae
6	*Pteris* sp.	Pteridiaceae	6	*Vittaria elongata*	Vittariaceae
7	*Pteris vittata*	Pteridaceae			
8	*Pyrrosia nuda*	Crptogrammaceae			
9	*Selaginella* sp.	Selaginellaceae			
10	*Vittaria elongata*	Vittariaceae			
BRYOPHYTES					
1	*Aerobryum* sp.	Meteoriaceae	1	*Aerobryum* sp.	Meteoriaceae
2	*Desmotheca* sp.	Orthotrichaceae	2	*Desmotheca* sp.	Orthotrichaceae
3	*Diphyscium* sp.	Buxbaumiaceae	3	*Lyellia* sp.	Polytrichaceae
4	*Funaria* sp.	Funariaceae	4	*Marchantia* sp.	Marchantiaceae

Sl. No.	Species name	Family	Sl. No.	Species name	Family
5	*Lyellia* sp.	Polytrichaceae	5	*Plagiobryum* sp.	Bryaceae
6	*Marchantia* sp.	Marchantiaceae			
7	*Plagiobryum* sp.	Bryaceae			
LICHENS					
1	*Alectoria* sp.	Alectoriaceae	1	*Alectoria* sp.	Alectoriaceae
2	*Cladonia* sp.	Cladoniaceae	2	*Cladonia* sp.	Cladoniaceae
3	*Graphis* sp.	Graphidaceae	3	*Graphis* sp.	Graphidaceae
4	*Lobaria* sp.	Lobariaceae	4	*Parmotrema* sp.	Parmeliaceae
5	*Parmelina* sp.	Parmeliaceae	5	*Pseudocyphellaria* sp.	Lobariaceae
6	*Parmotrema* sp.	Parmeliaceae	6	*Stereocaulon* sp.	Stereocaulaceae
7	*Pseudocyphellaria* sp.	Lobariaceae	7	*Usnea* sp.	Parmeliaceae
8	*Stereocaulon* sp.	Stereocaulaceae			
9	*Sticta* sp.	Lobariaceae			
10	*Usnea* sp.	Parmeliaceae			

Appendix II. 3.67: Species list of macro–fungi recorded from barrage and powerhouse sites of Mago chu

Species	Family	Species	Family
Barrage		**Powerhouse**	
Auricularia auriculiformis	Auriculariaceae	*Auricularia auriculiformis*	Auriculariaceae
Boletus reticulatus	Boletaceae	*Boletus reticulatus*	Boletaceae
Clathrus rubra	Phallaceae	*Coprinus disseminatus*	Agaricaceae
Coprinus disseminatus	Agaricaceae	*Fomes pinicola*	Fomitopsidaceae
Daldinia concentrica	Xylariaceae	*Gloeophyllum sepiarium*	Gloeophyllaceae
Fomes pinicola	Fomitopsidaceae	*Hydnum repandum*	Hydnaceae
Hericium erinaceus	Hericiaceae	*Lactarius rubidus*	Russulaceae
Hydnum repandum	Hydnaceae	*Pycnoporellus fibrillosus*	Formitopscidaceae
Hygrocybe miniata	Hygrophoraceae	*Schizophyllum commune*	Schizophyllaceae
Laccaria laccata	Hydnangiaceae	*Thelephora penicillata*	Thelephoraceae
Phellinus schweintizii	Hymenochaetaceae		
Polyporus arcularius	Polyporaceae		
Poria monticola	Polyporaceae		
Schizophyllum commune	Schizophyllaceae		
Strobilomyces strobilaceus	Boletaceae		
Thelephora penicillata	Thelephoraceae		
Catchment area			
Auricularia auriculiformis	Auriculariaceae		
Boletus reticulatus	Boletaceae		
Clathrus rubra	Phallaceae		
Coprinus disseminatus	Agaricaceae		
Daldinia concentrica	Xylariaceae		
Fomes pinicola	Fomitopsidaceae		
Gloeophyllum sepiarium	Gloeophyllaceae		
Hericium erinaceus	Hericiaceae		
Hydnum repandum	Hydnaceae		
Hygrocybe miniata	Hygrophoraceae		
Laccaria laccata	Hydnangiaceae		
Lactarius rubidus	Russulaceae		
Phellinus schweintizii	Hymenochaetaceae		
Polyporus arcularius	Polyporaceae		
Poria monticola	Polyporaceae		
Pycnoporellus fibrillosus	Formitopscidaceae		
Schizophyllum commune	Schizophyllaceae		
Strobilomyces strobilaceus	Boletaceae		
Thelephora penicillata	Thelephoraceae		

Appendix II. 3.68: Frequency, density, basal area and IVI for tree species in Mago chu barrage site

Sl. No.	Species name	Post–monsoon				Monsoon				Winter			
		Fr.	Dn.	BA	IVI	Fr.	Dn.	BA	IVI	Fr.	Dn.	BA	IVI
1	*Acer hookeri*	40	70	2.63	33.10	40	70	2.63	33.10	40	70	2.63	33.10
2	*Acer sikkimensis*	20	40	0.96	16.17	20	40	0.96	16.17	20	40	0.96	16.17
3	*Alnus nepalensis*	40	80	2.33	33.78	40	80	2.33	33.78	40	80	2.33	33.78
4	*Brassaiopsis glomerulata*	20	50	0.65	16.79	20	50	0.65	16.79	20	50	0.65	16.79
5	*Leucosceptrum canum*	20	40	0.48	14.47	20	40	0.48	14.47	20	40	0.48	14.47

Sl. No.	Species name	Post–monsoon				Monsoon				Winter			
6	*Pinus wallichiana*	20	40	3.76	26.04	20	40	3.76	26.04	20	40	3.76	26.04
7	*Populus ciliata*	40	60	6.11	43.67	40	60	6.11	43.67	40	60	6.11	43.67
8	*Quercus semicarpifolia*	30	40	1.76	21.93	30	40	1.76	21.93	30	40	1.76	21.93
9	*Rhododendron* sp.	10	20	0.39	7.78	10	20	0.39	7.78	10	20	0.39	7.78
10	*Taxus wallichiana*	20	30	0.33	12.22	20	30	0.33	12.22	20	30	0.33	12.22
11	*Tsuga dumosa*	60	90	8.46	63.02	60	90	8.46	63.02	60	90	8.46	63.02
12	*Corylus hetrophylla*	20	20	0.48	11.03	20	20	0.48	11.03	20	20	0.48	11.03
Total		**340**	**580**	**28.35**	**300**	**340**	**580**	**28.35**	**300**	**340**	**580**	**28.35**	**300**

Fr.–Frequency percentage, Dn.–Density (ha^{-1}), BA–Basal area (m^2 ha^{-1}), IVI–Importance value index

Appendix II. 3.69: Frequency, density and IVI of shrubs in Mago chu barrage site

Sl. No.	Species name	Post–monsoon			Monsoon			Winter		
		Fr.	**Dn.**	**IVI**	**Fr.**	**Dn.**	**IVI**	**Fr.**	**Dn.**	**IVI**
1	*Artemesia nilagirica*	55	1072	20.24	55	1072	20.24	55	1072	20.24
2	*Arundinaria manii*	50	1792	27.76	50	1792	27.76	50	1792	27.76
3	*Berberis aristrata*	60	720	16.94	60	720	16.94	60	720	16.94
4	*Coriaria nepalensis*	65	544	15.65	65	544	15.65	65	544	15.65
5	*Daphne papyracea*	60	1392	24.63	60	1392	24.63	60	1392	24.63
6	*Eleagnus parviflora*	20	144	4.55	20	144	4.55	20	144	4.55
7	*Euphorbia sikkimensis*	30	256	7.28	30	256	7.28	30	256	7.28
8	*Girardinia grandiflora*	35	336	8.92	35	336	8.92	35	336	8.92
9	*Hypericum choisianum*	40	192	7.99	40	192	7.99	40	192	7.99
10	*Ilex dipyrena*	45	416	11.28	45	416	11.28	45	416	11.28
11	*Neillia thyrsiflora*	25	128	5.09	25	128	5.09	25	128	5.09
12	*Philadelphus tomentosus*	25	96	4.72	25	96	4.72	25	96	4.72
13	*Piptanthus nepalensis*	55	688	15.85	55	688	15.85	55	688	15.85
14	*Rubus ellipticus*	50	608	14.21	50	608	14.21	50	608	14.21
15	*Zanthoxylum armatum*	35	192	7.27	35	192	7.27	35	192	7.27
16	*Zanthoxylum oxyphyllum*	40	160	7.63	40	160	7.63	40	160	7.63
	Total	**690**	**8736**	**200**	**690**	**8736**	**200**	**690**	**8736**	**200**

Fr.–Frequency percentage, Dn.–Density (ha^{-1}), IVI–Importance value index

Appendix II. 3.70: Frequency, density and IVI of herbs in Mago chu barrage site

Sl. No.	Species name	Post–monsoon			Monsoon			Winter		
		Fr.	**Dn.**	**IVI**	**Fr.**	**Dn.**	**IVI**	**Fr.**	**Dn.**	**IVI**
1	*Achyranthes aspera*	20	3600	3.68	28	9200	3.84			
2	*Ainsliaea* sp.	44	10800	9.07	44	18000	6.70	16	4400	5.38
3	*Anaphalis margaritacea*	32	6800	6.24	52	26800	8.96			
4	*Arisaema erubescens*				32	12400	4.75			
5	*Arisaema nepenthoides*	24	6000	4.99	32	6800	3.69			
6	*Aster* sp.				44	13200	5.80			
7	*Aster trinervius*	20	3200	3.54	32	7600	3.84			
8	*Astilbe rivularis*	44	7200	7.84	56	8400	5.81			
9	*Berginia ciliata*				16	2800	1.73			
10	*Cirsium falconeri*				16	2800	1.73			
11	*Cyanoglossum* sp.				44	17200	6.55	16	3600	5.03
12	*Cyathula capitata*	12	2400	2.29	32	12800	4.82	24	8400	8.86
13	*Didymocarpus* sp.				16	2400	1.66			
14	*Dracocephalum* sp.	56	15200	12.05	12	2800	1.43			
15	*Drymaria cordata*	48	28800	15.74	40	35600	9.71	28	13200	11.83
16	*Elsholtzia strobilifera*	52	24400	14.72				36	25600	19.01
17	*Eupatorium adenophorum*	12	2400	2.29	32	5600	3.47			
18	*Euphorbia sikkemensis*				16	2800	1.73			
19	*Fragaria* sp.	52	24400	14.72	36	7600	4.15	24	12400	10.62
20	*Galeola lindleyana*				16	2800	1.73			
21	*Galinsoga parviflora*	48	10800	9.56	44	22000	7.46	28	16000	13.06
22	*Galium* sp.	16	2800	2.91	32	12800	4.82	12	5600	5.05
23	*Geranium pretense*	40	10400	8.45	24	6000	2.94	16	5200	5.73
24	*Gonatanthus pumilus*				16	3200	1.81			
25	*Herpetospermum pendulosum*				12	2800	1.43			
26	*Hypoestes roxburghii*	32	11200	7.75	28	12000	4.37			
27	*Imperata cylindrica*	28	15200	8.63	28	21600	6.17	24	24800	16.07
28	*Iris lactea*				24	4800	2.71			
29	*Oplisminus compositus*	44	28800	15.26				28	34400	21.15

Sl. No.	Species name	Post–monsoon			Monsoon			Winter		
30	*Nepeta* sp.	16	2400	2.78	16	2800	1.73			
31	*Ophiopogon intermedius*				32	7200	3.77			
32	*Oxalis corniculata*	4	800	0.76				20	8000	7.83
33	*Oplisminus* sp.				56	53200	14.22			
34	*Panax bipinnatifidus*	4	800	0.76	12	2800	1.43			
35	*Paspallum* sp.	28	20000	10.28	32	17200	5.65	24	17200	12.73
36	*Persicaria runcinata*				32	18000	5.80	20	8000	7.83
37	*Pilea umbrosa*				32	30800	8.20			
38	*Plantago major*	44	24400	13.74	56	34800	10.77	32	11600	11.99
39	*Pleione praecox*				12	2800	1.43			
40	*Pogostemon* sp.	4	400	0.63	20	3600	2.19	20	4000	6.07
41	*Polygonum capitata*	24	6800	5.26	36	17600	6.02	28	5200	8.32
42	*Potentilla cuneata*	20	3200	3.54	36	6800	4.00	32	12400	12.34
43	*Rumex acetosella*	36	15600	9.75	48	26800	8.66			
44	*Sambucus adnata*	4	400	0.63						
45	*Swertia chirayita*				20	3600	2.19			
46	*Urtica dioica*	12	2000	2.15	36	9200	4.45	24	5200	7.46
47	*Valeriana hardwickii*				16	5200	2.19			
48	*Viola sikkimensis*				28	7200	3.47	12	2400	3.64
Total		**820**	**291200**	**200**	**1324**	**532400**	**200**	**464**	**227600**	**200**

Fr.–Frequency percentage, Dn.–Density (ha^{-1}), IVI–Importance value index

Appendix II. 3.71: Frequency, density, basal area and IVI for tree species in Mago chu powerhouse site

Sl. No.	Species name	Post–monsoon				Monsoon				Winter			
		Fr.	**Dn.**	**BA**	**IVI**	**Fr.**	**Dn.**	**BA**	**IVI**	**Fr.**	**Dn.**	**BA**	**IVI**
1	*Acer hookerii*	10	10	0.16	8.26	10	10	0.16	8.26	10	10	0.16	8.26
2	*Acer sikkimensis*	10	20	0.61	14.54	10	20	0.61	14.54	10	20	0.61	14.54
3	*Alangium alpinum*.	30	40	0.20	25.94	30	40	0.20	25.94	30	40	0.20	25.94
4	*Alnus nepalensis*	20	30	0.50	20.93	20	30	0.50	20.93	20	30	0.50	20.93
5	*Brassaiopsis glomerulata*	40	50	0.63	36.08	40	50	0.63	36.08	40	50	0.63	36.08
6	*Populus ciliata*	30	40	1.16	32.73	30	40	1.16	32.73	30	40	1.16	32.73
7	*Quercus lamellosa*	40	40	9.77	97.55	40	40	9.77	97.55	40	40	9.77	97.55
8	*Rhododendron* sp.	20	20	0.41	17.15	20	20	0.41	17.15	20	20	0.41	17.15
9	*Lindera neesiana*	20	20	0.13	15.20	20	20	0.13	15.20	20	20	0.13	15.20
10	*Rhus chinensis*	30	50	0.57	31.63	30	50	0.57	31.63	30	50	0.57	31.63
Total		**250**	**320**	**14.15**	**300**	**250**	**320**	**14.15**	**300**	**250**	**320**	**14.15**	**300**

Fr.–Frequency percentage, Dn.–Density (ha^{-1}), BA–Basal area ($m^2\ ha^{-1}$), IVI–Importance value index

Appendix II. 3.72: Frequency, density and IVI of shrubs in Mago chu powerhouse site

Sl. No.	Species name	Post–monsoon			Monsoon			Winter		
		Fr.	**Dn.**	**IVI**	**Fr.**	**Dn.**	**IVI**	**Fr.**	**Dn.**	**IVI**
1	*Artemesia nilagirica*	48	1248	21.48	48	1248	21.48	48	1248	21.48
2	*Arundinaria manii*	52	1568	25.69	52	1568	25.69	52	1568	25.69
3	*Berberis aristrata*	56	512	14.48	56	512	14.48	56	512	14.48
4	*Coraria napalensis*	32	448	10.02	32	448	10.02	32	448	10.02
5	*Daphne papyracea*	44	1248	20.85	44	1248	20.85	44	1248	20.85
6	*Elaeagnus parviflora*	12	144	3.49	12	144	3.49	12	144	3.49
7	*Euphorbia sikkemensis*	20	224	5.63	20	224	5.63	20	224	5.63
8	*Girardinia grandiflora*	32	432	9.84	32	432	9.84	32	432	9.84
9	*Hypericum choisianum*	16	112	3.75	16	112	3.75	16	112	3.75
10	*Ilex dipyrena*	48	544	13.59	48	544	13.59	48	544	13.59
11	*Neillia thyrsiflora*	52	272	11.17	52	272	11.17	52	272	11.17
12	*Philadelphus tomentosus*	24	128	5.18	24	128	5.18	24	128	5.18
13	*Piptanthus nepalensis*	44	720	14.94	44	720	14.94	44	720	14.94
14	*Plectranthus* sp.	16	144	4.11	16	144	4.11	16	144	4.11
15	*Rosa* sp.	36	288	8.85	36	288	8.85	36	288	8.85
16	*Rubus ellipticus*	52	464	13.32	52	464	13.32	52	464	13.32
17	*Zanthoxylum armatum*	20	176	5.10	20	176	5.10	20	176	5.10
18	*Zanthoxylum oxyphyllum*	36	256	8.49	36	256	8.49	36	256	8.49
Total		**640**	**8928**	**200**	**640**	**8928**	**200**	**640**	**8928**	**200**

Fr.–Frequency percentage, Dn.–Density (ha^{-1}), IVI–Importance value index

Appendix II. 3.73: Frequency, density and IVI of herbs in Mago chu powerhouse site

Sl. No.	Species name	Post–monsoon			Monsoon			Winter		
		Fr.	Dn.	IVI	Fr.	Dn.	IVI	Fr.	Dn.	IVI
1	*Achyranthes aspera*	8	1200	1.56	24	5600	3.31	16	2800	4.32
2	*Ainsliaea* sp.	20	6800	5.23	28	11200	4.87	16	3200	4.50
3	*Anaphalis margaritacea*	28	4400	5.53	48	23600	9.30			
4	*Arisaema erubescens*				16	5200	2.52			
5	*Arisaema nepenthoides*				20	6400	3.13			
6	*Aster* sp.	16	2800	3.26	32	8800	4.70			
7	*Aster trinervius*				36	11600	5.66			
8	*Astilbe rivularis*	4	800	0.85	28	11200	4.87			
9	*Cyanoglossum* sp.				44	22000	8.61	28	8400	9.15
10	*Cyathula capitata*				48	15200	7.49	32	8400	9.91
11	*Dracocephalum* sp.				20	3600	2.53			
12	*Drymaria cordata*	28	19200	10.69	44	26000	9.47	24	16800	12.19
13	*Elsholtzia strobilifera*	36	20000	12.12				52	34400	25.50
14	*Eupatorium adenophorum*	40	10800	9.48						
15	*Euphorbia sikkemensis*	12	2400	2.55	16	4400	2.35			
16	*Fragaria* sp.	40	22000	13.39	56	22400	9.74	36	16000	14.12
17	*Galinsoga parviflora*	28	6800	6.37	32	12800	5.57	20	8000	7.44
18	*Galium asperifolium*	24	6800	5.80						
19	*Galium* sp.				32	12800	5.57	28	6400	8.24
20	*Geranium pretense*				36	4800	4.19	8	2400	2.61
21	*Hypoestes roxburghii*	20	8400	5.79	36	19200	7.30			
22	*Imperata cylindrica*	32	24400	13.08	48	39200	12.68	36	23200	17.38
23	*Iris lactea*				20	3200	2.44			
24	*Nepeta* sp.	8	1600	1.70	28	3600	3.23			
25	*Ophiopogon intermedius*				32	6800	4.27			
26	*Oplisminus* sp.	32	24400	13.08						
27	*Oplisminus compositus*				48	26800	10.00	32	25600	17.70
28	*Oxalis corniculata*	36	12800	9.61				32	11600	11.36
29	*Persicaria runcinata*	28	14800	9.16	44	35600	11.55	20	6400	6.72
30	*Paspallum* sp.	36	24400	13.65	32	15600	6.17	24	15600	11.65
31	*Phlomis* sp.	4	1200	0.99	16	3600	2.18			
32	*Pilea umbrosa*				28	13200	5.30			
33	*Plantago major*	36	17600	11.28	36	22400	8.00			
34	*Pogostemon* sp.	4	800	0.85	24	4400	3.05	12	2400	3.38
35	*Polygonum capitatum*	48	22000	14.53	32	17600	6.61			
36	*Plantago major*							24	10000	9.11
37	*Potentilla cuneata*	4	800	0.85	44	9200	5.84	16	3600	4.68
38	*Sambucus adnata*	32	6800	6.94	28	13600	5.39			
39	*Senecio cappa*				28	4800	3.49			
40	*Rumex acetosella*	36	11200	9.05				44	10800	13.29
41	*Valeriana hardwickii*	20	3600	4.11						
42	*Urtica dioica*	24	6000	5.52	44	8400	5.66	16	3600	4.68
43	*Viola sikkimensis*	16	2000	2.98	16	7200	2.96	8	1200	2.07
Total		**700**	**286800**	**200**	**1144**	**462000**	**200**	**524**	**220800**	**200**

Fr.–Frequency percentage, Dn.–Density (ha^{-1}), IVI–Importance value index

Appendix II. 3.74: Frequency, density, basal area and IVI for tree species in Mago chu catchment area

Sl. No.	Species name	Post–monsoon				Monsoon				Winter			
		Fr.	Dn.	BA	IVI	Fr.	Dn.	BA	IVI	Fr.	Dn.	BA	IVI
1	*Acer sikkimensis*	90	170	15.22	88.12	90	170	15.22	88.12	90	170	15.22	88.12
2	*Alnus nepalensis*	10	20	0.59	8.49	10	20	0.59	8.49	10	20	0.59	8.49
3	*Brassaiopsis glomerulata*	20	30	0.40	13.68	20	30	0.40	13.68	20	30	0.40	13.68
4	*Pinus wallichiana*	20	20	1.11	12.46	20	20	1.11	12.46	20	20	1.11	12.46
5	*Populus ciliata*	40	50	13.21	42.51	40	50	13.21	42.51	40	50	13.21	42.51
6	*Quercus semicarpifolia*	50	70	7.57	42.29	50	70	7.57	42.29	50	70	7.57	42.29
7	*Rhododendron* sp.	20	20	0.34	11.38	20	20	0.34	11.38	20	20	0.34	11.38
8	*Taxus wallichiana*	20	20	0.29	11.31	20	20	0.29	11.31	20	20	0.29	11.31
9	*Tsuga dumosa*	40	50	32.68	69.77	40	50	32.68	69.77	40	50	32.68	69.77
Total		**310**	**450**	**71.42**	**300**	**310**	**450**	**71.42**	**300**	**310**	**450**	**71.42**	**300**

Fr.–Frequency percentage, Dn.–Density (ha^{-1}), BA–Basal area (m^2 ha^{-1}), IVI–Importance value index

Appendix II. 3.75: Frequency, density and IVI of shrubs in Mago chu catchment area

Sl. No.	Species name	Post–monsoon			Monsoon			Winter		
		Fr.	**Dn.**	**IVI**	**Fr.**	**Dn.**	**IVI**	**Fr.**	**Dn.**	**IVI**
1	*Artemesia nilagirica*	68	1216	23.98	68	1216	23.98	68	1216	23.98
2	*Arundinaria manii*	36	1248	19.43	36	1248	19.43	36	1248	19.43
3	*Berberis aristata*	48	512	13.07	48	512	13.07	48	512	13.07
4	*Coriaria napalensis*	52	368	12.08	52	368	12.08	52	368	12.08
5	*Daphne papyracea*	72	1568	28.51	72	1568	28.51	72	1568	28.51
6	*Eleagnus parviflora*	40	400	10.59	40	400	10.59	40	400	10.59
7	*Euphorbia sikkemensis*	20	368	7.17	20	368	7.17	20	368	7.17
8	*Girardinia diversifolia*	28	688	11.96	28	688	11.96	28	688	11.96
9	*Hypericum choisianum*	48	208	9.68	48	208	9.68	48	208	9.68
10	*Ilex dipyrena*	48	416	12.00	48	416	12.00	48	416	12.00
11	*Neillia thyrsiflora*	20	144	4.67	20	144	4.67	20	144	4.67
12	*Piptanthus nepalensis*	52	688	15.64	52	688	15.64	52	688	15.64
13	*Rosa* sp.	28	272	7.32	28	272	7.32	28	272	7.32
14	*Rubus ellipticus*	32	416	9.54	32	416	9.54	32	416	9.54
15	*Philadelphus tomentosus*	20	128	4.49	20	128	4.49	20	128	4.49
16	*Zanthoxylum armatum*	16	144	4.06	16	144	4.06	16	144	4.06
17	*Zanthoxylum oxyphyllum*	24	192	5.82	24	192	5.82	24	192	5.82
Total		**652**	**8976**	**200**	**652**	**8976**	**200**	**652**	**8976**	**200**

Fr.–Frequency percentage, Dn.–Density (ha^{-1}), IVI–Importance value index

Appendix II. 3.76: Frequency, density and IVI of herbs in Mago chu catchment area

Sl. No.	Species name	Post–monsoon			Monsoon			Winter		
		Fr.	**Dn.**	**IVI**	**Fr.**	**Dn.**	**IVI**	**Fr.**	**Dn.**	**IVI**
1	*Achyranthes aspera*	16	4000	3.08	24	9200	3.80	16	3600	5.07
2	*Ainsliaea* sp.	20	8400	4.84	20	7200	3.09	20	4400	6.30
3	*Anaphalis margaritacea*	28	15200	7.77	28	21600	6.40			
4	*Arisaema erubescens*				16	8800	3.02			
5	*Arisaema nepenthoides*				20	6800	3.01			
6	*Aster* sp.	16	4400	3.19	16	3200	2.01			
7	*Aster trinervius*	12	2800	2.25	36	14400	5.81			
8	*Astilbe rivularis*	16	2400	2.61	28	8000	3.94	16	5200	5.77
9	*Bergenia ciliata*				28	4400	3.29			
10	*Cirsium falconeri*				12	2800	1.58			
11	*Cyanoglossum* sp.				36	18000	6.46	20	6800	7.34
12	*Cyathula capitata*	36	8000	6.63	44	26000	8.62	16	6000	6.12
13	*Didymocarpus* sp.				16	2800	1.93			
14	*Dracocephalum* sp.	8	1600	1.42	20	3600	2.44			
15	*Drymaria cordata*	56	32400	16.13	20	19200	5.25	28	24400	16.75
16	*Elsholtzia strobilifera*	48	28000	13.89	32	10800	4.81			
17	*Eupatorium adenophorum*				36	8400	4.73			
18	*Euphorbia sikkimensis*	8	1600	1.42	12	3200	1.65			
19	*Fragaria* sp.	44	19200	10.85	48	26000	8.98	44	17600	17.30
20	*Galinsoga parviflora*	36	9200	6.98	44	21600	7.83	28	13600	12.05
21	*Galium* sp.	20	6000	4.14	28	12400	4.74	24	5600	7.70
22	*Geranium pretense*	12	4000	2.60	20	5200	2.72	12	2400	3.68
23	*Hypoestes roxburghii*	32	10400	6.85	8	1600	1.00			
24	*Imperata cylindrica*	52	28000	14.37	32	17600	6.03			
25	*Imperata cylindrica*				48	34000	10.42	24	14000	11.35
26	*Iris lactea*				16	4400	2.22			
27	*Nepeta* sp.	4	400	0.59	12	3600	1.72			
28	*Ophiopogon intermedius*				20	6400	2.94			
29	*Oplisminus* sp.	28	19600	9.05	24	35600	8.57	28	24400	16.75
30	*Oxalis corniculata*	44	32800	14.81				24	17600	12.92
31	*Paspallum* sp.	24	15200	7.29	32	30800	8.42	16	16000	10.47
32	*Persicaria runcinata*	32	15200	8.25	20	17600	4.96			
33	*Phlomis* sp.	8	1600	1.42	12	2800	1.58			
34	*Pilea umbrosa*				28	22400	6.54			
35	*Plantago major*	32	12000	7.32	44	27600	8.91	32	18000	14.84
36	*Pogostemon* sp.	8	1600	1.42	16	3200	2.01			
37	*Polygonum capitatum*				40	19200	7.04			
38	*Potentilla cuneata*	28	3600	4.40	28	8400	4.02	20	6800	7.34
39	*Rumex acetosella*	84	20800	16.10	36	27200	8.12	52	34000	26.19
40	*Sambucus adnata*	52	27600	14.25	60	30800	10.92			
41	*Senecio cappa*	8	1200	1.31	12	3200	1.65			
42	*Urtica dioica*	24	6400	4.73	28	9200	4.16	28	8400	9.79

Sl.	Species name	Post–monsoon			Monsoon			Winter		
43					20	4800	2.65	8	1200	2.28
Total		**836**	**343600**	**200.00**	**1120**	**554000**	**200.00**	**456**	**230000**	**200.00**

Fr.–Frequency percentage, Dn.–Density (ha^{-1}), IVI–Importance value index

Appendix II. 3.77: Dominant and co–dominant species determined on the basis of IVI/density values of species in the plant community at Mago chu site

Community components	Barrage	Powerhouse	Catchment area
Tree species*			
Dominant	*Tsuga dumosa*	*Quercus lamellosa*	*Acer* sp.
Co–Dominant	*Populus ciliata*	*Brassiopsis glomerulata*	*Tsuga dumosa*
Shrub species*			
Dominant	*Arundinaria manii*	*Arundinaria manii*	*Daphnae papyracea*
Co–Dominant	*Daphnae papyracea*	*Artemesia nilagirica*	*Artemesia nilagirica*
Herb species**			
i. Pre–monsoon season			
Dominant	*Opliomenus compositus*	*Opliomenus compositus*	*Opliomenus compositus*
Co–Dominant	*Anaphalis margaritacea*	*Fragaria nubicola*	*Elsholtzia stobilifera*
ii. Monsoon season			
Dominant	*Sambucus adnata*	*Fragaria* sp.	*Sambacus adnata*
Co–Dominant	*Opliomenus compositus*	*Drymaria cordata*	*Opliomenus compositus*
iii. Winter			
Dominant	*Opliomenus compositus*	*Elsholtzia stobilifera*	*Elsholtzia stobilifera*
Co–Dominant	*Plantago major*	*Fragaria* sp.	*Fragaria* sp.

* Dominance based on IVI; ** Dominance based on density

Appendix II. 3.78: List of plant species recorded from Nykcharong chu HEP site

Sl. No.	Species name	Family
TREES		
1	*Acer campbellii*	Aceraceae
2	*Acer sikkimensis*	Aceraceae
3	*Alangium alpinum*	Alangiaceae
4	*Alnus nepalensis*	Betulaceae
5	*Betula alnoides*	Betulaceae
6	*Brassaiopsis glomerulata*	Araliaceae
7	*Eurya acuminata*	Theaceae
8	*Fraxinus floribunda*	Oleaceae
9	*Leucosceptrum canum*	Lamiaceae
10	*Lindera neesiana*	Lauraceae
11	*Lyonia ovalifolia*	Ericaceae
12	*Magnolia campbellii*	Magnoliaceae
13	*Morus laevigata*	Moraceae
14	*Neolitsea* sp.	Lauraceae
15	*Persea odoratissima*	Lauraceae
16	*Quercus lamellosa*	Fagaceae
17	*Quercus semecarpifolia*	Fagaceae
18	*Rhododendron arboreum*	Ericaceae
19	*Rhododendron campanulatum*	Ericaceae
20	*Rhododendron maddeni*	Ericaceae
21	*Rhododendron* sp.	Ericaceae
22	*Rhus acuminata*	Anacardiaceae
SHRUBS		
23	*Artemisia nilagirica*	*Asteraceae*
24	*Berberis aristata*	*Berberidaceae*
25	*Berberis* sp.	*Berberidaceae*
26	*Coraria napalensis*	*Coriariaceae*
27	*Daphne papyracea*	Thymelaeaceae
28	*Elaeagnus parviflora*	*Elaegnaceae*
29	*Elsholtzia* sp.	*Lamiaceaea*
30	*Girardinia diversifolia*	*Urticaceae*
31	*Hypericum choisianum*	*Hypericaceae*
32	*Ilex dipyrena*	*Aquifoliaceae*
33	*Neillia thyrsiflora*	*Rosaceae*
34	*Philadelphus tomentosus*	*Hydrangeaceae*
35	*Piptanthus nepalensis*	*Papilionaceae*
36	*Rosa* sp.	*Rosaceae*

Sl. No.	Species name	Family
37	*Rubus ellipticus*	*Rosaceae*
38	*Sarcococca* sp.	Buxaceae
39	*Spirea* sp.	*Rosaceae*
40	*Zanthoxylum oxyphyllum*	*Rutaceae*
HERBS		
41	*Ainsliaea* sp.	Asteraceae
42	*Anaphalis margaritacea*	Asteraceae
43	*Arisaema erubescens*	Araceae
44	*Arisaema nepenthoides*	Araceae
45	*Aster* sp.	Ateraceae
46	*Aster trinervius*	Ateraceae
47	*Astilbe rivularis*	Saxifragaceae
48	*Calanthe tricarinata*	Orchidaceae
49	*Codonopsis gracilis*	Campanulaceae
50	*Crawfurdia* speciosa	Campanulaceae
51	*Cyanoglossum* sp.	Boraginaceae
52	*Cyathula capitata*	Amaranthaceae
53	*Dipsacus asper*	Dipsacaceae
54	*Dracocephalum* sp.	Lamiaceae
55	*Elatostemma sessile*	Lamiaceae
56	*Elsholtzia strobilifera*	Urticaceae
57	*Fragaria* sp.	Rosaceae
58	*Galium rotundifolia*	Rubiaceae
59	*Galium* sp.	Rubiaceae
60	*Gentiana capitata*	Gentianaceae
61	*Geranium pretense*	Geraniaceae
62	*Goldfusia nutans*	Orchidaceae
63	*Imperata cylindrica*	Poaceae
64	*Nepeta* sp.	Lamiaceae
65	*Ophiopogon intermedius*	Liliaceae
66	*Oplisminus compositus*	Poaceae
67	*Panax bipinnatifidus*	Araliaceae
68	*Parasenecio quinquelobus*	*Asteraceae*
69	*Paris polyphylla*	Triliaceae
70	*Persicaria runcinata*	*Polygonaceae*
71	*Phlomis* sp.	Lamiaceae
72	*Pilea umbrosa*	Urticaceae
73	*Plantago major*	Plantaginaceae
74	*Pogonotherum* sp.	Poaceae
75	*Pogostemon* sp.	Lamiaceae
76	*Potentilla cuneata*	Rosaceae
77	*Roscoea alpine*	Zingiberaceae
78	*Rumex acetosella*	Polygonaceae
79	*Salvia* sp.	Lamiaceae
80	*Sambucus adnata*	Adoxaceae
81	*Senecio cappa*	Asteraceae
82	*Thalictrum foliolosum*	Ranunculaceae
83	*Trifolium repens*	Ranunculaceae
84	*Urtica dioica*	Urticaceae
85	*Viola sikkimensis*	Violaceae
CLIMBERS		
86	*Aristolochia griffithii*	Aristolochiaceae
87	*Celastrus paniculata*	Celastraceae
88	*Cissampelos* sp.	Menispermaceae
89	*Clematis* sp.	Ranunculaceae
90	*Dioscorea* sp.	Dioscoreaceae
91	*Ficus* sp.	Moraceae
92	*Hedera helix*	Araliaceae
93	*Hedera nepalensis*	Araliaceae
94	*Herpetospermun pedunculosum*	Cucurbitaceae
95	*Holboellia latifolia*	Lardizabalaceae
96	*Periploca* sp.	Periplocaceae
97	*Philadephus tomentosus*	Hydrangeaceae
98	*Rubia cordifolia*	Rubiaceae
99	*Scziophgma* sp.	Hydrangeaceae
100	*Smilax* sp.	Smilacaceae

Sl. No.	Species name	Family
101	*Stephania glandulifera*	Menispermaceae
102	*Thladiantha cordifolia*	Cucurbitaceae
ORCHIDS		
103	*Cymbidium* sp.	Orchidaceae
104	*Bulbophyllum* sp.	Orchidaceae
105	*Calanthe tricarinata*	Orchidaceae
106	*Coelogynae* sp.	Orchidaceae
107	*Cymbidium grandiflorum*	Orchidaceae
108	*Dendrobium* sp.	Orchidaceae
109	*Galeola lindleyana*	Orchidaceae
110	*Oberonia* sp.	Orchidaceae
111	*Pleione praecox*	Orchidaceae
112	*Vanda* sp.	Orchidaceae
PTERIDOPHYTES		
113	*Adiantum* sp.	Adiantaceae
114	*Athyrium* sp.	Athyraceae
115	*Dicranopteris linearis*	Dicranopteridaceae
116	*Dryopteris wallichiana*	Dryopteridaceae
117	*Dynaria quercifolia*	Drynariaceae
118	*Lepisorus* sp.	Polypodiaceae
119	*Polypodium* sp.	Polypodiaceae
120	*Pteridium aquilinum*	Pteridaceae
121	*Pteris* sp.	Pteridiaceae
122	*Pteris vittata*	Pteridaceae
123	*Pyrrosia* sp.	Polypodiaceae
124	*Selaginella* sp.	Selaginellaceae
125	*Vittaria elongata*	Vittariaceae
BRYOPHYTES		
126	*Aerobryum* sp.	Meteoriaceae
127	*Desmotheca* sp.	Orthotrichaceae
128	*Diphyscium* sp.	Buxbaumiaceae
129	*Funaria* sp.	Funariaceae
130	*Lyellia* sp.	Polytrichaceae
131	*Marchantia* sp.	Marchantiaceae
132	*Plagiobryum* sp.	Bryaceae
LICHENS		
133	*Alectoria* sp.	Alectoriaceae
134	*Cladonia* sp.	Cladoniaceae
135	*Graphis* sp.	Graphidaceae
136	*Lobaria* sp.	Lobariaceae
137	*Parmelia* sp.	Parmeliaceae
138	*Parmotrema* sp.	Parmeliaceae
139	*Pseudocyphellaria* sp.	Lobariaceae
140	*Stereocaulon* sp.	Stereocaulaceae
141	*Sticta* sp.	Lobariaceae
142	*Teloschistes* sp.	Teloschistaceae
143	*Usnea* sp.	Parmeliaceae
FUNGI		
144	*Auricularia auriculiformis*	Auriculariaceae
145	*Boletus reticulatus*	Boletaceae
146	*Clathrus rubra*	Phallaceae
147	*Coprinus disseminatus*	Agaricaceae
148	*Fomes pinicola*	Fomitopsidaceae
149	*Gloeophyllum sepiarium*	Gloeophyllaceae
150	*Hericium erinaceus*	Hericiaceae
151	*Hydnum repandum*	Hydnaceae
152	*Laccaria laccata*	Hydnangiaceae
153	*Lactarius rubidus*	Russulaceae
154	*Phellinus schweintizii*	Hymenochaetaceae
155	*Polyporus arcularius*	Polyporaceae
156	*Pycnoporellus fibrillosus*	Formitopscidaceae
157	*Schizophyllum commune*	Schizophyllaceae
158	*Thelephora penicillata*	Thelephoraceae
159	*Xylaria polymorpha*	Xylariaceae

Appendix II. 3.79: Different groups of plant species present at Nykcharong chu HEP site

Sl. No.	Species name Barrage and Powerhouse	Family	Sl. No.	Species name Catchment area	Family
CLIMBERS					
1	*Aristolochia griffithii*	Aristolochiaceae	1	*Aristolochia griffithii*	Aristolochiaceae
2	*Celastrus paniculata*	Celastraceae	2	*Celastrus paniculata*	Celastraceae
3	*Cissampelos* sp.	Menispermaceae	3	*Clematis* sp.	Ranunculaceae
4	*Clematis* sp.	Ranunculaceae	4	*Dioscorea* sp.	Dioscoreaceae
5	*Dioscorea* sp.	Dioscoreaceae	5	*Ficus* sp.	Moraceae
6	*Ficus* sp.	Moraceae	6	*Hedera nepalensis*	Araliaceae
7	*Hedera helix*	Araliaceae	7	*Herpetospermun pedunculosum*	Cucurbitaceae
8	*Hedera nepalensis*	Araliaceae	8	*Holboellia latifolia*	Lardizabalaceae
9	*Herpetospermun pedunculosum*	Cucurbitaceae	9	*Periploca* sp.	Periplocaceae
10	*Holboellia latifolia*	Lardizabalaceae	10	*Rubia cordifolia*	Rubiaceae
11	*Periploca* sp.	Periplocaceae	11	*Stephania glandulifera*	Menispermaceae
12	*Philadephus tomentosus*	Hydrangeaceae	12	*Thladiantha cordifolia*	Cucurbitaceae
13	*Rubia cordifolia*	Rubiaceae			
14	*Scziophgma* sp.	Hydrangeaceae			
15	*Smilax* sp.	Smilacaceae			
16	*Stephania glandulifera*	Menispermaceae			
17	*Thladiantha cordifolia*	Cucurbitaceae			
ORCHIDS					
1	*Cymbidium* sp.	Orchidaceae	1	*Cymbidium* sp.	Orchidaceae
2	*Bulbophyllum* sp.	Orchidaceae	2	*Bulbophyllum* sp.	Orchidaceae
3	*Calanthe tricarinata*	Orchidaceae	3	*Calanthe tricarinata*	Orchidaceae
4	*Coelogynae* sp.	Orchidaceae	4	*Dendrobium* sp.	Orchidaceae
5	*Cymbidium grandiflorum*	Orchidaceae			
6	*Dendrobium* sp.	Orchidaceae			
7	*Galeola lindleyana*	Orchidaceae			
8	*Oberonia* sp.	Orchidaceae			
9	*Pleione praecox*	Orchidaceae			
10	*Vanda* sp.	Orchidaceae			
PTERIDOPHYTES					
1	*Adiantum* sp.	Adiantaceae	1	*Adiantum* sp.	Adiantaceae
2	*Athyrium* sp.	Athyraceae	2	*Dicranopteris linearis*	Dicranopteridaceae
3	*Dicranopteris linearis*	Dicranopteridaceae	3	*Dryopteris wallichiana*	Dryopteridaceae
4	*Dryopteris wallichiana*	Dryopteridaceae	4	*Dynaria quercifolia*	Drynariaceae
5	*Dynaria quercifolia*	Drynariaceae	5	*Lepisorus* sp.	Polypodiaceae
6	*Lepisorus* sp.	Polypodiaceae	6	*Polypodium* sp.	Polypodiaceae
7	*Polypodium* sp.	Polypodiaceae	7	*Pteridium aquilinum*	Pteridaceae
8	*Pteridium aquilinum*	Pteridaceae	8	*Pteris vittata*	Pteridaceae
9	*Pteris* sp.	Pteridiaceae	9	*Selaginella* sp.	Selaginellaceae
10	*Pteris vittata*	Pteridaceae	10	*Vittaria elongata*	Vittariaceae
11	*Pyrrosia* sp.	Polypodiaceae			
12	*Selaginella* sp.	Selaginellaceae			
13	*Vittaria elongata*	Vittariaceae			
BRYOPHYTES					
1	*Aerobryum* sp.	Meteoriaceae	1	*Aerobryum* sp.	Meteoriaceae
2	*Desmotheca* sp.	Orthotrichaceae	2	*Diphyscium* sp.	Buxbaumiaceae
3	*Diphyscium* sp.	Buxbaumiaceae	3	*Funaria* sp.	Funariaceae
4	*Funaria* sp.	Funariaceae	4	*Marchantia* sp.	Marchantiaceae
5	*Lyellia* sp.	Polytrichaceae			
6	*Marchantia* sp.	Marchantiaceae			
7	*Plagiobryum* sp.	Bryaceae			
LICHENS					
1	*Alectoria* sp.	Alectoriaceae	1	*Alectoria* sp.	Alectoriaceae
2	*Cladonia* sp.	Cladoniaceae	2	*Graphis* sp.	Graphidaceae
3	*Graphis* sp.	Graphidaceae	3	*Lobaria* sp.	Lobariaceae
4	*Lobaria* sp.	Lobariaceae	4	*Parmelia* sp.	Parmeliaceae
5	*Parmelia* sp.	Parmeliaceae	5	*Pseudocyphellaria* sp.	Lobariaceae
6	*Parmotrema* sp.	Parmeliaceae	6	*Stereocaulon* sp.	Stereocaulaceae
7	*Pseudocyphellaria* sp.	Lobariaceae	7	*Usnea* sp.	Parmeliaceae
8	*Stereocaulon* sp.	Stereocaulaceae			
9	*Sticta* sp.	Lobariaceae			
10	*Teloschistes* sp.	Teloschistaceae			
11	*Usnea* sp.	Parmeliaceae			

Appendix II. 3.80: Species list of macro–fungi recorded from barrage and powerhouse sites of Nykcharong chu

Species	Family	Species	Family
Barrage		**Powerhouse**	
Auricularia auriculiformis	Auriculariaceae	*Auricularia auriculiformis*	Auriculariaceae
Boletus reticulatus	Boletaceae	*Boletus reticulatus*	Boletaceae
Clathrus rubra	Phallaceae	*Coprinus disseminatus*	Agaricaceae
Coprinus disseminatus	Agaricaceae	*Fomes pinicola*	Fomitopsidaceae
Fomes pinicola	Fomitopsidaceae	*Gloeophyllum sepiarium*	Gloeophyllaceae
Gloeophyllum sepiarium	Gloeophyllaceae	*Hydnum repandum*	Hydnaceae
Hericium erinaceus	Hericiaceae	*Lactarius rubidus*	Russulaceae
Hydnum repandum	Hydnaceae	*Pycnoporellus fibrillosus*	Formitopscidaceae
Laccaria laccata	Hydnangiaceae	*Schizophyllum commune*	Schizophyllaceae
Lactarius rubidus	Russulaceae	*Thelephora penicillata*	Thelephoraceae
Phellinus schweintizii	Hymenochaetaceae		
Polyporus arcularius	Polyporaceae		
Pycnoporellus fibrillosus	Formitopscidaceae		
Schizophyllum commune	Schizophyllaceae		
Thelephora penicillata	Thelephoraceae		
Xylaria polymorpha	Xylariaceae		
Catchment area			
Auricularia auriculiformis	Auriculariaceae		
Boletus reticulatus	Boletaceae		
Clathrus rubra	Phallaceae		
Coprinus disseminatus	Agaricaceae		
Fomes pinicola	Fomitopsidaceae		
Hericium erinaceus	Hericiaceae		
Hydnum repandum	Hydnaceae		
Laccaria laccata	Hydnangiaceae		
Lactarius rubidus	Russulaceae		
Phellinus schweintizii	Hymenochaetaceae		
Polyporus arcularius	Polyporaceae		
Pycnoporellus fibrillosus	Formitopscidaceae		
Schizophyllum commune	Schizophyllaceae		
Thelephora penicillata	Thelephoraceae		
Xylaria polymorpha	Xylariaceae		

Appendix II. 3.81: Frequency, density, basal area and IVI for tree species in Nykcharong chu barrage site

Sl. No.	Species name	Post–monsoon				Monsoon				Winter			
		Fr.	Dn.	BA	IVI	Fr.	Dn.	BA	IVI	Fr.	Dn.	BA	IVI
1	*Acer campbellii*	20	40	5.30	19.57	20	40	5.30	19.57	20	40	5.30	19.57
2	*Alangium alpinum*	70	150	1.88	28.75	70	150	1.88	28.75	70	150	1.88	28.75
3	*Alnus nepalensis*	90	190	11.45	58.76	90	190	11.45	58.76	90	190	11.45	58.76
4	*Betula alnoides*	20	40	3.02	14.03	20	40	3.02	14.03	20	40	3.02	14.03
5	*Brassaiopsis glomerulata*	30	50	0.79	11.00	30	50	0.79	11.00	30	50	0.79	11.00
6	*Eurya acuminata*	20	40	0.30	7.37	20	40	0.30	7.37	20	40	0.30	7.37
7	*Lyonia ovalifolia*	70	90	3.39	27.09	70	90	3.39	27.09	70	90	3.39	27.09
8	*Neolitsea* sp.	20	20	0.61	6.34	20	20	0.61	6.34	20	20	0.61	6.34
9	*Persea odoratissima*	40	70	2.32	18.05	40	70	2.32	18.05	40	70	2.32	18.05
10	*Quercus semecarpifolia*	60	90	2.77	24.03	60	90	2.77	24.03	60	90	2.77	24.03
11	*Rhododendron campanulatum*	50	90	3.78	24.94	50	90	3.78	24.94	50	90	3.78	24.94
12	*Rhododendron maddeni*	20	40	1.21	9.59	20	40	1.21	9.59	20	40	1.21	9.59
13	*Rhus acuminata*	40	60	0.58	12.92	40	60	0.58	12.92	40	60	0.58	12.92
14	*Magnolia campbelli*	10	20	0.59	4.75	10	20	0.59	4.75	10	20	0.59	4.75
15	*Morus laevigata*	20	20	1.73	9.08	20	20	1.73	9.08	20	20	1.73	9.08
16	*Leucosceptrum canum*	30	50	0.87	11.21	30	50	0.87	11.21	30	50	0.87	11.21
17	*Lindera neesiana*	40	60	0.41	12.52	40	60	0.41	12.52	40	60	0.41	12.52
Total		**650**	**1120**	**40.98**	**300**	**650**	**1120**	**40.98**	**300**	**650**	**1120**	**40.98**	**300**

Fr.–Frequency percentage, Dn.–Density (ha^{-1}), BA–Basal area ($m^2\ ha^{-1}$), IVI–Importance value index

Appendix II. 3.82: Frequency, density and IVI of shrubs in Nykcharong chu barrage site

Sl. No.	Species name	Post–monsoon			Monsoon			Winter		
		Fr.	Dn.	IVI	Fr.	Dn.	IVI	Fr.	Dn.	IVI
1	*Artemesia nilagirica*	40	896	18.84	40	896	18.84	40	896	18.84
2	*Berberis* sp.	44	1424	25.86	44	1424	25.86	44	1424	25.86
3	*Daphne papyracea*	76	2144	40.97	76	2144	40.97	76	2144	40.97
4	*Eleagnus parviflora*	12	192	4.75	12	192	4.75	12	192	4.75

Sl. No.	Species name	Post–monsoon			Monsoon			Winter		
5	*Elsholtzia* sp.	16	128	4.83	16	128	4.83	16	128	4.83
6	*Girardinia diversiflora*	36	624	14.82	36	624	14.82	36	624	14.82
7	*Hypericum choisianum*	24	272	8.19	24	272	8.19	24	272	8.19
8	*Ilex dipyrena*	48	544	16.38	48	544	16.38	48	544	16.38
9	*Neillia thyrsiflora*	28	384	10.34	28	384	10.34	28	384	10.34
10	*Rosa* sp.	12	112	3.81	12	112	3.81	12	112	3.81
11	*Rubus ellipticus*	28	192	8.08	28	192	8.08	28	192	8.08
12	*Sarcococca* sp.	36	1072	20.07	36	1072	20.07	36	1072	20.07
13	*Spirea* sp.	52	304	14.40	52	304	14.40	52	304	14.40
14	*Zanthoxylum oxyphyllum*	28	240	8.65	28	240	8.65	28	240	8.65
Total		**480**	**8528**	**200**	**480**	**8528**	**200**	**480**	**8528**	**200**

Fr.–Frequency percentage, Dn.–Density (ha^{-1}), IVI–Importance value index

Appendix II. 3.83: Frequency, density and IVI of herbs in Nykcharong chu barrage site

Sl. No.	Species name	Post–monsoon			Monsoon			Winter		
		Fr.	**Dn.**	**IVI**	**Fr.**	**Dn.**	**IVI**	**Fr.**	**Dn.**	**IVI**
1	*Ainsliaea* sp.	32	10800	7.43	24	8000	3.65	16	3200	4.48
2	*Anaphalis margaritacea*	68	48400	24.47	60	67600	17.45	24	12400	10.30
3	*Aster* sp.	28	3600	4.51	20	6400	3.00			
4	*Aster trinervius*	48	6800	7.95	28	10800	4.52	12	3200	3.73
5	*Astilbe rivularis*	16	2000	2.56	20	5200	2.79			
6	*Calanthe tricarinata*				44	36400	10.49			
7	*Codonopsis gracilis*				16	3600	2.13			
8	*Crawfurdia speciosa*				12	4000	1.83			
9	*Cyathula capitata*	52	33200	17.41	56	51600	14.28	32	12400	11.79
10	*Dipsacus asper*	44	12000	9.25	36	18800	6.67			
11	*Dracocephalum* sp.	24	3200	3.91	24	7200	3.51			
12	*Elatostemma sessile*	32	24400	12.07	32	23200	7.06	32	16800	13.87
13	*Elsholtzia strobilifera*	76	28800	18.73				48	34800	25.34
14	*Fragaria* sp.	64	12000	11.60	44	18800	7.42	56	26800	23.04
15	*Galium* sp.	72	12000	12.54	32	14800	5.59			
16	*Galium rotundifolia*							32	8000	9.71
17	*Gentiana capitata*	24	4400	4.32						
18	*Geranium pretense*	24	4400	4.32	28	10000	4.38	32	5200	8.38
19	*Goldfusia nutans*	16	2800	2.83	24	5200	3.16			
20	*Nepeta* sp.	12	2000	2.09	20	5600	2.86	24	4000	6.33
21	*Ophiopogon intermedius*	36	5200	6.00	44	9200	5.74	24	4800	6.71
22	*Oplisminus compositus*	48	37600	18.44	60	60400	16.19	44	39200	26.67
23	*Panax bipinnatifidus*				32	10000	4.75			
24	*Paris polyphylla*				24	5600	3.23			
25	*Parasenecio quinquelobus*				12	3600	1.76			
26	*Persicaria runcinata*				24	18000	5.40			
27	*Phlomis* sp.				12	3200	1.69			
28	*Pilea umbrosa*	32	20800	10.84	32	22000	6.85	32	10000	10.65
29	*Pogonotherum* sp.	20	3600	3.57	24	5600	3.23			
30	*Pogostemon* sp.	16	3200	2.97	28	7600	3.96	20	3600	5.41
31	*Potentilla cuneata*	36	7600	6.81	36	10800	5.27	24	7200	7.85
32	*Rumex acetosella*				52	50400	13.69			
33	*Salvia* sp.				20	5600	2.86			
34	*Sambucus adnata*				44	27600	8.96	36	10000	11.39
35	*Senecio cappa*	12	1200	1.82	12	3600	1.76			
36	*Thalictrium foliosum*				28	9200	4.24	28	6400	8.21
37	*Urtica dioica*	8	1600	1.48	28	11200	4.59			
38	*Viola sikkimensis*	12	2000	2.09	32	11600	5.03	24	3600	6.15
Total		**852**	**293600**	**200**	**1064**	**572400**	**200**	**540**	**211600**	**200**

Fr.–Frequency percentage, Dn.–Density (ha^{-1}), IVI–Importance value index

Appendix II. 3.84: Frequency, density, basal area and IVI for tree species in Nykcharong chu powerhouse site

Sl. No.	Species name	Post–monsoon				Monsoon				Winter			
		Fr.	**Dn.**	**BA**	**IVI**	**Fr.**	**Dn.**	**BA**	**IVI**	**Fr.**	**Dn.**	**BA**	**IVI**
1	*Acer sikkimensis*	10	20	1.79	15.52	10	20	1.79	15.52	10	20	1.79	15.52
2	*Alangium alpinum*	60	100	1.42	48.76	60	100	1.42	48.76	60	100	1.42	48.76
3	*Alnus nepalensis*	60	80	4.09	55.61	60	80	4.09	55.61	60	80	4.09	55.61
4	*Fraxinus floribunda*	10	20	0.49	9.97	10	20	0.49	9.97	10	20	0.49	9.97

Sl.	Species name	Post–monsoon				Monsoon				Winter			
5	*Leucosceptrum canum*	20	30	0.44	15.37	20	30	0.44	15.37	20	30	0.44	15.37
6	*Lindera neesiana*	40	60	0.34	28.42	40	60	0.34	28.42	40	60	0.34	28.42
7	*Quercus lamellosa*	50	60	12.04	81.58	50	60	12.04	81.58	50	60	12.04	81.58
8	*Quercus semecarpifolia*	20	30	1.88	21.48	20	30	1.88	21.48	20	30	1.88	21.48
9	*Rhododendron* sp.	30	40	0.99	23.30	30	40	0.99	23.30	30	40	0.99	23.30
Total		**300**	**440**	**23.48**	**300**	**300**	**440**	**23.48**	**300**	**300**	**440**	**23.48**	**300**

Fr.–Frequency percentage, Dn.–Density (ha^{-1}), BA–Basal area (m^2 ha^{-1}), IVI–Importance value index

Appendix II. 3.85: Frequency, density and IVI of shrubs in Nykcharong chu powerhouse site

Sl. No.	Species name	Post–monsoon			Monsoon			Winter		
		Fr.	**Dn.**	**IVI**	**Fr.**	**Dn.**	**IVI**	**Fr.**	**Dn.**	**IVI**
1	*Artemesia nilagirica*	68	1360	28.17	68	1360	28.17	68	1360	28.17
2	*Berberis* sp.	28	352	9.23	28	352	9.23	28	352	9.23
3	*Coraria napalensis*	32	432	10.89	32	432	10.89	32	432	10.89
4	*Daphne papyracea*	64	1872	33.25	64	1872	33.25	64	1872	33.25
5	*Elaeagnus parviflora*	12	112	3.51	12	112	3.51	12	112	3.51
6	*Girardinia diversifloia*	44	896	18.41	44	896	18.41	44	896	18.41
7	*Hypericum choisianum*	16	144	4.62	16	144	4.62	16	144	4.62
8	*Ilex dipyrena*	32	368	10.16	32	368	10.16	32	368	10.16
9	*Neillia thyrsiflora*	24	192	6.66	24	192	6.66	24	192	6.66
10	*Piptanthus nepalensis*	36	512	12.55	36	512	12.55	36	512	12.55
11	*Rosa* sp.	44	592	14.95	44	592	14.95	44	592	14.95
12	*Rubus ellipticus*	52	784	18.63	52	784	18.63	52	784	18.63
13	*Philadelphus tomentosus*	28	256	8.14	28	256	8.14	28	256	8.14
14	*Zanthoxylum oxyphyllum*	20	192	5.92	20	192	5.92	20	192	5.92
15	*Sarcococca* sp.	36	720	14.91	36	720	14.91	36	720	14.91
Total		**536**	**8784**	**200**	**536**	**8784**	**200**	**536**	**8784**	**200**

Fr.–Frequency percentage, Dn.–Density (ha^{-1}), IVI–Importance value index

Appendix II. 3.86: Frequency, density and IVI of herbs in Nykcharong chu powerhouse site

Sl. No.	Species name	Post–monsoon			Monsoon			Winter		
		Fr.	**Dn.**	**IVI**	**Fr.**	**Dn.**	**IVI**	**Fr.**	**Dn.**	**IVI**
1	*Ainsliaea* sp.	16	3200	3.39	24	10800	5.22	28	8000	10.19
2	*Anaphalis margaritacea*	44	34000	17.70	56	58800	18.92	36	9200	12.52
3	*Arisaema erubescens*	24	5200	5.22	24	13200	5.71			
4	*Arisaema nepenthoides*	32	7600	7.18	28	10800	5.73	16	4400	5.73
5	*Aster trinervius*	20	3200	3.97	16	6400	3.32			
6	*Astilbe rivularis*	36	16400	10.68	20	8400	4.23			
7	*Cyanoglossum* sp.	56	29600	17.98	24	15200	6.11			
8	*Cyathula capitata*	20	3200	3.97	48	39200	13.98	32	6400	10.17
9	*Dicrosocephala* sp.	52	17200	13.28	16	6400	3.32			
10	*Dipsacus asper*	40	24400	13.93	44	16800	8.98	32	8400	11.25
11	*Elsholtzia strobilifera*							44	34800	27.99
12	*Fragaria* sp.	36	25200	13.61	32	10000	6.08	40	22400	20.47
13	*Galium rotundifolia*	32	7600	7.18						
14	*Geranium pretense*									
15	*Imperata cylindrica*	28	22800	3.97	40	24000	9.91	28	22400	17.95
16	*Galium* sp.	16	3200	3.39	36	12400	7.08	20	7200	8.08
17	*Nepeta* sp.	20	3200	11.65	28	10800	5.73	16	2800	4.87
18	*Ophiopogon intermedius*	12	2000	2.41	20	6000	3.75	20	4800	6.79
19	*Oplisminus compositus*	56	52000	25.43	56	64000	19.96	44	18000	18.94
20	*Parasenecio quinquelobus*				12	4400	2.41			
21	*Persicaria runcinata*				28	19600	7.50			
22	*Phlomis* sp.	8	1600	1.69	12	4000	2.33			
23	*Plantago major*	28	12000	8.06	24	15200	6.11	32	15200	14.91
24	*Pogostemon* sp.	16	2400	3.12	12	5200	2.57	16	2800	4.87
25	*Potentilla cuneata*	32	7600	7.18	24	6400	4.34	20	3200	5.93
26	*Roscoea alpine*				12	3600	2.25			
27	*Rumex acetosella*				44	46000	14.83			
28	*Sambacus adnata*	36	12000	9.22	56	59600	19.08	36	12800	14.46
29	*Senecio cappa*	12	1600	2.28	8	4400	1.90			
30	*Thalictrum foliolosum*				24	10000	5.06			
31	*Viola sikkimensis*	16	3600	3.52	16	7600	3.56	16	2800	4.87
Total		**688**	**300800**	**200**	**784**	**499200**	**200**	**476**	**185600**	**200**

Fr.–Frequency percentage, Dn.–Density (ha^{-1}), IVI–Importance value index

Appendix II. 3.87: Frequency, density, basal area and IVI for tree species in Nykcharong chu catchment area

Sl. No.	Species name	Post–monsoon				Monsoon				Winter			
		Fr.	**Dn.**	**BA**	**IVI**	**Fr.**	**Dn.**	**BA**	**IVI**	**Fr.**	**Dn.**	**BA**	**IVI**
1	*Acer campbellii*	30	40	2.52	21.34	30	40	2.52	21.34	30	40	2.52	21.34
2	*Alangium alpinum*	60	90	1.12	30.12	60	90	1.12	30.12	60	90	1.12	30.12
3	*Alnus nepalensis*	50	120	9.37	61.89	50	120	9.37	61.89	50	120	9.37	61.89
4	*Betula alnoides*	60	80	5.37	43.90	60	80	5.37	43.90	60	80	5.37	43.90
5	*Brassaiopsis glomerulata*	60	70	1.01	26.81	60	70	1.01	26.81	60	70	1.01	26.81
6	*Leucosceptrum canum*	30	40	0.64	14.62	30	40	0.64	14.62	30	40	0.64	14.62
7	*Lindera neesiana*	50	60	0.72	22.14	50	60	0.72	22.14	50	60	0.72	22.14
8	*Magnolia campbellii*	40	50	1.80	22.39	40	50	1.80	22.39	40	50	1.80	22.39
9	*Persea odoratissima*	40	60	3.00	28.17	40	60	3.00	28.17	40	60	3.00	28.17
10	*Rhododendron arboreum*	20	40	0.94	13.51	20	40	0.94	13.51	20	40	0.94	13.51
11	*Rhododendron campanulatum*	20	40	1.38	15.09	20	40	1.38	15.09	20	40	1.38	15.09
Total		**460**	**690**	**27.86**	**300**	**460**	**690**	**27.86**	**300**	**460**	**690**	**27.86**	**300.00**

Fr.–Frequency percentage, Dn.–Density (ha^{-1}), BA–Basal area ($m^2\ ha^{-1}$), IVI–Importance value index

Appendix II. 3.88: Frequency, density and IVI of shrubs in Nykcharong chu catchment area

Sl. No.	Species name	Post–monsoon			Monsoon			Winter		
		Fr.	**Dn.**	**IVI**	**Fr.**	**Dn.**	**IVI**	**Fr.**	**Dn.**	**IVI**
1	*Berberis aristata*	72	1488	35.99	72	1488	35.99	72	1488	35.99
2	*Daphne papyracea*	60	1248	30.10	60	1248	30.10	60	1248	30.10
3	*Elaeagnus parviflora*	24	192	7.66	24	192	7.66	24	192	7.66
4	*Girardinia diversifolia*	48	1056	24.90	48	1056	24.90	48	1056	24.90
5	*Hypericum choisianum*	32	224	9.75	32	224	9.75	32	224	9.75
6	*Ilex dipyrena*	36	416	13.31	36	416	13.31	36	416	13.31
7	*Neillia thyrsiflora*	28	256	9.39	28	256	9.39	28	256	9.39
8	*Rosa* sp.	32	272	10.44	32	272	10.44	32	272	10.44
9	*Rubus ellipticus*	44	368	14.27	44	368	14.27	44	368	14.27
10	*Philadelphus tomentosus*	16	112	4.88	16	112	4.88	16	112	4.88
11	*Spirea* sp.	28	192	8.48	28	192	8.48	28	192	8.48
12	*Zanthoxylum oxyphyllum*	28	288	9.85	28	288	9.85	28	288	9.85
13	*Sarcococca* sp.	40	896	20.98	40	896	20.98	40	896	20.98
Total		**488**	**7008**	**200**	**488**	**7008**	**200**	**488**	**7008**	**200**

Fr.–Frequency percentage, Dn.–Density (ha^{-1}), IVI–Importance value index

Appendix II. 3.89: Frequency, density and IVI of herbs in Nykcharong chu catchment area

Sl. No.	Species name	Post–monsoon			Monsoon			Winter		
		Fr.	**Dn.**	**IVI**	**Fr.**	**Dn.**	**IVI**	**Fr.**	**Dn.**	**IVI**
1	*Ainsliaea* sp.	24	3600	4.46	24	14800	6.53	16	4400	4.87
2	*Anaphalis margaritacea*	48	47200	21.64	32	10400	6.51	20	19600	12.00
3	*Arisaema nepenthoides*	20	3600	3.91	32	8000	5.94			
4	*Aster trinervius*				28	8000	5.43	28	6400	7.98
5	*Astilbe rivularis*	24	4400	4.71	24	6000	4.46			
6	*Cyathula capitata*	52	29200	16.47	56	52000	19.34	44	13600	14.03
7	*Dipsacus asper*	44	12400	10.02	52	14800	10.08	56	12000	15.63
8	*Dracocephalum* sp.	20	3600	3.91	16	6000	3.44			
9	*Elatostemma sessile*	32	16800	9.76	56	36000	15.57	52	32800	23.58
10	*Elsholtzia strobilifera*	36	25600	13.11				44	28800	20.39
11	*Fragaria* sp.	40	22000	12.52				28	23200	15.02
12	*Galium* sp.				20	10400	4.98			
13	*Geranium pretense*	20	3600	3.91	36	14000	7.86			
14	*Nepeta* sp.	28	4400	5.27	20	6000	3.95	20	2000	4.63
15	*Ophiopogon intermedius*	24	5200	4.97	36	10400	7.01	16	3200	4.37
16	*Oplisminus compositus*	28	25600	12.01	52	59200	20.52	48	41600	26.51
17	*Panax bipinnatifidus*				24	9600	5.30			
18	*Panicum* sp.				16	6000	3.44			
19	*Parasenecio quinquelobus*				12	4000	2.46			
20	*Persicaria runcinata*				32	23600	9.61			
21	*Phlomis* sp.	48	8000	9.17	20	6000	3.95			
22	*Pilea umbrosa*	56	48000	23.00	36	32400	12.19	36	23200	16.53
23	*Pogostemon* sp.	20	8000	5.31	12	3200	2.28	16	3200	4.37
24	*Potentilla cuneata*	28	3600	5.01	12	4000	2.46	36	6400	9.50
25	*Sambucus adnata*	48	12400	10.57	52	36800	15.25	32	8800	9.75
26	*Senecio cappa*	16	1600	2.72	20	4400	3.57			
27	*Trifolium repens*	24	21200	10.06	20	22800	7.90			

Sl. No.	Species name	Post–monsoon			Monsoon			Winter		
28	*Urtica dioica*	16	2000	2.85	28	10400	6.00	24	6400	7.23
29	*Viola sikkimensis*	28	2400	4.63	20	6000	3.95	12	3200	3.61
Total		**724**	**314400**	**200.00**	**788**	**425200**	**200.00**	**528**	**238800**	**200.00**

Fr.–Frequency percentage, Dn.–Density (ha^{-1}), IVI–Importance value index

Appendix II. 3.90: Dominant and Co–dominant species determined on the basis of IVI/density values of species in the plant communities at Nykcharong chu site

Community components	Barrage	Powerhouse	Catchment area
Tree species*			
Dominant	*Alnus nepalensis*	*Quercus lamellosa*	*Alnus nepaulensis*
Co–Dominant	*Alangium alpinum*	*Alnus nepalensis*	*Betula alnoides*
Shrub species*			
Dominant	*Daphnae papyracea*	*Daphnae papyracea*	*Berberis aristrata*
Co–Dominant	*Berberis* sp.	*Artemesia nilagirica*	*Daphnae papyracea*
Herb species**			
i. Post–monsoon season			
Dominant	*Anaphalis margaritacea*	*Cyathula capitata*	*Pilea umbrosa*
Co–Dominant	*Elsholtzia stobilifera*	*Opliomenus compositus*	*Anaphalis margaritacea*
ii. Monsoon season			
Dominant	*Anaphalis margaritacea*	*Opliomenus compositus*	*Opliomenus composites*
Co–Dominant	*Opliomenus compositus*	*Sambacus adnata*	*Elatostemma sessile*
iii. Winter			
Dominant	*Opliomenus compositus*	*Elsholtzia stobilifera*	*Opliomenus composites*
Co–Dominant	*Elsholtzia stobilifera*	*Fragaria* sp.	*Elatostemma sessile*

* Dominance based on IVI; ** Dominance based on density

Appendix II. 3.91: List of plant species recorded from Rho HEP site

Sl. No.	Species name	Family
TREES		
1	*Acer campbellii*	Aceraceae
2	*Acer sikkimensis*	Aceraceae
3	*Alangium alpinum*	Alangiaceae
4	*Alnus nepalensis*	Betulaceae
5	*Brassaiopsis glomerulata*	Araliaceae
6	*Euvodia fraxinifolia*	Rutaceae
7	*Lindera neesiana*	Lauraceae
8	*Magnolia campbellii*	Magnoliaceae
9	*Photinia integrifolia*	Rosaceae
10	*Pinus wallichiana*	Pinaceae
11	*Populus ciliata*	Salicaceae
12	*Quercus griffithii*	Fagaceae
13	*Quercus lamellosa*	Fagaceae
14	*Quercus serrata*	Fagaceae
15	*Rhododendron arboreum*	Ericaceae
16	*Rhus chinensis*	Anacardiaceae
17	*Schima wallichii*	Theaceae
18	*Torricellia tiliifolia*	Torricelliaceae
SHRUBS		
19	*Artemesia nilagirica*	Asteraceae
20	*Arundinaria maling*	Poaceae
21	*Berberis aristata*	Berberidaceae
22	*Boenninghausenia albiflora*	Rutaceae
23	*Coraria napalensis*	Coriariaceae
24	*Daphne papyracea*	Thymelaeaceae
25	*Elaeagnus parviflora*	Elaegnaceae
26	*Euphorbia sikkemensis*	Euphorbiaceae
27	*Girardinia diversifolia*	Urticaceae
28	*Hypericum choisianum*	Hypericaceae
29	*Neillia thyrsiflora*	Rosaceae
30	*Piptanthus nepalensis*	Papilionaceae
31	*Rosa* sp.	Rosaceae
32	*Rubus ellipticus*	Rosaceae
33	*Sarcococca* sp.	Buxaceae
34	*Viburnum foetidum*	Adoxaceae
HERBS		

Sl. No.	Species name	Family
35	*Achyranthes aspera*	Amaranthaceae
36	*Ainsliaea* sp.	Asteraceae
37	*Anaphalis margaritacea*	Asteraceae
38	*Arisaema erubescens*	Araceae
39	*Arisaema nepenthoides*	Araceae
40	*Aster* sp.	Asteraceae
41	*Aster trinervius*	Asteraceae
42	*Astilbe rivularis*	Saxifragaceae
43	*Bergenia ciliata*	Saxifragaceae
44	*Cirsium falconeri*	Asteraceae
45	*Cyanoglossum* sp.	Boraginaceae
46	*Cyathula capitata*	Amaranthaceae
47	*Didymocarpus* sp.	Gesneriaceae
48	*Dracocephalum* sp.	Lamiaceae
49	*Drymaria cordata*	Caryophyllaceae
50	*Elsholtzia strobilifera*	Lamiaceae
51	*Eupatorium adenophorum*	Asteraceae
52	*Euphorbia sikkimensis*	Euphorbiaceae
53	*Fragaria* sp.	Rosaceae
54	*Galeola lindleyana*	Orchidaceae
55	*Galinsoga parviflora*	Asteraceae
56	*Galium asperifolium*	Rubiaceae
57	*Galium* sp.	Rubiaceae
58	*Geranium pretense*	Geraniaceae
59	*Gonatanthus pumilus*	Araceae
60	*Herpetospermum pendulosum*	Cucurbitaceae
61	*Hypoestes roxburghii*	Acanthaceae
62	*Imperata cylindrica*	Poaceae
63	*Iris lactea*	Iridaceae
64	*Nepeta* sp.	Lamiaceae
65	*Ophiopogon intermedius*	Liliaceae
66	*Oplismenus compositus*	Poaceae
67	*Oplismenus* sp.	Poaceae
68	*Oxalis corniculata*	Oxalidaceae
69	*Paspallum* sp.	Poaceae
70	*Persicaria runcinata*	Polygonaceae
71	*Phlomis* sp.	Lamiaceae
72	*Pilea umbrosa*	Urticaceae
73	*Plantago major*	Plantaginaceae
74	*Pleione praecox*	Orchidaceae
75	*Pogostemon* sp.	Lamiaceae
76	*Polygonum capitata*	Polygonaceae
77	*Potentilla cuneata*	Rosaceae
78	*Rumex acetosella*	Polygonaceae
79	*Sambucus adnata*	Adoxaceae
80	*Senecio cappa*	Asteraceae
81	*Urtica dioica*	Urticaceae
82	*Valeriana hardwickii*	Caprifoliaceae
83	*Viola sikkimensis*	Violaceae
CLIMBERS		
84	*Celastrus paniculata*	Celastraceae
85	*Cissampelos* sp.	Menispermaceae
86	*Clematis* sp.	Ranunculaceae
87	*Dioscorea* sp.	Dioscoreaceae
88	*Ficus* sp.	Moraceae
89	*Hedera helix*	Araliaceae
90	*Hedera nepalensis*	Araliaceae
91	*Herpetospermun pedunculosum*	Cucurbitaceae
92	*Holboellia latifolia*	Lardizabalaceae
93	*Periploca* sp.	Periplocaceae
94	*Philadelphus tomentosus*	Hydrangeaceae
95	*Rubia cordifolia*	Rubiaceae
96	*Scziophgma* sp.	Hydrangeaceae
97	*Smilax* sp.	Smilacaceae
98	*Stephania glandulifera*	Menispermaceae
99	*Thladiantha cordifolia*	Cucurbitaceae
ORCHIDS		
100	*Bulbophyllum* sp.	Orchidaceae

Sl. No.	Species name	Family
101	*Calanthe tricarinata*	Orchidaceae
102	*Coelogynae* sp.	Orchidaceae
103	*Cymbidium grandiflorum*	Orchidaceae
104	*Cymbidium* sp.	Orchidaceae
105	*Dendrobium* sp.	Orchidaceae
106	*Galeola lindleyana*	Orchidaceae
107	*Oberonia* sp.	Orchidaceae
108	*Pleione praecox*	Orchidaceae
109	*Vanda* sp.	Orchidaceae
PTERIDOPHYTES		
110	*Athyrium* sp.	Athyraceae
111	*Adiantum* sp.	Adiantaceae
112	*Dicranopteris linearis*	Dicranopteridaceae
113	*Dynaria quercifolia*	Drynariaceae
114	*Dryopteris wallichiana*	Dryopteridaceae
115	*Lepisorus* sp.	Polypodiaceae
116	*Polypodium* sp.	Polypodiaceae
117	*Pteridium aquilinum*	Pteridaceae
118	*Pteris* sp.	Pteridiaceae
119	*Pteris vittata*	Pteridaceae
120	*Pyrrosia nuda*	Polypodiaceae
121	*Selaginella* sp.	Selaginellaceae
122	*Vittaria elongata*	Vittariaceae
BRYOPHYTES		
123	*Aerobryum* sp.	Meteoriaceae
124	*Desmotheca* sp.	Orthotrichaceae
125	*Diphyscium* sp.	Buxbaumiaceae
126	*Funaria* sp.	Funariaceae
127	*Lyellia* sp.	Polytrichaceae
128	*Marchantia* sp.	Marchantiaceae
129	*Plagiobryum* sp.	Bryaceae
LICHENS		
130	*Alectoria* sp.	Alectoriaceae
131	*Cladonia* sp.	Cladoniaceae
132	*Graphis* sp.	Graphidaceae
133	*Lobaria* sp.	Lobariaceae
134	*Parmelia* sp.	Parmeliaceae
135	*Parmotrema* sp.	Parmeliaceae
136	*Pseudocyphellaria* sp.	Lobariaceae
137	*Stereocaulon* sp.	Stereocaulaceae
138	*Sticta* sp.	Lobariaceae
139	*Teloschistes* sp.	Teloschistaceae
FUNGI		
140	*Boletus reticulatus*	Boletaceae
141	*Clathrus rubra*	Phallaceae
142	*Coprinus disseminatus*	Agaricaceae
143	*Daldinia concentrica*	Xylariaceae
144	*Fomes pinicola*	Fomitopsidaceae
145	*Gloeophyllum sepiarium*	Gloeophyllaceae
146	*Hericium erinaceus*	Hericiaceae
147	*Hydnum repandum*	Hydnaceae
148	*Laccaria laccata*	Hydnangiaceae
149	*Lactarius rubidus*	Russulaceae
150	*Polyporus arcularius*	Polyporaceae
151	*Poria monticola*	Polyporaceae
152	*Pycnoporellus fibrillosus*	Formitopscidaceae
153	*Schizophyllum commune*	Schizophyllaceae
154	*Strobilomyces strobilaceus*	Boletaceae
155	*Tremella mesenterica*	Tremellaceae
156	*Xylaria polymorpha*	Xylariaceae

Appendix II. 3.92: Different groups of plant species present at Rho HEP site

Sl. No.	Species name Barrage and Powerhouse	Family	Sl. No.	Species name Catchment area	Family
CLIMBERS					
1	*Celastrus paniculata*	Celastraceae	1	*Celastrus paniculata*	Celastraceae
2	*Cissampelos* sp.	Menispermaceae	2	*Clematis* sp.	Ranunculaceae
3	*Clematis* sp.	Ranunculaceae	3	*Ficus* sp.	Moraceae
4	*Dioscorea* sp.	Dioscoreaceae	4	*Hedera helix*	Araliaceae
5	*Ficus* sp.	Moraceae	5	*Hedera nepalensis*	Araliaceae
6	*Hedera helix*	Araliaceae	6	*Herpetospermun pedunculosum*	Cucurbitaceae
7	*Hedera nepalensis*	Araliaceae	7	*Holboellia latifolia*	Lardizabalaceae
8	*Herpetospermun pedunculosum*	Cucurbitaceae	8	*Periploca* sp.	Periplocaceae
9	*Holboellia latifolia*	Lardizabalaceae	9	*Philadelphus tomentosus*	Hydrangeaceae
10	*Periploca* sp.	Periplocaceae	10	*Rubia cordifolia*	Rubiaceae
11	*Philadelphus tomentosus*	Hydrangeaceae	11	*Smilax* sp.	Smilacaceae
12	*Rubia cordifolia*	Rubiaceae	12	*Stephania glandulifera*	Menispermaceae
13	*Scziophgma* sp.	Hydrangeaceae	13	*Thladiantha cordifolia*	Cucurbitaceae
14	*Smilax* sp.	Smilacaceae			
15	*Stephania glandulifera*	Menispermaceae			
16	*Thladiantha cordifolia*	Cucurbitaceae			
ORCHIDS					
1	*Bulbophyllum* sp.	Orchidaceae	1	*Bulbophyllum* sp.	Orchidaceae
2	*Calanthe tricarinata*	Orchidaceae	2	*Calanthe tricarinata*	Orchidaceae
3	*Coelogynae* sp.	Orchidaceae	3	*Coelogynae* sp.	Orchidaceae
4	*Cymbidium grandiflorum*	Orchidaceae	4	*Cymbidium grandiflorum*	Orchidaceae
5	*Cymbidium* sp.	Orchidaceae	5	*Cymbidium* sp.	Orchidaceae
6	*Dendrobium* sp.	Orchidaceae	6	*Galeola lindleyana*	Orchidaceae
7	*Galeola lindleyana*	Orchidaceae	7	*Oberonia* sp.	Orchidaceae
8	*Oberonia* sp.	Orchidaceae	8	*Pleione praecox*	Orchidaceae
9	*Pleione praecox*	Orchidaceae			
10	*Vanda* sp.	Orchidaceae			
PTERIDOPHYTES					
1	*Athyrium* sp.	Athyraceae	1	*Athyrium* sp.	Athyraceae
2	*Adiantum* sp.	Adiantaceae	2	*Adiantum* sp.	Adiantaceae
3	*Dicranopteris linearis*	Dicranopteridaceae	3	*Dicranopteris linearis*	Dicranopteridaceae
4	*Dynaria quercifolia*	Drynariaceae	4	*Dynaria quercifolia*	Drynariaceae
5	*Dryopteris wallichiana*	Dryopteridaceae	5	*Dryopteris wallichiana*	Dryopteridaceae
6	*Lepisorus* sp.	Polypodiaceae	6	*Polypodium* sp.	Polypodiaceae
7	*Polypodium* sp.	Polypodiaceae	7	*Pteridium aquilinum*	Pteridaceae
8	*Pteridium aquilinum*	Pteridaceae	8	*Pteris* sp.	Pteridiaceae
9	*Pteris* sp.	Pteridiaceae	9	*Selaginella* sp.	Selaginellaceae
10	*Pteris vittata*	Pteridaceae	10	*Vittaria elongata*	Vittariaceae
11	*Pyrrosia nuda*	Polypodiaceae			
12	*Selaginella* sp.	Selaginellaceae			
13	*Vittaria elongata*	Vittariaceae			
BRYOPHYTES					
1	*Aerobryum* sp.	Meteoriaceae	1	*Aerobryum* sp.	Meteoriaceae
2	*Desmotheca* sp.	Orthotrichaceae	2	*Desmotheca* sp.	Orthotrichaceae
3	*Diphyscium* sp.	Buxbaumiaceae	3	*Diphyscium* sp.	Buxbaumiaceae
4	*Funaria* sp.	Funariaceae	4	*Marchantia* sp.	Marchantiaceae
5	*Lyellia* sp.	Polytrichaceae	5	*Plagiobryum* sp.	Bryaceae
6	*Marchantia* sp.	Marchantiaceae			
7	*Plagiobryum* sp.	Bryaceae			
LICHENS					
1	*Alectoria* sp.	Alectoriaceae	1	*Alectoria* sp.	Alectoriaceae
2	*Cladonia* sp.	Cladoniaceae	2	*Lobaria* sp.	Lobariaceae
3	*Graphis* sp.	Graphidaceae	3	*Pseudocyphellaria* sp.	Lobariaceae
4	*Lobaria* sp.	Lobariaceae	4	*Stereocaulon* sp.	Stereocaulaceae
5	*Parmelia* sp.	Parmeliaceae	5	*Sticta* sp.	Lobariaceae
6	*Parmotrema* sp.	Parmeliaceae	6	*Teloschistes* sp.	Teloschistaceae
7	*Pseudocyphellaria* sp.	Lobariaceae	7	*Parmelia* sp.	Parmeliaceae
8	*Stereocaulon* sp.	Stereocaulaceae	8	*Parmotrema* sp.	Parmeliaceae
9	*Sticta* sp.	Lobariaceae			
10	*Teloschistes* sp.	Teloschistaceae			

Appendix II. 3.93: Species list of macro–fungi recorded from barrage and powerhouse sites of Rho

Species	Family	Species	Family
Barrage		**Powerhouse**	
Boletus reticulatus	Boletaceae	*Boletus reticulatus*	Boletaceae
Clathrus rubra	Phallaceae	*Clathrus rubra*	Phallaceae
Coprinus disseminatus	Agaricaceae	*Coprinus disseminatus*	Agaricaceae
Daldinia concentrica	Xylariaceae	*Daldinia concentrica*	Xylariaceae
Fomes pinicola	Fomitopsidaceae	*Gloeophyllum sepiarium*	Gloeophyllaceae
Gloeophyllum sepiarium	Gloeophyllaceae	*Hericium erinaceus*	Hericiaceae
Hericium erinaceus	Hericiaceae	*Hydnum repandum*	Hydnaceae
Hydnum repandum	Hydnaceae	*Lactarius rubidus*	Russulaceae
Laccaria laccata	Hydnangiaceae	*Polyporus arcularius*	Polyporaceae
Lactarius rubidus	Russulaceae	*Poria monticola*	Polyporaceae
Polyporus arcularius	Polyporaceae	*Schizophyllum commune*	Schizophyllaceae
Poria monticola	Polyporaceae	*Strobilomyces strobilaceus*	Boletaceae
Pycnoporellus fibrillosus	Formitopscidaceae	*Tremella mesenterica*	Tremellaceae
Schizophyllum commune	Schizophyllaceae	*Xylaria polymorpha*	Xylariaceae
Strobilomyces strobilaceus	Boletaceae		
Tremella mesenterica	Tremellaceae		
Xylaria polymorpha	Xylariaceae		
Catchment area			
Boletus reticulatus	Boletaceae		
Clathrus rubra	Phallaceae		
Coprinus disseminatus	Agaricaceae		
Daldinia concentrica	Xylariaceae		
Fomes pinicola	Fomitopsidaceae		
Hericium erinaceus	Hericiaceae		
Hydnum repandum	Hydnaceae		
Laccaria laccata	Hydnangiaceae		
Lactarius rubidus	Russulaceae		
Polyporus arcularius	Polyporaceae		
Poria monticola	Polyporaceae		
Pycnoporellus fibrillosus	Formitopscidaceae		
Schizophyllum commune	Schizophyllaceae		
Tremella mesenterica	Tremellaceae		
Xylaria polymorpha	Xylariaceae		

Appendix II. 3.94: Frequency, density, basal area and IVI for tree species in Rho barrage site

Sl. No.	Species name	Post–monsoon				Monsoon				Winter			
		Fr.	Dn.	BA	IVI	Fr.	Dn.	BA	IVI	Fr.	Dn.	BA	IVI
1	*Acer sikkimensis*	20	20	0.84	11.10	20	20	0.84	11.10	20	20	0.84	11.10
2	*Alangium alpinum*	30	40	0.30	15.36	30	40	0.30	15.36	30	40	0.30	15.36
3	*Alnus nepalensis*	70	150	5.96	61.15	70	150	5.96	61.15	70	150	5.96	61.15
4	*Brassaiopsis glomerulata*	20	30	0.28	11.04	20	30	0.28	11.04	20	30	0.28	11.04
5	*Euvodia fraxinifolia*	10	10	0.23	4.98	10	10	0.23	4.98	10	10	0.23	4.98
6	*Quercus lamellosa*	60	100	15.69	79.96	60	100	15.69	79.96	60	100	15.69	79.96
7	*Rhododendron arboreum*	20	40	1.00	14.85	20	40	1.00	14.85	20	40	1.00	14.85
8	*Rhus chinensis*	40	50	1.05	21.92	40	50	1.05	21.92	40	50	1.05	21.92
9	*Schima wallichii*	40	60	5.41	36.83	40	60	5.41	36.83	40	60	5.41	36.83
10	*Acer sikkimensis*	10	20	1.06	9.13	10	20	1.06	9.13	10	20	1.06	9.13
11	*Lindera neesiana*	20	40	0.30	12.73	20	40	0.30	12.73	20	40	0.30	12.73
12	*Photinia integrifolia*	40	50	0.73	20.96	40	50	0.73	20.96	40	50	0.73	20.96
Total		**380**	**610**	**32.84**	**300**	**380**	**610**	**32.84**	**300**	**380**	**610**	**32.84**	**300**

Fr.–Frequency percentage, Dn.–Density (ha^{-1}), BA–Basal area ($m^2 ha^{-1}$), IVI–Importance value index

Appendix II. 3.95: Frequency, density and IVI of shrubs in Rho barrage site

Sl. No.	Species name	Post–monsoon			Monsoon			Winter		
		Fr.	Dn.	IVI	Fr.	Dn.	IVI	Fr.	Dn.	IVI
1	*Artemesia nilagirica*	60	1424	29.33	60	1424	29.33	60	1424	29.33
2	*Arundinaria manii*	32	592	13.68	32	592	13.68	32	592	13.68
3	*Berberis aristata*	48	432	15.16	48	432	15.16	48	432	15.16
4	*Coriaria napalensis*	52	896	21.45	52	896	21.45	52	896	21.45
5	*Daphne papyracea*	48	1504	27.75	48	1504	27.75	48	1504	27.75
6	*Elaeagnus parviflora*	24	192	7.30	24	192	7.30	24	192	7.30
7	*Girardinia diversifolia*	32	912	17.44	32	912	17.44	32	912	17.44
8	*Hypericum choisianum*	16	144	5.05	16	144	5.05	16	144	5.05

Sl. No.	Species name	Post–monsoon			Monsoon			Winter		
9	*Neillia thyrsiflora*	24	256	8.05	24	256	8.05	24	256	8.05
10	*Piptanthus nepalensis*	36	512	13.58	36	512	13.58	36	512	13.58
11	*Rosa* sp.	28	368	10.21	28	368	10.21	28	368	10.21
12	*Rubus ellipticus*	40	432	13.48	40	432	13.48	40	432	13.48
13	*Sarcococca*	28	816	15.47	28	816	15.47	28	816	15.47
14	*Viburnum foetidum*	8	32	2.06	8	32	2.06	8	32	2.06
Total		**476**	**8512**	**200**	**476**	**8512**	**200**	**476**	**8512**	**200**

Fr.–Frequency percentage, Dn.–Density (ha^{-1}), IVI–Importance value index

Appendix II. 3.96: Frequency, density and IVI of herbs in Rho barrage site

Sl. No.	Species name	Post–monsoon			Monsoon			Winter		
		Fr.	Dn.	IVI	Fr.	Dn.	IVI	Fr.	Dn.	IVI
1	*Achyranthes aspera*	20	3600	3.68	28	9200	3.84			
2	*Ainsliaea* sp.	44	10800	9.07	44	18000	6.70	16	4400	5.38
3	*Anaphalis margaritacea*	32	6800	6.24	52	26800	8.96			
4	*Arisaema erubescens*				32	12400	4.75			
5	*Arisaema nepenthoides*	24	6000	4.99	32	6800	3.69			
6	*Aster* sp.				44	13200	5.80			
7	*Aster trinervius*	20	3200	3.54	32	7600	3.84			
8	*Astilbe rivularis*	44	7200	7.84	56	8400	5.81			
9	*Berginia ciliata*				16	2800	1.73			
10	*Cirsium falconeri*				16	2800	1.73			
11	*Cyanoglossum* sp.				44	17200	6.55	16	3600	5.03
12	*Cyathula capitata*	12	2400	2.29	32	12800	4.82	24	8400	8.86
13	*Didymocarpus* sp.				16	2400	1.66			
14	*Dracocephalum* sp.	56	15200	12.05	12	2800	1.43			
15	*Drymaria cordata*	48	28800	15.74	40	35600	9.71	28	13200	11.83
16	*Elsholtzia strobilifera*	52	24400	14.72				36	25600	19.01
17	*Eupatorium adenophorum*	12	2400	2.29	32	5600	3.47			
18	*Euphorbia sikkemensis*				16	2800	1.73			
19	*Fragaria* sp.	52	24400	14.72	36	7600	4.15	24	12400	10.62
20	*Galeola lindleyana*				16	2800	1.73			
21	*Galinsoga parviflora*	48	10800	9.56	44	22000	7.46	28	16000	13.06
22	*Galium* sp.	16	2800	2.91	32	12800	4.82	12	5600	5.05
23	*Geranium pretense*	40	10400	8.45	24	6000	2.94	16	5200	5.73
24	*Gonatanthus pumilus*				16	3200	1.81			
25	*Herpetospermum pendulosum*				12	2800	1.43			
26	*Hypoestes roxburghii*	32	11200	7.75	28	12000	4.37			
27	*Imperata cylindrica*	28	15200	8.63	28	21600	6.17	24	24800	16.07
28	*Iris lactea*				24	4800	2.71			
29	*Oplisminus compositus*	44	28800	15.26				28	34400	21.15
30	*Nepeta* sp.	16	2400	2.78	16	2800	1.73			
31	*Ophiopogon intermedius*				32	7200	3.77			
32	*Oxalis corniculata*	4	800	0.76				20	8000	7.83
33	*Oplisminus* sp.				56	53200	14.22			
34	*Paspallum* sp.	28	20000	10.28	32	17200	5.65	24	17200	12.73
35	*Persicaria runcinata*				32	18000	5.80	20	8000	7.83
36	*Phlomis* sp.	4	800	0.76	12	2800	1.43			
37	*Pilea umbrosa*				32	30800	8.20			
38	*Plantago major*	44	24400	13.74	56	34800	10.77	32	11600	11.99
39	*Pleione praecox*				12	2800	1.43			
40	*Pogostemon* sp.	4	400	0.63	20	3600	2.19	20	4000	6.07
41	*Polygonum capitata*	24	6800	5.26	36	17600	6.02	28	5200	8.32
42	*Potentilla cuneata*	20	3200	3.54	36	6800	4.00	32	12400	12.34
43	*Rumex acetosella*	36	15600	9.75	48	26800	8.66			
44	*Sambucus adnata*	4	400	0.63						
45	*Senecio cappa*				20	3600	2.19			
46	*Urtica dioica*	12	2000	2.15	36	9200	4.45	24	5200	7.46
47	*Valeriana hardwickii*				16	5200	2.19			
48	*Viola sikkimensis*				28	7200	3.47	12	2400	3.64
Total		**820**	**291200**	**200**	**1324**	**532400**	**200**	**464**	**227600**	**200**

Fr.–Frequency percentage, Dn.–Density (ha^{-1}), IVI–Importance value index

Appendix II. 3.97: Frequency, density, basal area and IVI for tree species in Rho powerhouse site

Sl. No.	Species name	Post–monsoon				Monsoon				Winter			
		Fr.	**Dn.**	**BA**	**IVI**	**Fr.**	**Dn.**	**BA**	**IVI**	**Fr.**	**Dn.**	**BA**	**IVI**
1	*Alnus nepalensis*	80	180	6.98	92.33	80	180	6.98	92.33	80	180	6.98	92.33
2	*Brassaiopsis glomerulata*	20	20	0.31	10.90	20	20	0.31	10.90	20	20	0.31	10.90
3	*Photinia integrifolia*	40	60	0.89	26.80	40	60	0.89	26.80	40	60	0.89	26.80
4	*Quercus serrata*	20	30	0.84	15.53	20	30	0.84	15.53	20	30	0.84	15.53
5	*Rhododendron arboreum*	40	70	1.41	31.35	40	70	1.41	31.35	40	70	1.41	31.35
6	*Rhus chinensis*	20	40	0.92	17.73	20	40	0.92	17.73	20	40	0.92	17.73
7	*Schima wallichii*	30	40	2.46	28.95	30	40	2.46	28.95	30	40	2.46	28.95
8	*Torricellia tiliifolia*	30	50	1.27	24.23	30	50	1.27	24.23	30	50	1.27	24.23
9	*Quercus griffithi*	70	80	3.34	52.18	70	80	3.34	52.18	70	80	3.34	52.18
Total		**350**	**570**	**18.41**	**300**	**350**	**570**	**18.41**	**300**	**350**	**570**	**18.41**	**300**

Fr.–Frequency percentage, Dn.–Density (ha^{-1}), BA–Basal area ($m^2\ ha^{-1}$), IVI–Importance value index

Appendix II. 3.98: Frequency, density and IVI of shrubs in Rho powerhouse site

Sl. No.	Species name	Post–monsoon			Monsoon			Winter		
		Fr.	**Dn.**	**IVI**	**Fr.**	**Dn.**	**IVI**	**Fr.**	**Dn.**	**IVI**
1	*Artemesia nilagirica*	64	2544	45.16	64	2544	45.16	64	2544	45.16
2	*Arundinaria manii*	28	544	12.85	28	544	12.85	28	544	12.85
3	*Berberis aristrata*	16	272	6.87	16	272	6.87	16	272	6.87
4	*Coriaria nepalensis*	28	1072	19.26	28	1072	19.26	28	1072	19.26
5	*Daphne papyracea*	28	544	12.85	28	544	12.85	28	544	12.85
6	*Elaeagnus parviflora*	36	208	10.56	36	208	10.56	36	208	10.56
7	*Girardinia diversifolia*	28	512	12.46	28	512	12.46	28	512	12.46
8	*Neillia thyrsiflora*	16	144	5.32	16	144	5.32	16	144	5.32
9	*Piptanthus nepalensis*	44	368	14.29	44	368	14.29	44	368	14.29
10	*Rosa* sp.	24	272	8.66	24	272	8.66	24	272	8.66
11	*Rubus ellipticus*	44	720	18.56	44	720	18.56	44	720	18.56
12	*Sarcococca*	36	656	16.00	36	656	16.00	36	656	16.00
13	*Viburnum foetidum*	32	176	9.28	32	176	9.28	32	176	9.28
14	*Boenninghausenia albiflora*	24	208	7.88	24	208	7.88	24	208	7.88
Total		**448**	**8240**	**200**	**448**	**8240**	**200**	**448**	**8240**	**200**

Fr.–Frequency percentage, Dn.–Density (ha^{-1}), IVI–Importance value index

Appendix II. 3.99: Frequency, density and IVI of herbs in Rho powerhouse site

Sl. No.	Species name	Post–monsoon			Monsoon			Winter		
		Fr.	**Dn.**	**IVI**	**Fr.**	**Dn.**	**IVI**	**Fr.**	**Dn.**	**IVI**
1	*Achyranthes aspera*	8	1200	1.56	24	5600	3.31	16	2800	4.32
2	*Ainsliaea* sp.	20	6800	5.23	28	11200	4.87	16	3200	4.50
3	*Anaphalis margaritacea*	28	4400	5.53	48	23600	9.30			
4	*Arisaema erubescens*				16	5200	2.52			
5	*Arisaema nepenthoides*				20	6400	3.13			
6	*Aster* sp.	16	2800	3.26	32	8800	4.70			
7	*Aster trinervius*				36	11600	5.66			
8	*Astilbe rivularis*	4	800	0.85	28	11200	4.87			
9	*Cyanoglossum* sp.				44	22000	8.61	28	8400	9.15
10	*Cyathula capitata*				48	15200	7.49	32	8400	9.91
11	*Dracocephalum* sp.				20	3600	2.53			
12	*Drymaria cordata*	28	19200	10.69	44	26000	9.47	24	16800	12.19
13	*Elsholtzia strobilifera*	36	20000	12.12				52	34400	25.50
14	*Eupatorium adenophorum*	40	10800	9.48						
15	*Euphorbia sikkemensis*	12	2400	2.55	16	4400	2.35			
16	*Fragaria* sp.	40	22000	13.39	56	22400	9.74	36	16000	14.12
17	*Galinsoga parviflora*	28	6800	6.37	32	12800	5.57	20	8000	7.44
18	*Galium asperifolium*	24	6800	5.80						
19	*Galium* sp.				32	12800	5.57	28	6400	8.24
20	*Geranium pretense*				36	4800	4.19	8	2400	2.61
21	*Hypoestes roxburghii*	20	8400	5.79	36	19200	7.30			
22	*Imperata cylindrica*	32	24400	13.08	48	39200	12.68	36	23200	17.38
23	*Iris lactea*				20	3200	2.44			
24	*Nepeta* sp.	8	1600	1.70	28	3600	3.23			
25	*Ophiopogon intermedius*				32	6800	4.27			
26	*Oplisminus* sp.	32	24400	13.08						
27	*Oplisminus compositus*				48	26800	10.00	32	25600	17.70
28	*Oxalis corniculata*	36	12800	9.61				32	11600	11.36

Sl.	Species name	Post–monsoon			Monsoon			Winter		
29	*Persicaria runcinata*	28	14800	9.16	44	35600	11.55	20	6400	6.72
30	*Paspallum* sp.	36	24400	13.65	32	15600	6.17	24	15600	11.65
31	*Phlomis* sp.	4	1200	0.99	16	3600	2.18			
32	*Pilea umbrosa*				28	13200	5.30			
33	*Plantago major*	36	17600	11.28	36	22400	8.00			
34	*Pogostemon* sp.	4	800	0.85	24	4400	3.05	12	2400	3.38
35	*Polygonum capitatum*	48	22000	14.53	32	17600	6.61			
36	*Plantago major*							24	10000	9.11
37	*Potentilla cuneata*	4	800	0.85	44	9200	5.84	16	3600	4.68
38	*Sambucus adnata*	32	6800	6.94	28	13600	5.39			
39	*Senecio cappa*				28	4800	3.49			
40	*Rumex acetosella*	36	11200	9.05				44	10800	13.29
41	*Valeriana hardwickii*	20	3600	4.11						
42	*Urtica dioica*	24	6000	5.52	44	8400	5.66	16	3600	4.68
43	*Viola sikkimensis*	16	2000	2.98	16	7200	2.96	8	1200	2.07
Total		**700**	**286800**	**200**	**1144**	**462000**	**200**	**524**	**220800**	**200**

Fr.–Frequency percentage, Dn.–Density (ha^{-1}), IVI–Importance value index

Appendix II. 3.100: Frequency, density, basal area and IVI for tree species in Rho catchment area

Sl. No.	Species name	Post–monsoon				Monsoon				Winter			
		Fr.	**Dn.**	**BA**	**IVI**	**Fr.**	**Dn.**	**BA**	**IVI**	**Fr.**	**Dn.**	**BA**	**IVI**
1	*Acer campbellii*	20	30.00	1.85	14.20	20	30.00	1.85	14.20	20	30.00	1.85	14.20
2	*Alangium alpinum*	60	80.00	0.68	28.23	60	80.00	0.68	28.23	60	80.00	0.68	28.23
3	*Alnus nepalensis*	70	140.00	7.87	58.42	70	140.00	7.87	58.42	70	140.00	7.87	58.42
4	*Brassaiopsis glomerulata*	30	70.00	0.56	18.99	30	70.00	0.56	18.99	30	70.00	0.56	18.99
5	*Quercus lamellosa*	60	120.00	17.42	78.47	60	120.00	17.42	78.47	60	120.00	17.42	78.47
6	*Rhododendron arboreum*	30	60.00	1.28	19.48	30	60.00	1.28	19.48	30	60.00	1.28	19.48
7	*Populus ciliata*	20	20.00	1.63	12.19	20	20.00	1.63	12.19	20	20.00	1.63	12.19
8	*Rhus chinensis*	30	50.00	0.93	17.12	30	50.00	0.93	17.12	30	50.00	0.93	17.12
9	*Magnolia campbellii*	10	20.00	0.57	6.88	10	20.00	0.57	6.88	10	20.00	0.57	6.88
10	*Schima wallichii*	40	70.00	4.27	31.37	40	70.00	4.27	31.37	40	70.00	4.27	31.37
11	*Lindera neesiana*	30	40.00	0.54	14.66	30	40.00	0.54	14.66	30	40.00	0.54	14.66
Total		**400**	**700**	**38**	**300**	**400**	**700**	**38**	**300**	**400**	**700**	**38**	**300**

Fr.–Frequency percentage, Dn.–Density (ha^{-1}), BA–Basal area (m^2 ha^{-1}), IVI–Importance value index

Appendix II. 3.101: Frequency, density and IVI of shrubs in Rho catchment area

Sl. No.	Species name	Post–monsoon			Monsoon			Winter		
		Fr.	**Dn.**	**IVI**	**Fr.**	**Dn.**	**IVI**	**Fr.**	**Dn.**	**IVI**
1	*Artemesia nilagirica*	64	2368	41.25	64	2368	41.25	64	2368	41.25
2	*Arundinaria manii*	28	272	9.00	28	272	9.00	28	272	9.00
3	*Berberis aristata*	24	256	7.99	24	256	7.99	24	256	7.99
4	*Coraria napalensis*	52	720	19.27	52	720	19.27	52	720	19.27
5	*Daphne papyracea*	56	1248	26.34	56	1248	26.34	56	1248	26.34
6	*Elaeagnus parviflora*	32	272	9.83	32	272	9.83	32	272	9.83
7	*Euphorbia sikkemensis*	32	576	13.43	32	576	13.43	32	576	13.43
8	*Girardinia diversifolia*	36	624	14.82	36	624	14.82	36	624	14.82
9	*Hypericum choisianum*	16	96	4.44	16	96	4.44	16	96	4.44
10	*Neillia thyrsiflora*	28	208	8.25	28	208	8.25	28	208	8.25
11	*Piptanthus nepalensis*	44	720	17.61	44	720	17.61	44	720	17.61
12	*Rosa* sp.	20	208	6.59	20	208	6.59	20	208	6.59
13	*Rubus ellipticus*	36	784	16.72	36	784	16.72	36	784	16.72
14	*Viburnum foetidum*	16	96	4.44	16	96	4.44	16	96	4.44
Total		**484**	**8448**	**200**	**484**	**8448**	**200**	**484**	**8448**	**200**

Fr.–Frequency percentage, Dn.–Density (ha^{-1}), IVI–Importance value index

Appendix II. 3.102: Frequency, density and IVI of herbs in Rho catchment area

Sl. No.	Species name	Post–monsoon			Monsoon			Winter		
		Fr.	**Dn.**	**IVI**	**Fr.**	**Dn.**	**IVI**	**Fr.**	**Dn.**	**IVI**
1	*Achyranthes aspera*	16	4000	3.08	24	9200	3.80	16	3600	5.07
2	*Ainsliaea* sp.	20	8400	4.84	20	7200	3.09	20	4400	6.30
3	*Anaphalis margaritacea*	28	15200	7.77	28	21600	6.40			
4	*Arisaema erubescens*				16	8800	3.02			
5	*Arisaema nepenthoides*				20	6800	3.01			
6	*Aster* sp.	16	4400	3.19	16	3200	2.01			

Sl. No.	Species name	Post–monsoon			Monsoon			Winter		
7	*Aster trinervius*	12	2800	2.25	36	14400	5.81			
8	*Astilbe rivularis*	16	2400	2.61	28	8000	3.94	16	5200	5.77
9	*Bergenia ciliata*				28	4400	3.29			
10	*Cirsium falconeri*				12	2800	1.58			
11	*Cyanoglossum* sp.				36	18000	6.46	20	6800	7.34
12	*Cyathula capitata*	36	8000	6.63	44	26000	8.62	16	6000	6.12
13	*Didymocarpus* sp.				16	2800	1.93			
14	*Dracocephalum* sp.	8	1600	1.42	20	3600	2.44			
15	*Drymaria cordata*	56	32400	16.13	20	19200	5.25	28	24400	16.75
16	*Elsholtzia strobilifera*	48	28000	13.89	32	10800	4.81			
17	*Eupatorium adenophorum*				36	8400	4.73			
18	*Euphorbia sikkimensis*	8	1600	1.42	12	3200	1.65			
19	*Fragaria* sp.	44	19200	10.85	48	26000	8.98	44	17600	17.30
20	*Galinsoga parviflora*	36	9200	6.98	44	21600	7.83	28	13600	12.05
21	*Galium* sp.	20	6000	4.14	28	12400	4.74	24	5600	7.70
22	*Geranium pretense*	12	4000	2.60	20	5200	2.72	12	2400	3.68
23	*Hypoestes roxburghii*	32	10400	6.85	8	1600	1.00			
24	*Imperata cylindrica*	52	28000	14.37	32	17600	6.03			
25	*Imperata cylindrica*				48	34000	10.42	24	14000	11.35
26	*Iris lactea*				16	4400	2.22			
27	*Nepeta* sp.	4	400	0.59	12	3600	1.72			
28	*Ophiopogon intermedius*				20	6400	2.94			
29	*Oplisminus* sp.	28	19600	9.05	24	35600	8.57	28	24400	16.75
30	*Oxalis corniculata*	44	32800	14.81				24	17600	12.92
31	*Paspallum* sp.	24	15200	7.29	32	30800	8.42	16	16000	10.47
32	*Persicaria runcinata*	32	15200	8.25	20	17600	4.96			
33	*Phlomis* sp.	8	1600	1.42	12	2800	1.58			
34	*Pilea umbrosa*				28	22400	6.54			
35	*Plantago major*	32	12000	7.32	44	27600	8.91	32	18000	14.84
36	*Pogostemon* sp.	8	1600	1.42	16	3200	2.01			
37	*Polygonum capitatum*				40	19200	7.04			
38	*Potentilla cuneata*	28	3600	4.40	28	8400	4.02	20	6800	7.34
39	*Rumex acetosella*	84	20800	16.10	36	27200	8.12	52	34000	26.19
40	*Sambucus adnata*	52	27600	14.25	60	30800	10.92			
41	*Senecio cappa*	8	1200	1.31	12	3200	1.65			
42	*Urtica dioica*	24	6400	4.73	28	9200	4.16	28	8400	9.79
43	*Viola sikkimensis*				20	4800	2.65	8	1200	2.28
Total		**836**	**343600**	**200.00**	**1120**	**554000**	**200.00**	**456**	**230000**	**200.00**

Fr.–Frequency percentage, Dn.–Density (ha^{-1}), IVI–Importance value index

Appendix II. 3.103: Dominant and co–dominant species determined on the basis of IVI/density values of species in the plant communities at Rho village

Community components	Barrage	Powerhouse	Catchment area
Tree species*			
Dominant	*Alnus nepalensis*	*Alnus nepalensis*	*Alnus nepalensis*
Co–Dominant	*Quercus lamellosa*	*Quercus griffithi*	*Quercus lamellosa*
Shrub species**			
Dominant	*Artemesia nilagirica*	*Artemesia nilagirica*	*Artemesia nilagirica*
Co–Dominant	*Daphnae papyracea*	*Coraria napalensis*	*Daphnae papyracea*
Herb species**			
i. Post–monsoon season			
Dominant	*Drymaria cordata*	*Polygonum capitata*	*Drymaria cordata*
Co–Dominant	*Opliomenus compositus*	*Paspallum* sp.	*Rumex acetosella*
ii. Monsoon season			
Dominant	*Opliomenus compositus*	*Imperata cylindrica*	*Sambacus adnata*
Co–Dominant	*Plantago major*	*Persicaria runcinata*	*Imperata cylindrica*
iii. Winter			
Dominant	*Opliomenus* sp.	*Elsholtzia stobilifera*	*Rumex acetosella*
Co–Dominant	*Elsholtzia stobilifera*	*Opliomenus compositus*	*Fragaria* sp.

* Dominance based on IVI; ** Dominance based on density

Appendix II. 3.104: List of plant species recorded from Tawang–I HEP site

Sl. No.	Species name	Family
TREES		
1	*Alangium chinensis*	Alangiaceae
2	*Albizia arunachalensis*	Mimosaceae
3	*Alnus nepalensis*	Betulaceae
4	*Brassaiopsis glomerulata*	Araliaceae
5	*Brassaiopsis mitis*	Araliaceae
6	*Erythrina arborescens*	Papilionaceae
7	*Eurya acuminata*	Theaceae
8	*Ficus auriculata*	Moraceae
9	*Ilex* sp.	Aquifoliaceae
10	*Leucosceptrum canum*	Lamiaceae
11	*Litsea citrata*	Lauraceae
12	*Macaranga denticulata*	Euphorbiaceae
13	*Merrilliopanax alpinus*	Araliaceae
14	*Myrica* sp.	Myricaceae
15	*Photinia integrifolia*	Rosaceae
16	*Pinus wallichiana*	Pinaceae
17	*Prunus cerasoides*	Rosaceae
18	*Quercus griffithii*	Fagaceae
19	*Quercus serrata*	Fagaceae
20	*Quercus semecarpifolia*	Fagaceae
21	*Rhododendron arboreum*	Ericaceae
22	*Rhus chinensis*	Anacardiaceae
23	*Rhus javanica*	Anacardiaceae
24	*Salix wallichiana*	Salicaceae
25	*Saurauia punduana*	Actinidiaceae
26	*Schima wallichii*	Theaceae
27	*Torricellia tiliifolia*	Torricelliaceae
SHRUBS		
28	*Aconogonum molle*	Polygonaceae
29	*Ardesia crenata*	Myrsinaceae
30	*Artemisia nilagirica*	Asteraceae
31	*Arundinaria maling*	Poaceae
32	*Boehmeria macrophylla*	Urticaceae
33	*Buddleja asiatica*	Buddlejaceae
34	*Butea buteiformis*	Papilionaceae
35	*Coriaria nepalensis*	Coriariaceae
36	*Cyathula tomentosa*	Amaranthaceae
37	*Debregeasia longifolia*	Urticaceae
38	*Dicranopteis* sp.	Gleicheniaceae
39	*Dobinia vulgaris*	Anacardiaceae
40	*Elaeagnus parvifolia*	Elaegnaceae
41	*Flemingia macrophylla*	Papiloionaceae
42	*Girardiana diversifolia*	Urticaceae
43	*Hydrangea* sp.	Hydrangiaceae
44	*Hypericum* sp.	Hypericaceae
45	*Indigofera* sp.	Papilionaceae
46	*Maesa indica*	Myrsinaceae
47	*Morus rubra*	Moraceae
48	*Mussaenda* sp.	Rubiaceae
49	*Neillia thyrsiflora*	Rosaceae
50	*Rubus ellipticus*	Rosaceae
51	*Rubus rugosus*	Rosaceae
52	*Senecio* sp.	Asteraceae
53	*Solanum khasianum*	Solanaceae
54	Spirea sp.	Rosaceae
55	*Strobilanthes* sp.	Acanthaceae
56	*Triumfetta rhomboidea*	Malvaceae
57	*Urena lobata*	Malvaceae
58	*Viburnum foetidum*	adoxaceae
59	*Woodfordia fructicosa*	Lythraceae
60	*Yushania hirsuta*	Poaceae
HERBS		
61	*Ageratum conyzoides*	Asteraceae
62	*Agrimonia pilosa*	Rosaceae

Sl. No.	Species name	Family
63	*Anaphalis margaritacea*	Asteraceae
64	*Anemone rivularis*	Ranunculaceae
65	*Ariesaema* sp.	Araceae
66	*Bidens pilosa*	Asteraceae
67	*Campanula pallida*	Campanulaceae
68	*Cannabis sativa*	Cannabaceae
69	*Centella asiatica*	Apiaceae
70	*Cirsium* sp.	Asteraceae
71	*Cissampelos pareira*	Menispermaceae
72	*Crassocephalum crepidioides*	Asteraceae
73	*Cyathula tomentosus*	Amaranthaceae
74	*Cymbopogon citratus*	Poaceae
75	*Cynoglossum* sp.	Boraginaceae
76	*Cyperus* sp.	Cyperaceae
77	*Delphenium* sp.	Ranunculaceae
78	*Drymaria cordata*	Caryophyllaceae
79	*Eleusine coracana*	Poaceae
80	*Equisetum diffusum*	Equisetaceae
81	*Eupatorium adenophorum*	Asteraceae
82	*Euphorbia hirta*	Euphorbiaceae
83	*Fagopyrum esculentum*	Polygonaceae
84	*Fragaria nubicola*	Rosaceae
85	*Galinsoga parviflora*	Asteraceae
86	*Galium asperifolium*	Rubiaceae
87	*Galium rotundifolium*	Rubiaceae
88	*Galium* sp.	Rubiaceae
89	*Geranium nepalense*	Geraniaceae
90	*Geranium* sp.	Geraniaceae
91	*Houttuynia cordata*	Saururaceae
92	*Hydrocotyle nepalensis*	Araliaceae
93	*Hypoestes* sp.	Acanthaceae
94	*Impatiens* sp.	Balsaminaceae
95	*Ipomea* sp.	Convolvulaceae
96	*Juncus* sp.	Juncaceae
97	*Lecanthus peduncularis*	Urticaceae
98	*Lindenbergia* sp.	Scrophulariaceae
99	*Lysionotus* sp.	Gesneriaceae
100	*Melastoma* sp.	Melastomaceae
101	*Musa* sp.	Musaceae
102	*Oxalis corniculata*	Oxalidaceae
103	*Oxalis* sp.	Oxalidaceae
104	*Pedicularis* sp.	Orobanchaceae
105	*Pedicularis* sp*1*	Orobanchaceae
106	*Peperomia tetraphylla*	Piperaceae
107	*Persicaria capitata*	Polygonaceae
108	*Persicaria chinensis*	Polygonaceae
109	*Pimpinella diversifolia*	Apiaceae
110	*Piper pedicellatum*	Piperaceae
111	*Plantago erosa*	Plantaginaceae
112	*Plantago major*	Plantaginaceae
113	*Pogostemon* sp.	Lamiaceae
114	*Pteridium aequilinum*	Dennstaedtiaceae
115	*Ranunculus diffusus*	Ranunculaceae
116	*Roscoea* sp.	Zingiberaceae
117	*Rumex nepalensis*	Polygonaceae
118	*Seigesbeckia orientalis*	Asteraceae
119	*Selinum* sp.	Apiaceae
120	*Urtica dioica*	Urticaceae
121	*Verbasacum thapsus*	Scrophulariaceae
122	*Vernonia* sp.	Asteraceae
123	*Viola pilosa*	Violaceae
124	*Viola sikkimensis*	Violaceae
125	*Xanthium strumarium*	Asteraceae
CLIMBERS		
126	*Cissampelos* sp.	Menispermaceae
127	*Clematis acuminata*	Ranunculaceae

Sl. No.	Species name	Family
128	*Clematis Bucchaniana*	Ranunculaceae
129	*Clematis* sp.	Ranunculaceae
130	*Cuscuta reflexa*	Cuscutaceae
131	*Dioscorea* sp.	Dioscoreaceae
132	*Ficus* sp.	Moraceae
133	*Hedera helix*	Araliaceae
134	*Hedera nepalensis*	Araliaceae
135	*Holboellia latifolia*	Lardizabalaceae
136	*Periploca* sp.	Periplocaceae
137	*Rubia cordifolia*	Rubiaceae
138	*Smilax aspera*	Smilacaceae
139	*Stephania glandulifera*	Menispermaceae
ORCHIDS		
140	*Cymbidium* sp.	Orchidaceae
141	*Dendrobium* sp.	Orchidaceae
142	*Coelogynae* sp.	Orchidaceae
143	*Bulbophyllum* sp.	Orchidaceae
PTERIDOPHYTES		
144	*Blechnum* sp.	Blechnaceae
145	*Dicranopteris linearis*	Dicranopteridaceae
146	*Drynaria* sp.	Drynariaceae
147	*Dryopteris sparsa*	Dryopteridaceae
148	*Dryopteris wallichiana*	Dryopteridaceae
149	*Dynaria quercifolia*	Drynariaceae
150	*Lepisorus nudus*	Polypodiaceae
151	*Lycopodium clavatum*	Lycopodiaceae
152	*Polypodium* sp.	Polypodiaceae
153	*Pteridium aquilinum*	Pteridaceae
154	*Nephrolepis cordifolia*	Dryopteridaceae
155	*Pteris* sp.	Pteridiaceae
156	*Pteris vittata*	Pteridaceae
157	*Pyrossia rupestris*	Polypodiaceae
158	*Pyrrosia lanceolata*	Polypodiaceae
159	*Pyrrosia* sp.	Polypodiaceae
160	*Selaginella* sp.	Selaginellaceae
161	*Vittaria elongata*	Vittariaceae
BRYOPHYTES		
162	*Aerobryum* sp.	Meteoriaceae
163	*Desmotheca* sp.	Orthotrichaceae
164	*Diphyscium* sp.	Buxbaumiaceae
165	*Lyellia* sp.	Polytrichaceae
166	*Plagiobryum* sp.	Bryaceae
LICHENS		
167	*Alectoria* sp.	Alectoriaceae
168	*Bulbothrix* sp.	Parmeliaceae
169	*Cladonia* sp.	Cladoniaceae
170	*Everniastrum nepalense*	Parmeliaceae
171	*Graphis* sp.	Graphidaceae
172	*Heterodermia* sp.	Physciaceae
173	*Lecanora perplexa*	Lecanoraceae
174	*Lobaria* sp.	Lobariaceae
175	*Parmelinella* sp.	Parmeliaceae
176	*Parmotrema* sp.	Parmeliaceae
177	*Pseudocyphellaria* sp.	Lobariaceae
178	*Stereocaulon* sp.	Stereocaulaceae
179	*Sticta* sp.	Lobariaceae
180	*Teloschistes* sp.	Teloschistaceae
181	*Usnea* sp.	Parmeliaceae
FUNGI		
182	*Boletus reticulatus*	Boletaceae
183	*Clathrus rubra*	Phallaceae
184	*Coprinus disseminatus*	Agaricaceae
185	*Daldinia concentrica*	Xylariaceae
186	*Fomes pinicola*	Fomitopsidaceae
187	*Gloeophyllum sepiarium*	Gloeophyllaceae
188	*Hericium erinaceus*	Hericiaceae

Sl. No.	Species name	Family
189	*Hygrocybe miniata*	Hygrophoraceae
190	*Lactarius rubidus*	Russulaceae
191	*Phellinus schweintizii*	Hymenochaetaceae
192	*Polyporus arcularius*	Polyporaceae
193	*Poria monticola*	Polyporaceae
194	*Schizophyllum commune*	Schizophyllaceae
195	*Strobilomyces strobilaceus*	Boletaceae
196	*Thelephora penicillata*	Thelephoraceae
197	*Tremella mesenterica*	Tremellaceae
198	*Xylaria polymorpha*	Xylariaceae

Appendix II. 3.105: Different groups of plant species present at Tawang–I HEP site

Sl. No.	Species name Barrage and Powerhouse	Family	Sl. No.	Species name Catchment area	Family
CLIMBERS					
1	*Cissampelos* sp.	Menispermaceae	1	*Clematis acuminata*	Ranunculaceae
2	*Clematis acuminata*	Ranunculaceae	2	*Clematis Bucchaniana*	Ranunculaceae
3	*Clematis Bucchaniana*	Ranunculaceae	3	*Cuscuta reflexa*	Cuscutaceae
4	*Clematis* sp.	Ranunculaceae	4	*Ficus* sp.	Moraceae
5	*Cuscuta reflexa*	Cuscutaceae	5	*Hedera helix*	Araliaceae
6	*Dioscorea* sp.	Dioscoreaceae	6	*Hedera nepalensis*	Araliaceae
7	*Ficus* sp.	Moraceae	7	*Periploca* sp.	Periplocaceae
8	*Hedera helix*	Araliaceae	8	*Rubia cordifolia*	Rubiaceae
9	*Hedera nepalensis*	Araliaceae	9	*Stephania glandulifera*	Menispermaceae
10	*Holboellia latifolia*	Lardizabalaceae			
11	*Periploca* sp.	Periplocaceae			
12	*Rubia cordifolia*	Rubiaceae			
13	*Smilax aspera*	Smilacaceae			
14	*Stephania glandulifera*	Menispermaceae			
ORCHIDS					
1	*Cymbidium* sp.	Orchidaceae	1	*Cymbidium* sp.	Orchidaceae
2	*Dendrobium* sp.	Orchidaceae	2	*Coelogynae* sp.	Orchidaceae
3	*Coelogynae* sp.	Orchidaceae	3	*Bulbophyllum* sp.	Orchidaceae
4	*Bulbophyllum* sp.	Orchidaceae			
PTERIDOPHYTES					
1	*Blechnum* sp.	Blechnaceae	1	*Blechnum* sp.	Blechnaceae
2	*Dicranopteris linearis*	Dicranopteridaceae	2	*Dicranopteris linearis*	Dicranopteridaceae
3	*Drynaria* sp.	Drynariaceae	3	*Drynaria* sp.	Drynariaceae
4	*Dryopteris sparsa*	Dryopteridaceae	4	*Dryopteris wallichiana*	Dryopteridaceae
5	*Dryopteris wallichiana*	Dryopteridaceae	5	*Dynaria quercifolia*	Drynariaceae
6	*Dynaria quercifolia*	Drynariaceae	6	*Lepisorus nudus*	Polypodiaceae
7	*Lepisorus nudus*	Polypodiaceae	7	*Lycopodium clavatum*	Lycopodiaceae
8	*Lycopodium clavatum*	Lycopodiaceae	8	*Pteridium aquilinum*	Pteridaceae
9	*Polypodium* sp.	Polypodiaceae	9	*Nephrolepis cordifolia*	Dryopteridaceae
10	*Pteridium aquilinum*	Pteridaceae	10	*Pteris* sp.	Pteridiaceae
11	*Nephrolepis cordifolia*	Dryopteridaceae	11	*Pteris vittata*	Pteridaceae
12	*Pteris* sp.	Pteridiaceae	12	*Pyrrosia* sp.	Polypodiaceae
13	*Pteris vittata*	Pteridaceae	13	*Selaginella* sp.	Selaginellaceae
14	*Pyrossia rupestris*	Polypodiaceae			
15	*Pyrrosia lanceolata*	Polypodiaceae			
16	*Pyrrosia* sp.	Polypodiaceae			
17	*Selaginella* sp.	Selaginellaceae			
18	*Vittaria elongata*	Vittariaceae			
BRYOPHYTES					
1	*Aerobryum* sp.	Meteoriaceae	1	*Aerobryum* sp.	Meteoriaceae
2	*Desmotheca* sp.	Orthotrichaceae	2	*Desmotheca* sp.	Orthotrichaceae
3	*Diphyscium* sp.	Buxbaumiaceae	3	*Diphyscium* sp.	Buxbaumiaceae
4	*Lyellia* sp.	Polytrichaceae	4	*Plagiobryum* sp.	Bryaceae
5	*Plagiobryum* sp.	Bryaceae			
LICHENS					
1	*Alectoria* sp.	Alectoriaceae	1	*Alectoria* sp.	Alectoriaceae
2	*Bulbothrix* sp.	Parmeliaceae	2	*Bulbothrix* sp.	Parmeliaceae
3	*Cladonia* sp.	Cladoniaceae	3	*Cladonia* sp.	Cladoniaceae
4	*Everniastrum nepalense*	Parmeliaceae	4	*Everniastrum nepalense*	Parmeliaceae
5	*Graphis* sp.	Graphidaceae	5	*Graphis* sp.	Graphidaceae

Sl. No.	Species name Barrage and Powerhouse	Family	Sl. No.	Species name Catchment area	Family
6	*Heterodermia* sp.	Physciaceae	6	*Parmelinella* sp.	Parmeliaceae
7	*Lecanora perplexa*	Lecanoraceae	7	*Pseudocyphellaria* sp.	Lobariaceae
8	*Lobaria* sp.	Lobariaceae	8	*Stereocaulon* sp.	Stereocaulaceae
9	*Parmelinella* sp.	Parmeliaceae	9	*Sticta* sp.	Lobariaceae
10	*Parmotrema* sp.	Parmeliaceae	10	*Usnea* sp.	Parmeliaceae
11	*Pseudocyphellaria* sp.	Lobariaceae			
12	*Stereocaulon* sp.	Stereocaulaceae			
13	*Sticta* sp.	Lobariaceae			
14	*Teloschistes* sp.	Teloschistaceae			
15	*Usnea* sp.	Parmeliaceae			

Appendix II. 3.106: Species list of macro–fungi recorded from barrage and powerhouse sites of Tawang–I

Species	Family	Species	Family
Barrage site		**Catchment area**	
Boletus reticulatus	Boletaceae	*Boletus reticulatus*	Boletaceae
Clathrus rubra	Phallaceae	*Clathrus rubra*	Phallaceae
Coprinus disseminatus	Agaricaceae	*Coprinus disseminatus*	Agaricaceae
Daldinia concentrica	Xylariaceae	*Daldinia concentrica*	Xylariaceae
Fomes pinicola	Fomitopsidaceae	*Fomes pinicola*	Fomitopsidaceae
Gloeophyllum sepiarium	Gloeophyllaceae	*Gloeophyllum sepiarium*	Gloeophyllaceae
Hericium erinaceus	Hericiaceae	*Hericium erinaceus*	Hericiaceae
Hygrocybe miniata	Hygrophoraceae	*Hygrocybe miniata*	Hygrophoraceae
Lactarius rubidus	Russulaceae	*Lactarius rubidus*	Russulaceae
Phellinus schweintizii	Hymenochaetaceae	*Phellinus schweintizii*	Hymenochaetaceae
Polyporus arcularius	Polyporaceae	*Polyporus arcularius*	Polyporaceae
Poria monticola	Polyporaceae	*Poria monticola*	Polyporaceae
Schizophyllum commune	Schizophyllaceae	*Schizophyllum commune*	Schizophyllaceae
Strobilomyces strobilaceus	Boletaceae	*Strobilomyces strobilaceus*	Boletaceae
Thelephora penicillata	Thelephoraceae	*Thelephora penicillata*	Thelephoraceae
Tremella mesenterica	Tremellaceae	*Tremella mesenterica*	Tremellaceae
Xylaria polymorpha	Xylariaceae	*Xylaria polymorpha*	Xylariaceae
Powerhouse site			
Boletus reticulatus	Boletaceae		
Coprinus disseminatus	Agaricaceae		
Daldinia concentrica	Xylariaceae		
Fomes pinicola	Fomitopsidaceae		
Gloeophyllum sepiarium	Gloeophyllaceae		
Hygrocybe miniata	Hygrophoraceae		
Lactarius rubidus	Russulaceae		
Poria monticola	Polyporaceae		
Tremella mesenterica	Tremellaceae		

Appendix II. 3.107: Frequency, density, basal area and IVI for tree species in Tawang–I barrage site

Sl. No.	Species name	Post–monsoon				Monsoon				Winter			
		Fr.	**Dn.**	**BA**	**IVI**	**Fr.**	**Dn.**	**BA**	**IVI**	**Fr.**	**Dn.**	**BA**	**IVI**
1	*Alangium chinensis*	12	20	0.21	4.29	12	20	0.21	4.29	12	20	0.21	4.29
2	*Alnus nepalensis*	72	692	16.79	94.90	72	692	16.79	94.90	72	692	16.79	94.90
3	*Brassaiopsis glomerulata*	32	72	0.69	12.76	32	72	0.69	12.76	32	72	0.69	12.76
4	*Eurya acuminata*	12	20	0.13	4.08	12	20	0.13	4.08	12	20	0.13	4.08
5	*Leucoceptrum cannum*	36	40	0.79	12.14	36	40	0.79	12.14	36	40	0.79	12.14
6	*Photinia integrifolia*	36	36	0.55	11.33	36	36	0.55	11.33	36	36	0.55	11.33
7	*Pinus wallichiana*	40	92	3.66	22.91	40	92	3.66	22.91	40	92	3.66	22.91
8	*Prunus cerasoides*	8	12	0.21	2.94	8	12	0.21	2.94	8	12	0.21	2.94
9	*Quercus griffithi*	64	492	10.14	65.93	64	492	10.14	65.93	64	492	10.14	65.93
10	*Quercus serrata*	36	172	5.46	30.80	36	172	5.46	30.80	36	172	5.46	30.80
11	*Querqus semicarpifolia*	16	28	0.67	6.74	16	28	0.67	6.74	16	28	0.67	6.74
12	*Rhododendron arboreum*	36	48	0.56	12.01	36	48	0.56	12.01	36	48	0.56	12.01
13	*Rhus javanica*	16	24	0.29	5.59	16	24	0.29	5.59	16	24	0.29	5.59
14	*Salix wallichiana*	32	92	0.58	13.57	32	92	0.58	13.57	32	92	0.58	13.57
Total		**448**	**1840**	**40.74**	**300**	**448**	**1840**	**40.74**	**300**	**448**	**1840**	**40.74**	**300**

Fr.–Frequency percentage, Dn.–Density (ha^{-1}), BA–Basal area (m^2 ha^{-1}), IVI–Importance value index

Appendix II. 3.108: Frequency, density and IVI of shrubs in Tawang–I HEP at barrage site

Sl. No.	Species name	Post–monsoon			Monsoon			Winter		
		Fr.	**Dn.**	**IVI**	**Fr.**	**Dn.**	**IVI**	**Fr.**	**Dn.**	**IVI**
1	*Aconogonum molle*	448	1792	27.48	448	1792	27.48	448	1792	27.48
2	*Artemesia nilagarica*	420	1680	25.77	420	1680	25.77	420	1680	25.77
3	*Arundinella malling*	128	512	7.85	128	512	7.85	128	512	7.85
4	*Budleja asiatica*	124	496	7.61	124	496	7.61	124	496	7.61
5	*Coriaria nepalensis*	268	1072	16.44	268	1072	16.44	268	1072	16.44
6	*Debregessia longifolia*	344	1376	21.10	344	1376	21.10	344	1376	21.10
7	*Dicranopteis* sp.	224	896	13.74	224	896	13.74	224	896	13.74
8	*Elaeagnus parvifolia*	84	336	5.15	84	336	5.15	84	336	5.15
9	*Girardiana diversifolia*	136	544	8.34	136	544	8.34	136	544	8.34
10	*Hypericum*	44	176	2.70	44	176	2.70	44	176	2.70
11	*Morus rubra*	32	128	1.96	32	128	1.96	32	128	1.96
12	*Neilia thyrsiflora*	84	336	5.15	84	336	5.15	84	336	5.15
13	*Rubus ellipticus*	260	1040	15.95	260	1040	15.95	260	1040	15.95
14	*Rubus rugosus*	48	192	2.94	48	192	2.94	48	192	2.94
15	*Spirea* sp.	24	96	1.47	24	96	1.47	24	96	1.47
16	*Strobilanthes* sp.	180	720	11.04	180	720	11.04	180	720	11.04
17	*Triumfetta rhomboidea*	84	336	5.15	84	336	5.15	84	336	5.15
18	*Viburnum foetidum*	64	256	3.93	64	256	3.93	64	256	3.93
19	*Yushania hirsuta*	264	1056	16.20	264	1056	16.20	264	1056	16.20
Total		**3260**	**13040**	**200**	**3260**	**13040**	**200**	**3260**	**13040**	**200**

Fr.–Frequency percentage, Dn.–Density (ha^{-1}), IVI–Importance value index

Appendix II. 3.109: Frequency, density and IVI of herbs in Tawang–I barrage site

Sl. No.	Species name	Post–monsoon			Monsoon			Winter		
		Fr.	**Dn.**	**IVI**	**Fr.**	**Dn.**	**IVI**	**Fr.**	**Dn.**	**IVI**
1	*Ageratum conyzoides*	40	13250	8.72	40	21000	5.53	17.5	8000	6.49
2	*Agrimonia pilosa*	20	3250	3.23	27.5	10000	3.19			
3	*Anaphalis margaritacea*	22.5	5000	4.08	30	12750	3.73	12.5	4000	3.99
4	*Anemone rivularis*	32.5	7750	6.08	25	9000	2.89			
5	*Ariesaema* sp.	22.5	5000	4.08	30	10000	3.36			
6	*Bidens pilosa*	17.5	5000	3.55	22.5	9000	2.72	12.5	4500	4.18
7	*Campanula pallida*				27.5	12250	3.50			
8	*Cannabis sativa*	17.5	4000	3.21	25	16750	3.95	10	6750	4.53
9	*Centella asiatica*	25	8250	5.44	37.5	16750	4.78	15	8250	6.09
10	*Cirsium* sp.	5	1000	0.87	17.5	4000	1.71			
11	*Crassocephalum crepidioides*	10	1500	1.57	32.5	11250	3.69	10	3000	3.12
12	*Cyathula tomentosus*				40	19750	5.36	30	10750	10.01
13	*Cymbopogon citratus*	20	3000	3.15	37.5	11750	4.09	20	5750	6.14
14	*Cynoglossum* sp.	32.5	10750	7.08	32.5	19500	4.82	22.5	8750	7.77
15	*Drymaria cordata*	40	18500	10.49	35	51250	9.34	17.5	16750	9.78
16	*Equisetum diffusum*	17.5	3500	3.05	22.5	8500	2.65	15	5750	5.15
17	*Eupatorium adenophorum*	32.5	7500	5.99	30	11250	3.53	30	8500	9.17
18	*Euphorbia hirta*	17.5	3750	3.13	27.5	12000	3.47			
19	*Fagopyrum esculentum*				35	8750	3.52			
20	*Fragaria nubicola*	42.5	16000	9.91	42.5	16250	5.04	22.5	16000	10.49
21	*Galinsoga parviflora*	35	13000	8.11	32.5	22250	5.20	27.5	18250	12.33
22	*Galium aparine*	27.5	6250	5.04	32.5	8250	3.28	7.5	3250	2.71
23	*Galium rotundifolium*	30	4750	4.80	20	4250	1.91	17.5	10750	7.52
24	*Geranium nepalensis*	5	1500	1.04	35	9250	3.59			
25	*Geranium* sp.	27.5	3250	4.03	17.5	3500	1.64	15	5750	5.15
26	*Houttuynia cordata*	32.5	10750	7.08	42.5	33500	7.41	17.5	3250	4.70
27	*Hydrocotyle nepalensis*	20	5000	3.82	35	13000	4.10			
28	*Hypoestes* sp.				32.5	28000	5.99			
29	*Impatiens* sp.	20	10250	5.58	22.5	16750	3.79			
30	*Ipomea* sp.				20	5250	2.04			
31	*Juncus* sp.				27.5	10750	3.29			
32	*Leucanthus peduncularis*	27.5	18750	9.23	40	51250	9.67	30	22500	14.43
33	*Musa* sp.	2.5	750	0.52	2.5	1000	0.30	2.5	750	0.78
34	*Oxalis corniculata*	35	32750	14.73	37.5	19500	5.16	15	14000	8.25
35	*Oxalis* sp.				32.5	2000	2.43			
36	*Peperomia tetraphylla*	20	4000	3.48	32.5	14000	4.07	7.5	2250	2.34
37	*Persicaria capitata*	22.5	7500	4.92	27.5	19000	4.42	17.5	13500	8.56
38	*Persicaria chinensis*	30	7750	5.81	52.5	32000	7.86	25	16750	11.27
39	*Piper pedicellosum*				30	10750	3.46			

Sl.	Species name	Post–monsoon			Monsoon			Winter		
40	*Plantago major*	27.5	13000	7.30	42.5	23750	6.07	27.5	21000	13.37
41	*Pogostemon* sp.	7.5	1250	1.22	22.5	8500	2.65	7.5	2500	2.43
42	*Pedicularis sp1*				45	12500	4.69			
43	*Pedicularis* sp.				20	3250	1.77			
44	*Ranunculus diffusus*	30	7250	5.64	27.5	8500	2.99			
45	*Roscoea* sp.				7.5	1500	0.70			
46	*Rumex nepalensis*	27.5	6250	5.04				30	18250	12.83
47	*Pimpinella diversifolia*	32.5	13500	8.01	27.5	33750	6.45			
48	*Urtica dioica*	22.5	5000	4.08						
49	*Pimpinella diversifolia*				52.5	22250	6.53			
50	*Verbasacum thapsus*	5	1000	0.87	15	3250	1.44			
51	*Vernonia* sp.	17.5	5000	3.55	37.5	10750	3.96	10	3750	3.40
52	*Viola sikkimensis*	15	2500	2.44	22.5	5750	2.28	10	2750	3.02
Total		**935**	**298000**	**200**	**1510**	**729750**	**200**	**502.5**	**266000**	**200**

Fr.–Frequency percentage, Dn.–Density (ha^{-1}), IVI–Importance value index

Appendix II. 3.110: Frequency, density, basal area and IVI for tree species in Tawang–I powerhouse site

Sl. No.	Species name	Post–monsoon				Monsoon				Winter			
		Fr.	**Dn.**	**BA**	**IVI**	**Fr.**	**Dn.**	**BA**	**IVI**	**Fr.**	**Dn.**	**BA**	**IVI**
1	*Alangium chinensis*	20	40	0.31	6.70	20	40	0.31	6.70	20	40	0.31	6.70
2	*Albizia arunachalensis*	64	260	6.84	45.24	64	260	6.84	45.24	64	260	6.84	45.24
3	*Alnus nepalensis*	36	124	2.48	20.43	36	124	2.48	20.43	36	124	2.48	20.43
4	*Brassaiopsis mitis*	52	80	0.47	15.09	52	80	0.47	15.09	52	80	0.47	15.09
5	*Erythrina arborescence*	32	36	0.76	9.74	32	36	0.76	9.74	32	36	0.76	9.74
6	*Ficus auriculata*	28	40	0.89	9.62	28	40	0.89	9.62	28	40	0.89	9.62
7	*Ilex* sp.	4	8	0.19	1.69	4	8	0.19	1.69	4	8	0.19	1.69
8	*Litsea citrata*	12	20	0.34	4.20	12	20	0.34	4.20	12	20	0.34	4.20
9	*Merillopanax alpinus*	20	28	0.61	6.77	20	28	0.61	6.77	20	28	0.61	6.77
10	*Myrica* sp.	12	20	0.57	4.82	12	20	0.57	4.82	12	20	0.57	4.82
11	*Prunus cerasoides*	16	40	1.04	7.99	16	40	1.04	7.99	16	40	1.04	7.99
12	*Quercus griffithi*	64	280	6.56	45.73	64	280	6.56	45.73	64	280	6.56	45.73
13	*Quercus serrata*	24	40	1.22	9.83	24	40	1.22	9.83	24	40	1.22	9.83
14	*Rhus chinensis*	68	240	5.18	40.26	68	240	5.18	40.26	68	240	5.18	40.26
15	*Saurauia punduana*	8	16	0.26	3.04	8	16	0.26	3.04	8	16	0.26	3.04
16	*Schima wallichii*	20	48	1.89	11.42	20	48	1.89	11.42	20	48	1.89	11.42
17	*Torricellia tiliifolia*	36	64	0.52	11.51	36	64	0.52	11.51	36	64	0.52	11.51
18	*Macaranga denticulata*	68	240	7.30	45.92	68	240	7.30	45.92	68	240	7.30	45.92
Total		**584**	**1624**	**37**	**300**	**584**	**1624**	**37**	**300**	**584**	**1624**	**37**	**300**

Fr.–Frequency percentage, Dn.–Density (ha^{-1}), BA–Basal area (m^2 ha^{-1}), IVI–Importance value index

Appendix II. 3.111: Frequency, density and IVI of shrubs in Tawang–II powerhouse site

Sl. No.	Species name	Post–monsoon			Monsoon			Winter		
		Fr.	**Dn.**	**IVI**	**Fr.**	**Dn.**	**IVI**	**Fr.**	**Dn.**	**IVI**
1	*Aconogonum molle*	36	352	7.41	36	352	7.41	36	352	7.41
2	*Ardesia crenata*	32	256	6.13	32	256	6.13	32	256	6.13
3	*Artemesia nilagarica*	52	2864	29.55	52	2864	29.55	52	2864	29.55
4	*Boehmeria macrophylla*	32	432	7.54	32	432	7.54	32	432	7.54
5	*Buddleja asiatica*	44	368	8.56	44	368	8.56	44	368	8.56
6	*Butea buteiformis*	28	288	5.88	28	288	5.88	28	288	5.88
7	*Coriaria nepalensis*	48	768	12.27	48	768	12.27	48	768	12.27
8	*Cyathula tomentosa*	36	912	11.89	36	912	11.89	36	912	11.89
9	*Debregesia longifolia*	52	528	10.86	52	528	10.86	52	528	10.86
10	*Dobinia vulgaris*	16	144	3.19	16	144	3.19	16	144	3.19
11	*Elaeagnus parvifolia*	16	80	2.68	16	80	2.68	16	80	2.68
12	*Flemingia macrophylla*	32	448	7.67	32	448	7.67	32	448	7.67
13	*Hydrangea* sp.	36	336	7.28	36	336	7.28	36	336	7.28
14	*Indigofera* sp.	56	528	11.37	56	528	11.37	56	528	11.37
15	*Maesa indica*	52	896	13.80	52	896	13.80	52	896	13.80
16	*Mussaenda* sp.	24	192	4.60	24	192	4.60	24	192	4.60
17	*Rubus ellipticus*	48	944	13.68	48	944	13.68	48	944	13.68
18	*Rubus rugosus*	16	176	3.45	16	176	3.45	16	176	3.45
19	*Senecio* sp.	16	112	2.94	16	112	2.94	16	112	2.94
20	*Urena lobata*	28	416	6.90	28	416	6.90	28	416	6.90
21	*Woodfordia fructicosa*	36	560	9.07	36	560	9.07	36	560	9.07
22	*Solanum khasianum*	48	896	13.29	48	896	13.29	48	896	13.29
Total		**784**	**12496**	**200**	**784**	**12496**	**200**	**784**	**12496**	**200**

Fr.–Frequency percentage, Dn.–Density (ha^{-1}), IVI–Importance value index

Appendix II. 3.112: Frequency, density and IVI of herbs in Tawang–II powerhouse site

Sl. No.	Species name	Post–monsoon			Monsoon			Winter		
		Fr.	Dn.	IVI	Fr.	Dn.	IVI	Fr.	Dn.	IVI
1	*Ageratum conyzoides*	40	20500	10.51	40	26000	8.07	17.5	8000	10.49
2	*Anaphalis margaritacea*	20	3750	3.30	25	9250	3.75	15	3500	6.75
3	*Bidens pilosa*	27.5	9500	5.85	27.5	11750	4.42	17.5	5000	8.49
4	*Campanula pallida*	25	5750	4.45	25	9000	3.71			
5	*Cannabis sativa*	35	13000	7.71	35	21250	6.79	22.5	6250	10.79
6	*Centella asiatica*	27.5	15750	7.72				15	11250	11.92
7	*Crassocephalum crepidioides*	30	9000	5.97	27.5	14500	4.93	12.5	4500	6.68
8	*Cymbopogon citratus*	27.5	10500	6.15	30	16000	5.41	20	6000	9.89
9	*Cymbopogon citratus*				27.5	13500	4.74			
10	*Cyperus*				30	11250	4.53			
11	*Delphenium* sp.	30	2750	4.09	22.5	4000	2.58			
12	*Drymaria cordata*	22.5	18500	8.00	42.5	21750	7.49	17.5	14000	14.50
13	*Eleusine coracana*				32.5	19500	6.26			
14	*Equisetum diffusum*	42.5	5250	6.21	40	15750	6.18	12.5	3000	5.68
15	*Eupatorium adenophorum*	32.5	13000	7.44	35	22250	6.97	17.5	4750	8.32
16	*Euphorbia hirta*	40	20750	10.58	32.5	19500	6.26			
17	*Fagopyrum esculentum*	35	10250	6.89	35	9250	4.57			
18	*Fragaria nubicola*	32.5	12500	7.29	30	14000	5.04	20	10500	12.89
19	*Galinsoga parviflora*	35	18250	9.29	35	18500	6.28	20	13750	15.06
20	*Galium* sp.				35	11250	4.94			
21	*Geranium* sp.	30	3750	4.39	27.5	8500	3.82	12.5	2000	5.01
22	*Houttuynia cordata*	42.5	8500	7.18	37.5	24000	7.50			
23	*Hydrocotyle nepalensis*	42.5	13000	8.53	42.5	12750	5.83	12.5	4000	6.35
24	*Pimpinella diversifolia*	45	20500	11.05	37.5	18000	6.39			
25	*Impatiens* sp.	42.5	29750	13.55	40	25250	7.93			
26	*Ipomea* sp.	27.5	5500	4.65	20	5750	2.70			
27	*Lindenbergia* sp.				42.5	11250	5.55			
28	*Lysionanthus* sp.				27.5	10250	4.14			
29	*Melastoma* sp.				22.5	4500	2.67			
30	*Oxalis corniculata*	27.5	18500	8.54	27.5	11250	4.33	15	11750	12.26
31	*Persicaria capitata*	32.5	7250	5.72	40	16750	6.37	17.5	10750	12.33
32	*Persicaria chinensis*				52.5	33500	10.48	27.5	11750	15.93
33	*Piper pedicellosum*				20	4500	2.47			
34	*Plantago erosa*	37.5	12500	7.84	37.5	19500	6.67	22.5	11750	14.46
35	*Ranunculus diffusus*	20	7250	4.35						
36	*Seigesbeckia orientalis*	22.5	5750	4.18	30	8500	4.02	10	3000	4.94
37	*Pimpinella diversifolia*				42.5	16750	6.57			
38	*Vernonia* sp.	22.5	7500	4.70	27.5	8500	3.82			
39	*Vernonia* sp.				17.5	5750	2.49	15	4250	7.25
40	*Xanthium strumarium*	22.5	4750	3.88	22.5	8000	3.32			
Total		**917.5**	**333500**	**200**	**1222.5**	**541500**	**200**	**340**	**149750**	**200**

Fr.–Frequency percentage, Dn.–Density (ha^{-1}), IVI–Importance value index

Appendix II. 3.113: Frequency, density, basal area and IVI for tree species in Tawang–II catchment area

Sl. No.	Species name	Post–monsoon				Monsoon				Winter			
		Fr.	Dn.	BA	IVI	Fr.	Dn.	BA	IVI	Fr.	Dn.	BA	IVI
1	*Alnus nepalensis*	72	616	12.83	102.28	72	616	12.83	102.28	72	616	12.83	102.28
2	*Brassaiopsis glomerulata*	28	84	1.12	16.54	28	84	1.12	16.54	28	84	1.12	16.54
3	*Leucosceptrum cannum*	20	32	0.34	8.40	20	32	0.34	8.40	20	32	0.34	8.40
4	*Photinia integrifolia*	24	28	0.30	9.00	24	28	0.30	9.00	24	28	0.30	9.00
5	*Pinus wallichina*	48	152	3.55	34.18	48	152	3.55	34.18	48	152	3.55	34.18
6	*Quercus griffithii*	56	196	5.65	46.06	56	196	5.65	46.06	56	196	5.65	46.06
7	*Quercus serrata*	28	136	2.36	24.14	28	136	2.36	24.14	28	136	2.36	24.14
8	*Rhododendron arboreum*	16	36	0.54	8.32	16	36	0.54	8.32	16	36	0.54	8.32
9	*Salix wallichiana*	28	44	0.47	11.70	28	44	0.47	11.70	28	44	0.47	11.70
10	*Schima wallichii*	40	88	3.07	26.20	40	88	3.07	26.20	40	88	3.07	26.20
11	*Rhus chinensis*	32	44	0.61	13.17	32	44	0.61	13.17	32	44	0.61	13.17
Total		**392**	**1456**	**30.84**	**300**	**392**	**1456**	**30.84**	**300**	**392**	**1456**	**30.84**	**300**

Fr.–Frequency percentage, Dn.–Density (ha^{-1}), BA–Basal area ($m^2\ ha^{-1}$), IVI–Importance value index

Appendix II. 3.114: Frequency, density and IVI of shrubs in Tawang–II catchment area

Sl. No.	Species name	Post–monsoon			Monsoon			Winter		
		Fr.	Dn.	IVI	Fr.	Dn.	IVI	Fr.	Dn.	IVI
1	*Aconogonum molle*	60	1040	17.13	60	1040	17.13	60	1040	17.13
2	*Artemesia nilagarica*	52	1792	22.22	52	1792	22.22	52	1792	22.22
3	*Arundinella manni*	32	720	10.51	32	720	10.51	32	720	10.51
4	*Buddleja asiatica*	32	256	6.66	32	256	6.66	32	256	6.66
5	*Coriaria nepalensis*	36	944	12.93	36	944	12.93	36	944	12.93
6	*Debregesia longifolia*	48	1232	17.02	48	1232	17.02	48	1232	17.02
7	*Dicranopteis* sp.	52	1216	17.45	52	1216	17.45	52	1216	17.45
8	*Elaeagnus parvifolia*	36	336	7.90	36	336	7.90	36	336	7.90
9	*Girardiana diversifolia*	36	592	10.01	36	592	10.01	36	592	10.01
10	*Hypericum*	24	160	4.73	24	160	4.73	24	160	4.73
11	*Morus rubra*	12	96	2.50	12	96	2.50	12	96	2.50
12	*Neillia thyrsiflora*	36	288	7.50	36	288	7.50	36	288	7.50
13	*Rubus ellipticus*	56	992	16.17	56	992	16.17	56	992	16.17
14	*Rubus rugosus*	16	160	3.60	16	160	3.60	16	160	3.60
15	*Spirea* sp.	28	208	5.70	28	208	5.70	28	208	5.70
16	*Strobilanthes* sp.	48	752	13.04	48	752	13.04	48	752	13.04
17	*Triumfetta rhomboidea*	20	144	4.03	20	144	4.03	20	144	4.03
18	*Viburnum foetidum*	32	256	6.66	32	256	6.66	32	256	6.66
19	*Yushania hirsuta*	48	896	14.24	48	896	14.24	48	896	14.24
Total		**704**	**12080**	**200**	**704**	**12080**	**200**	**704**	**12080**	**200**

Fr.–Frequency percentage, Dn.–Density (ha^{-1}), IVI–Importance value index

Appendix II. 3.115: Frequency, density and IVI of herbs in Tawang–II catchment area

Sl. No.	Species name	Post–monsoon			Monsoon			Winter		
		Fr.	Dn.	IVI	Fr.	Dn.	IVI	Fr.	Dn.	IVI
1	*Ageratum conyzoides*	30	14000	7.21	30	20250	5.03	22.5	11000	11.44
2	*Agrimonia pilosa*	15	4000	2.83	20	6500	2.43			
3	*Anaphalis margaritacea*	20	5750	3.88	20	12000	3.15	7.5	2750	3.30
4	*Anemone rivularis*	25	8500	5.19	25	14750	3.91			
5	*Ariesaema* sp.	15	3000	2.57	22.5	9250	2.99			
6	*Bidens pilosa*	22.5	5750	4.18	27.5	14000	4.01	10	3250	4.17
7	*Campanula pallida*				17.5	8500	2.50			
8	*Cannabis sativa*	10	2250	1.78	27.5	18000	4.53			
9	*Centella asiatica*	22.5	11750	5.73	30	19750	4.96	15	8750	8.42
10	*Cirsium*	5	1000	0.86	17.5	5750	2.13			
11	*Cissampelos pareira*				22.5	9750	3.05			
12	*Crassocephalum crepidioides*	15	3500	2.70	32.5	11250	4.04	17.5	4750	6.77
13	*Cyathula tomentosus*				40	21750	6.01	20	6250	8.20
14	*Cybopogon citratus*	17.5	3500	3.00	35	14500	4.66	22.5	6000	8.65
15	*Cynoglossum* sp.	32.5	15500	7.89	32.5	16750	4.76	17.5	6750	7.89
16	*Drymaria cordata*	22.5	15500	6.69	35	34250	7.27	15	14750	11.77
17	*Equisetum diffusum*	35	8250	6.33	30	16750	4.57	17.5	4000	6.35
18	*Eupatorium adenophorum*	20	4500	3.56	22.5	8500	2.89	25	4500	8.40
19	*Euphorbia hirta*	22.5	10500	5.41	20	10250	2.92			
20	*Fagopyrum esculentum*				37.5	14500	4.86			
21	*Fragaria nubicola*	35	15500	8.19	27.5	19000	4.67	27.5	12750	13.59
22	*Galinsoga parviflora*	20	7000	4.20	22.5	17250	4.04	20	10750	10.71
23	*Galium asperifolium*	25	5500	4.42	32.5	10750	3.97	15	5250	6.46
24	*Galium rotundifolium*	12.5	2250	2.08	27.5	5750	2.92	10	3750	4.45
25	*Geranium nepalensis*	17.5	4000	3.13	30	8750	3.51	7.5	1500	2.60
26	*Geranium* sp.	22.5	8250	4.83	17.5	5750	2.13			
27	*Houttuynia cordata*	22.5	12750	5.98	35	24500	5.98			
28	*Hydrocotyle nepalensis*	30	11000	6.44	30	19500	4.93	7.5	3750	3.86
29	*Hypoestes*				37.5	31750	7.14			
30	*Impatiens* sp.	17.5	4500	3.26	35	36250	7.53			
31	*Ipomea* sp.				17.5	5750	2.13			
32	*Leucanthus peduncularis*	12.5	18250	6.20						
33	*Juncus* sp.				17.5	16250	3.52			
34	*Oxalis corniculata*	20	16000	6.52	32.5	26000	5.98			
35	*Oxalis* sp.				17.5	4250	1.93	12.5	9750	8.39
36	*Peperomia tetraphylla*	15	4500	2.96	22.5	8500	2.89	15	3000	5.21
37	*Persicaria capitata*	17.5	18250	6.80	25	19500	4.54	35	21750	20.39
38	*Persicaria chinensis*	35	29500	11.80	40	34250	7.66			

Sl.	Species name	Post–monsoon			Monsoon			Winter		
39	*Piper pedicellosum*				30	8500	3.48			
40	*Plantago erosa*	25	18250	7.70	27.5	22250	5.10	27.5	14000	14.29
41	*Pogostemon* sp.	10	2000	1.72	20	6000	2.36	10	2000	3.47
42	*Pteridium aequilinum*	27.5	32250	11.60	35	37000	7.63			
43	*Ranunculus diffusus*	30	10000	6.18	22.5	10500	3.15			
44	*Roscoea* sp.				15	2750	1.54			
45	*Rumex nepalensis*	30	20500	8.88	40	39000	8.29	30	14250	15.02
46	*Selenium* sp.	35	19750	9.29	27.5	31250	6.29			
47	*Vernonia* sp.	20	4500	3.56	20	14000	3.42	17.5	3750	6.21
48	*Viola pilosa*				25	5000	2.62			
49	*Viola sikkimensis*	22.5	6750	4.44						
Total		**832.5**	**388500**	**200.00**	**1275**	**757000**	**200.00**	**425**	**179000**	**200.00**

Fr.–Frequency percentage, Dn.–Density (ha^{-1}), IVI–Importance value index

Appendix II. 3.116: Dominant and Co–dominant species determined on the basis of IVI/density values of species in the plant communities at Tawang–I site

Community components	Barrage	Powerhouse	Catchment area
Tree species*			
Dominant	*Alnus nepalensis*	*Macaranga denticulata*	*Alnus nepalensis*
Co–Dominant	*Quercus griffithi*	*Albizzia arunachalensis*	*Quercus griffithii*
Shrub species*			
Dominant	*Aconogonum molle*	*Artemesia nilagarica*	*Artemesia nilagarica*
Co–Dominant	*Artemesia nilagarica*	*Maesea indica*	*Dicranopteis* sp.
Herb species**			
i. Post–monsoon season			
Dominant	*Oxalis corniculata*	*Impatiens* sp.	*Persicaria chinensis*
Co–Dominant	*Drymaria cordata*	*Pimpinella diversifolia*	*Pteridium aquilinum*
i. Monsoon season			
Dominant	*Lecanthus peduncularis*	*Persicaria chinensis*	*Rumex nepalensis*
Co–Dominant	*Drymaria cordata*	*Ageratum conizoides*	*Persicaria chinensis*
ii. Winter			
Dominant	*Lecanthu peduncularis*	*Persicaria chinensis*	*Persicaria chinensis*
Co–Dominant	*Plantago major*	*Galinsoga parviflora*	*Rumex nepalensis*

* Dominance based on IVI, ** Dominance based on density

Appendix II. 3.117: List of plant species recorded from Tawang–II HEP site

Sl. No.	Species name	Family
TREES		
1	*Alangium chinensis*	Alangiaceae
2	*Albizzia arunachelesis*	Mimosaceae
3	*Alnus nepalensis*	Betulaceae
4	*Brassaiopsis glomerulata*	Araliaceae
5	*Cyathea* sp.	Cyatheaceae
6	*Phyllanthus emblica*	Euphorbiaceae
7	*Ficus auriculata*	Moraceae
8	*Macaranga denticulata*	Euphorbiaceae
9	*Merilliopanax alpinus*	Araliaceae
10	*Pinus wallichiana*	Pinaceae
11	*Quercus griffithii*	Fagaceae
12	*Rhus chinensis*	Anacardiaceae
13	*Rhus javanica*	Anacardiaceae
14	*Saurauia napaulensis*	Saurauiaceae
15	*Schima wallichii*	Theaceae
16	*Torricellia tiliifolia*	Torricelliaceae
17	*Viburnum foetidum*	Adoxaceae
18	*Wendlandia* sp.	Rubiaceae
SHRUBS		
19	*Ardisia crenata*	Myrsinaceae
20	*Artemisia nilagirica*	Asteraceae
21	*Boehmeria macrophylla*	Urticaceae
22	*Buddleja asiatica*	Buddlejaceae
23	*Butea buteiformis*	Papilionaceae
24	*Coriaria nepalensis*	Coriariaceae
25	*Cyathula tomentosa*	Amaranthaceae
26	*Debregeasia longifolia*	Urticaceae

Sl. No.	Species name	Family
27	*Desmodium* sp.	Papilionaceae
28	*Dobinia vulgaris*	Anacardiaceae
29	*Elaeagnus* sp.	Elaegnaceae
30	*Flemingia macrophylla*	Papilionaceae
31	*Girardinia* sp.	Urticaceae
32	*Hydrangea* sp.	Hydrangeaceae
33	*Indigofera* sp.	Papilionaceae
34	*Maesa indica*	Myrsinaceae
35	*Mussaenda* sp.	Rubiaceae
36	*Rubus ellipticus*	Rosaceae
37	*Rubus rugosus*	Rosaceae
38	*Solanum khasianum*	Solanaceae
39	*Urena lobata*	Malvaceae
40	*Woodfordia fructicosa*	Lythraceae
HERBS		
41	*Acanthospermum hispidum*	Asteraceae
42	*Achyranthes aspera*	Amaranthaceae
43	*Ageratum conyzoides*	Asteraceae
44	*Anaphalis margaritacea*	Asteraceae
45	*Bidens pilosa*	Asteraceae
46	*Campanula pallida*	Capanulaceae
47	*Cannabis sativa*	Canabbaceae
48	*Crassocephalum crepidioides*	Asteraceae
49	*Cyanoglossum* sp.	Boraginaceae
50	*Cymbopogon citratus*	Poaceae
51	*Cyperus rotundus*	Cyperaceae
52	*Cyperus* sp.	Cyperaceae
53	*Drymaria cordata*	Caryophyllaceae
54	*Eleusine coracana*	Poaceae
55	*Eleusine* sp.	Poaceae
56	*Equisetum diffusum*	Equisetaceae
57	*Eupatorium adenophorum*	Asteraceae
58	*Eupatorium odoratum*	Asteraceae
59	*Euphorbia hirta*	Euphorbiaceae
60	*Fagopyrum esculentum*	Polygonaceae
61	*Fragaria nubicola*	Rosaceae
62	*Galinsoga parviflora*	Asteraceae
63	*Galium* sp.	Rubiaceae
64	*Geranium* sp.	Geraniaceae
65	*Houttuynia cordata*	Saururaceae
66	*Hydrocotyle nepalensis*	Araliaceae
67	*Hydrocotyle* sp.	Araliaceae
68	*Hypoestes* sp.	Acanthaceae
69	*Impatiens bicolour*	Balsaminaceae
70	*Impatiens* sp.	Balsaminaceae
71	*Ipomea* sp.	Convovulaceae
72	*Lindenbergia* sp.	Scrophulariaceae
73	*Lysionanthus* sp.	Gesneriaceae
74	*Oxalis corniculata*	Oxalidaceae
75	*Persicaria capitata*	Polygonaceae
76	*Persicaria chinensis*	Polygonaceae
77	*Pimpinella diversifolia*	Apiaceae
78	*Piper pedicellatum*	Piperaceae
79	*Plantago erosa*	Plantaginaceae
80	*Seigesbeckia orientalis*	Asteraceae
81	*Strobilanthes* sp.	Acanthaceae
82	*Urtica dioica*	Urticaceae
83	*Verbascum thapsus*	Schrophulariaceae
84	*Vernonia* sp.	Asteraceae
85	*Xanthium strumarium*	Asteraceae
CLIMBERS		
87	*Clematis Bucchaniana*	Ranunculaceae
88	*Cissampelos* sp.	Menispermaceae
89	*Clematis* sp.	Ranunculaceae
90	*Cuscuta reflexa*	Cuscutaceae
91	*Dioscorea bulbifera*	Dioscoreaceae

Sl. No.	Species name	Family
92	*Ficus* sp.	Moraceae
93	*Hedera helix*	Araliaceae
94	*Hedera nepalensis*	Araliaceae
95	*Holboellia latifolia*	Lardizabalaceae
96	*Periploca* sp.	Periplocaceae
97	*Rubia cordifolia*	Rubiaceae
98	*Smilax aspera*	Smilacaceae
99	*Stephania glandulifera*	Menispermaceae
ORCHIDS		
100	*Bulbophyllum* sp.	Orchidaceae
101	*Coelogynae* sp.	Orchidaceae
102	*Cymbidium* sp.	Orchidaceae
103	*Dendrobium* sp.	Orchidaceae
104	*Oberonia* sp.	Orchidaceae
PTERIDOPHYTES		
105	*Blechnum* sp.	Blechnaceae
106	*Dicranopteris linearis*	Dicranopteridaceae
107	*Drynaria propinqua*	Drynariaceae
108	*Dryopteris wallichiana*	Dryopteridaceae
109	*Dynaria quercifolia*	Drynariaceae
110	*Lepisorus nudus*	Polypodiaceae
111	*Lycopodium clavatum*	Lycopodiaceae
112	*Asplenium* sp.	Aspleniaceae
113	*Neprolepsis cordifolia*	Lomariopsidaceae
114	*Polypodium* sp.	Polypodiaceae
115	*Pteridium aquilinum*	Pteridaceae
116	*Pteris* sp.	Pteridiaceae
117	*Pteris vittata*	Pteridaceae
118	*Pyrrosia nuda*	Polypodiaceae
119	*Pyrrosia* sp.	Polypodiaceae
120	*Selaginella* sp.	Selaginellaceae
121	*Vittaria elongata*	Vittariaceae
BRYOPHYTES		
122	*Aerobryum* sp.	Meteoriaceae
123	*Brachymenium* sp.	Bryaceae
124	*Bryum billardieri*	Bryaceae
125	*Desmotheca* sp.	Orthotrichaceae
126	*Hymenostylium* sp.	Pottiaceae
127	*Lyellia* sp.	Polytrichaceae
128	*Plagiobryum* sp.	Bryaceae
LICHENS		
129	Bulbothrix sp.	Parmeliaceae
130	Cladonia sp.	Cladoniaceae
131	Everniastrum nepalense	Parmeliaceae
132	Graphis sp.	Graphidaceae
133	Heterodermia sp.	Physciaceae
134	Lecanora perplexa	Lecanoraceae
135	Lobaria retigera	Lobariaceae
136	Parmelinella sp.	Parmeliaceae
137	Stereocaulon sp.	Stereocaulaceae
FUNGI		
138	*Boletus reticulatus*	Boletaceae
139	*Coprinus disseminatus*	Agaricaceae
140	*Daldinia concentrica*	Xylariaceae
141	*Fomes pinicola*	Fomitopsidaceae
142	*Gloeophyllum sepiarium*	Gloeophyllaceae
143	*Hericium erinaceus*	Hericiaceae
144	*Hygrocybe miniata*	Hygrophoraceae
145	*Lactarius rubidus*	Russulaceae
146	*Phellinus schweintizii*	Hymenochaetaceae
147	*Poria monticola*	Polyporaceae
148	*Tremella mesenterica*	Tremellaceae
149	*Xylaria polymorpha*	Xylariaceae
150	*Cerrena consors*	Polyporaceae
151	*Coltricia cinnamomeus*	Hymenochaetaceae
152	*Daldinia concentrica*	Xylariaceae

Sl. No.	Species name	Family
153	*Daedalea incana*	Coriolaceae
154	*Flavodon flavus*	Meruliaceae
155	*Ganoderma lucidum*	Ganodermataceae
156	*Laccaria laccata*	Hydnangiaceae
157	*Lenzites acuta*	Coriolaceae
158	*Phellinus gilvus*	Hymenochaetaceae
159	*Pycnoporellus sanguineus*	Formitopscidaceae
160	*Schizophyllum commune*	Schizophyllaceae
161	*Trametes hirsuta*	Polyporaceae
162	*Xylaria longipes*	Xylariaceae

Appendix II. 3.118: Different groups of plant species present at Tawang–II HEP site

Sl. No.	Species name Barrage and Powerhouse	Family	Sl. No.	Species name Catchment area	Family
CLIMBERS					
1	*Clematis Bucchaniana*	Ranunculaceae	1	*Clematis Bucchaniana*	Ranunculaceae
2	*Cissampelos* sp.	Menispermaceae	2	*Cuscuta reflexa*	Cuscutaceae
3	*Clematis* sp.	Ranunculaceae	3	*Ficus* sp.	Moraceae
4	*Cuscuta reflexa*	Cuscutaceae	4	*Hedera nepalensis*	Araliaceae
5	*Dioscorea bulbifera*	Dioscoreaceae	5	*Holboellia latifolia*	Lardizabalaceae
6	*Ficus* sp.	Moraceae	6	*Periploca* sp.	Periplocaceae
7	*Hedera helix*	Araliaceae	7	*Rubia cordifolia*	Rubiaceae
8	*Hedera nepalensis*	Araliaceae	8	*Stephania glandulifera*	Menispermaceae
9	*Holboellia latifolia*	Lardizabalaceae			
10	*Periploca* sp.	Periplocaceae			
11	*Rubia cordifolia*	Rubiaceae			
12	*Smilax aspera*	Smilacaceae			
13	*Stephania glandulifera*	Menispermaceae			
ORCHIDS					
1	*Bulbophyllum* sp.	Orchidaceae	1	*Bulbophyllum* sp.	Orchidaceae
2	*Coelogynae* sp.	Orchidaceae	2	*Coelogynae* sp.	Orchidaceae
3	*Cymbidium* sp.	Orchidaceae	3	*Cymbidium* sp.	Orchidaceae
4	*Dendrobium* sp.	Orchidaceae			
5	*Oberonia* sp.	Orchidaceae			
PTERIDOPHYTES					
1	*Blechnum* sp.	Blechnaceae	1	*Blechnum* sp.	Blechnaceae
2	*Dicranopteris linearis*	Dicranopteridaceae	2	*Dicranopteris linearis*	Dicranopteridaceae
3	*Drynaria propinqua*	Drynariaceae	3	*Drynaria propinqua*	Drynariaceae
4	*Dryopteris wallichiana*	Dryopteridaceae	4	*Dryopteris wallichiana*	Dryopteridaceae
5	*Dynaria quercifolia*	Drynariaceae	5	*Dynaria quercifolia*	Drynariaceae
7	*Lepisorus nudus*	Polypodiaceae	6	*Lepisorus nudus*	Polypodiaceae
8	*Lycopodium clavatum*	Lycopodiaceae	7	*Lycopodium clavatum*	Lycopodiaceae
9	*Asplenium* sp.	Aspleniaceae	8	*Neprolepsis cordifolia*	Lomariopsidaceae
10	*Neprolepsis cordifolia*	Lomariopsidaceae	9	*Pteridium aquilinum*	Pteridaceae
11	*Polypodium* sp.	Polypodiaceae	10	*Pteris vittata*	Pteridaceae
12	*Pteridium aquilinum*	Pteridaceae	11	*Pyrrosia nuda*	Polypodiaceae
13	*Pteris* sp.	Pteridiaceae	12	*Selaginella* sp.	Selaginellaceae
14	*Pteris vittata*	Pteridaceae	13	*Vittaria elongata*	Vittariaceae
15	*Pyrrosia nuda*	Polypodiaceae			
16	*Pyrrosia* sp.	Polypodiaceae			
17	*Selaginella* sp.	Selaginellaceae			
18	*Vittaria elongata*	Vittariaceae			
BRYOPHYTES					
1	*Aerobryum* sp.	Meteoriaceae	1	*Aerobryum* sp.	Meteoriaceae
2	*Brachymenium* sp.	Bryaceae	2	*Brachymenium* sp.	Bryaceae
3	*Bryum billardieri*	Bryaceae	3	*Bryum billardieri*	Bryaceae
4	*Desmotheca* sp.	Orthotrichaceae	4	*Hymenostylium* sp.	Pottiaceae
5	*Hymenostylium* sp.	Pottiaceae	5	*Lyellia* sp.	Polytrichaceae
6	*Lyellia* sp.	Polytrichaceae	6	*Plagiobryum* sp.	Bryaceae
7	*Plagiobryum* sp.	Bryaceae			
LICHENS					
1	Bulbothrix sp.	Parmeliaceae	1	Bulbothrix sp.	Parmeliaceae
2	Cladonia sp.	Cladoniaceae	2	Cladonia sp.	Cladoniaceae
3	Everniastrum nepalense	Parmeliaceae	3	Everniastrum nepalense	Parmeliaceae
4	Graphis sp.	Graphidaceae	4	Graphis sp.	Graphidaceae

Sl. No.	Species name Barrage and Powerhouse	Family	Sl. No.	Species name Catchment area	Family
5	Heterodermia sp.	Physciaceae	5	Heterodermia sp.	Physciaceae
6	Lecanora perplexa	Lecanoraceae	6	Lobaria retigera	Lobariaceae
7	Lobaria retigera	Lobariaceae	7	Parmelinella sp.	Parmeliaceae
8	Parmelinella sp.	Parmeliaceae	8	Stereocaulon sp.	Stereocaulaceae
9	Stereocaulon sp.	Stereocaulaceae			

Appendix II. 3.119: Species list of macro–fungi recorded from barrage and powerhouse sites of Tawang–II

Species	Family	Species	Family
Barrage		**Powerhouse**	
Boletus reticulatus	Boletaceae	*Cerrena consors*	Polyporaceae
Coprinus disseminatus	Agaricaceae	*Coltricia cinnamomeus*	Hymenochaetaceae
Daldinia concentrica	Xylariaceae	*Daldinia concentrica*	Xylariaceae
Fomes pinicola	Fomitopsidaceae	*Daedalea incana*	Coriolaceae
Gloeophyllum sepiarium	Gloeophyllaceae	*Flavodon flavus*	Meruliaceae
Hericium erinaceus	Hericiaceae	*Ganoderma lucidum*	Ganodermataceae
Hygrocybe miniata	Hygrophoraceae	*Laccaria laccata*	Hydnangiaceae
Lactarius rubidus	Russulaceae	*Lenzites acuta*	Coriolaceae
Phellinus schweintizii	Hymenochaetaceae	*Phellinus gilvus*	Hymenochaetaceae
Poria monticola	Polyporaceae	*Pycnoporellus sanguineus*	Formitopscidaceae
Tremella mesenterica	Tremellaceae	*Schizophyllum commune*	Schizophyllaceae
Xylaria polymorpha	Xylariaceae	*Trametes hirsuta*	Polyporaceae
		Xylaria longipes	Xylariaceae
Catchment area			
Boletus reticulatus	Boletaceae		
Coprinus disseminatus	Agaricaceae		
Daldinia concentrica	Xylariaceae		
Fomes pinicola	Fomitopsidaceae		
Hericium erinaceus	Hericiaceae		
Hygrocybe miniata	Hygrophoraceae		
Lactarius rubidus	Russulaceae		
Phellinus schweintizii	Hymenochaetaceae		
Poria monticola	Polyporaceae		
Tremella mesenterica	Tremellaceae		
Xylaria polymorpha	Xylariaceae		

Appendix II. 3.120: Frequency, density, basal area and IVI for tree species in Tawang–II HEP at barrage site

Sl. No.	Species name	Post–monsoon				Monsoon				Winter			
		Fr.	Dn.	BA	IVI	Fr.	Dn.	BA	IVI	Fr.	Dn.	BA	IVI
1	*Alangium chinensis*	32	64	0.79	12.84	32	64	0.79	12.84	32	64	0.79	12.84
2	*Albizia arunachalesis*	48	136	7.42	32.60	48	136	7.42	32.60	48	136	7.42	32.60
3	*Alnus nepalensis*	76	580	19.91	88.92	76	580	19.91	88.92	76	580	19.91	88.92
4	*Brassaiopsis glomerulata*	28	64	1.15	12.54	28	64	1.15	12.54	28	64	1.15	12.54
5	*Macaranga dendiculata*	48	224	8.63	40.28	48	224	8.63	40.28	48	224	8.63	40.28
6	*Merillopanax alpinus*	24	64	1.08	11.49	24	64	1.08	11.49	24	64	1.08	11.49
7	*Pinus wallichiana*	60	92	5.33	28.96	60	92	5.33	28.96	60	92	5.33	28.96
8	*Quercus griffithi*	36	180	10.00	37.07	36	180	10.00	37.07	36	180	10.00	37.07
9	*Rhus javanica*	40	92	2.64	19.68	40	92	2.64	19.68	40	92	2.64	19.68
10	*Saurauia napaulensis*	12	16	0.25	4.24	12	16	0.25	4.24	12	16	0.25	4.24
11	*Torricellia tiliifolia*	20	36	0.45	7.71	20	36	0.45	7.71	20	36	0.45	7.71
12	*Viburnum foetidum*	8	24	0.17	3.67	8	24	0.17	3.67	8	24	0.17	3.67
Total		**432**	**1572**	**57.81**	**300**	**432**	**1572**	**57.81**	**300**	**432**	**1572**	**57.81**	**300**

Fr.–Frequency percentage, Dn.–Density (ha^{-1}), BA–Basal area ($m^2\ ha^{-1}$), IVI–Importance value index

Appendix II. 3.121: Frequency, density and IVI of shrubs in Tawang–II barrage site

Sl. No.	Species name	Post–monsoon			Monsoon			Winter		
		Fr.	Dn.	IVI	Fr.	Dn.	IVI	Fr.	Dn.	IVI
1	*Ardisia crenata*	12	96	2.01	12	96	2.01	12	96	2.01
2	*Artemisia nilagirica*	76	3696	33.57	76	3696	33.57	76	3696	33.57
3	*Boehmeria macrophylla*	36	192	5.37	36	192	5.37	36	192	5.37
4	*Buddleja asiatica*	48	512	8.89	48	512	8.89	48	512	8.89
5	*Butea buteiformis*	24	368	5.20	24	368	5.20	24	368	5.20
6	*Coriaria nepalensis*	64	1984	20.65	64	1984	20.65	64	1984	20.65
7	*Cyathula tomentosa*	40	896	10.58	40	896	10.58	40	896	10.58

Sl. No.	Species name	Post–monsoon			Monsoon			Winter		
8	*Debregeasia longifolia*	72	592	12.14	72	592	12.14	72	592	12.14
9	*Dobinia vulgaris*	8	112	1.66	8	112	1.66	8	112	1.66
10	*Flemingia macrophylla*	60	368	9.27	60	368	9.27	60	368	9.27
11	*Hydrangea* sp.	12	128	2.22	12	128	2.22	12	128	2.22
12	*Indigofera* sp.	56	720	11.20	56	720	11.20	56	720	11.20
13	*Maesa indica*	64	896	13.29	64	896	13.29	64	896	13.29
14	*Mussaenda* sp.	24	176	3.90	24	176	3.90	24	176	3.90
15	*Rubus ellipticus*	48	912	11.59	48	912	11.59	48	912	11.59
16	*Rubus rugosus*	28	208	4.57	28	208	4.57	28	208	4.57
17	*Solanum khasianum*	136	1488	25.44	136	1488	25.44	136	1488	25.44
18	*Urena lobata*	20	528	5.83	20	528	5.83	20	528	5.83
19	*Woodfordia fructicosa*	56	928	12.61	56	928	12.61	56	928	12.61
Total		**884**	**14800**	**200**	**884**	**14800**	**200**	**884**	**14800**	**200**

Fr.–Frequency percentage, Dn.–Density (ha^{-1}), IVI–Importance value index

Appendix II. 3.122: Frequency, density and IVI of herbs in Tawang–II barrage site

Sl. No.	Species name	Post–monsoon			Monsoon			Winter		
		Fr.	**Dn.**	**IVI**	**Fr.**	**Dn.**	**IVI**	**Fr.**	**Dn.**	**IVI**
1	*Achyranthes aspera*	30	5000	5.64	32.5	10250	4.41	10	2000	3.99
2	*Ageratum conyzoides*	30	10500	7.72	47.5	21750	7.71	12.5	4750	6.36
3	*Anaphalis margaritacea*	32.5	7250	6.81	32.5	8250	4.04			
4	*Bidens pilosa*	25	6000	5.40	27.5	11250	4.21	12.5	4250	6.06
5	*Campanula pallida*				37.5	10750	4.89			
6	*Cannabis sativa*	27.5	10000	7.22	47.5	19000	7.19	22.5	11500	13.26
7	*Crassocephalum crepidioides*	32.5	7500	6.90	32.5	13500	5.02	20	10250	11.81
8	*Cyanoglossum* sp.	45	10000	9.41	45	19750	7.14	17.5	6500	8.82
9	*Cymbopogon citratus*	22.5	3500	4.14	37.5	19500	6.52			
10	*Cyperus* sp.				30	24000	6.79			
11	*Drymaria cordata*	45	30500	17.17	57.5	25250	9.13	17.5	11250	11.73
12	*Eleusine*				35	16000	5.68			
13	*Equisetum diffusum*	30	18750	10.85	30	15250	5.15	20	8500	10.73
14	*Eupatorium adenophorum*	20	5500	4.58	37.5	17750	6.19	27.5	9250	13.26
15	*Euphorbia hirta*	35	13250	9.39	25	12750	4.30			
16	*Fagopyrum esculentum*	22.5	5000	4.70	32.5	9750	4.32			
17	*Fragaria nubicola*	27.5	13250	8.45	27.5	18500	5.57	17.5	7000	9.12
18	*Galinsoga parviflora*	30	10000	7.53	40	26000	7.93	22.5	14000	14.80
19	*Galium* sp.				25	10750	3.93			
20	*Geranium* sp.	22.5	5250	4.80	37.5	5750	3.95	17.5	4750	7.74
21	*Houttuynia cordata*				35	6750	3.95			
22	*Hydrocotyle* sp.	35	7500	7.21	22.5	8750	3.36	30	4250	10.88
23	*Hypoestes* sp.				40	14000	5.69			
24	*Impatiens bicolour*				15	2000	1.53			
25	*Impatiens* sp.	27.5	7750	6.37	30	17750	5.62			
26	*Ipomea* sp.				10	2250	1.19			
27	*Lindenbergia* sp.				7.5	10000	2.44			
28	*Lysionanthus*				22.5	5750	2.80			
29	*Oxalis corniculata*	25	13250	8.14	27.5	16750	5.24	17.5	13000	12.80
30	*Persicaria capitata*	37.5	20750	12.54	40	21750	7.13	22.5	11250	13.11
31	*Persicaria chinensis*	47.5	13500	11.05	47.5	24500	8.22	32.5	22250	22.62
32	*Pimpinella diversifolia*	22.5	5000	4.70	35	8250	4.23			
33	*Piper pedicellosum*	10	2000	2.01	17.5	3500	2.00			
34	*Plantago erosa*	40	18500	12.00	40	18500	6.53	22.5	14250	14.95
35	*Seigesbeckia orientalis*	15	3500	3.20	30	11500	4.45			
36	*Strobilanthes*				45	16750	6.58			
37	*Urtica dioica*	12.5	2250	2.41	27.5	10750	4.12			
38	*Verbascum thapsus*	7.5	1000	1.32	25	4500	2.76			
39	*Vernonia* sp.	15	3250	3.10	30	8500	3.89	20	4000	7.97
40	*Xanthium strumarium*	27.5	4750	5.24	37.5	7250	4.23			
Total		**800**	**264250**	**200**	**1302.5**	**535500**	**200**	**362.5**	**163000**	**200**

Fr.–Frequency percentage, Dn.–Density (ha^{-1}), IVI–Importance value index

Appendix II. 3.123: Frequency, density, basal area and IVI for tree species in Tawang–II HEP at powerhouse site

Sl. No.	Species name	Post–monsoon				Monsoon				Winter			
		Fr.	**Dn.**	**BA**	**IVI**	**Fr.**	**Dn.**	**BA**	**IVI**	**Fr.**	**Dn.**	**BA**	**IVI**
1	*Emblica officinalis*	72	180	2.31	119.14	72	180	2.31	119.14	72	180	2.31	119.14
2	*Ficus auriculata*	56	68	1.74	71.02	56	68	1.74	71.02	56	68	1.74	71.02
3	*Pinus wallichiana*	36	52	1.82	57.34	36	52	1.82	57.34	36	52	1.82	57.34
4	*Schima wallichii*	36	44	1.63	52.50	36	44	1.63	52.50	36	44	1.63	52.50
Total		**200**	**344**	**7.49**	**300**	**200**	**344**	**7.49**	**300**	**200**	**344**	**7.49**	**300**

Fr.–Frequency percentage, Dn.–Density (ha^{-1}), BA–Basal area (m^2 ha^{-1}), IVI–Importance value index

Appendix II. 3.124: Frequency, density and IVI of shrubs in Tawang–II powerhouse site

Sl. No.	Species name	Post–monsoon			Monsoon			Winter		
		Fr.	**Dn.**	**IVI**	**Fr.**	**Dn.**	**IVI**	**Fr.**	**Dn.**	**IVI**
1	*Artemesia nilagirica*	60	3120	38.07	60	3120	38.07	60	3120	38.07
2	*Buddleja asiatica*	28	224	7.47	28	224	7.47	28	224	7.47
3	*Coriaria nepalensis*	52	2016	27.24	52	2016	27.24	52	2016	27.24
4	*Cyathula tomentosa*	28	368	8.67	28	368	8.67	28	368	8.67
5	*Debregeasia longifolia*	28	512	9.88	28	512	9.88	28	512	9.88
6	*Flemingia macrophylla*	36	720	13.22	36	720	13.22	36	720	13.22
7	*Indigofera*	32	608	11.48	32	608	11.48	32	608	11.48
8	*Maesa indica*	40	656	13.48	40	656	13.48	40	656	13.48
9	*Rubus ellipticus*	36	1040	15.89	36	1040	15.89	36	1040	15.89
10	*Rubus rugosus*	16	112	4.14	16	112	4.14	16	112	4.14
11	*Solanum khasianum*	48	752	15.88	48	752	15.88	48	752	15.88
12	*Urena lobata*	60	944	19.89	60	944	19.89	60	944	19.89
13	*Woodfordia fructicosa*	36	896	14.69	36	896	14.69	36	896	14.69
Total		**500**	**11968**	**200**	**500**	**11968**	**200**	**500**	**11968**	**200**

Fr.–Frequency percentage, Dn.–Density (ha^{-1}), IVI–Importance value index

Appendix II. 3.125: Frequency, density and IVI of herbs in Tawang–II powerhouse site

Sl. No.	Species name	Post–monsoon			Monsoon			Winter		
		Fr.	**Dn.**	**IVI**	**Fr.**	**Dn.**	**IVI**	**Fr.**	**Dn.**	**IVI**
1	*Acanthospermum hispidum*				20	3000	3.05			
2	*Ageratum conyzoides*	32.5	10250	12.37	30	14000	7.03	20	7750	11.62
3	*Anaphalis margaritacea*	15	3250	4.82	22.5	4250	3.66			
4	*Bidens pilosa*	32.5	6000	9.83	32.5	16250	7.90	15	4000	7.40
5	*Campanula pallida*				20	3000	3.05			
6	*Cannabis sativa*	42.5	18750	19.37	42.5	33500	13.50	32.5	22250	25.87
7	*Crassocephalum crepidioides*	35	10250	12.85	27.5	16750	7.46	17.5	5250	9.06
8	*Cyanoglossum* sp.	22.5	4750	7.16	20	10750	5.06			
9	*Cymbopogon citratus*	57.5	28250	27.92	47.5	41250	16.08	35	24000	27.89
10	*Cyperus rotundus*				30	18500	8.20			
11	*Drymaria cordata*	22.5	10250	10.45	22.5	16750	6.89			
12	*Eleusine coracana*				32.5	17750	8.29			
13	*Equisetum diffusum*	30	4750	8.61	20	5250	3.63	22.5	6750	11.65
14	*Eupatorium adenophorum*	25	7000	8.99	27.5	11250	6.04	17.5	10000	12.50
15	*Eupatorium odoratum*				30	19000	8.33			
16	*Euphorbia hirta*				22.5	6750	4.30			
17	*Fagopyrum esculentum*				20	5750	3.76			
18	*Fragaria nubicola*				30	8500	5.61	12.5	3500	6.29
19	*Galinsoga parviflora*	27.5	15750	14.69	37.5	19750	9.37	17.5	8750	11.59
20	*Galium* sp.				25	8500	5.04			
21	*Geranium* sp.	15	3250	4.82	22.5	5250	3.92	15	1750	5.78
22	*Hydrocotyle nepalensis*				22.5	6000	4.11	10	3000	5.18
23	*Impatiens* sp.	17.5	4250	5.90	15	3250	2.55			
24	*Lindenbergia* sp.				20	6500	3.96			
25	*Oxalis corniculata*	20	6000	7.43	30	16750	7.75	17.5	10500	12.86
26	*Persicaria capitata*	22.5	7500	8.80	42.5	19000	9.75	17.5	8500	11.41
27	*Persicaria chinensis*	20	5750	7.28				25	8000	13.31
28	*Plantago erosa*	25	10250	10.93	45	19750	10.23	20	5750	10.17
29	*Seigesbeckia orientalis*				20	8500	4.47	22.5	4000	9.66
30	*Pimpinella diversifolia*				25	4250	3.94			
31	*Strobilanthes*				20	2750	2.98			
32	*Urtica dioica*	20	4250	6.38	22.5	4750	3.79			
33	*Vernonia* sp.	20	4250	6.38	12.5	3000	2.20	15	4500	7.77
34	*Xanthium strumarium*	17.5	2750	5.01	22.5	6000	4.11			
Total		**520**	**167500**	**200**	**880**	**386250**	**200**	**332.5**	**138250**	**200**

Fr.–Frequency percentage, Dn.–Density (ha^{-1}), IVI–Importance value index

Appendix II. 3.126: Frequency, density, basal area and IVI for tree species in Tawang–II HEP catchment area

Sl. No.	Species name	Post–monsoon				Monsoon				Winter			
		Fr.	Dn.	BA	IVI	Fr.	Dn.	BA	IVI	Fr.	Dn.	BA	IVI
1	*Alangium chinensis*	24.00	44.00	0.55	8.36	24.00	44.00	0.55	8.36	24.00	44.00	0.55	8.36
2	*Albizzia arunachelesis*	60.00	136.00	4.24	29.62	60.00	136.00	4.24	29.62	60.00	136.00	4.24	29.62
3	*Alnus nepalensis*	76.00	500.00	12.24	73.65	76.00	500.00	12.24	73.65	76.00	500.00	12.24	73.65
4	*Cyathea* sp.	40.00	60.00	0.92	13.17	40.00	60.00	0.92	13.17	40.00	60.00	0.92	13.17
5	*ficus auriculata*	36.00	64.00	1.48	14.07	36.00	64.00	1.48	14.07	36.00	64.00	1.48	14.07
6	*Macaranga denticulata*	64.00	268.00	6.04	42.49	64.00	268.00	6.04	42.49	64.00	268.00	6.04	42.49
7	*Pinus wallichiana*	44.00	104.00	3.65	23.33	44.00	104.00	3.65	23.33	44.00	104.00	3.65	23.33
8	*Quercus griffithi*	56.00	224.00	5.27	36.52	56.00	224.00	5.27	36.52	56.00	224.00	5.27	36.52
9	*Rhus chinensis*	40.00	172.00	1.43	20.87	40.00	172.00	1.43	20.87	40.00	172.00	1.43	20.87
10	*Saurauia napaulensis*	16.00	32.00	0.51	6.08	16.00	32.00	0.51	6.08	16.00	32.00	0.51	6.08
11	*Schima wallichi*	32.00	64.00	2.54	16.02	32.00	64.00	2.54	16.02	32.00	64.00	2.54	16.02
12	*Torricellia tiliifolia*	48.00	64.00	0.52	13.87	48.00	64.00	0.52	13.87	48.00	64.00	0.52	13.87
13	*Wendlandia* sp.	4.00	12.00	0.21	1.95	4.00	12.00	0.21	1.95	4.00	12.00	0.21	1.95
Total		**540**	**1744**	**40**	**300**	**540**	**1744**	**40**	**300**	**540**	**1744**	**40**	**300**

Fr.–Frequency percentage, Dn.–Density (ha^{-1}), BA–Basal area ($m^2\ ha^{-1}$), IVI–Importance value index

Appendix II. 3.127: Frequency, density and IVI of shrubs in Tawang–II catchment area

Sl. No.	Species name	Post–monsoon			Monsoon			Winter		
		Fr.	Dn.	IVI	Fr.	Dn.	IVI	Fr.	Dn.	IVI
1	*Ardisia crenata*	12	80	2.18	12	80	2.18	12	80	2.18
2	*Artemisia nilagirica*	64	3792	34.97	64	3792	34.97	64	3792	34.97
3	*Boehmeria macrophylla*	24	224	4.81	24	224	4.81	24	224	4.81
4	*Buddleja asiatica*	36	256	6.67	36	256	6.67	36	256	6.67
5	*Coriaria nepalensis*	36	1072	12.32	36	1072	12.32	36	1072	12.32
6	*Cyathula tomentosa*	28	544	7.57	28	544	7.57	28	544	7.57
7	*Debregeasia longifolia*	40	656	9.98	40	656	9.98	40	656	9.98
8	*Desmodium* sp.	24	224	4.81	24	224	4.81	24	224	4.81
9	*Dobinia vulgaris*	12	128	2.52	12	128	2.52	12	128	2.52
10	*Elaeagnus* sp.	12	80	2.18	12	80	2.18	12	80	2.18
11	*Flemingia macrophylla*	48	864	12.51	48	864	12.51	48	864	12.51
12	*Girardinia* sp.	32	384	7.01	32	384	7.01	32	384	7.01
13	*Hydrangea* sp.	36	224	6.44	36	224	6.44	36	224	6.44
14	*Indigofera*	48	496	9.96	48	496	9.96	48	496	9.96
15	*Maesa indica*	44	1168	14.07	44	1168	14.07	44	1168	14.07
16	*Mussaenda* sp.	28	208	5.25	28	208	5.25	28	208	5.25
17	*Rubus ellipticus*	48	912	12.84	48	912	12.84	48	912	12.84
18	*Rubus rugosus*	24	224	4.81	24	224	4.81	24	224	4.81
19	*Solanum khasianum*	52	1184	15.27	52	1184	15.27	52	1184	15.27
20	*Urena lobata*	52	576	11.06	52	576	11.06	52	576	11.06
21	*Woodfordia fructicosa*	36	1136	12.76	36	1136	12.76	36	1136	12.76
Total		**736**	**14432**	**200**	**736**	**14432**	**200**	**736**	**14432**	**200**

Fr.–Frequency percentage, Dn.–Density (ha^{-1}), IVI–Importance value index

Appendix II. 3.128: Frequency, density and IVI of herbs in Tawang–II catchment area

Sl. No.	Species name	Post–monsoon			Monsoon			Winter		
		Fr.	Dn.	IVI	Fr.	Dn.	IVI	Fr.	Dn.	IVI
1	*Achyranthes aspera*	30	6000	5.98	37.5	11750	4.91	10	2750	4.82
2	*Ageratum conizoides*	42.5	12250	9.83	47.5	19000	6.95	20	8500	11.74
3	*Anaphalis margrateata*	32.5	8250	7.11	32.5	13500	4.84			
4	*Bidens pilosa*	30	7250	6.43	27.5	13000	4.38	12.5	4250	6.60
5	*Campanula pallida*				37.5	10250	4.64			
6	*Cannabis sativa*	27.5	9250	6.84	47.5	13500	5.97	20	9750	12.62
7	*Crassocephalum crepidioides*	27.5	8250	6.48	32.5	18000	5.64	15	4500	7.49
8	*Cymbopogon citratus*	17.5	3250	3.40	45	8500	4.89	12.5	3750	6.25
9	*Cyperus* sp.				40	16750	5.98			
10	*Cyanoglossum* sp.	35	11250	8.52	35	16750	5.61	20	6750	10.52
11	*Drymaria cordata*	45	30250	16.70	45	35500	9.69	20	17000	17.69
12	*Eleusine coracana*				27.5	14000	4.56			
13	*Equisetum diffusum*	30	10500	7.62	27.5	15750	4.87	22.5	8500	12.47
14	*Eupatorium adenophorum*	25	11000	7.16	32.5	16250	5.33	27.5	6500	12.52
15	*Euphorbia hirta*	35	7250	7.07	30	12500	4.48			
16	*Fagopyrum esculentum*	22.5	7750	5.67	30	15500	5.01			
17	*Fragaria nubicola*	32.5	15750	9.84	45	21000	7.12	22.5	11750	14.74

Sl.	Species name	Post–monsoon			Monsoon			Winter		
18	*Galinsoga parviflora*	30	15750	9.52	25	18000	5.08	20	12750	14.71
19	*Galium* sp.				20	5750	2.53			
20	*Geranium* sp.	30	8000	6.71	32.5	13250	4.80	10	2000	4.30
21	*Hydrocotyle nepalensis*	35	9750	7.98	40	19500	6.47			
22	*Hydrocotyle* sp.				40	15250	5.72	12.5	3000	5.72
23	*Hypoestes* sp.				45	28750	8.49			
24	*Impatiens bicolour*				22.5	5750	2.71			
25	*Impatiens* sp.	27.5	13250	8.30						
26	*Ipomea* sp.				25	4250	2.63			
27	*Lindenbergia* sp.				35	9000	4.23			
28	*Lysionanthus*				42.5	12000	5.33			
29	*Oxalis corniculata*				37.5	20750	6.51	17.5	9250	11.54
30	*Persicaria capitata*	25	18000	9.71	35	14000	5.12	17.5	8250	10.84
31	*Persicaria chinensis*	37.5	15500	10.38	47.5	26500	8.28	25	7250	12.32
32	*Piper pedicellosum*	17.5	2750	3.22	40	4250	3.76			
33	*Plantago erosa*	47.5	21250	13.74	40	28000	7.98	17.5	10750	12.59
34	*Pimpinella diversifolia*	40	6250	7.34	30	11000	4.21			
35	*Strobilanthes*				47.5	21750	7.44			
36	*Seigesbeckia orientalis*				30	8500	3.77	12.5	3000	5.72
37	*Vernonia* sp.	22.5	5750	4.94	22.5	8250	3.16	10	2750	4.82
38	*Urtica dioica*	27.5	7500	6.21	27.5	9000	3.67			
39	*Xanthium strumarium*	17.5	3000	3.31	25	7750	3.26			
Total		**790**	**275000**	**200.00**	**1330**	**562750**	**200.00**	**345**	**143000**	**200.00**

Fr.–Frequency percentage, Dn.–Density (ha^{-1}), IVI–Importance value index

Appendix II. 3.129: Dominant and Co–dominant species determined on the basis of IVI/density values of species in the plant communities at Tawang–II

Community components	Barrage	Powerhouse	Catchment area
Tree species*			
Dominant	*Alnus nepalensis*	*Embelica officinalis*	*Alnus nepalensis*
Co–Dominant	*Macaranga dendiculata*	*Ficus auriculata*	*Macaranga denticulata*
Shrub species**			
Dominant	*Artemesia nilagarica*	*Artemesia nilagarica*	*Artemesa nelagarica*
Co–Dominant	*Solanum khasianum*	*Coriaria nepalensis*	*Solanum khasianum*
Herb species**			
i. Post monsoon season			
Dominant	*Drymaria cordata*	*Cymbopogon citratus*	*Drymaria cordata*
Co–Dominant	*Persicaria capitata*	*Canabis sativus*	*Plantago major*
ii. Monsoon season			
Dominant	*Drymaria cordata*	*Cymbopogon citratus*	*Drymaria cordata*
Co–Dominant	*Persicaria chinensis*	*Canabis sativus*	*Hypoetes* sp.
iii. Winter			
Dominant	*Persicaria chinensis*	*Canabis sativus*	*Drymaria cordata*
Co–Dominant	*Plantago major*	*Cymbopogon citratus*	*Frageria nubicola*

* Dominance based on IVI ** Dominance based on density

Appendix II. 3.130: List of plant species recorded from Nyamjang chu HEP site

Sl. No.	Species name	Family
TREES		
1	*Albizia lucida*	Mimosaceae
2	*Alnus nepalensis*	Betulaceae
3	*Betula alnoides*	Betulaceae
4	*Cryptomeria japonica*	Cupressaceae
5	*Cupressus* sp.	Cupressaceae
6	*Erythirina arborescens*	Papilionaceae
7	*Ilex* sp.	Aquifoliaceae
8	*Juglans regia*	Juglandaceae
9	*Lyonia ovalifolia*	Ericaceae
10	*Macaranga denticulata*	Euphorbiaceae
11	*Morus* sp.	Moraceae
12	*Populus gamblei*	Salicaceae
13	*Quercus griffithii*	Fagaceae
14	*Rhododendron campanulatum*	Ericaceae
15	*Rhododendron maddeni*	Ericaceae
16	*Rhododendron nerifolium*	Ericaceae

Sl. No.	Species name	Family
17	*Salix* sp.	Salicaceae
18	*Schima khasiana*	Theaceae
SHRUBS		
19	*Artemisia nilagirica*	Asteraceae
20	*Cotoneaster* sp.	Rosaceae
21	*Debregaesia longifolia*	Urticaceae
22	*Drynaria propinqua*	Polypodiaceae
23	*Elaeagnus* sp.	Elaegnaceae
24	*Gaultheria fragrantissima*	Ericaceae
25	*Maesa indica*	Myrsinaceae
26	*Mussaenda roxburghii*	Rubiaceae
27	*Neillia thyrsiflora*	Rosaceae
28	*Plectranthus coetsa*	Lamiaceae
29	*Prinsepia utilis*	Rosaceae
30	*Rhus chinensis*	Anacardiaceae
31	*Rubus ellipticus*	Rosaceae
32	*Rubus hypergynus*	Rosaceae
33	*Rubus rugosus*	Rosaceae
34	*Saccharum* spontaneum	Poaceae
35	Spiraea *canescens*	Rosaceae
36	*Viburnum erubescens*	Adoxaceae
HERBS		
37	*Aconogonum* sp.	Polygonaceae
38	*Anaphalis triplinervis*	Asteraceae
39	*Anemone vitifolia*	Ranunculaceae
40	*Axonopus compressus*	Poaceae
41	*Bidens pilosa*	Asteraceae
42	*Bistorta* sp.	Polygonaceae
43	*Blechnum* sp.	Blechnaceae
44	*Cannabis* sativa	Cannabaceae
45	*Centella asiatica*	Apiaceae
46	*Cirsium* sp.	Asteraceae
47	*Corydalis rutifolia*	Papaveraceae
48	*Cynoglossum furcatum*	Boraginaceae
49	*Cypsella bursa–pastoris*	Brassicaceae
50	*Equisetum* sp.	Equisetaceae
51	*Fagopyrum dibotrys*	Polygonaceae
52	*Fragaria indica*	Rosaceae
53	*Galinsoga parvifolia*	Asteraceae
54	*Galium asperifolium*	Rubiaceae
55	*Geranium nepalense*	Geraniaceae
56	*Gerardinia diversifolia*	Urticaceae
57	*Gnaphalium* sp.	Asteraceae
58	*Heracleum* sp.	Apiaceae
59	*Houttuynia cordata*	Saururaceae
60	*Hydrocotyle javanica*	Apiaceae
61	*Inula cappa*	Asteraceae
62	*Lepisorus nudus*	Polypodiaceae
63	*Leucas ciliata*	Lamiaceae
64	*Lycopodium clavatum*	Lycopodiaceae
65	*Mazus surculosus*	Scrophulariaceae
66	*Nicandra physalodes*	Solanaceae
67	*Oenanthe* sp.	Apiaceae
68	*Oxalis corniculata*	Oxalidaceae
69	*Parochaetus communis*	Papilionaceae
70	*Paspalum* sp.	Poaceae
71	*Periploca* sp.	Periplocaceae
72	*Pilea lineolatum*	Urticaceae
73	*Plantago major*	Plantaginaceae
74	*Poa annua*	Poaceae
75	*Polygonum capitatum*	Polygonaceae
76	*Potentilla fulgens*	Rosaceae
77	*Pouzolzia hirta*	Urticaceae
78	*Pouzolzia* sp.	Urticaceae
79	*Pteridium aquilinum*	Dennstaedtiaceae
80	*Ranunculus scleratus*	Rannunculaceae

Sl. No.	Species name	Family
81	*Rosa sericea*	Rosaceae
82	*Rubia cordifolia*	Rubiaceae
83	*Rumex nepalensis*	Polygonaceae
84	*Sedum multicaule*	Crassulaceae
85	*Selaginella* sp.	Selaginellaceae
86	*Smithia* sp.	Papilionaceae
87	*Solanum viarum*	Solanaceae
88	*Stellaria* sp.	Caryophyllaceae
89	*Urtica dioica*	Urticaceae
90	*Viola* sp.	Violaceae
91	*Vittaria* sp.	Vittariaceae
CLIMBERS		
92	*Clematis Bucchaniana*	Ranunculaceae
93	*Clematis* sp.	Ranunculaceae
94	*Dioscorea bulbifera*	Dioscoreaceae
95	*Ficus* sp.	Moraceae
96	*Hedera nepalensis*	Araliaceae
97	*Periploca* sp.	Periplocaceae
98	*Rubia cordifolia*	Rubiaceae
99	*Smilax* sp.	Smilacaceae
100	*Stephania glandulifera*	Menispermaceae
ORCHIDS		
101	*Bulbophyllum* sp.	Orchidaceae
102	*Coelogynae* sp.	Orchidaceae
103	*Cymbidium* sp. sp.	Orchidaceae
104	*Dendrobium* sp.	Orchidaceae
PTERIDOPHYTES		
105	*Adiantum* sp.	Adiantaceae
106	*Blechnum* sp.	Blechnaceae
107	*Dicranopteris linearis*	Dicranopteridaceae
108	*Drynaria propinqua*	Drynariaceae
109	*Lepisorus nudus*	Polypodiaceae
110	*Lycopodium clavatum*	Lycopodiaceae
111	*Osmunda cinnamomea*	Osmundaceae
112	*Polypodium* sp.	Polypodiaceae
113	*Pteridium aquilinum*	Pteridaceae
114	*Pteris* sp.	Pteridiaceae
115	*Pteris vittata*	Pteridaceae
116	*Pyrrosia* sp.	Crptogrammaceae
117	*Selaginella* sp.	Selaginellaceae
118	*Vittaria elongata*	Vittariaceae
BRYOPHYTES		
119	*Brachymenium* sp.	Bryaceae
120	*Bryum billardieri*	Bryaceae
121	*Funaria*	Funariaceae
122	*Hymenostylium aurantiacum*	Pottiaceae
123	*Marchantia*	Marchantiaceae
124	*Pohlia minor*	Mniaceae
LICHENS		
125	*Aderkomyces albostrigosus*	Gomphillaceae
126	*Cladonia* sp.	Cladoniaceae
127	*Everniastrum nepalense*	Parmeliaceae
128	*Graphis* sp.	Graphidaceae
129	*Lecanora perplexa*	Lecanoraceae
130	*Lobaria* sp.	Lobariaceae
131	*Parmelaria* sp.	Parmeliaceae
132	*Parmotrema* sp.	Parmeliaceae
133	*Stereocaulon* sp.	Stereocaulaceae
134	*Sticta* sp.	Lobariaceae
135	*Usnea* sp.	Parmeliaceae
FUNGI		
136	*Auricularia auriculiformis*	Auriculariaceae
137	*Boletus reticulatus*	Boletaceae
138	*Clathrus rubra*	Phallaceae
139	*Coprinus disseminatus*	Agaricaceae
140	*Daldinia concentrica*	Xylariaceae

Sl. No.	Species name	Family
141	*Fomes pinicola*	Fomitopsidaceae
142	*Gloeophyllum sepiarium*	Gloeophyllaceae
143	*Hydnum repandum*	Hydnaceae
144	*Hygrocybe miniata*	Hygrophoraceae
145	*Laccaria laccata*	Hydnangiaceae
146	*Lactarius rubidus*	Russulaceae
147	*Polyporus arcularius*	Polyporaceae
148	*Poria monticola*	Polyporaceae
149	*Schizophyllum commune*	Schizophyllaceae
150	*Strobilomyces strobilaceus*	Boletaceae
151	*Thelephora penicillata*	Thelephoraceae
152	*Xylaria polymorpha*	Xylariaceae
153	*Cerrena consors*	Polyporaceae
154	*Coltricia cinnamomeus*	Hymenochaetaceae
155	*Daldinia concentrica*	Xylariaceae
156	*Daedalea incana*	Coriolaceae
157	*Ganoderma lucidum*	Ganodermataceae
158	*Hexagonia tenuis*	Polyporaceae
159	*Junghuhnia nitida*	Meruliaceae
160	*Microporus xanthopus*	Polyporaceae
161	*Pseudotrametes gibbosa*	Polyporaceae
162	*Pycnoporellus sanguineus*	Formitopscidaceae
163	*Trichaptum versatilis*	Polyporaceae
164	*Trametes hirsuta*	Polyporaceae
165	*Xylaria longipes*	Xylariaceae

Appendix II. 3.131: Different groups of plant species present at Nyamjang chu HEP site

Sl. No.	Species name Barrage and Powerhouse	Family	Sl. No.	Species name Catchment area	Family
CLIMBERS					
1	*Clematis Bucchaniana*	Ranunculaceae	1	*Clematis Bucchaniana*	Ranunculaceae
2	*Clematis* sp.	Ranunculaceae	2	*Clematis* sp.	Ranunculaceae
3	*Dioscorea bulbifera*	Dioscoreaceae	3	*Dioscorea bulbifera*	Dioscoreaceae
4	*Ficus* sp.	Moraceae	4	*Ficus* sp.	Moraceae
5	*Hedera nepalensis*	Araliaceae	5	*Hedera nepalensis*	Araliaceae
6	*Periploca* sp.	Periplocaceae	6	*Periploca* sp.	Periplocaceae
7	*Rubia cordifolia*	Rubiaceae	7	*Rubia cordifolia*	Rubiaceae
8	*Smilax* sp.	Smilacaceae	8	*Smilax* sp.	Smilacaceae
9	*Stephania glandulifera*	Menispermaceae			
ORCHIDS					
1	*Bulbophyllum* sp.	Orchidaceae	1	*Bulbophyllum* sp.	Orchidaceae
2	*Coelogynae* sp.	Orchidaceae	2	*Coelogynae* sp.	Orchidaceae
3	*Cymbidium* sp. sp.	Orchidaceae	3	*Cymbidium* sp. sp.	Orchidaceae
4	*Dendrobium* sp.	Orchidaceae			
PTERIDOPHYTES					
1	*Adiantum* sp.	Adiantaceae	1	*Adiantum* sp.	Adiantaceae
2	*Blechnum* sp.	Blechnaceae	2	*Blechnum* sp.	Blechnaceae
3	*Dicranopteris linearis*	Dicranopteridaceae	3	*Lepisorus nudus*	Polypodiaceae
4	*Drynaria propinqua*	Drynariaceae	4	*Lycopodium clavatum*	Lycopodiaceae
5	*Lepisorus nudus*	Polypodiaceae	5	*Polypodium* sp.	Polypodiaceae
6	*Lycopodium clavatum*	Lycopodiaceae	6	*Pteridium aquilinum*	Pteridaceae
7	*Osmunda cinnamomea*	Osmundaceae	7	*Pteris* sp.	Pteridiaceae
8	*Polypodium* sp.	Polypodiaceae	8	*Pyrrosia* sp.	Crptogrammaceae
9	*Pteridium aquilinum*	Pteridaceae	9	*Selaginella* sp.	Selaginellaceae
10	*Pteris* sp.	Pteridiaceae	10	*Vittaria elongata*	Vittariaceae
11	*Pteris vittata*	Pteridaceae			
12	*Pyrrosia* sp.	Crptogrammaceae			
13	*Selaginella* sp.	Selaginellaceae			
14	*Vittaria elongata*	Vittariaceae			
BRYOPHYTES					
1	*Brachymenium* sp.	Bryaceae	1	*Brachymenium* sp.	Bryaceae
2	*Bryum billardieri*	Bryaceae	2	*Funaria*	Funariaceae
3	*Funaria*	Funariaceae	3	*Hymenostylium aurantiacum*	Pottiaceae
4	*Hymenostylium aurantiacum*	Pottiaceae	4	*Pohlia minor*	Mniaceae
5	*Marchantia*	Marchantiaceae			
6	*Pohlia minor*	Mniaceae			

Sl. No.	Species name Barrage and Powerhouse	Family	Sl. No.	Species name Catchment area	Family
LICHENS					
1	*Aderkomyces albostrigosus*	Gomphillaceae	1	*Aderkomyces albostrigosus*	Gomphillaceae
2	*Cladonia* sp.	Cladoniaceae	2	*Everniastrum nepalense*	Parmeliaceae
3	*Everniastrum nepalense*	Parmeliaceae	3	*Graphis* sp.	Graphidaceae
4	*Graphis* sp.	Graphidaceae	4	*Lecanora perplexa*	Lecanoraceae
5	*Lecanora perplexa*	Lecanoraceae	5	*Lobaria* sp.	Lobariaceae
6	*Lobaria* sp.	Lobariaceae	6	*Parmelaria* sp.	Parmeliaceae
7	*Parmelaria* sp.	Parmeliaceae	7	*Stereocaulon* sp.	Stereocaulaceae
8	*Parmotrema* sp.	Parmeliaceae	8	*Sticta* sp.	Lobariaceae
9	*Stereocaulon* sp.	Stereocaulaceae	9	*Usnea* sp.	Parmeliaceae
10	*Sticta* sp.	Lobariaceae			
11	*Usnea* sp.	Parmeliaceae			

Appendix II. 3.132: Species list of macro–fungi recorded from barrage and powerhouse sites of Nyamjang chu

Species	Family	Species	Family
Barrage		**Powerhouse**	
Auricularia auriculiformis	Auriculariaceae	*Cerrena consors*	Polyporaceae
Boletus reticulatus	Boletaceae	*Coltricia cinnamomeus*	Hymenochaetaceae
Clathrus rubra	Phallaceae	*Daldinia concentrica*	Xylariaceae
Coprinus disseminatus	Agaricaceae	*Daedalea incana*	Coriolaceae
Daldinia concentrica	Xylariaceae	*Ganoderma lucidum*	Ganodermataceae
Fomes pinicola	Fomitopsidaceae	*Hexagonia tenuis*	Polyporaceae
Gloeophyllum sepiarium	Gloeophyllaceae	*Junghuhnia nitida*	Meruliaceae
Hydnum repandum	Hydnaceae	*Laccaria laccata*	Hydnangiaceae
Hygrocybe miniata	Hygrophoraceae	*Microporus xanthopus*	Polyporaceae
Laccaria laccata	Hydnangiaceae	*Pseudotrametes gibbosa*	Polyporaceae
Lactarius rubidus	Russulaceae	*Pycnoporellus sanguineus*	Formitopscidaceae
Polyporus arcularius	Polyporaceae	*Schizophyllum commune*	Schizophyllaceae
Poria monticola	Polyporaceae	*Trichaptum versatilis*	Polyporaceae
Schizophyllum commune	Schizophyllaceae	*Trametes hirsuta*	Polyporaceae
Strobilomyces strobilaceus	Boletaceae	*Xylaria longipes*	Xylariaceae
Thelephora penicillata	Thelephoraceae		
Xylaria polymorpha	Xylariaceae		
Catchment area			
Auricularia auriculiformis	Auriculariaceae		
Boletus reticulatus	Boletaceae		
Coprinus disseminatus	Agaricaceae		
Daldinia concentrica	Xylariaceae		
Fomes pinicola	Fomitopsidaceae		
Gloeophyllum sepiarium	Gloeophyllaceae		
Hydnum repandum	Hydnaceae		
Hygrocybe miniata	Hygrophoraceae		
Laccaria laccata	Hydnangiaceae		
Lactarius rubidus	Russulaceae		
Polyporus arcularius	Polyporaceae		
Poria monticola	Polyporaceae		
Schizophyllum commune	Schizophyllaceae		
Xylaria polymorpha	Xylariaceae		

Appendix II. 3.133: Frequency, density, basal area and IVI for tree species in Nyamjang chu barrage site

Sl. No.	Species name	Monsoon			
		Fr.	**Dn.**	**BA**	**IVI**
1	*Alnus nepalensis*	45	125	3.12	126.08
2	*Cryptomeria japonica*	30	20	0.37	31.89
3	*Cupressus* sp.	20	30	0.51	31.95
4	*Ilex* sp.	10	10	0.23	13.65
5	*Lyonia ovalifolia*	10	20	0.39	20.09
6	*Morus* sp.	10	20	0.12	15.70
7	*Rhododendron campanulatum*	20	15	0.29	22.61
8	*Rhododendron maddeni*	20	20	1.12	38.02
	Total	**165**	**260**	**6.15**	**300**

Fr.–Frequency percentage, Dn.–Density (ha^{-1}), BA–Basal area ($m^2\ ha^{-1}$), IVI–Importance value index

Appendix II. 3.134: Frequency, density and IVI of shrubs in Nyamjang chu barrage site

Sl. No.	Species name	Monsoon		
		Fr.	**Dn.**	**IVI**
1	*Artemisia nilagirica*	30	140	19.40
2	*Elaeagnus* sp.	50	590	53.43
3	*Gaultheria fragrantissima*	30	60	14.66
4	*Prinsepia utilis*	20	60	10.96
5	*Rubus ellipticus*	90	650	71.79
6	*Plectranthus coetsa*	20	40	9.77
7	*Spiraea canescens*	30	150	19.99
Total		**270**	**1690**	**200**

Fr.–Frequency percentage, Dn.–Density (ha^{-1}), IVI–Importance value index

Appendix II. 3.135: Frequency, density and IVI of herbs in Nyamjang chu barrage site

Sl. No.	Species name	Monsoon		
		Fr.	**Dn.**	**IVI**
1	*Anaphalis triplinervis*	20	15000	4.46
2	*Axonopus compressus*	15	12000	3.44
3	*Bidens pilosa*	15	13000	3.58
4	*Cannabis sativa*	35	36000	9.09
5	*Centella asiatica*	30	33000	8.07
6	*Cirsium* sp.	40	41000	10.37
7	*Cynoglossum furcatum*	5	5000	1.28
8	*Fagopyrum dibotrys*	65	63000	16.37
9	*Fragaria indica*	25	25000	6.40
10	*Galinsoga parviflora*	100	98000	25.33
11	*Galium asperifolium*	5	6000	1.41
12	*Gerardinia diversifolia*	25	24000	6.27
13	*Gnaphalium* sp.	15	15000	3.84
14	*Houttuynia cordata*	20	19000	4.99
15	*Hydrocotyl javanica*	25	28000	6.79
16	*Inula cappa*	5	6000	1.41
17	*Leucas ciliata*	10	7000	2.16
18	*Lycopodium clavatum*	10	8000	2.30
19	*Mazus surculosus*	5	4000	1.15
20	*Nicandra physalodes*	10	8000	2.30
21	*Oxalis corniculata*	35	37000	9.22
22	*Parochaetus communis*	15	13000	3.58
23	*Paspalum* sp.	25	28000	6.79
24	*Pouzolzia hirta*	20	16000	4.59
25	*Pilea lineolatum*	10	9000	2.43
26	*Plantago major*	20	15000	4.46
27	*Polygonum capitatum*	70	70000	17.92
28	*Pteridium aequilinum*	5	4000	1.15
29	*Ranunculus scleratus*	15	12000	3.44
30	*Rubia cordifolia*	5	1000	0.75
31	*Rumex nepalensis*	15	11000	3.31
32	*Sedum multicaule*	15	14000	3.71
33	*Selaginella* sp.	20	23000	5.51
34	*Solanum viarum*	15	12000	3.44
35	*Stellaria* sp.	15	11000	3.31
36	*Smythea* sp.	10	6000	2.03
37	*Urtica dioica*	5	5000	1.28
38	*Urtica* sp.	10	6000	2.03
Total		**805**	**759000**	**200**

Fr.–Frequency percentage, Dn.–Density (ha^{-1}), IVI–Importance value index

Appendix II. 3.136: Frequency, density, basal area and IVI for tree species in Nyamjang chu powerhouse site

Sl. No.	Species name	Monsoon			
		Fr.	**Dn.**	**BA**	**IVI**
1	*Albizia lucida*	20	15	0.71	17.95
2	*Alnus nepalensis*	60	220	10.53	147.31
3	*Erythirina arborescens*	20	20	0.67	19.02
4	*Macaranga denticulata*	50	65	2.67	57.14
5	*Quercus griffithii*	30	50	2.27	40.96
6	*Schima khasiana*	20	15	0.65	17.61
Total		**200**	**385**	**17.5**	**300**

Fr.–Frequency percentage, Dn.–Density (ha^{-1}), BA–Basal area (m^2 ha^{-1}), IVI–Importance value index

Appendix II. 3.137: Frequency, density and IVI of shrubs in Nyamjang chu powerhouse site

Sl. No.	Species name	Monsoon		
		Fr.	**Dn.**	**IVI**
1	*Artemesia nilagirica*	45	215	65.83
2	*Cotoneaster* sp.	25	40	20.36
3	*Debregaesia longifolia*	15	25	12.42
4	*Elaeagnus* sp.	30	55	25.86
5	*Maesa indica*	10	20	8.96
6	*Mussaenda roxburghii*	15	45	16.50
7	*Neillia thyrsiflora*	15	20	11.40
8	*Rubus ellipticus*	20	30	15.88
9	*Saccharum spontaneum*	15	15	10.38
10	*Spirea canescens*	10	15	7.94
11	*Viburnum erubescens*	5	10	4.48
Total		**205**	**490**	**200**

Fr.–Frequency percentage, Dn.–Density (ha^{-1}), IVI–Importance value index

Appendix II. 3.138: Frequency, density and IVI of herbs in Nyamjang chu powerhouse site

Sl. No.	Species name	Monsoon		
		Fr.	**Dn.**	**IVI**
1	*Anaphalis triplinervis*	25	21000	11.72
2	*Bidens pilosa*	35	31000	16.83
3	*Centella asiatica*	30	27000	14.55
4	*Cynoglossum furcatum*	10	8000	4.58
5	*Equisetum* sp.	15	12000	6.87
6	*Fagopyrum dibotrys*	35	31000	16.83
7	*Fragaria indica*	25	21000	11.72
8	*Galinsoga parvifolia*	30	29000	15.09
9	*Houttuynia cordata*	25	21000	11.72
10	*Hydrocotyle javanica*	25	23000	12.26
11	*Lycopodium clavatum*	10	7000	4.31
12	*Mazus surculosus*	15	13000	7.14
13	*Oxalis corniculata*	5	4000	2.29
14	*Polygonum capitatum*	35	31000	16.83
15	*Pouzolzia hirta*	15	15000	7.68
16	*Rubia cordifolia*	40	37000	19.67
17	*Rumex nepalensis*	40	38000	19.94
Total		**415**	**369000**	**200**

Fr.–Frequency percentage, Dn.–Density (ha^{-1}), IVI–Importance value index

Appendix II. 3.139: Frequency, density, basal area and IVI for tree species in Nyamjang chu catchment area

Sl. No.	Species name	Monsoon			
		Fr.	**Dn.**	**BA**	**IVI**
1	*Alnus nepalensis*	25	80	1.9	58.31
2	*Betula alnoides*	15	20	0.43	17.63
3	*Cupressus* sp.	20	20	0.44	19.84
4	*Erythirina arborescens*	30	55	0.87	39.68
5	*Juglans regia*	20	30	0.72	26.39
6	*Lyonia ovalifolia*	15	15	0.42	16.07
7	*Macaranga denticulata*	25	45	0.6	31.18
8	*Populus gamblei*	20	20	0.48	20.37
9	*Quercus griffithii*	15	10	0.44	14.90
10	*Rhododendron campanulatum*	15	10	0.63	17.41
11	*Rhododendron nerifolium*	20	25	0.35	20.09
12	*Salix* sp.	20	20	0.31	18.13
Total		**240**	**350**	**7.59**	**300**

Fr.–Frequency percentage, Dn.–Density (ha^{-1}), BA–Basal area (m^2 ha^{-1}), IVI–Importance value index

Appendix II. 3.140: Frequency, density and IVI of shrubs in Nyamjang chu catchment area

Sl. No.	Species name	Monsoon		
		Fr.	**Dn.**	**IVI**
1	*Artemisia nilagirica*	80	250	20.76
2	*Drynaria propinqua*	40	50	7.58
3	*Elaeagnus* sp.	70	730	37.24
4	*Gaultheria fragrantissima*	70	160	15.97

Sl. No.	Species name	Monsoon		
5	*Prinsepia utilis*	60	420	24.24
6	*Rhus chinensis*	80	250	20.76
7	*Rubus ellipticus*	110	440	32.13
8	*Rubus hypergynus*	50	80	10.13
9	*Rubus rugosus*	60	70	11.18
10	*Spiraea canescens*	80	230	20.01
Total		**700**	**2680**	**200**

Fr.–Frequency percentage, Dn.–Density (ha^{-1}), IVI–Importance value index

Appendix II. 3.141: Frequency, density and IVI of herbs in Nyamjang chu catchment area

Sl. No.	Species name	Monsoon		
		Fr.	Dn.	IVI
1	*Anemone vitifolia*	15	14000	3.92
2	*Aconogonum* sp.	15	15000	4.06
3	*Anaphalis triplinervis*	75	73000	20.02
4	*Bistorta* sp.	50	50000	13.54
5	*Blechnum* sp.	10	10000	2.71
6	*Cannabis* sativa	35	33000	9.19
7	*Cypsella bursa–pastoris*	40	37000	10.41
8	*Cirsium* sp.	5	5000	1.35
9	*Corydalis rutifolia*	15	11000	3.50
10	*Cynoglossum furcatum*	5	5000	1.35
11	*Fagopyrum dibotrys*	30	26000	7.56
12	*Fragaria indica*	25	24000	6.63
13	*Galium asperifolium*	10	10000	2.71
14	*Geranium nepalense*	20	19000	5.27
15	*Gerardinia diversifolia*	20	18000	5.13
16	*Gnaphalium* sp.	5	4000	1.21
17	*Heracleum* sp.	10	7000	2.28
18	*Houttuynia cordata*	25	21000	6.20
19	*Hydrocotyl javanica*	40	37000	10.41
20	*Lepisorus nudus*	10	9000	2.57
21	*Mazus surculosus*	5	4000	1.21
22	*Oenanthe* sp.	10	8000	2.43
23	*Oxalis corniculata*	20	18000	5.13
24	*Periploca* sp.	25	25000	6.77
25	*Pilea lineolatum*	10	9000	2.57
26	*Piptanthus nepalensis*	15	15000	4.06
27	*Plantago major*	15	13000	3.78
28	*Poa annua*	60	56000	15.68
29	*Polygonum capitatum*	60	58000	15.96
30	*Potentilla fulgens*	5	4000	1.21
31	*Pouzolzia* sp.	25	23000	6.49
32	*Pteridium aequilinum*	10	8000	2.43
33	*Rosa sericea*	15	12000	3.64
34	*Rumex nepalensis*	10	9000	2.57
35	*Solanum viarum*	10	6000	2.14
36	*Stellaria* sp.	5	3000	1.07
37	*Viola* sp.	5	6000	1.49
38	*Stellaria* sp.	5	5000	1.35
Total		**770**	**710000**	**200**

Fr.–Frequency percentage, Dn.–Density (ha^{-1}), IVI–Importance value index

Appendix II. 3.142: Dominant and Co–dominant species determined on the basis of IVI/density values of species in the plant communities at Nyamjang chu

Community components	Barrage	Powerhouse	Catchment area
Tree species: *			
Dominant	*Alnus nepalensis*	*Macaranga denticulata*	*Alnus nepalensis*
Co–Dominant	*Rhododendron maddeni*	*Alnus nepalensis*	*Erythirina arborescens*
Shrub species: * *			
Dominant	*Rubus ellipticus*	*Artemesia nilagirica*	*Eleagnus* sp.
Co–Dominant	*Elaeagnus* sp.	*Eleagnus* sp.	*Rubus ellipticus*
Herb species: **			
Dominant	*Galinsoga parviflora*	*Rumex nepalensis*	*Anaphalis triplinervis*
Co–Dominant	*Polygonum capitatum*	*Rubia cordifolia*	*Polygonum capitatum*

* Dominance based on IVI; ** Dominance based on density

Appendix II. 3.143: List of plant species recorded from Paikangrong chu HEP site

Sl. No.	Species name	Family
TREES		
1	*Alnus nepalensis*	Betulaceae
2	*Lindera* sp.	Lauraceae
3	*Pinus wallichiana*	Pinaceae
4	*Quercus griffithii*	Fagaceae
5	*Quercus serrata*	Fagaceae
6	*Rhododendron arboreum*	Ericaceae
7	*Schima wallichii*	Theaceae
SHRUBS		
8	*Artemisia nilagirica*	Asteraceae
9	*Berberis* sp.	Berberidaceae
10	*Buddleja asiatica*	Buddlejaceae
11	*Coriaria nepalensis*	Coriariaceae
12	*Elaeagnus* sp.	Elaegnaceae
13	*Neillia thyrsiflora*	Rosaceae
14	*Rubus ellipticus*	Rosaceae
15	*Triumfetta rhomboidea*	Malvaceae
16	*Viburnum foetidum*	Adoxaceae
HERBS		
17	*Ageratum conyzoides*	Asteraceae
18	*Bidens pilosa*	Asteraceae
19	*Centella asiatica*	Apiaceae
20	*Crassocephalum crepidioides*	Asteraceae
21	*Cyanoglossum* sp.	Boraginaceae
22	*Drymaria cordata*	Caryophyllaceae
23	*Equisetum* sp.	Equisetaceae
24	*Eupatorium adenophorum*	Asteraceae
25	*Fragaria nubicola*	Rosaceae
26	*Galinsoga parviflora*	Asteraceae
27	*Galium rotundifolium*	Rubiaceae
28	*Geranium* sp.	Geraniaceae
29	*Oxalis corniculata*	Oxalidaceae
30	*Peperomia tetraphylla*	Piperaceae
31	*Plantago major*	Plantaginaceae
32	*Rumex nepalensis*	Polygonaceae
33	*Viola pilosa*	Violaceae
CLIMBERS		
34	*Clematis* sp.	Ranunculaceae
35	*Ficus* sp.	Moraceae
36	*Hedera nepalensis*	Araliaceae
37	*Periploca* sp.	Periplocaceae
38	*Rubia cordifolia*	Rubiaceae
39	*Smilax* sp.	Smilacaceae
40	*Stephania glandulifera*	Menispermaceae
ORCHIDS		
41	*Bulbophyllum* sp.	Orchidaceae
42	*Calanthe tricarinata*	Orchidaceae
43	*Coelogynae* sp.	Orchidaceae
44	*Cymbidium* sp.	Orchidaceae
45	*Dendrobium* sp.	Orchidaceae
46	*Oberonia* sp.	Orchidaceae
47	*Pleione praecox*	Orchidaceae
48	*Vanda* sp.	Orchidaceae
PTERIDOPHYTES		
49	*Dicranopteris linearis*	Dicranopteridaceae
50	*Dynaria quercifolia*	Drynariaceae
51	*Lepisorus nudus*	Polypodiaceae
52	*Lycopodium clavatum*	Lycopodiaceae
53	*Polypodium* sp.	Polypodiaceae
54	*Pteris* sp.	Pteridiaceae
55	*Pyrrosia nuda*	Polypodiaceae
56	*Selaginella* sp.	Selaginellaceae
57	*Vittaria elongata*	Vittariaceae
BRYOPHYTES		
58	*Desmotheca* sp.	Orthotrichaceae
59	*Diphyscium* sp.	Buxbaumiaceae
60	*Lyellia* sp.	Polytrichaceae

Sl. No.	Species name	Family
LICHENS		
61	*Cladonia* sp.	Cladoniaceae
62	*Graphis* sp.	Graphidaceae
63	*Lobaria* sp.	Lobariaceae
64	*Parmelia* sp.	Parmeliaceae
65	*Stereocaulon* sp.	Stereocaulaceae
66	*Sticta* sp.	Lobariaceae
67	*Usnea* sp.	Parmeliaceae
FUNGI		
68	*Boletus reticulatus*	Boletaceae
69	*Coprinus disseminatus*	Agaricaceae
70	*Daldinia concentrica*	Xylariaceae
71	*Fomes pinicola*	Fomitopsidaceae
72	*Hygrocybe miniata*	Hygrophoraceae
73	*Lactarius rubidus*	Russulaceae
74	*Polyporus arcularius*	Polyporaceae
75	*Poria monticola*	Polyporaceae
76	*Tremella mesenterica*	Tremellaceae

Appendix II. 3.144: Different groups of plant species present at Paikangrong chu HEP site

Sl. No.	Species name Barrage and Powerhouse	Family	Sl. No.	Species name Catchment area	Family
CLIMBERS					
1	*Clematis Bucchaniana*	Ranunculaceae	1	*Clematis Bucchaniana*	Ranunculaceae
2	*Cissampelos* sp.	Menispermaceae	2	*Clematis* sp.	Ranunculaceae
3	*Clematis* sp.	Ranunculaceae	3	*Ficus* sp.	Dioscoreaceae
4	*Ficus* sp.	Dioscoreaceae	4	*Hedera nepalensis*	Araliaceae
5	*Hedera nepalensis*	Araliaceae	5	*Herpetospermun pedunculosum*	Araliaceae
6	*Herpetospermun pedunculosum*	Araliaceae	6	*Holboellia latifolia*	Lardizabalaceae
7	*Holboellia latifolia*	Lardizabalaceae	7	*Periploca* sp.	Periplocaceae
8	*Periploca* sp.	Periplocaceae	8	*Rubia cordifolia*	Rubiaceae
9	*Philadephus tomentosus*	Hydrangeaceae	9	*Smilax aspera*	Smilacaceae
10	*Rubia cordifolia*	Rubiaceae	10	*Thladiantha cordifolia*	Cucubitaceae
11	*Smilax aspera*	Smilacaceae			
12	*Stephania glandulifera*	Menispermaceae			
13	*Thladiantha cordifolia*	Cucubitaceae			
ORCHIDS					
1	*Bulbophyllum* sp.	Orchidaceae	1	*Bulbophyllum* sp.	Orchidaceae
2	*Calanthe tricarinata*	Orchidaceae	2	*Calanthe tricarinata*	Orchidaceae
3	*Coelogynae* sp.	Orchidaceae	3	*Coelogynae* sp.	Orchidaceae
4	*Cymbidium* sp.	Orchidaceae	4	*Cymbidium* sp.	Orchidaceae
5	*Dendrobium* sp.	Orchidaceae	5	*Dendrobium* sp.	Orchidaceae
6	*Oberonia* sp.	Orchidaceae	6	*Oberonia* sp.	Orchidaceae
PTERIDOPHYTES					
1	*Botrychium* sp.	Ophioglossaceae	1	*Botrychium* sp.	Ophioglossaceae
2	*Dicranopteris linearis*	Dicranopteridaceae	2	*Dicranopteris linearis*	Dicranopteridaceae
3	*Dryopteris wallichiana*	Dryopteridaceae	3	*Dryopteris wallichiana*	Dryopteridaceae
4	*Lepisorus* sp.	Polypodiaceae	4	*Lepisorus* sp.	Polypodiaceae
5	*Polypodium* sp.	Polypodiaceae	5	*Polypodium* sp.	Polypodiaceae
6	*Pteris* sp.	Pteridiaceae	6	*Pteris vittata*	Pteridaceae
7	*Pteris vittata*	Pteridaceae	7	*Pyrrosia nuda*	Polypodiaceae
8	*Pyrrosia nuda*	Polypodiaceae	8	*Selaginella* sp.	Selaginellaceae
9	*Selaginella* sp.	Selaginellaceae			
BRYOPHYTES					
1	*Desmotheca* sp.	Orthotrichaceae	1	*Funaria* sp.	Funariaceae
2	*Diphyscium* sp.	Buxbaumiaceae	2	*Lyellia* sp.	Polytrichaceae
3	*Funaria* sp.	Funariaceae	3	*Marchantia* sp.	Marchantiaceae
4	*Lyellia* sp.	Polytrichaceae	4	*Plagiobryum* sp.	Bryaceae
5	*Marchantia* sp.	Marchantiaceae			
6	*Plagiobryum* sp.	Bryaceae			
LICHENS					
1	*Alectoria* sp.	Alectoriaceae	1	*Alectoria* sp.	Alectoriaceae
2	*Cladonia* sp.	Cladoniaceae	2	*Cladonia* sp.	Cladoniaceae
3	*Graphis* sp.	Graphidaceae	3	*Graphis* sp.	Graphidaceae
4	*Lobaria* sp.	Lobariaceae	4	*Lobaria* sp.	Lobariaceae
5	*Parmelia* sp.	Parmeliaceae	5	*Parmelia* sp.	Parmeliaceae

Sl. No.	Species name Barrage and Powerhouse	Family	Sl. No.	Species name Catchment area	Family
6	*Parmotrema* sp.	Parmeliaceae	6	*Stereocaulon* sp.	Stereocaulaceae
7	*Pseudocyphellaria* sp.	Lobariaceae	7	*Sticta* sp.	Lobariaceae
8	*Stereocaulon* sp.	Stereocaulaceae	8	*Teloschistes* sp.	Teloschistaceae
9	*Sticta* sp.	Lobariaceae	9	*Usnea* sp.	Parmeliaceae
10	*Teloschistes* sp.	Teloschistaceae			
11	*Usnea* sp.	Parmeliaceae			
FUNGI					
	Barrage		1	*Boletus reticulatus*	Boletaceae
1	*Boletus reticulatus*	Boletaceae	2	*Coprinus disseminatus*	Agaricaceae
2	*Coprinus disseminatus*	Agaricaceae	3	*Daldinia concentrica*	Xylariaceae
3	*Daldinia concentrica*	Xylariaceae	4	*Fomes pinicola*	Fomitopsidaceae
4	*Fomes pinicola*	Fomitopsidaceae	5	*Lactarius rubidus*	Russulaceae
5	*Hygrocybe miniata*	Hygrophoraceae	6	*Polyporus arcularius*	Polyporaceae
6	*Lactarius rubidus*	Russulaceae	7	*Poria monticola*	Polyporaceae
7	*Polyporus arcularius*	Polyporaceae	8	*Tremella mesenterica*	Tremellaceae
8	*Poria monticola*	Polyporaceae			
9	*Tremella mesenterica*	Tremellaceae			
	Powerhouse				
1	*Boletus reticulatus*	Boletaceae			
2	*Coprinus disseminatus*	Agaricaceae			
3	*Daldinia concentrica*	Xylariaceae			
4	*Fomes pinicola*	Fomitopsidaceae			
5	*Lactarius rubidus*	Russulaceae			
6	*Poria monticola*	Polyporaceae			
7	*Tremella mesenterica*	Tremellaceae			

Appendix II. 3.145: Frequency, density, basal area and IVI for tree species in Paikangrong chu barrage site

Sl. No.	Species name	Post–monsoon				Monsoon				Winter			
		Fr.	Dn.	BA	IVI	Fr.	Dn.	BA	IVI	Fr.	Dn.	BA	IVI
1	*Quercus serrata*	60	130	3.73	76.87	60	130	3.73	76.87	60	130	3.73	76.87
2	*Alnus nepalensis*	40	80	1.39	40.85	40	80	1.39	40.85	40	80	1.39	40.85
3	*Schima wallichii*	40	60	1.33	36.30	40	60	1.33	36.30	40	60	1.33	36.30
4	*Rhododendron arboreum*	50	70	1.59	43.81	50	70	1.59	43.81	50	70	1.59	43.81
5	*Pinus wallichiana*	40	50	1.98	39.68	40	50	1.98	39.68	40	50	1.98	39.68
6	*Quercus griffithii*	50	80	1.81	47.65	50	80	1.81	47.65	50	80	1.81	47.65
7	*Lindera* sp.	20	30	0.26	14.83	20	30	0.26	14.83	20	30	0.26	14.83
Total		**300**	**500**	**12.08**	**300**	**300**	**500**	**12.08**	**300**	**300**	**500**	**12.08**	**300**

Fr.–Frequency percentage, Dn.–Density (ha^{-1}), BA–Basal area ($m^2\ ha^{-1}$), IVI–Importance value index

Appendix II. 3.146: Frequency, density and IVI of shrubs and herbs in Paikangrong chu barrage site

Sl. No.	Species name	Post–monsoon			Monsoon			Winter		
		Fr.	Dn.	IVI	Fr.	Dn.	IVI	Fr.	Dn.	IVI
Shrub										
1	*Artemesia nilagarica*	36	688	47.34	36	688	47.34	36	688	47.34
2	*Buddleja asiatica*	44	272	31.33	44	272	31.33	44	272	31.33
3	*Coriaria nepalensis*	40	272	29.64	40	272	29.64	40	272	29.64
4	*Elaeagnus*	20	112	13.70	20	112	13.70	20	112	13.70
5	*Neilia thyrsiflora*	16	176	14.99	16	176	14.99	16	176	14.99
6	*Rubus ellipticus*	48	368	37.50	48	368	37.50	48	368	37.50
7	*Triumfetta rhomboidea*	16	128	12.75	16	128	12.75	16	128	12.75
8	*Viburnum foetidum*	16	128	12.75	16	128	12.75	16	128	12.75
	Total	**236**	**2144**	**200**	**236**	**2144**	**200**	**236**	**2144**	**200**
Herb										
1	*Ageratum conyzoides*	24	5200	13.11	36	9200	14.30	28	6400	12.72
2	*Bidens pilosa*	16	3200	8.45	32	7200	12.03	20	4000	8.60
3	*Centella asiatica*				20	4800	7.73	16	3600	7.22
4	*Crassocephalum crepidioides*	24	4000	11.79	24	3600	7.77	16	4400	7.90
5	*Cyanoglossum* sp.	28	6400	15.66	28	5600	10.04	24	7600	12.69
6	*Drymaria cordata*	24	9600	17.93	20	13600	13.86	40	20400	27.70
7	*Equisetum* sp.				24	4800	8.61	24	5200	10.66
8	*Eupatorium adenophorum*	28	6400	15.66	16	3600	6.02	16	3600	7.22
9	*Fragaria nubicola*	44	13600	28.49	44	18000	22.18	48	17200	27.08
10	*Galinsoga parviflora*	20	6000	12.75	24	12800	14.18	28	10000	15.77

Sl. No.	Species name	Post–monsoon			Monsoon			Winter		
11	*Galium rotundifolium*	20	5200	11.87	32	6800	11.75	12	3200	5.84
12	*Geranium* sp.	28	4000	13.03	52	7600	16.70	16	3600	7.22
13	*Plantago major*	32	14400	25.67	28	14800	16.45	36	10800	18.53
14	*Peperomia tetraphylla*	16	2800	8.01	12	3200	4.86	16	4400	7.90
15	*Oxalis corniculata*	20	10400	17.58	56	26800	30.94	36	12000	19.54
16	*Viola pilosa*				8	1200	2.59	8	1600	3.44
	Total	**324**	**91200**	**200.00**	**456**	**143600**	**200.00**	**384**	**118000**	**200.00**

Fr.–Frequency percentage, Dn.–Density (ha^{-1}), IVI–Importance value index

Appendix II. 3.147: Frequency, density, basal area and IVI for tree species in Paikangrong chu powerhouse site

Sl. No.	Species name	Post–monsoon				Monsoon				Winter			
		Fr.	**Dn.**	**BA**	**IVI**	**Fr.**	**Dn.**	**BA**	**IVI**	**Fr.**	**Dn.**	**BA**	**IVI**
1	*Quercus serrata*	70	120	2.82	87.80	70	120	2.82	87.80	70	120	2.82	87.80
2	*Alnus nepalensis*	40	80	1.14	47.89	40	80	1.14	47.89	40	80	1.14	47.89
3	*Schima wallichii*	30	50	1.60	41.39	30	50	1.60	41.39	30	50	1.60	41.39
4	*Rhododendron arboreum*	40	90	1.91	58.28	40	90	1.91	58.28	40	90	1.91	58.28
5	*Pinus wallichiana*	20	40	1.01	28.51	20	40	1.01	28.51	20	40	1.01	28.51
6	*Quercus griffithii*	30	50	1.10	36.13	30	50	1.10	36.13	30	50	1.10	36.13
Total		**230**	**430**	**9.58**	300	**230**	**430**	**9.58**	300	**230**	**430**	**9.58**	300

Fr.–Frequency percentage, Dn.–Density (ha^{-1}), BA–Basal area ($m^2\ ha^{-1}$), IVI–Importance value index

Appendix II. 3.148: Frequency, density and IVI of shrubs in Paikangrong chu powerhouse site

Sl. No.	Species name	Post–monsoon			Monsoon			Winter		
		Fr.	**Dn.**	**IVI**	**Fr.**	**Dn.**	**IVI**	**Fr.**	**Dn.**	**IVI**
1	*Artemesia nilagarica*	44	624	46.35	44	624	46.35	44	624	46.35
2	*Buddleja asiatica*	28	192	20.00	28	192	20.00	28	192	20.00
3	*Coriaria nepalensis*	44	368	34.50	44	368	34.50	44	368	34.50
4	*Elaeagnus*	48	96	23.49	48	96	23.49	48	96	23.49
5	*Neilia thyrsiflora*	20	144	14.60	20	144	14.60	20	144	14.60
6	*Rubus ellipticus*	40	544	41.06	40	544	41.06	40	544	41.06
7	*Viburnum foetidum*	28	192	20.00	28	192	20.00	28	192	20.00
Total		**252**	**2160**	**200**	**252**	**2160**	**200**	**252**	**2160**	**200**

Fr.–Frequency percentage, Dn.–Density (ha^{-1}), IVI–Importance value index

Appendix II. 3.149: Frequency, density and IVI of herbs in Paikangrong chu powerhouse site

Sl. No.	Species name	Post–monsoon			Monsoon			Winter		
		Fr.	**Dn.**	**IVI**	**Fr.**	**Dn.**	**IVI**	**Fr.**	**Dn.**	**IVI**
1	*Ageratum conyzoides*	28	8000	15.80	36	11200	14.42	28	8000	16.08
2	*Bidens pilosa*	20	4000	9.65	16	3200	5.25	16	4000	8.67
3	*Centella asiatica*				36	12400	15.19			
4	*Crassocephalum crepidioides*	16	6800	11.16	48	10000	16.02	20	6800	12.47
5	*Cyanoglossum* sp.	44	20000	31.95	32	9200	12.32	28	6000	14.28
6	*Drymaria cordata*	20	6000	11.56	48	23200	24.59	48	20000	33.24
7	*Equisetum* sp.				20	4400	6.83	16	4000	8.67
8	*Eupatorium adenophorum*	16	3600	8.10	12	2800	4.20	16	3600	8.31
9	*Fragaria nubicola*	48	14000	27.36	48	17200	20.69	32	14000	22.76
10	*Galinsoga parviflora*	28	10000	17.72	36	13200	15.71	28	10000	17.89
11	*Galium rotundifolium*	12	2400	5.79	20	4800	7.09	12	3600	7.05
12	*Geranium* sp.	8	1600	3.86	12	2800	4.20	8	1600	3.98
13	*Oxalis corniculata*	36	12000	21.96	40	15200	17.81	16	12000	15.89
14	*Peperomia tetraphylla*	4	1200	2.31	16	3200	5.25	8	2400	4.70
15	*Plantago major*	28	5600	13.50	36	8800	12.86	20	5600	11.38
16	*Rumex nepalensis*	36	9200	19.28	48	12400	17.58	20	9200	14.63
Total		**344**	**104400**	**200**	**504**	**154000**	**200**	**316**	**110800**	**200**

Fr.–Frequency percentage, Dn.–Density (ha^{-1}), IVI–Importance value index

Appendix II. 3.150: Frequency, density, basal area and IVI for tree species in Paikangrong chu catchment area

Sl. No.	Species name	Post–monsoon				Monsoon				Winter			
		Fr.	**Dn.**	**BA**	**IVI**	**Fr.**	**Dn.**	**BA**	**IVI**	**Fr.**	**Dn.**	**BA**	**IVI**
1	*Quercus serrata*	40	70	1.29	60.82	40	70	1.29	60.82	40	70	1.29	60.82
2	*Alnus nepalensis*	40	60	0.61	48.04	40	60	0.61	48.04	40	60	0.61	48.04
3	*Rhododendron arboreum*	50	120	2.86	103.73	50	120	2.86	103.73	50	120	2.86	103.73
4	*Pinus wallichiana*	20	30	0.92	32.90	20	30	0.92	32.90	20	30	0.92	32.90
5	*Quercus griffithii*	40	50	1.27	54.52	40	50	1.27	54.52	40	50	1.27	54.52
Total		**190**	**330**	**6.96**	**300**	**190**	**330**	**6.96**	**300**	**190**	**330**	**6.96**	**300**

Fr.–Frequency percentage, Dn.–Density (ha^{-1}), BA–Basal area ($m^2\ ha^{-1}$), IVI–Importance value index

Appendix II. 3.151: Frequency, density and IVI of shrubs in Paikangrong chu catchment area

Sl. No.	Species name	Post–monsoon			Monsoon			Winter		
		Fr.	Dn.	IVI	Fr.	Dn.	IVI	Fr.	Dn.	IVI
1	*Artemesia nilagirica*	48	656	52.79	48	656	52.79	48	656	52.79
2	*Berberis* sp.	20	176	17.52	20	176	17.52	20	176	17.52
3	*Buddleja asiatica*	32	240	26.12	32	240	26.12	32	240	26.12
4	*Coriaria nepalensis*	32	272	27.59	32	272	27.59	32	272	27.59
5	*Neillia thyrsiflora*	20	208	18.99	20	208	18.99	20	208	18.99
6	*Rubus ellipticus*	48	512	46.17	48	512	46.17	48	512	46.17
7	*Triumfetta rhomboidea*	12	112	10.81	12	112	10.81	12	112	10.81
Total		**212**	**2176**	**200**	**212**	**2176**	**200**	**212**	**2176**	**200**

Fr.–Frequency percentage, Dn.–Density (ha^{-1}), IVI–Importance value index

Appendix II. 3.152: Frequency, density and IVI of herbs in Paikangrong chu catchment area

Sl. No.	Species name	Post–monsoon			Monsoon			Winter		
		Fr.	Dn.	IVI	Fr.	Dn.	IVI	Fr.	Dn.	IVI
1	*Ageratum conyzoides*	32	8.25	17.89	24	8400	14.17	20	6400	14.13
2	*Bidens pilosa*	16	4.37	9.19	20	5200	10.16	16	3200	9.27
3	*Centella asiatica*	16	2.43	7.25	16	3600	7.61	36	12800	26.79
4	*Crassocephalum crepidioides*	16	4.37	9.19	28	6000	13.04			
5	*Cyanoglossum* sp.	24	5.83	13.05	28	7200	14.14	24	8400	17.72
6	*Drymaria cordata*				36	19200	27.32	32	15200	27.87
7	*Oxalis corniculata*	32	20.39	30.03						
8	*Eupatorium adenophorum*	36	8.25	19.10	44	9200	20.28	20	7200	14.98
9	*Fragaria nubicola*	52	17.96	33.62	52	17200	29.79	44	19200	36.52
10	*Galinsoga parviflora*	28	7.28	15.72	28	8400	15.25	16	6400	12.66
11	*Galium rotundifolium*	20	4.85	10.88	24	6400	12.33	12	3600	8.23
12	*Geranium* sp.	12	2.43	6.04	20	3600	8.69	8	1600	4.64
13	*Drymaria cordata*	32	9.22	18.86	28	9200	15.98	28	7200	17.92
14	*Peperomia tetraphylla*	16	4.37	9.19	24	5200	11.23	16	3200	9.27
Total		**332**	**100.00**	**200**	**372**	**108800**	**200**	**272**	**94400**	**200**

Fr.–Frequency percentage, Dn.–Density (ha^{-1}), IVI–Importance value index

Appendix II. 3.153: Dominant and Co–dominant species determined on the basis of IVI/density values of species in the plant communities at Paikangrong chu site

Community components	Barrage	Powerhouse	Catchment area
Tree species*			
Dominant	*Quercus serrata*	*Quercus serrata*	*Rhododendron arboreum*
Co–Dominant	*Quercus griffithii*	*Rhododendron arboreum*	*Quercus serrata*
Shrub species*			
Dominant	*Artemesia nilagarica*	*Artemesia nilagarica*	*Artemesia nilagarica*
Co–Dominant	*Rubus ellipticus*	*Rubus ellipticus*	*Rubus ellipticus*
Herb species**			
i. Post monsoon season			
Dominant	*Fragaria nubicola*	*Cynoglossum* sp.	*Fragaria nubicola*
Co–Dominant	*Plantago major*	*Fragaria nubicola*	*Oxalis corniculata*
ii. Monsoon season			
Dominant	*Oxalis corniculata*	*Drymaria cordata*	*Fragaria nubicola*
Co–Dominant	*Fragaria nubicola*	*Fragaria nubicola*	*Drymaria cordata*
iii. Winter			
Dominant	*Drymaria cordata*	*Drymaria cordata*	*Fragaria nubicola*
Co–Dominant	*Fragaria nubicola*	*Fragaria nubicola*	*Drymaria cordata*

* Dominance based on IVI; ** Dominance based on density

Appendix II. 3.154: List of plant species recorded from Jaswantgarh Stage–I HEP site

Sl. No.	SPECIES NAME	FAMILY
TREES		
1	*Abies densa*	Pinaceae
2	*Acer* sp.	Aceraceae
3	*Juniperus* sp.	Cupressaceae
4	*Rhododendron* sp.	Ericaceae
5	*Salix* sp.	Salicaceae
SHRUBS		
6	*Berberis* sp.	Berberidaceae
7	*Periscaria chinensis*	Polygonaceae

Sl. No.	SPECIES NAME	FAMILY
8	*Rhododendron nivale*	Ericaceae
9	*Rhododendron* sp.	Ericaceae
10	*Rosa* sp.	Rosaceae
HERBS		
11	*Aconogonon alpinum*	Polygonaceae
12	*Elsholtzia strobilifera*	Lamiaceae
13	*Fragaria* sp.	Rosaceae
14	*Galinsoga parviflora*	Asteraceae
15	*Galium* sp.	Rubiaceae
16	*Meconopsis* sp.	Papaveraceae
17	*Polygonum* sp.	Polygonaceae
18	*Primula denticulata*	Primulaceae
19	*Primula* sp.	Primulaceae
20	*Rumex nepalensis*	Polygonaceae
21	*Swertia paniculata*	gentianaceae
22	*Swertia* sp.	gentianaceae
ORCHIDS		
23	*Bulbophyllum* sp.	Orchidaceae
PTERIDOPHYTES		
24	*Equisetum diffusum*	Equisetaceae
25	*Lycopodium japonicum*	Lycopodiaceae
26	*Selaginella indica*	Selaginellaceae
LICHENS		
27	*Cladia* sp.	Cladoniaceae
28	*Stereocaulon* sp.	Stereocaulaceae
29	*Usnea dasaea*	Parmeliaceae

Appendix II. 3.155: Different groups of plant species present at Jaswantgarh Stage–I HEP site

Sl. No.	Species name Barrage and Powerhouse	Family	Sl. No.	Species name Catchment area	Family
ORCHIDS					
1	*Bulbophyllum* sp.	Orchidaceae	1	*Bulbophyllum* sp.	Orchidaceae
PTERIDOPHYTES					
1	*Equisetum diffusum*	Equisetaceae	1	*Lycopodium japonicum*	Lycopodiaceae
2	*Lycopodium japonicum*	Lycopodiaceae	2	*Selaginella indica*	Selaginellaceae
3	*Selaginella indica*	Selaginellaceae			
LICHENS					
1	*Cladia* sp.	Cladoniaceae	1	*Cladia* sp.	Cladoniaceae
2	*Stereocaulon* sp.	Stereocaulaceae	2	*Stereocaulon* sp.	Stereocaulaceae
3	*Usnea dasaea*	Parmeliaceae	3	*Usnea dasaea*	Parmeliaceae

Appendix II. 3.156: Species list of macro–fungi recorded from barrage and powerhouse sites of Paikangrong chu

Species	Family	Species	Family
Barrage		**Powerhouse**	
Boletus reticulatus	Boletaceae	*Boletus reticulatus*	Boletaceae
Coprinus disseminatus	Agaricaceae	*Coprinus disseminatus*	Agaricaceae
Daldinia concentrica	Xylariaceae	*Daldinia concentrica*	Xylariaceae
Fomes pinicola	Fomitopsidaceae	*Fomes pinicola*	Fomitopsidaceae
Hygrocybe miniata	Hygrophoraceae	*Lactarius rubidus*	Russulaceae
Lactarius rubidus	Russulaceae	*Poria monticola*	Polyporaceae
Polyporus arcularius	Polyporaceae	*Tremella mesenterica*	Tremellaceae
Poria monticola	Polyporaceae		
Tremella mesenterica	Tremellaceae		
Catchment area			
Boletus reticulatus	Boletaceae		
Coprinus disseminatus	Agaricaceae		
Daldinia concentrica	Xylariaceae		
Fomes pinicola	Fomitopsidaceae		
Lactarius rubidus	Russulaceae		
Polyporus arcularius	Polyporaceae		
Poria monticola	Polyporaceae		
Tremella mesenterica	Tremellaceae		

Appendix II. 3.157: Frequency, density, basal area and IVI for tree species in Jaswantgarh Stage–I barrage site

Sl. No.	Species name	Post–monsoon				Monsoon				Winter			
		Fr.	**Dn.**	**BA**	**IVI**	**Fr.**	**Dn.**	**BA**	**IVI**	**Fr.**	**Dn.**	**BA**	**IVI**
1	*Abies densa*	70	130	3.7	147.7	70	130	3.7	147.7	70	130	3.7	147.7
2	*Acer* sp.	40	40	0.8	49.7	40	40	0.8	49.7	40	40	0.8	49.7
3	*Juniperus* sp.	30	30	0.7	39.3	30	30	0.7	39.3	30	30	0.7	39.3
4	*Rhododendron* sp.	20	20	1.0	33.9	20	20	1.0	33.9	20	20	1.0	33.9
5	*Salix* sp.	30	20	0.3	29.4	30	20	0.3	29.4	30	20	0.3	29.4
Total		**190**	**240**	**6.6**	**300**	**190**	**240**	**6.6**	**300**	**190**	**240**	**6.6**	**300**

Fr.–Frequency percentage, Dn.–Density (ha^{-1}), BA–Basal area ($m^2\ ha^{-1}$), IVI–Importance value index

Appendix II. 3.158: Frequency, density and IVI of shrubs in Jaswantgarh Stage–I barrage site

Sl. No.	Species name	Post–monsoon			Monsoon			Winter		
		Fr.	**Dn.**	**IVI**	**Fr.**	**Dn.**	**IVI**	**Fr.**	**Dn.**	**IVI**
1	*Berberis* sp.	24	304	37	24	304	37	24	304	37
2	*Rhododendron nivale*	56	592	79	56	592	79	56	592	79
3	*Rhododendron* sp.	40	464	59	40	464	59	40	464	59
4	*Rosa* sp.	20	144	24	20	144	24	20	144	24
Total		**140**	**1504**	**200**	**140**	**1504**	**200**	**140**	**1504**	**200**

Fr.–Frequency percentage, Dn.–Density (ha^{-1}), IVI–Importance value index

Appendix II. 3.159: Frequency, density and IVI of herbs in Jaswantgarh Stage–I barrage site

Sl. No.	Species name	Post–monsoon			Monsoon			Winter		
		Fr.	**Dn.**	**IVI**	**Fr.**	**Dn.**	**IVI**	**Fr.**	**Dn.**	**IVI**
1	*Aconogonon alpinum*	24	9600	30.82	20	4800	12.26	24	3600	23.57
2	*Elsholtzia strobilifera*	28	8400	30.77	28	4400	14.34	28	10000	41.31
3	*Fragaria* sp.				32	6800	18.55			
4	*Galinsoga parviflora*	44	13600	49.10	36	13600	28.12	24	6800	31.19
5	*Galium* sp.				24	6800	15.98			
6	*Meconopsis* sp.				16	3600	9.52			
7	*Polygonum* sp.	20	6000	21.98	44	18000	36.05	24	6800	31.19
8	*Primula* sp.	40	11200	42.48	68	15600	40.82	32	8400	40.00
9	*Swertia* sp.				16	3600	9.52			
10	*Rumex nepalensis*	28	5200	24.85	28	4800	14.83	28	6400	32.74
Total		**184**	**54000**	**200.00**	**312**	**82000**	**200.00**	**160**	**42000**	**200.00**

Fr.–Frequency percentage, Dn.–Density (ha^{-1}), IVI–Importance value index

Appendix II. 3.160: Frequency, density, basal area and IVI for tree species in Jaswantgarh Stage–I powerhouse site

Sl. No.	Species name	Post–monsoon				Monsoon				Winter			
		Fr.	**Dn.**	**BA**	**IVI**	**Fr.**	**Dn.**	**BA**	**IVI**	**Fr.**	**Dn.**	**BA**	**IVI**
1	*Abies densa*	50	120	2.38	150.78	50	120	2.38	150.78	50	120	2.38	150.78
2	*Acer* sp.	30	30	0.62	51.73	30	30	0.62	51.73	30	30	0.62	51.73
3	*Juniperus* sp.	20	20	0.56	37.59	20	20	0.56	37.59	20	20	0.56	37.59
4	*Rhododendron* sp.	10	10	0.82	30.66	10	10	0.82	30.66	10	10	0.82	30.66
5	*Salix* sp.	20	20	0.18	29.24	20	20	0.18	29.24	20	20	0.18	29.24
Total		**130**	**200**	**4.55**	**300**	**130**	**200**	**4.55**	**300**	**130**	**200**	**4.55**	**300**

Fr.–Frequency percentage, Dn.–Density (ha^{-1}), BA–Basal area ($m^2\ ha^{-1}$), IVI–Importance value index

Appendix II. 3.161: Frequency, density and IVI of shrubs in Jaswantgarh Stage–I powerhouse site

Sl. No.	Species name	Post–monsoon			Monsoon			Winter		
		Fr.	**Dn.**	**IVI**	**Fr.**	**Dn.**	**IVI**	**Fr.**	**Dn.**	**IVI**
1	*Berberis* sp.	20	176	30.80	20	176	30.80	20	176	30.80
2	*Periscaria chinensis*	28	336	50.58	28	336	50.58	28	336	50.58
3	*Rhododendron nivale*	40	432	68.26	40	432	68.26	40	432	68.26
4	*Rhododendron* sp.	20	144	28.13	20	144	28.13	20	144	28.13
5	*Rosa* sp.	16	112	22.24	16	112	22.24	16	112	22.24
Total		**124**	**1200**	**200.00**	**124**	**1200**	**200.00**	**124**	**1200**	**200.00**

Fr.–Frequency percentage, Dn.–Density (ha^{-1}), IVI–Importance value index

Appendix II. 3.162: Frequency, density and IVI of herbs in Jaswantgarh Stage–I powerhouse site

Sl. No.	Species name	Post–monsoon			Monsoon			Winter		
		Fr.	Dn.	IVI	Fr.	Dn.	IVI	Fr.	Dn.	IVI
1	*Aconogonon alpinum*	20	4000	28.29	16	4400	13.39	16	3600	20.25
2	*Elsholtzia strobilifera*	36	10800	61.40	32	7600	24.81	48	17200	76.44
3	*Fragaria* sp.				36	9200	28.98			
4	*Galinsoga parviflora*	24	8400	44.42	24	6800	20.41	28	10000	44.51
5	*Galium* sp.				28	5200	19.32			
6	*Meconopsis* sp.				28	4800	18.66			
7	*Rumex nepalensis*	24	7600	42.09	28	5200	19.32	20	4400	25.07
8	*Primula denticulata*				44	12400	37.32			
9	*Primula* sp.	16	3600	23.80				28	5600	33.73
10	*Swertia* sp.				24	5200	17.78			
Total		**120**	**34400**	**200**	**260**	**60800**	**200**	**140**	**40800**	**200**

Fr.–Frequency percentage, Dn.–Density (ha^{-1}), IVI–Importance value index

Appendix II. 3.163: Frequency, density, basal area and IVI for tree species in Jaswantgarh Stage–I catchment area

Sl. No.	Species name	Post–monsoon				Monsoon				Winter			
		Fr.	Dn.	BA	IVI	Fr.	Dn.	BA	IVI	Fr.	Dn.	BA	IVI
1	*Abies densa*	50	110	1.72	156.83	50	110	1.72	156.83	50	110	1.72	156.83
2	*Acer* sp.	20	20	0.67	48.18	20	20	0.67	48.18	20	20	0.67	48.18
3	*Juniperus* sp.	10	10	0.61	30.68	10	10	0.61	30.68	10	10	0.61	30.68
4	*Rhododendron* sp.	10	10	0.87	37.09	10	10	0.87	37.09	10	10	0.87	37.09
5	*Salix* sp.	10	20	0.23	27.27	10	20	0.23	27.27	10	20	0.23	27.27
Total		**100**	**170**	**4.09**	**300**	**100**	**170**	**4.09**	**300**	**100**	**170**	**4.09**	**300**

Fr.–Frequency percentage, Dn.–Density (ha^{-1}), BA–Basal area ($m^2\ ha^{-1}$), IVI–Importance value index

Appendix II. 3.164: Frequency, density and IVI of shrubs in Jaswantgarh Stage–I catchment area

Sl. No.	Species name	Post–monsoon			Monsoon			Winter		
		Fr.	Dn.	IVI	Fr.	Dn.	IVI	Fr.	Dn.	IVI
1	*Berberis* sp.	20	128	29.24	20	128	29.24	20	128	29.24
2	*Rhododendron nivale*	48	448	84.61	48	448	84.61	48	448	84.61
3	*Rhododendron* sp.	40	272	60.12	40	272	60.12	40	272	60.12
4	*Rosa* sp.	16	128	26.01	16	128	26.01	16	128	26.01
Total		**124**	**976**	**200**	**124**	**976**	**200**	**124**	**976**	**200**

Fr.–Frequency percentage, Dn.–Density (ha^{-1}), IVI–Importance value index

Appendix II. 3.165: Frequency, density and IVI of herbs in Jaswantgarh Stage–I catchment area

Sl. No.	Species name	Post–monsoon			Monsoon			Winter		
		Fr.	Dn.	IVI	Fr.	Dn.	IVI	Fr.	Dn.	IVI
1	*Aconogonon alpinum*	32	6800	33.52	16	4400	11.94	36	6800	35.50
2	*Elsholtzia strobilifera*	52	10400	52.96	48	17200	41.09	36	7200	36.38
3	*Fragaria* sp.				44	12400	33.24			
4	*Galinsoga parviflora*	40	8400	41.67	36	7200	23.32	16	3600	17.06
5	*Galium* sp.				16	3600	10.89			
6	*Meconopsis* sp.				36	4800	20.16			
7	*Rumex nepalensis*	20	4800	22.22	16	4400	11.94	48	17200	65.33
8	*Primula denticulata*				40	20400	42.23			
9	*Primula* sp.	36	12800	49.63				24	7600	30.45
10	*Swertia paniculata*				8	1600	5.18	16	2800	15.29
Total		**180**	**43200**	**200**	**260**	**76000**	**200**	**176**	**45200**	**200**

Fr.–Frequency percentage, Dn.–Density (ha^{-1}), IVI–Importance value index

Appendix II. 3.166: Dominant and co–dominant species determined on the basis of IVI/density values of species in the plant communities at Jaswantgarh

Community components	Barrage	Powerhouse	Catchment area
Tree species: *			
Dominant	*Abies densa*	*Abies densa*	*Abies densa*
Co–Dominant	*Acer* sp.	*Acer* sp.	*Acer* sp.
Shrub species: **			
Dominant	*Rhododendron nivale*	*Rhododendron nivale*	*Rhododendron nivale*
Co–Dominant	*Rhododendron* sp.	*Periscaria chinensis*	*Rhododendron* sp.
Herb species: **			
i. Post monsoon season			

Community components	Barrage	Powerhouse	Catchment area
Dominant	*Galinsoga parviflora*	*Elsholtzia strobilifera*	*Elsholtzia strobilifera*
Co–Dominant	*Primula* sp.	*Galinsoga parviflora*	*Primula* sp.
ii. Monsoon season			
Dominant	*Primula denticulata*	*Fragaria* sp.	*Primula denticulata*
Co–Dominant	*Polygonum* sp.	*Primula denticulata*	*Elsholtzia strolifera*
iii. Winter season			
Dominant	*Elsholtzia strolifera*	*Elsholtzia strolifera*	Rumex nepalensis
Co–Dominant	*Primula denticulata*	*Galinsoga parviflora*	*Elsholtzia strolifera*

* Dominance based on IVI; ** Dominance based on density

Appendix II. 3.167: Probable list of Herpetofauna that could occur in Tawang district (Common to all the sites)

Sl. No.	Name	Altitude in m	Project area	IUCN Red List (2013)	WPA 1972 Schedule
A.	**Amphibians**				
I.	**Megophryidae**				
1	Mountain Horned Frog (*Xenophrys parva*)	150–2700	*	LC	
II.	**Dicroglossidae**				
2	Indian Skipping /Skittering Frog (*Euphlyctis cyanophlyctis*)	40–2500	*	LC	IV
III.	**Rhacophoridae**				
3	Twin–spotted Tree Frog (*Rhacophorus bipunctatus*)	80–2200	*	LC	
4	Large Tree Frog (*Rhacophorus maximus*)	80–2000	*	LC	
IV.	**Salamandridae**				
5	Himalayan Newt (*Tylototriton verrucosus*)	1300–2727	*		
B.	**Reptiles**				
V.	**Agamidae**				
6	Jerdon's Forest Lizard (*Calotes jerdoni*)	500–2500	*	DD	
7	Indian Garden Lizard (*Calotes versicolor*)	Up to 2700	*	NT	IV
VI.	**Geckkonidae**				
8	Flat–tailed Gecko (*Hemidactylus Platyurus*)	50–2500	*	LC	IV
VII.	**Anuguidae**				
9	Asian Glass Lizard (*Ophisaurus gracilis*)	500–2500	*	NT	
C.	**Snakes**				
VIII.	**Elapidae**				
10	Banded Krait (*Bungarus fasciatus*)	40–2300	*	NT	IV
11	King Cobra (*Ophiophagus hannah*)	60–2700	*	NT	II
IX.	**Viperidae**				
12	Jerdon's Pit Viper (*Protobothrops jerdonii*)	1300–2700	*		IV
D.	**Turtles and Tortoises**				
X.	**Geoemydidae**				
13	Keeled Box Turtle (*Cuora mouhotii*)	200–2500	*	EN	

Secondary source Ahmed *et al.* (2009)–Project Area: * possibility of occurrence, EN–Endangered, NT–Near threatened, LC–Least concern, DD–Data deficient.

Appendix II. 3.168: Check list and ecological status of birds recorded in the Tsa chu–I project area

Sl. No.	Family and species name	Common name	FS	MS	CS	PM	M	W	Overall
1	**Accipitridae**								
1	*Milvus migrans lineatus*	Black (eared) Kite	C	WV	LC	–	1	0	1
2	*Gyps himalayensis*	Himalayan Vulture	C	WV	LC	–	0	2	2
2	**Apodidae**								
3	*Apus pacificus*	Pacific Swift	I	BV	LC	–	9	0	9
3	**Certhiidae**								
4	*Certhia familiaris mandellii*	Eurasian Treecreeper	I	R	LC	–	6	0	6
5	*Certhia nepalensis*	Rusty–flanked Treecreeper	I	R	LC	–	2	0	2
4	**Columbidae**								
6	*Streptopelia orientalis*	Oriental Turtle–dove	G	WV	LC	–	0	2	2
5	**Corvidae**								
7	*Dendrocitta formosae*	Grey Treepie	O	R	LC	–	0	1	1
8	*Corvus culminatus*	Large–billed Crow	O	R	LC	–	0	2	2
9	*Nucifraga caryocatactes*	Spotted Nutcracker	Nu	R	LC	–	0	4	4
10	*Urocissa flavirostris*	Yellow–bellied Blue Magpie	C	R	LC	–	2	0	2
6	**Emberizidae**								
11	*Emberiza godlewskii*	Godlewski's Bunting	G	R	LC	–	0	9	9
7	**Estrildidae**								
12	*Lon chura punctulata*	Scaly–breasted Munia	G	R	LC	–	1	0	1

Sl. No.	Family and species name	Common name	FS	MS	CS	PM	M	W	Overall
8	**Fringillidae**								
13	*Carpodacus nepalensis*	Dark–breasted Rosefinch	G	R	LC	–	13	2	15
14	*Carpodacus edwardsii*	Dark–rumped Rosefinch	G	R	LC	–	15	0	15
15	*Leucosticte nemoricola*	Plain Mountain–finch	G	R	LC	–	42	0	42
16	*Mycerobas carnipes*	White–winged Grosbeak	G	R	LC	–	0	5	5
9	**Hirundinidae**								
17	*Delichon dasypus*	Asian House Martin	I	BV	LC	–	113	0	113
10	**Motacillidae**								
18	*Anthus hodgsoni hodgsoni*	Olive–backed Pipit	I	R	LC	–	13	0	13
11	**Muscicapidae**								
19	*Phoenicurus ochruros*	Black Redstart	I	WV	LC	–	1	0	1
20	*Phoenicurus frontalis*	Blue–fronted Redstart	I	BV	LC	–	1	2	3
21	*Saxicola torquatus indicus*	Common Stonechat	I	BV	LC	–	2	0	2
22	*Muscicapa ferruginea*	Ferruginous Flycatcher	I	BV	LC	–	1	0	1
23	*Saxicola ferreus*	Grey Bushchat	I	R	LC	–	1	0	1
24	*Ficidula strophiata*	Orange–gorgeted Flycatcher	I	R	LC	–	5	0	5
25	*Rhyacornis fuliginosa*	Plumbeous Water–redstart	I	R	LC	–	2	0	2
26	*Chaimarrornis leucocephalus*	White–capped River–chat	I	R	LC	–	2	0	2
12	**Paridae**								
27	*Parus ater*	Coal Tit	I	R	LC	–	2	0	2
28	*Parus monticolus*	Green–backed Tit	I	R	LC	–	2	0	2
29	*Parus rubidiventris*	Rufous–vented Tit	I	R	LC	–	3	0	3
13	**Prunellidae**								
30	*Prunella rubeculoides*	Robin Accentor	I	WV	LC	–	0	2	2
31	*Prunella strophiata*	Rufous–breasted Accentor	I	R	LC	–	0	12	12
14	**Sylviidae**								
32	*Phylloscopus reguloides*	Blyth's Leaf–Warbler	I	WV	LC	–	12	0	12
33	*Phylloscopus pulcher*	Buff–barred Warbler	I	BV	LC	–	3	0	3
34	*Seicercus castaniceps*	Chestnut–crowned Warbler	I	BV	LC	–	2	0	2
35	*Phylloscopus coronatus*	Eastern Crowned Warbler	I	WV	LC	–	5	0	5
36	*Seicercus burkii*	Green–crowned Warbler	I	BV	LC	–	3	0	3
37	*Phylloscopus trochiloides*	Greenish Warbler	I	WV	LC	–	4	0	4
38	*Phylloscopus maculipennis*	Grey–faced Leaf–warbler	I	R	LC	–	3	0	3
39	*Cettia brunnifrons*	Grey–sided Bush–Warbler	I	BV	LC	–	3	0	3
40	*Phylloscopus chloronotus*	Lemon–rumped Leaf Warbler	I	BV	LC	–	4	0	4
15	**Timaliidae**								
41	*Trochalopteron imbricatum*	Bhutan Laughingthrush	I	R	LC	–	0	4	4
42	*Trochalopteron affine*	Black–faced Laughingthrush	I	R	LC	–	3	5	8
43	*Trochalopteron erthrocephalum*	Red–headed Launghingthrush	I	R	LC	–	1	4	5
16	**Troglodytidae**								
44	*Troglodytes troglodytes*	Winter Wren	I	R	LC	–	1	0	1
17	**Turdidae**								
45	*Myophonus caeruleus*	Blue Whistling–thrush	I	R	LC	–	4	0	4
46	*Turdus albocinctus*	White–collared Blackbird	I	R	LC	–	0	1	1

FS: Aq–Aquatic Feeder, C–Carnivores, F–Frugivore, G–Granivore, I–Insectivore, N–Nectarivore, Nc–Nucivore, O–Omnivore, P–Piscivore; MS–Migratory Status–BV–Breeding Visitor, IR–Isolated Record, R–Resident, WV–Winter Visitor; CS–Conservation status–IUCN Red List and WPA–1972 Schedule: VU–Vulnerable, LC–Least Concern; PM–Post monsoon, M–Monsoon, W–Winter

Appendix II. 3.169: List of possible mammalian fauna of the Tawang region and contribution of species reported in the Tsa chu–I project area

Sl. No.	Common name	Scientific name	SPA	Conservation status	
				IUCN	**WPA**
	Primates				
1	Arunachal macaque	*Macaca munzala*		EN	–
2	Assamese macaque	*M. assamensis*		NT	II
3	Capped langur	*Trachypithecus pileatus*		VU	I
4	Slow loris	*Nycticebus coucang*		VU	I
	Ungulates				
5	Barking deer	*Muntiacus muntjak*		LC	III
6	Bharal	*Pseudois nayaur*		LC	I
7	Chinese goral	*Nemorhaedus caudatus*		VU	III
8	Himalayan goral	*N. goral*	*	NT	III
9	Musk deer	*Mos chus* sp.		EN	–
10	Sambar	*Cervus unicolor*		VU	III
11	Serow	*N. sumatraensis*			
12	Wild pig	*Sus scrofa*	*	LC	III

Sl. No.	Common name	Scientific name	SPA	Conservation status	
	Carnivores				
13	Common leopard	*Panthera pardus*		NT	I
14	Jungle Cat	*Felis Chaus*	*	LC	II
15	Dhole	*Cuon alpinus*		EN	II
16	Himalayan black bear	*Ursus thibetanus*		VU	II
17	Himalayan palm civet	*Paguma larvata*	*	LC	II
18	Leopard cat	*Prionailurus bengalensis*		LC	–
19	Otter	*Lutra* sp.		VU	–
20	Red panda	*Ailurus fulgens*		VU	I
21	Snow leopard	*Uncia uncia*		EN	I
22	Yellow–throated marten	*Martes flavigula*	*	LC	II
	Rodents				
23	Hairy–footed flying squirrel	*Belomys pearsonii*		DD	II
24	Himalayan marmot	*Marmota himalayana*		LC	II
25	Himalayan striped squirrel	*Tamiops macclellandi*	*	LC	–
26	Orange–bellied Himalayan squirrel	*Dremomys lokriah*		LC	–
	*Hoary–bellied Himalayan Squirrel	*Callosciurus pygerythrus*		LC	–
27	Porcupine	*Hystrix* sp.		LC	IV
	*Chesnut rat	*Niviventer fluvescens*		LC	V
	Lagomorphs				
28	Large–eared pika	*Ochotona macrotis*		LC	–
29	Moupin pika	*Ochotona thibetana*		LC	–
	29 species		**6 species R% 20.68%**		

Data Source: 1–Mishra et al. 2006, SPA–Species of Project Area, * Additional species reported during the study

Appendix II. 3.170: Status of birds at Tsa chu–I barrage and powerhouse site

Sl. No.	Family and species name	Common name	FS	MS	CS	No. of birds recorded
1	**Accipitridae**					
1	*Milvus migrans lineatus*	Black (eared) Kite	C	WV	LC	1
2	**Columbidae**					
2	*Streptopelia orientalis*	Oriental Turtle–dove	G	WV	LC	1
3	**Corvidae**					
3	*Urocissa flavirostris*	Yellow–bellied Blue Magpie	C	R	LC	1
4	**Motacillidae**					
4	*Anthus hodgsoni hodgsoni*	Olive–backed Pipit	I	R	LC	8
5	*Motacilla cinerea*	Grey Wagtail	I	WV	LC	2
5	**Muscicapidae**					
6	*Chaimarrornis leucocephalus*	White–capped River–chat	I	R	LC	2
7	*Ficidula strophiata*	Orange–gorgeted Flycatcher	I	R	LC	3
8	*Phoenicurus ochruros*	Black Redstart	I	WV	LC	5
9	*Rhyacornis fuliginosa*	Plumbeous Water–redstart	I	R	LC	7
6	**Paridae**					
10	*Parus monticolus*	Green–backed Tit	I	R	LC	2
7	**Sylviidae**					
11	*Cettia major*	Large/Chest–crowned Bush Warbler	I	R	LC	6
12	*Phylloscopus fuligiventer*	Smoky Leaf–warbler	I	WV	LC	2
13	*Phylloscopus pulcher*	Orange–barred Leaf–warbler	I	WV	LC	1
14	*Phylloscopus reguloides*	Blyth's Leaf–warbler	I	WV	LC	4
15	*Phylloscopus trochiloides*	Greenish Warbler	I	WV	LC	5
16	*Seicercus burkii*	Green–crowned Warbler	I	BV	LC	5
17	*Seicercus castaniceps*	Chestnut–crowned Warbler	I	BV	LC	2
8	**Timaliidae**					
18	*Trochalopteron affine*	Black–faced Laughing thrush	I	R	LC	5
9	**Troglodytidae**					
19	*Troglodytes troglodytes*	Winter Wren	I	R	LC	1
10	**Turdidae**					
20	*Monticola solitarius*	Blue Rock–thrush	I	WV	LC	1
21	*Myophonus caeruleus*	Blue Whistling–thrush	I	R	LC	2

FS–Foraging Status: C–Carnivores, G–Granivore, I–Insectivore; MS–Migratory Status–BV–Breeding Visitor, R–Resident, WV–Winter Visitor; CS–Conservation status–IUCN Red List and WPA–1972 Schedule: LC–Least Concern

Appendix II. 3.171: Check List and ecological status of birds recorded in the proposed Tsa chu–I Lower HEP area

Sl. No.	Family and species name	Common name	FS	MS	CS	PM	M	W	Overall
1	**Accipitridae**								
1	*Milvus migrans lineatus*	Black (eared) Kite	C	WV	LC		2	0	2
2	*Gyps himalayensis*	Himalayan Vulture	C	WV	LC		0	2	2
2	**Apodidae**								
3	*Apus pacificus*	Pacific Swift	I	BV	LC		9	0	9
3	**Columbidae**								
4	*Streptopelia orientalis*	Oriental Turtle–dove	G	WV	LC		1	2	3
5	*Columba leuconota*	Snow Pigeon	G	R	LC		76	0	76
4	**Corvidae**								
6	*Dendrocitta formosae*	Grey Treepie	O	R	LC		0	1	1
7	*Corvus culminatus*	Large–billed Crow	O	R	LC		0	2	2
8	*Nucifraga caryocatactes*	Spotted Nutcracker	Nu	R	LC		0	4	4
9	*Urocissa flavirostris*	Yellow–bellied Blue Magpie	C	R	LC		1	0	1
5	**Emberizidae**								
10	*Emberiza godlewskii*	Godlewski's Bunting	G	R	LC		0	9	9
6	**Estrildidae**								
11	*Lon chura punctulata*	Scaly–breasted Munia	G	R	LC		1	0	1
7	**Fringillidae**								
12	*Carpodacus nepalensis*	Dark–breasted Rosefinch	G	R	LC		0	2	2
13	*Mycerobas carnipes*	White–winged Grosbeak	G	R	LC		0	5	5
8	**Hirundinidae**								
14	*Delichon dasypus*	Asian House Martin	I	BV	LC		113	0	113
9	**Motacillidae**								
15	*Motacilla cinerea*	Grey Wagtail	I	WV	LC		2	0	2
16	*Anthus hodgsoni hodgsoni*	Olive–backed Pipit	I	R	LC		13	0	13
17	*Motacilla alba alboides*	White Wagtail	I	WV	LC		3	0	3
10	**Muscicapidae**								
18	*Phoenicurus ochruros*	Black Redstart	I	WV	LC		6	0	6
19	*Phoenicurus frontalis*	Blue–fronted Redstart	I	BV	LC		0	2	2
20	*Saxicola ferreus*	Grey Bushchat	I	R	LC		1	0	1
21	*Ficidula strophiata*	Orange–gorgeted Flycatcher	I	R	LC		7	0	7
22	*Rhyacornis fuliginosa*	Plumbeous Water–redstart	I	R	LC		12	0	12
23	*Chaimarrornis leucocephalus*	White–capped River–chat	I	R	LC		2	0	2
11	**Paridae**								
24	*Parus monticolus*	Green–backed Tit	I	R	LC		2	0	2
12	**Prunellidae**								
25	*Prunella rubeculoides*	Robin Accentor	I	WV	LC		0	2	2
26	*Prunella strophiata*	Rufous–breasted Accentor	I	R	LC		0	12	12
13	**Sylviidae**								
27	*Phylloscopus reguloides*	Blyth's Leaf–Warbler	I	WV	LC		10	0	10
28	*Phylloscopus pulcher*	Buff–barred Warbler	I	BV	LC		1	0	1
29	*Seicercus castaniceps*	Chestnut–crowned Warbler	I	BV	LC		2	0	2
30	*Phylloscopus coronatus*	Eastern Crowned Warbler	I	WV	LC		6	0	6
31	*Seicercus burkii*	Green–crowned Warbler	I	BV	LC		5	0	5
32	*Phylloscopus trochiloides*	Greenish Warbler	I	WV	LC		10	0	10
33	*Phylloscopus maculipennis*	Grey–faced Leaf–warbler	I	R	LC		2	0	2
34	*Cettia brunnifrons*	Grey–sided Bush–Warbler	I	BV	LC		1	0	1
35	*Cettia flavolivacea*	Himalayan' Aberrant Bush–warbler	I	WV	LC		2	0	2
36	*Phylloscopus fuligiventer*	Smoky Leaf–warbler	I	WV	LC		2	0	2
14	**Timaliidae**								
37	*Trochalopteron imbricatum*	Bhutan Laughingthrush	I	R	LC		0	4	4
38	*Trochalopteron affine*	Black–faced Laughingthrush	I	R	LC		5	5	10
39	*Trachalopteron erthrocephalum*	Red–headed Launghingthrush	I	R	LC		1	4	5
15	**Troglodytidae**								
40	*Troglodytes troglodytes*	Winter Wren	I	R	LC		1	0	1
16	**Turdidae**								
41	*Monticola solitarius*	Blue Rock–thrush	I	WV	LC		1	0	1
42	*Myophonus caeruleus*	Blue Whistling–thrush	I	R	LC		7	0	7
43	*Turdus albocinctus*	White–collared Blackbird	I	R	LC		0	1	1

FS: Aq–Aquatic Feeder, C–Carnivores, F–Frugivore, G–Granivore, I–Insectivore, N–Nectarivore, Nc–Nucivore, O–Omnivore, P–Piscivore; MS–Migratory Status–BV–Breeding Visitor, IR–Isolated Record, R–Resident, WV–Winter Visitor; CS–Conservation status–IUCN Red List and WPA–1972 Schedule: VU–Vulnerable, LC–Least Concern; PM–Post monsoon, M–Monsoon, W–Winter

Appendix II. 3.172: Status of mammalian fauna of the Tawang region and contribution of species reported in the Tsa chu–I Lower HEP area

Sl. No.	Common name	Scientific name	SPA	Conservation status	
				IUCN	WPA
	Primates				
1	Arunachal macaque	*Macaca munzala*		EN	–
2	Assamese macaque	*M. assamensis*		NT	II
3	Capped langur	*Trachypithecus pileatus*		VU	I
4	Slow loris	*Nycticebus coucang*		VU	I
	Ungulates				
5	Barking deer	*Muntiacus muntjak*		LC	III
6	Bharal	*Pseudois nayaur*		LC	I
7	Chinese goral	*Nemorhaedus caudatus*		VU	III
8	Himalayan goral	*N. goral*	*	NT	III
9	Musk deer	*Mos chus* sp.		EN	–
10	Sambar	*Cervus unicolor*		VU	III
11	Serow	*N. sumatraensis*			
12	Wild pig	*Sus scrofa*	*	LC	III
	Carnivores				
13	Common leopard	*Panthera pardus*		NT	I
14	Jungle Cat	*Felis Chaus*	*	LC	II
15	Dhole	*Cuon alpinus*		EN	II
16	Himalayan black bear	*Ursus thibetanus*		VU	II
17	Himalayan palm civet	*Paguma larvata*		LC	II
18	Leopard cat	*Prionailurus bengalensis*		LC	–
19	Otter	*Lutra* sp.		VU	–
20	Red panda	*Ailurus fulgens*		VU	I
21	Snow leopard	*Uncia uncia*		EN	I
22	Yellow–throated marten	*Martes flavigula*	*	LC	II
	Rodents				
23	Hairy–footed flying squirrel	*Belomys pearsonii*		DD	II
24	Himalayan marmot	*Marmota himalayana*		LC	II
25	Himalayan striped squirrel	*Tamiops macclellandi*	*	LC	–
26	Orange–bellied Himalayan squirrel	*Dremomys lokriah*	*	LC	–
	*Hoary–bellied Himalayan Squirrel	*Callosciurus pygerythrus*		LC	–
27	Porcupine	*Hystrix* sp.		LC	IV
	*Chesnut rat	*Niviventer fluvescens*		LC	V
	Lagomorphs				
28	Large–eared pika	*Ochotona macrotis*		LC	–
29	Moupin pika	*Ochotona thibetana*		LC	–
	29 species		6 species R% 20.68%		

Data Source: 1–Mishra et al 2006, SPA–Species of Project Area, * Additional species reported during the Study

Appendix II. 3.173: Status of birds at barrage and powerhouse site of Tsa chu–I Lower

Sl. No.	Family and species name	Common name	FS	MS	CS	No. of birds recorded
1	**Apodidae**					
1	*Aerodramus brevirostris*	Himalayan Swiftlet	I	R	LC	5
2	**Certhiidae**					
2	*Certhia nepalensis*	Rusty–flanked Treecreeper	I	R	LC	3
3	**Dicruridae**					
3	*Dicrurus leucophaeus*	Ashy Drongo	O	WV	LC	4
4	*Dicrurus macrocercus*	Black Drongo	O	R	LC	2
4	**Fringillidae**					
5	*Fringilla montifringilla*	Brambling	I	IR	LC	4
5	**Hirundinidae**					
6	*Delichon dasypus*	Asian House Martin	I	BV	LC	3
7	*Delichon nipalense*	Nepal House Martin	I	R	LC	8
6	**Leiothrichidae**					
8	*Heterophasia capistrata*	Rufous Sibia	O	R	LC	4
7	**Muscicapidae**					
9	*Enicurus scouleri*	Little Forktail	I	R	LC	1
10	*Phoenicurus frontalis*	Blue–fronted Redstart	I	BV	LC	4
11	*Phoenicurus hodgsoni*	Hodgson's Redstart	I	WV	LC	1
8	**Nectariniidae**					
12	*Aethopyga nipalensis*	Green–tailed Sunbird	N	R	LC	2
9	**Paridae**					

Sl. No.	Family and species name	Common name	FS	MS	CS	No. of birds recorded
13	*Melanochlora sultanea*	Sultan Tit	I	R	LC	2
14	*Parus dichrous*	Grey–crested Tit	I	R	LC	2
15	*Parus monticolus*	Green–backed Tit	I	R	LC	2
10	**Prunellidae**					
16	*Prunella immaculata*	Maroon–backed Accentor	I	WV	LC	9
11	**Pycnonotidae**					
17	*Hemixos flavala*	Ashy Bulbul	O	R	LC	1
18	*Hypsipetes leucocephalus*	Himalayan Black Bulbul	O	R	LC	2
12	**Stenostiridae**					
19	*Culicicapa ceylonensis*	Grey–headed Canary–flycatcher	I	BV	LC	2
13	**Sylviidae**					
20	*Phylloscopus coronatus*	Eastern Crowned Warbler	I	WV	LC	3
21	*Phylloscopus reguloides*	Blyth's Leaf–warbler	I	WV	LC	1
22	*Phylloscopus trochiloides*	Greenish Warbler	I	WV	LC	1
23	*Phylloscopus xanthoschistos*	Grey–hooded Warbler	I	R	LC	4
14	**Timaliidae**					
24	*Trachalopteron erthrocephalum*	Red–headed Launghingthrush	I	R	LC	3
25	*Trochalopteron affine*	Black–faced Laughingthrush	I	R	LC	3
26	*Trochalopteron imbricatum*	Bhutan Laughing Thrush	I	R	LC	5
15	**Turdidae**					
27	*Monticola cinclorhyn chus*	Blue–headed Rock–thrush	I	BV	LC	2
28	*Myophonus caeruleus*	Blue Whistling–thrush	I	R	LC	4

FS–Foraging Status: I–Insectivore, N–Nectarivore, Nc–Nucivore, O–Omnivore, MS–Migratory Status–BV–Breeding Visitor, IR–Isolated Record, R–Resident, WV–Winter Visitor; CS–Conservation status–IUCN Red List and WPA–1972 Schedule: LC–Least Concern

Appendix II. 3.174: Ecological status of birds recorded in the Tsa chu–II HEP area

Sl. No.	Family and species name	Common name	FS	MS	CS	PM	M	W	Overall
1	**Accipitridae**								
1	*Gyps himalayensis*	Himalayan Vulture	C	WV	LC	–	0	2	2
2	**Apodidae**								
2	*Aerodramus brevirostris*	Himalayan Swiftlet	I	R	LC	–	22	0	22
3	**Certhiidae**								
3	*Certhia familiaris mandellii*	Eurasian Treecreeper	I	R	LC	–	2	0	2
4	**Columbidae**								
4	*Streptopelia orientalis*	Oriental Turtle–dove	G	WV	LC	–	0	2	2
5	**Corvidae**								
5	*Dendrocitta formosae*	Grey Treepie	O	R	LC	–	0	1	1
6	*Corvus culminatus*	Large–billed Crow	O	R	LC	–	0	2	2
7	*Nucifraga caryocatactes*	Spotted Nutcracker	Nu	R	LC	–	0	4	4
6	**Dicaeidae**								
8	*Dicaeum ignipectus*	Fire–breasted Flowerpecker	N	R	LC	–	2	0	2
7	**Emberizidae**								
9	*Emberiza godlewskii*	Godlewski's Bunting	G	R	LC	–	0	9	9
8	**Fringillidae**								
10	*Carpodacus nepalensis*	Dark–breasted Rosefinch	G	R	LC	–	3	2	5
11	*Mycerobas carnipes*	White–winged Grosbeak	G	R	LC	–	0	5	5
9	**Hirundinidae**								
12	*Delichon dasypus*	Asian House Martin	I	BV	LC	–	52	0	52
13	*Delichon nipalense*	Nepal House–martin	I	R	LC	–	32	0	32
10	**Leiothrichidae**								
14	*Heterophasia capistrata*	Rufous Sibia	O	R	LC	–	9	0	9
11	**Motacillidae**								
15	*Anthus hodgsoni hodgsoni*	Olive–backed Pipit	I	R	LC	–	5	0	5
12	**Muscicapidae**								
16	*Phoenicurus ochruros*	Black Redstart	I	WV	LC	–	2	0	2
17	*Phoenicurus frontalis*	Blue–fronted Redstart	I	BV	LC	–	0	2	2
18	*Muscicapa sibirica*	Dark–sided Flycatcher	I	BV	LC	–	1	0	1
19	*Ficidula strophiata*	Orange–gorgeted Flycatcher	I	R	LC	–	3	0	3
20	*Rhyacornis fuliginosa*	Plumbeous Water–redstart	I	R	LC	–	5	0	5
21	*Chaimarrornis leucocephalus*	White–capped River–chat	I	R	LC	–	3	0	3
13	**Paridae**								
22	*Parus monticolus*	Green–backed Tit	I	R	LC	–	5	0	5
14	**Prunellidae**								
23	*Prunella rubeculoides*	Robin Accentor	I	WV	LC	–	0	2	2

Sl. No.	Family and species name	Common name	FS	MS	CS	PM	M	W	Overall
24	*Prunella strophiata*	Rufous–breasted Accentor	I	R	LC	–	0	12	12
15	**Stenostiridae**								
25	*Culicicapa ceylonensis*	Grey–headed Canary–flycatcher	I	BV	LC	–	1	0	1
16	**Sylviidae**								
26	*Phylloscopus reguloides*	Blyth's Leaf–Warbler	I	WV	LC	–	9	0	9
27	*Phylloscopus pulcher*	Buff–barred Warbler	I	BV	LC	–	4	0	4
28	*Seicercus castaniceps*	Chestnut–crowned Warbler	I	BV	LC	–	1	0	1
29	*Phylloscopus coronatus*	Eastern Crowned Warbler	I	WV	LC	–	2	0	2
30	*Seicercus burkii*	Green–crowned Warbler	I	BV	LC	–	2	0	2
31	*Phylloscopus trochiloides*	Greenish Warbler	I	WV	LC	–	8	0	8
32	*Seicercus poliogenys*	Grey–cheeked Warbler	I	R	LC	–	2	0	2
33	*Phylloscopus maculipennis*	Grey–faced Leaf–warbler	I	R	LC	–	3	0	3
34	*Phylloscopus xanthoschistos*	Grey–hooded Warbler	I	R	LC	–	2	0	2
35	*Phylloscopus chloronotus*	Lemon–rumped Leaf Warbler	I	BV	LC	–	3	0	3
36	*Cettia fortipes*	Strong–footed Bush–warbler	I	R	LC	–	1	0	1
17	**Timaliidae**								
37	*Trochalopteron imbricatum*	Bhutan Laughingthrush	I	R	LC	–	4	4	8
38	*Trochalopteron affine*	Black–faced Laughingthrush	I	R	LC	–	3	5	8
39	*Trochalopteron erthrocephalum*	Red–headed Launghingthrush	I	R	LC	–	5	4	9
40	*Yuhina flavicollis*	Whiskered Yuhina	I	R	LC	–	3	0	3
18	**Troglodytidae**								
41	*Troglodytes troglodytes*	Winter Wren	I	R	LC	–	1	0	1
19	**Turdidae**								
42	*Myophonus caeruleus*	Blue Whistling–Thrush	I	R	LC	–	5	0	5
43	*Turdus albocinctus*	White–collared Blackbird	I	R	LC	–	0	1	1

FS: Aq–Aquatic Feeder, C–Carnivores, F–Frugivore, G–Granivore, I–Insectivore, N–Nectarivore, Nc–Nucivore, O–Omnivore, P–Piscivore; MS–Migratory Status–BV–Breeding Visitor, IR–Isolated Record, R–Resident, WV–Winter Visitor; CS–Conservation status–IUCN Red List and WPA–1972 Schedule: VU–Vulnerable, LC–Least Concern; PM–Post monsoon, M–Monsoon, W–Winter

Appendix II. 3.175: List of possible mammalian fauna of the Tawang region and contribution of species reported in the Tsa chu–II HEP area

Sl. No.	Common name	Scientific name	SPA	Conservation status	
				IUCN	WPA
	Primates				
1	Arunachal macaque	*Macaca munzala*		EN	–
2	Assamese macaque	*M. assamensis*		NT	II
3	Capped langur	*Trachypithecus pileatus*		VU	I
4	Slow loris	*Nycticebus coucang*		VU	I
	Ungulates				
5	Barking deer	*Muntiacus muntjak*	*	LC	III
6	Bharal	*Pseudois nayaur*		LC	I
7	Chinese goral	*Nemorhaedus caudatus*		VU	III
8	Himalayan goral	*N. goral*	*	NT	III
9	Musk deer	*Moschus* sp.		EN	–
10	Sambar	*Cervus unicolor*		VU	III
11	Serow	*N. sumatraensis*			
12	Wild pig	*Sus scrofa*	*	LC	III
	Carnivores				
13	Common leopard	*Panthera pardus*		NT	I
14	Jungle Cat	*Felis Chaus*	*	LC	II
15	Dhole	*Cuon alpinus*		EN	II
16	Himalayan black bear	*Ursus thibetanus*		VU	II
17	Himalayan palm civet	*Paguma larvata*		LC	II
18	Leopard cat	*Prionailurus bengalensis*		LC	–
19	Otter	*Lutra* sp.		VU	–
20	Red panda	*Ailurus fulgens*		VU	I
21	Snow leopard	*Uncia uncia*		EN	I
22	Yellow–throated marten	*Martes flavigula*	*	LC	II
	Rodents				
23	Hairy–footed flying squirrel	*Belomys pearsonii*		DD	II
24	Himalayan marmot	*Marmota himalayana*		LC	II
25	Himalayan striped squirrel	*Tamiops macclellandi*	*	LC	–
26	Orange–bellied Himalayan squirrel	*Dremomys lokriah*		LC	–
	*Hoary–bellied Himalayan Squirrel	*Callosciurus pygerythrus*	*	LC	–
27	Porcupine	*Hystrix* sp.		LC	IV

Sl. No.	Common name	Scientific name	SPA	Conservation status	
	*Chesnut rat	*Niviventer fluvescens*		LC	V
	Lagomorphs				
28	Large–eared pika	*Ochotona macrotis*		LC	–
29	Moupin pika	*Ochotona thibetana*		LC	–
	29 species		**7 species R% 24.13%**		

Data Source: 1–Mishra et al 2006, SPA–Species of Project Area, * Additional species reported during the study

Appendix II. 3.176: Status of birds at Tsa chu–II barrage and powerhouse site

Sl. No.	Family and species name	Common name	FS	MS	CS	No. of birds recorded
1	**Accipitridae**					
1	*Accipiter gentilis*	Northern Goshawk	C	WV	LC	2
2	*Hieraaetus fasciatus*	Bonelli's Eagle	C	R	LC	1
2	**Campephagidae**					
3	*Pericrocotus ethologus*	Long–tailed Minvet	I	BV	LC	2
4	*Pericrocotus speciosus*	Scarlet Minivet	I	R	LC	5
3	**Cinclidae**					
5	*Cinclus cinclus*	White–throated Dipper	I	R	LC	1
4	**Leiothrichidae**					
6	*Heterophasia capistrata*	Rufous Sibia	O	R	LC	2
5	**Muscicapidae**					
7	*Cyomis magnirostris*	Large Blue Flycatcher	I	BV	LC	1
8	*Ficedula hodgsonii*	Slaty–backed Flycatcher	I	WV	LC	1
6	**Paridae**					
9	*Parus ater*	Coal Tit	I	R	LC	1
7	**Stenostiridae**					
10	*Chelidorhynx hypoxantha*	Yellow–bellied Fantail	I	R	LC	2
8	**Sylviidae**					
11	*Phylloscopus maculipennis*	Grey–faced Leaf–warbler	I	R	LC	7
12	*Phylloscopus xanthoschistos*	Grey–hooded Warbler	I	R	LC	2
9	**Timaliidae**					
13	*Actinodura egertoni*	Rusty–fronted Barwing	I	R	LC	7
14	*Alcippe dubia*	Rusty–capped Fulvetta	I	R	LC	2
15	*Dryonastes caerulatus*	Grey–sided Laughingthrush	I	R	LC	6
16	*Minla ignotincta*	Red–tailed Minla	I	R	LC	5
17	*Yuhina flavicollis*	Whiskered Yuhina	I	R	LC	5
10	**Troglodytidae**					
18	*Troglodytes troglodytes*	Winter Wren	I	R	LC	1

FS–Foraging Status: C–Carnivores, I–Insectivore, O–Omnivore; MS–Migratory Status–BV–Breeding Visitor, Record, R–Resident, WV–Winter Visitor; CS–Conservation status–IUCN Red List and WPA–1972 Schedule: LC–Least Concern

Appendix II. 3.177: Check list and ecological status of birds recorded in the Thingbu chu HEP area

Sl. No.	Family and species name	Common name	FS	MS	CS	PM	M	W	TNB
1	**Accipitridae**								
1	*Gyps himalayensis*	Himalayan Vulture	C	WV	LC	0	0	2	2
2	**Aegithalidae**								
2	*Aegithalos iouschistos*	Rufous–fronted Tit	I	R	LC	0	0	13	13
3	**Apodidae**								
3	*Aerodramus brevirostris*	Himalayan Swiftlet	I	R	LC	0	62	0	62
4	**Campephagidae**								
4	*Hemipus picatus*	Pied Flycatcher–shrike	I	R	LC	2	0	0	2
5	**Certhiidae**								
5	*Certhia familiaris mandellii*	Eurasian Treecreeper	I	R	LC	0	0	3	3
6	*Certhia nepalensis*	Rusty–flanked Treecreeper	I	R	LC	0	0	1	1
6	**Cinclidae**								
7	*Cinclus pallasii*	Brown Dipper	Aq	R	LC	2	0	0	2
8	*Cinclus cinclus*	White–throated Dipper	I	R	LC	0	1	15	16
7	**Columbidae**								
9	*Ducula badia*	Mountain Imperial–pigeon	G	R	LC	3	3	0	6
10	*Treron sphenurus*	Wedge–tailed Green–pigeon	G	R	LC	9	0	0	9
8	**Corvidae**								
11	*Nucifraga caryocatactes*	Spotted Nutcracker	Nu	R	LC	0	17	0	17
9	**Cuculidae**								
12	*Hierococcyx sparverioides*	Large Hawk–cuckoo	I	BV	LC	2	0	0	2
10	**Dicaeidae**								
13	*Dicaeum ignipectus*	Fire–breasted Flowerpecker	N	R	LC	5	3	0	8

Sl. No.	Family and species name	Common name	FS	MS	CS	PM	M	W	TNB
11	**Dicruridae**								
14	*Dicrurus leucophaeus*	Ashy Drongo	O	WV	LC	7	2	0	9
15	*Dicrurus macrocercus*	Black Drongo	O	R	LC	12	0	0	12
16	*Dicrurus aeneus*	Bronzed Drongo	O	R	LC	5	0	0	5
12	**Fringillidae**								
17	*Carpodacus nepalensis*	Dark–breasted Rosefinch	G	R	LC	0	2	0	2
13	**Hirundinidae**								
18	*Delichon nipalense*	Nepal House–martin	I	R	LC	0	70	0	70
14	**Leiothrichidae**								
19	*Heterophasia capistrata*	Rufous Sibia	O	R	LC	12	3	0	15
15	**Motacillidae**								
20	*Anthus hodgsoni hodgsoni*	Olive–backed Pipit	I	R	LC	0	3	0	3
21	*Motacilla alba alboides*	White Wagtail	I	WV	LC	0	6	0	6
16	**Muscicapidae**								
22	*Phoenicurus frontalis*	Blue–fronted Redstart	I	BV	LC	0	0	6	6
23	*Muscicapa sibirica*	Dark–sided Flycatcher	I	BV	LC	0	1	0	1
24	*Tarsiger chrysaeus*	Golden Bush–robin	I	R	LC	0	0	2	2
25	*Tarsiger rufilatus*	Himalayan Red–flanked Bush Robin	I	R	LC	0	0	1	1
26	*Enicurus scouleri*	Little Forktail	I	R	LC	0	2	4	6
27	*Ficedula westermanni*	Little Pied Flycatcher	I	R	LC	0	1	0	1
28	*Ficidula strophiata*	Orange–gorgeted Flycatcher	I	R	LC	0	2	0	2
29	*Rhyacornis fuliginosa*	Plumbeous Water–redstart	I	R	LC	11	21	0	32
30	*Ficedula tricolor*	Slaty–blue Flycatcher	I	BV	LC	0	1	0	1
31	*Eumyias thalassinus*	Verditer Flycatcher	I	BV	LC	4	0	0	4
32	*Niltava (vivda) catesi*	Vivid Niltava	I	BV	LC	0	1	0	1
33	*Chaimarrornis leucocephalus*	White–capped River–chat	I	R	LC	8	16	6	30
17	**Nectariniidae**								
34	*Aethopyga saturata*	Black–breasted Sunbird	N	R	LC	0	1	0	1
35	*Aethopyga nipalensis*	Green–tailed Sunbird	N	R	LC	7	0	1	8
18	**Oriolidae**								
36	*Oriolus tenuirostris*	Slender–billed Oriole	O	R	LC	2	0	0	2
19	**Paridae**								
37	*Parus ater*	Coal Tit	I	R	LC	0	0	19	19
38	*Parus monticolus*	Green–backed Tit	I	R	LC	6	6	2	14
39	*Parus dichrous*	Grey–crested Tit	I	R	LC	2	0	0	2
20	**Prunellidae**								
40	*Prunella collaris*	Alpine Accentor	I	WV	LC	0	0	5	5
41	*Prunella strophiata*	Rufous–breasted Accentor	I	R	LC	0	0	3	3
21	**Pycnonotidae**								
42	*Hypsipetes leucocephalus*	Himalayan Black Bulbul	O	R	LC	38	0	0	38
22	**Sittidae**								
43	*Sitta himalayensis*	White–tailed Nuthatch	I	R	LC	3	0	0	3
23	**Stenostiridae**								
44	*Culicicapa ceylonensis*	Grey–headed Canary–flycatcher	I	BV	LC	6	2	0	8
45	*Chelidorhynx hypoxantha*	Yellow–bellied Fantail	I	R	LC	0	2	0	2
24	**Sylviidae**								
46	*Phylloscopus reguloides*	Blyth's Leaf–Warbler	I	WV	LC	3	15	1	19
47	*Phylloscopus pulcher*	Buff–barred Warbler	I	BV	LC	0	14	0	14
48	*Seicercus castaniceps*	Chestnut–crowned Warbler	I	BV	LC	0	2	0	2
49	*Phylloscopus coronatus*	Eastern Crowned Warbler	I	WV	LC	8	0	0	8
50	*Phylloscopus trochiloides*	Greenish Warbler	I	WV	LC	7	11	0	18
51	*Seicercus poliogenys*	Grey–cheeked Warbler	I	R	LC	0	1	0	1
52	*Phylloscopus maculipennis*	Grey–faced Leaf–warbler	I	R	LC	0	8	3	11
53	*Phylloscopus xanthoschistos*	Grey–hooded Warbler	I	R	LC	5	8	0	13
54	*Phylloscopus chloronotus*	Lemon–rumped Leaf Warbler	I	BV	LC	0	10	0	10
55	*Phylloscopus fuligiventer*	Smoky Leaf–warbler	I	WV	LC	0	3	0	3
56	*Cettia fortipes*	Strong–footed Bush–warbler	I	R	LC	0	3	0	3
57	*Phylloscopus affinis*	Tickell's Leaf–warbler	I	BV	LC	0	4	0	4
25	**Tichodromidae**								
58	*Tichodroma muraria*	Wallcreeper	I	WV	LC	0	0	2	2
26	**Timaliidae**								
59	*Trochalopteron imbricatum*	Bhutan Laughingthrush	I	R	LC	0	7	15	22
60	*Trochalopteron affine*	Black–faced Laughingthrush	I	R	LC	0	0	7	7
61	*Trachalopteron erthrocephalum*	Red–headed Launghingthrush	I	R	LC	10	0	6	16
62	*Ianthocincla rufogularis*	Rufous–chinned Laughingthrush	I	R	LC	5	0	0	5
63	*Yuhina flavicollis*	Whiskered Yuhina	I	R	LC	7	0	0	7

Sl. No.	Family and species name	Common name	FS	MS	CS	PM	M	W	TNB
27	**Troglodytidae**								
64	*Troglodytes troglodytes*	Winter Wren	I	R	LC	0	0	5	5
28	**Turdidae**								
65	*Myophonus caeruleus*	Blue Whistling–thrush	I	R	LC	14	2	3	19
66	*Monticola rufiventris*	Chestnut–bellied Rock Thrush	I	R	LC	1	0	0	1
67	*Turdus albocinctus*	White–collared Blackbird	I	R	LC	0	0	3	3

FS: Aq–Aquatic Feeder, C–Carnivores, F–Frugivore, G–Granivore, I–Insectivore, N–Nectarivore, Nc–Nucivore, O–Omnivore, P–Piscivore; MS–Migratory status–BV–Breeding sisitor, IR–Isolated secord, R–Resident, WV–Winter visitor; CS–Conservation status–IUCN Red List and WPA–1972 Schedule: VU–Vulnerable, LC–Least concern; PM–Post monsoon, M–Monsoon, W–Winter, TNB–Total number of birds Reported.

Appendix II. 3.178: List of possible mammalian fauna of Tawang region and Thingbu chu HEP area

Sl. No.	Common name	Scientific name	SPA	Conservation status	
				IUCN	**WPA**
	Primates				
1	Arunachal macaque	*Macaca munzala*	*	EN	–
2	Assamese macaque	*M. assamensis*		NT	II
3	Capped langur	*Trachypithecus pileatus*		VU	I
4	Slow loris	*Nycticebus coucang*		VU	I
	Ungulates				
5	Barking deer	*Muntiacus muntjak*		LC	III
6	Bharal	*Pseudois nayaur*		LC	I
7	Chinese goral	*Nemorhaedus caudatus*		VU	III
8	Himalayan goral	*N. goral*	*	NT	III
9	Musk deer	*Mos chus* sp.		EN	–
10	Sambar	*Cervus unicolor*		VU	III
11	Serow	*N. sumatraensis*			
12	Wild pig	*Sus scrofa*	*	LC	III
	Carnivores				
13	Common leopard	*Panthera pardus*		NT	I
14	Jungle Cat	*Felis Chaus*	*	LC	II
15	Dhole	*Cuon alpinus*		EN	II
16	Himalayan black bear	*Ursus thibetanus*		VU	II
17	Himalayan palm civet	*Paguma larvata*	*	LC	II
18	Leopard cat	*Prionailurus bengalensis*		LC	–
19	Otter	*Lutra* sp.		VU	–
20	Red panda	*Ailurus fulgens*		VU	I
21	Snow leopard	*Uncia uncia*		EN	I
22	Yellow–throated marten	*Martes flavigula*	*	LC	II
	Rodents				
23	Hairy–footed flying squirrel	*Belomys pearsonii*		DD	II
24	Himalayan marmot	*Marmota himalayana*		LC	II
25	Himalayan striped squirrel	*Tamiops macclellandi*	*	LC	–
26	Orange–bellied Himalayan squirrel	*Dremomys lokriah*	*	LC	–
	*Hoary–bellied Himalayan Squirrel	*Callosciurus pygerythrus*	*	LC	–
27	Porcupine	*Hystrix* sp.		LC	IV
	Chesnut rat	*Niviventer fluvescens*		LC	V
	Lagomorphs				
28	Large–eared pika	*Ochotona macrotis*		LC	–
29	*Moupin pika	*Ochotona thibetana*		LC	–
	29 species		**9 species R% 34.42%**		

Data Source: 1–Mishra *et al.* 2006, SPA–Species of Project Area , * Additional species reported during the study

Appendix II. 3.179: Status of birds at Thingbu chu barrage and powerhouse site

Sl. No.	Family and species name	Common name	FS	MS	CS	No. of birds recorded
1	**Accipitridae**					
1	*Gyps himalayensis*	Himalayan Vulture	C	WV	LC	2
2	**Aegithalidae**					
2	*Aegithalos iouschistos*	Rufous–fronted Tit	I	R	LC	8
3	**Apodidae**					
3	*Aerodramus brevirostris*	Himalayan Swiftlet	I	R	LC	62
4	**Certhiidae**					
4	*Certhia familiaris mandellii*	Eurasian Treecreeper	I	R	LC	2
5	*Certhia nepalensis*	Rusty–flanked Treecreeper	I	R	LC	1
5	**Cinclidae**					

Sl. No.	Family and species name	Common name	FS	MS	CS	No. of birds recorded
6	*Cinclus cinclus*	White–throated Dipper	I	R	LC	3
6	**Corvidae**					
7	*Corvus culminatus*	Large–billed Crow	O	R	LC	1
8	*Nucifraga caryocatactes*	Spotted Nutcracker	Nu	R	LC	4
7	**Dicaeidae**					
9	*Dicaeum ignipectus*	Fire–breasted Flowerpecker	N	R	LC	3
8	**Dicruridae**					
10	*Dicrurus leucophaeus*	Ashy Drongo	O	WV	LC	1
9	**Fringillidae**					
11	*Leucosticte nemoricola*	Plain Mountain–finch	G	R	LC	1
10	**Laniidae**					
12	*Lanius cristatus*	Brown Shrike	I	WV	LC	1
13	*Lanius tephronotus*	Grey–backed Shrike	I	BV	LC	1
11	**Leiothrichidae**					
14	*Heterophasia capistrata*	Rufous Sibia	O	R	LC	2
12	**Motacillidae**					
15	*Anthus hodgsoni hodgsoni*	Olive–backed Pipit	I	R	LC	4
16	*Motacilla alba alboides*	White Wagtail	I	WV	LC	1
13	**Muscicapidae**					
17	*Chaimarrornis leucocephalus*	White–capped River–chat	I	R	LC	7
18	*Enicurus scouleri*	Little Forktail	I	R	LC	2
19	*Ficedula hodgsonii*	Slaty–backed Flycatcher	I	WV	LC	1
20	*Ficedula tricolor*	Slaty–blue Flycatcher	I	BV	LC	1
21	*Ficidula strophiata*	Orange–gorgeted Flycatcher	I	R	LC	1
22	*Muscicapa sibirica*	Dark–sided Flycatcher	I	BV	LC	1
23	*Phoenicurus frontalis*	Blue–fronted Redstart	I	BV	LC	2
24	*Rhyacornis fuliginosa*	Plumbeous Water–redstart	I	R	LC	9
25	*Tarsiger rufilatus*	Himalayan Red–flanked Bush Robin	I	R	LC	1
14	**Nectariniidae**					
26	*Aethopyga saturata*	Black–breasted Sunbird	N	R	LC	1
15	**Paridae**					
27	*Parus ater*	Coal Tit	I	R	LC	6
28	*Parus monticolus*	Green–backed Tit	I	R	LC	2
16	**Picidae**					
29	*Picus flavinucha*	Greater Yellownape	I	R	LC	3
17	**Prunellidae**					
30	*Prunella strophiata*	Rufous–breasted Accentor	I	R	LC	3
18	**Stenostiridae**					
31	*Culicicapa ceylonensis*	Grey–headed Canary–flycatcher	I	BV	LC	2
32	*Chelidorhynx hypoxantha*	Yellow–bellied Fantail	I	R	LC	2
19	**Sylviidae**					
33	*Phylloscopus maculipennis*	Ashy–throated Warbler	I	R	LC	1
34	*Phylloscopus reguloides*	Blyth's Leaf–warbler	I	WV	LC	10
35	*Seicercus burkii*	Green–crowned Warbler	I	BV	LC	3
36	*Phylloscopus trochiloides*	Greenish Warbler	I	WV	LC	7
37	*Seicercus poliogenys*	Grey–cheeked Warbler	I	R	LC	2
38	*Phylloscopus maculipennis*	Grey–faced Leaf–warbler	I	R	LC	5
39	*Phylloscopus xanthoschistos*	Grey–hooded Warbler	I	R	LC	5
40	*Phylloscopus chloronotus*	Lemon–rumped Leaf Warbler	I	BV	LC	6
41	*Phylloscopus pulcher*	Orange–barred Leaf–warbler	I	WV	LC	9
42	*Phylloscopus fuligiventer*	Smoky Leaf–warbler	I	WV	LC	2
43	*Phylloscopus affinis*	Tickell's Leaf–warbler	I	BV	LC	1
44	*Phylloscopus inornatus*	Yellow–browed Leaf–warbler	I	WV	LC	2
20	**Tichodromidae**					
45	*Tichodroma muraria*	Wallcreeper	I	WV	LC	2
21	**Timaliidae**					
46	*Trochalopteron imbricatum*	Bhutan Laughing Thrush	I	R	LC	6
47	*Trochalopteron affine*	Black–faced Laughingthrush	I	R	LC	5
48	*Trochalopteron squamatum*	Blue–winged Laughingthrush	I	R	LC	4
49	*Trachalopteron erthrocephalum*	Red–headed Launghingthrush	I	R	LC	6
50	*Lanthocincla ocellata*	Spotted Laughingthrush	I	R	LC	1
51	*Yuhina gularis*	Stripe–throated Yuhina	O	R	LC	3
52	*Pteruthius flaviscapis*	White–browed Shrike–babbler	I	R	LC	1
22	**Troglodytidae**					
53	*Troglodytes troglodytes*	Winter Wren	I	R	LC	2
23	**Turdidae**					
54	*Myophonus caeruleus*	Blue Whistling–thrush	I	R	LC	3
55	*Turdus albocinctus*	White–collared Blackbird	I	R	LC	2

FS–Foraging Status: C–Carnivores, F–Frugivore, G–Granivore, I–Insectivore, N–Nectarivore, Nc–Nucivore, O–Omnivore, MS–Migratory status–BV–Breeding visitor, R–Resident, WV–Winter visitor; CS–Conservation status–IUCN Red List and WPA–1972 Schedule: LC–Least concern;

Appendix II. 3.180: Ecological status of bird species recorded in the New Melling HEP area

Sl. No.	Family and species name	Common name	FS	MS	CS	PM	M	W	Overall
1	**Aegithalidae**								
1	*Aegithalos iouschistos*	Rufous–fronted Tit	I	R	LC	0	0	8	8
2	**Apodidae**								
2	*Aerodramus brevirostris*	Himalayan Swiftlet	I	R	LC	0	20	0	20
3	**Campephagidae**								
3	*Hemipus picatus*	Pied Flycatcher–shrike	I	R	LC	11	0	0	11
4	**Certhiidae**								
4	*Certhia familiaris mandellii*	Eurasian Treecreeper	I	R	LC	0	1	2	3
5	*Certhia nepalensis*	Rusty–flanked Treecreeper	I	R	LC	0	0	3	3
5	**Cinclidae**								
6	*Cinclus pallasii*	Brown Dipper	Aq	R	LC	1	0	0	1
7	*Cinclus cinclus*	White–throated Dipper	I	R	LC	0	3	16	19
6	**Cisticolidae**								
8	*Prinia atrogularis*	Black–throated Prinia	I	R	LC	0	0	3	3
7	**Columbidae**								
9	*Ducula badia*	Mountain Imperial–pigeon	G	R	LC	0	3	0	3
10	*Treron sphenurus*	Wedge–tailed Green–pigeon	G	R	LC	21	0	0	21
8	**Corvidae**								
11	*Corvus culminatus*	Large–billed Crow	O	R	LC	0	0	3	3
12	*Nucifraga caryocatactes*	Spotted Nutcracker	Nu	R	LC	0	12	1	13
9	**Cuculidae**								
13	*Chrysococcyx maculatus*	Asian Emerald Cuckoo	I	BV	LC	1	0	0	1
14	*Hierococcyx sparverioides*	Large Hawk–cuckoo	I	BV	LC	11	0	0	11
10	**Dicaeidae**								
15	*Dicaeum ignipectus*	Fire–breasted Flowerpecker	N	R	LC	12	0	0	12
11	**Dicruridae**								
16	*Dicrurus leucophaeus*	Ashy Drongo	O	WV	LC	12	1	0	13
17	*Dicrurus macrocercus*	Black Drongo	O	R	LC	16	0	0	16
18	*Dicrurus aeneus*	Bronzed Drongo	O	R	LC	21	0	0	21
12	**Fringillidae**								
19	*Carpodacus rubescens*	Blandford's Rosefinch	G	R	LC	0	4	0	4
20	*Carpodacus dubius*	Chinese White–browed Rosefinch	G	IR	LC	0	0	11	11
21	*Carpodacus nepalensis*	Dark–breasted Rosefinch	G	R	LC	0	2	0	2
22	*Carpodacus edwardsii*	Dark–rumped Rosefinch	G	R	LC	0	0	20	20
23	*Carduelis spinoides*	Himalayan Greenfinch	G	WV	LC	0	3	0	3
13	**Hirundinidae**								
24	*Delichon dasypus*	Asian House Martin	I	BV	LC	0	0	5	5
25	*Delichon nipalense*	Nepal House–martin	I	R	LC	12	70	83	165
14	**Leiothrichidae**								
26	*Heterophasia capistrata*	Rufous Sibia	O	R	LC	21	4	0	25
15	**Motacillidae**								
27	*Anthus hodgsoni hodgsoni*	Olive–backed Pipit	I	R	LC	0	6	0	6
28	*Motacilla alba alboides*	White Wagtail	I	WV	LC	0	9	1	10
16	**Muscicapidae**								
29	*Phoenicurus frontalis*	Blue–fronted Redstart	I	BV	LC	0	0	7	7
30	*Muscicapa sibirica*	Dark–sided Flycatcher	I	BV	LC	0	2	0	2
31	*Cyomis magnirostris*	Large Blue Flycatcher	I	BV	LC	0	1	0	1
32	*Enicurus scouleri*	Little Forktail	I	R	LC	0	1	2	3
33	*Rhyacornis fuliginosa*	Plumbeous Water–redstart	I	R	LC	21	22	0	43
34	*Ficedula hodgsonii*	Slaty–backed Flycatcher	I	WV	LC	0	1	0	1
35	*Eumyias thalassinus*	Verditer Flycatcher	I	BV	LC	17	0	0	17
36	*Niltava (vivda) catesi*	Vivid Niltava	I	BV	LC	0	3	0	3
37	*Chaimarrornis leucocephalus*	White–capped River–chat	I	R	LC	17	9	12	38
38	*Myiomela leucura*	White–tailed Blue Robin	I	R	LC	3	0	0	3
17	**Nectariniidae**								
39	*Aethopyga nipalensis*	Green–tailed Sunbird	N	R	LC	13	1	1	15
18	**Oriolidae**								
40	*Oriolus tenuirostris*	Slender–billed Oriole	O	R	LC	3	0	0	3
19	**Paridae**								
41	*Parus ater*	Coal Tit	I	R	LC	0	0	13	13
42	*Parus monticolus*	Green–backed Tit	I	R	LC	0	9	5	14

Sl. No.	Family and species name	Common name	FS	MS	CS	PM	M	W	Overall
43	*Parus dichrous*	Grey–crested Tit	I	R	LC	13	0	0	13
20	**Passeridae**								
44	*Passer montanus*	Eurasian Tree Sparrow	G	R	LC	0	0	4	4
21	**Prunellidae**								
45	*Prunella collaris*	Alpine Accentor	I	WV	LC	0	0	11	11
46	*Prunella strophiata*	Rufous–breasted Accentor	I	R	LC	0	0	8	8
22	**Pycnonotidae**								
47	*Hypsipetes leucocephalus*	Himalayan Black Bulbul	O	R	LC	60	0	0	60
23	**Sylviidae**								
48	*Phylloscopus reguloides*	Blyth's Leaf–Warbler	I	WV	LC	0	0	2	2
49	*Phylloscopus pulcher*	Buff–barred Warbler	I	BV	LC	0	5	0	5
50	*Seicercus castaniceps*	Chestnut–crowned Warbler	I	BV	LC	0	2	0	2
51	*Phylloscopus coronatus*	Eastern Crowned Warbler	I	WV	LC	16	0	0	16
52	*Seicercus burkii*	Green–crowned Warbler	I	BV	LC	2	0	0	2
53	*Phylloscopus trochiloides*	Greenish Warbler	I	WV	LC	0	6	0	6
54	*Phylloscopus maculipennis*	Grey–faced Leaf–warbler	I	R	LC	0	3	3	6
55	*Phylloscopus xanthoschistos*	Grey–hooded Warbler	I	R	LC	0	4	1	5
56	*Phylloscopus chloronotus*	Lemon–rumped Leaf Warbler	I	BV	LC	0	8	0	8
57	*Phylloscopus fuligiventer*	Smoky Leaf–warbler	I	WV	LC	0	1	0	1
58	*Cettia fortipes*	Strong–footed Bush–warbler	I	R	LC	0	1	0	1
24	**Timaliidae**								
59	*Trochalopteron imbricatum*	Bhutan Laughingthrush	I	R	LC	0	4	28	32
60	*Trochalopteron affine*	Black–faced Laughingthrush	I	R	LC	0	0	25	25
61	*Trochalopteron erthrocephalum*	Red–headed Launghingthrush	I	R	LC	16	12	7	35
62	*Ianthocincla rufogularis*	Rufous–chinned Laughingthrush	I	R	LC	12	0	0	12
63	*Yuhina flavicollis*	Whiskered Yuhina	I	R	LC	11	0	0	11
25	**Troglodytidae**								
64	*Troglodytes troglodytes*	Winter Wren	I	R	LC	0	0	3	3
26	**Turdidae**								
65	*Myophonus caeruleus*	Blue Whistling–thrush	I	R	LC	23	3	7	33
66	*Monticola rufiventris*	Chestnut–bellied Rock Thrush	I	R	LC	2	0	0	2
67	*Turdus albocinctus*	White–collared Blackbird	I	R	LC	0	0	8	8

FS: Aq–Aquatic Feeder, C–Carnivores, F–Frugivore, G–Granivore, I–Insectivore, N–Nectarivore, Nc–Nucivore, O–Omnivore, P–Piscivore; MS–Migratory Status–BV–Breeding Visitor, IR–Isolated Record, R–Resident, WV–Winter Visitor; CS–Conservation status–IUCN Red List and WPA–1972 Schedule: VU–Vulnerable, LC–Least Concern; PM–Post monsoon, M–Monsoon, W–Winter

Appendix II. 3.181: List of possible mammalian fauna of the Tawang region and contribution of species reported in the New Melling HEP area

Sl. No.	Common name	Scientific name	SPA	Conservation status	
				IUCN	**WPA**
	Primates				
1	Arunachal macaque	*Macaca munzala*	*	EN	–
2	Assamese macaque	*M. assamensis*		NT	II
3	Capped langur	*Trachypithecus pileatus*		VU	I
4	Slow loris	*Nycticebus coucang*		VU	I
	Ungulates				
5	Barking deer	*Muntiacus muntjak*	*	LC	III
6	Bharal	*Pseudois nayaur*		LC	I
7	Chinese goral	*Nemorhaedus caudatus*		VU	III
8	Himalayan goral	*N. goral*	*	NT	III
9	Musk deer	*Mos chus* sp.		EN	–
10	Sambar	*Cervus unicolor*		VU	III
11	Serow	*N. sumatraensis*			
12	Wild pig	*Sus scrofa*	*	LC	III
	Carnivores				
13	Common leopard	*Panthera pardus*		NT	I
14	Jungle Cat	*Felis Chaus*		LC	II
15	Dhole	*Cuon alpinus*		EN	II
16	Himalayan black bear	*Ursus thibetanus*		VU	II
17	Himalayan palm civet	*Paguma larvata*	*	LC	II
18	Leopard cat	*Prionailurus bengalensis*		LC	–
19	Otter	*Lutra* sp.		VU	–
20	Red panda	*Ailurus fulgens*		VU	I
21	Snow leopard	*Uncia uncia*		EN	I
22	Yellow–throated marten	*Martes flavigula*		LC	II

Sl. No.	Common name	Scientific name	SPA	Conservation status	
	Rodents				
23	Hairy–footed flying squirrel	*Belomys pearsonii*		DD	II
24	Himalayan marmot	*Marmota himalayana*		LC	II
25	Himalayan striped squirrel	*Tamiops macclellandi*		LC	–
26	Orange–bellied Himalayan squirrel	*Dremomys lokriah*		LC	–
	*Hoary–bellied Himalayan Squirrel	*Callosciurus pygerythrus*	*	LC	–
27	Porcupine	*Hystrix* sp.		LC	IV
	*Chesnut rat	*Niviventer fluvescens*	*	LC	V
	Lagomorphs				
28	Large–eared pika	*Ochotona macrotis*		LC	–
29	Moupin pika	*Ochotona thibetana*		LC	–
	29 species		7 species R% 24.13%		

Data Source: 1–Mishra *et al.* 2006, SPA–Species of Project Area. * Additional species reported during the study

Appendix II. 3.182: Status of birds at New Melling barrage site

Sl. No.	Family and species name	Common name	FS	MS	CS	No. of birds recorded
1	**Campephagidae**					
1	*Hemipus picatus*	Pied Flycatcher–shrike	I	R	LC	2
2	**Certhiidae**					
2	*Certhia nepalensis*	Rusty–flanked Treecreeper	I	R	LC	1
3	**Cinclidae**					
3	*Cinclus cinclus*	White–throated Dipper	I	R	LC	3
4	**Cisticolidae**					
4	*Prinia atrogularis*	Black–throated Prinia	I	R	LC	2
5	**Columbidae**					
5	*Treron sphenurus*	Wedge–tailed Green–pigeon	G	R	LC	3
6	**Cuculidae**					
6	*Hierococcyx sparverioides*	Large Hawk–cuckoo	I	BV	LC	1
7	**Dicaeidae**					
7	*Dicaeum ignipectus*	Fire–breasted Flowerpecker	N	R	LC	2
8	**Dicruridae**					
8	*Dicrurus aeneus*	Bronzed Drongo	O	R	LC	2
9	*Dicrurus leucophaeus*	Ashy Drongo	O	WV	LC	1
10	*Dicrurus macrocercus*	Black Drongo	O	R	LC	4
9	**Fringillidae**					
11	*Carpodacus edwardsii*	Dark–rumped Rosefinch	G	R	LC	8
10	**Hirundinidae**					
12	*Delichon nipalense*	Nepal House Martin	I	R	LC	9
11	**Leiothrichidae**					
13	*Heterophasia capistrata*	Rufous Sibia	O	R	LC	5
12	**Muscicapidae**					
14	*Phoenicurus frontalis*	Blue–fronted Redstart	I	BV	LC	2
15	*Rhyacornis fuliginosa*	Plumbeous Water–redstart	I	R	LC	2
13	**Nectariniidae**					
16	*Aethopyga nipalensis*	Green–tailed Sunbird	N	R	LC	2
14	**Prunellidae**					
17	*Prunella collaris*	Alpine Accentor	I	WV	LC	3
18	*Prunella strophiata*	Rufous–breasted Accentor	I	R	LC	4
15	**Pycnonotidae**					
19	*Hypsipetes leucocephalus*	Himalayan Black Bulbul	O	R	LC	17
16	**Sylviidae**					
20	*Phylloscopus coronatus*	Eastern Crowned Warbler	I	WV	LC	2
21	*Seicercus burkii*	Green–crowned Warbler	I	BV	LC	1
17	**Timaliidae**					
22	*Ianthocincla rufogularis*	Rufous–chinned Laughingthrush	I	R	LC	6
23	*Trochalopteron affine*	Black–faced Laughingthrush	I	R	LC	4
24	*Trachalopteron erthrocephalum*	Red–headed Launghingthrush	I	R	LC	3
25	*Trochalopteron imbricatum*	Bhutan Laughing Thrush	I	R	LC	9
18	**Turdidae**					
26	*Monticola rufiventris*	Chestnut–bellied Rock Thrush	I	R	LC	1
27	*Myophonus caeruleus*	Blue Whistling–thrush	I	R	LC	2

FS–Foraging Status, G–Granivore, I–Insectivore, N–Nectarivore, O–Omnivore, MS–Migratory Status–BV–Breeding Visitor, R–Resident, WV–Winter Visitor; CS–Conservation status–IUCN Red List and WPA–1972 Schedule: LC–Least Concern;

Appendix II. 3.183: Ecological status of birds recorded in the Mago chu HEP area

Sl. No.	Family and species name	Common name	FS	MS	CS	PM	M	W	Overall
1	**Accipitridae**								
1	*Hieraaetus fasciatus*	Bonelli's Eagle	C	R	LC	0	1	0	1
2	*Buteo rufinus*	Long–legged Buzzard	C	WV	LC	0	1	0	1
2	**Aegithalidae**								
3	*Aegithalos iouschistos*	Rufous–fronted Tit	I	R	LC	0	0	3	3
3	**Apodidae**								
4	*Aerodramus brevirostris*	Himalayan Swiftlet	I	R	LC	16	88	70	174
4	**Bucerotidae**								
5	*Aceros nipalensis**	Rufous–necked Hornbill	F	R	VU	1	0	0	1
5	**Campephagidae**								
6	*Pericrocotus speciosus*	Scarlet Minivet	I	R	LC	0	9	0	9
6	**Certhiidae**								
7	*Certhia familiaris mandellii*	Eurasian Treecreeper	I	R	LC	0	2	1	3
8	*Certhia nepalensis*	Rusty–flanked Treecreeper	I	R	LC	0	0	2	2
7	**Cinclidae**								
9	*Cinclus pallasii*	Brown Dipper	Aq	R	LC	1	0	0	1
10	*Cinclus cinclus*	White–throated Dipper	I	R	LC	0	2	9	11
8	**Cisticolidae**								
11	*Prinia atrogularis*	Black–throated Prinia	I	R	LC	0	0	1	1
9	**Columbidae**								
12	*Streptopelia orientalis*	Oriental Turtle–dove	G	WV	LC	0	2	3	5
10	**Corvidae**								
13	*Corvus culminatus*	Large–billed Crow	O	R	LC	0	0	4	4
14	*Nucifraga caryocatactes*	Spotted Nutcracker	Nu	R	LC	0	0	1	1
11	**Cuculidae**								
15	*Cuculus poliocephalus*	Small Cuckoo	I	BV	LC	0	0	1	1
12	**Dicaeidae**								
16	*Dicaeum ignipectus*	Fire–breasted Flowerpecker	N	R	LC	0	0	3	3
17	*Dicaeum minullum*	Plain Flowerpecker	N	R	LC	0	4	0	4
13	**Dicruridae**								
18	*Dicrurus leucophaeus*	Ashy Drongo	O	WV	LC	16	1	0	17
19	*Dicrurus macrocercus*	Black Drongo	O	R	LC	17	0	0	17
14	**Falconidae**								
20	*Falco tinnunculus*	Common Kestrel	C	WV	LC	0	0	1	1
15	**Fringillidae**								
21	*Carpodacus rubescens*	Blandford's Rosefinch	G	R	LC	0	4	0	4
22	*Carpodacus edwardsii*	Dark–rumped Rosefinch	G	R	LC	0	0	5	5
23	*Carduelis spinoides*	Himalayan Greenfinch	G	WV	LC	0	3	0	3
24	*Pyrrhula erythrocephala*	Red–headed Bullfinch	G	R	LC	0	0	7	7
25	*Haematospiza sipahi*	Scarlet Finch	G	R	LC	0	6	0	6
16	**Hirundinidae**								
26	*Delichon dasypus*	Asian House Martin	I	BV	LC	0	0	5	5
27	*Delichon nipalense*	Nepal House–martin	I	R	LC	0	27	106	133
17	**Leiothrichidae**								
28	*Heterophasia capistrata*	Rufous Sibia	O	R	LC	24	24	12	60
18	**Motacillidae**								
29	*Anthus hodgsoni hodgsoni*	Olive–backed Pipit	I	R	LC	0	5	0	5
30	*Motacilla alba alboides*	White Wagtail	I	WV	LC	11	3	0	14
19	**Muscicapidae**								
31	*Phoenicurus ochruros*	Black Redstart	I	WV	LC	0	0	1	1
32	*Phoenicurus frontalis*	Blue–fronted Redstart	I	BV	LC	0	0	2	2
33	*Cyornis rubeculoides*	Blue–throated Flycatcher	I	BV	LC	0	0	1	1
34	*Muscicapa sibirica*	Dark–sided Flycatcher	I	BV	LC	0	4	0	4
35	*Cyomis magnirostris*	Large Blue Flycatcher	I	BV	LC	0	1	0	1
36	*Niltava grandis*	Large Niltava	I	R	LC	0	1	0	1
37	*Enicurus scouleri*	Little Forktail	I	R	LC	0	1	1	2
38	*Ficidula strophiata*	Orange–gorgeted Flycatcher	I	R	LC	0	2	0	2
39	*Copsy chus saularis*	Oriental Magpie–robin	I	R	LC	0	0	1	1
40	*Rhyacornis fuliginosa*	Plumbeous Water–redstart	I	R	LC	22	19	3	44
41	*Niltava sundara*	Rufous–bellied Niltava	I	BV	LC	0	3	0	3
42	*Ficedula hodgsonii*	Slaty–backed Flycatcher	I	WV	LC	0	1	0	1
43	*Ficedula superciliaris*	Ultramarine Flycatcher	I	BV	LC	6	0	0	6
44	*Eumyias thalassinus*	Verditer Flycatcher	I	BV	LC	16	0	0	16
45	*Niltava (vivda) catesi*	Vivid Niltava	I	BV	LC	0	2	0	2
46	*Chaimarrornis leucocephalus*	White–capped River–chat	I	R	LC	16	9	4	29
47	*Myiomela leucura*	White–tailed Blue Robin	I	R	LC	2	0	0	2
20	**Nectariniidae**								

Sl. No.	Family and species name	Common name	FS	MS	CS	PM	M	W	Overall
48	*Aethopyga saturata*	Black–breasted Sunbird	N	R	LC	0	0	1	1
49	*Aethopyga nipalensis*	Green–tailed Sunbird	N	R	LC	14	6	4	24
50	*Aethopyga goulgiae*	Mrs Gould's Sunbird	N	R	LC	2	0	0	2
21	**Oriolidae**								
51	*Oriolus tenuirostris*	Slender–billed Oriole	O	R	LC	5	0	0	5
22	**Paridae**								
52	*Parus spilonotus*	Black–spotted Yellow Tit	I	R	LC	8	0	0	8
53	*Parus ater*	Coal Tit	I	R	LC	5	0	3	8
54	*Parus monticolus*	Green–backed Tit	I	R	LC	18	12	10	40
55	*Parus dichrous*	Grey–crested Tit	I	R	LC	15	0	0	15
23	**Passeridae**								
56	*Passer montanus*	Eurasian Tree Sparrow	G	R	LC	0	0	2	2
24	**Picidae**								
57	*Dendrocopos darjellensis*	Darjeeling Pied Woodpecker	I	R	LC	2	0	0	2
25	**Prunellidae**								
58	*Prunella collaris*	Alpine Accentor	I	WV	LC	0	0	4	4
59	*Prunella strophiata*	Rufous–breasted Accentor	I	R	LC	0	0	5	5
26	**Pycnonotidae**								
60	*Hypsipetes leucocephalus*	Himalayan Black Bulbul	O	R	LC	48	0	0	48
61	*Pycnonotus cafer*	Red–vented Bulbul	O	R	LC	0	0	2	2
27	**Sittidae**								
62	*Sitta himalayensis*	White–tailed Nuthatch	I	R	LC	9	1	0	10
28	**Stenostiridae**								
63	*Culicicapa ceylonensis*	Grey–headed Canary–flycatcher	I	BV	LC	16	3	0	19
64	*Chelidorhynx hypoxantha*	Yellow–bellied Fantail	I	R	LC	0	8	0	8
29	**Sylviidae**								
65	*Abroscopus schisticeps*	Black–faced Warbler	I	R	LC	0	5	0	5
66	*Phylloscopus reguloides*	Blyth's Leaf–Warbler	I	WV	LC	11	7	1	19
67	*Phylloscopus pulcher*	Buff–barred Warbler	I	BV	LC	0	5	0	5
68	*Seicercus castaniceps*	Chestnut–crowned Warbler	I	BV	LC	0	4	0	4
69	*Tesia castaneocoronata*	Chestnut–headed Tesia	I	R	LC	0	2	0	2
70	*Seicercus burkii*	Green–crowned Warbler	I	BV	LC	0	2	0	2
71	*Phylloscopus trochiloides*	Greenish Warbler	I	WV	LC	0	5	0	5
72	*Seicercus poliogenys*	Grey–cheeked Warbler	I	R	LC	0	2	0	2
73	*Phylloscopus maculipennis*	Grey–faced Leaf–warbler	I	R	LC	0	5	4	9
74	*Phylloscopus xanthoschistos*	Grey–hooded Warbler	I	R	LC	16	3	3	22
75	*Phylloscopus chloronotus*	Lemon–rumped Leaf Warbler	I	BV	LC	0	8	0	8
76	*Orthotomus cuculatus*	Mountain Tailorbird	I	R	LC	14	0	0	14
77	*Phylloscopus fuligiventer*	Smoky Leaf–warbler	I	WV	LC	0	1	0	1
78	*Cettia fortipes*	Strong–footed Bush–warbler	I	R	LC	4	5	0	9
30	**Tichodromidae**								
79	*Tichodroma muraria*	Wallcreeper	I	WV	LC	0	0	4	4
31	**Timaliidae**								
80	*Trochalopteron imbricatum*	Bhutan Laughingthrush	I	R	LC	0	10	30	40
81	*Trochalopteron affine*	Black–faced Laughingthrush	I	R	LC	0	0	9	9
82	*Trochalopteron squamatum*	Blue–winged Laughingthrush	I	R	LC	0	0	5	5
83	*Alcippe nipalensis*	Nepal Fulvetta	I	R	LC	0	3	0	3
84	*Pellorneum ruficeps*	Puff–throated Babbler	I	R	LC	2	0	0	2
85	*Leiothrix lutea*	Red–billed Leiothrix	O	R	LC	0	4	0	4
86	*Trachalopteron erthrocephalum*	Red–headed Launghingthrush	I	R	LC	0	23	5	28
87	*Ianthocincla rufogularis*	Rufous–chinned Laughingthrush	I	R	LC	11	0	0	11
88	*Yuhina occipitalis*	Rufous–vented Yuhina	I	R	LC	0	4	0	4
89	*Actinodura waldeni*	Streak–throated Barwing	I	R	LC	4	0	0	4
90	*Yuhina flavicollis*	Whiskered Yuhina	I	R	LC	12	0	3	15
32	**Troglodytidae**								
91	*Troglodytes troglodytes*	Winter Wren	I	R	LC	0	0	3	3
33	**Turdidae**								
92	*Turdus atrogularis*	Black–throated Thrush	I	WV	LC	**0**	0	1	1
93	*Myophonus caeruleus*	Blue Whistling–thrush	I	R	LC	21	6	6	33
94	*Turdus albocinctus*	White–collared Blackbird	I	R	LC	0	0	8	8
34	**Zosteropidae**								
95	*Zosterops palpebrosus*	Oriental White–eye	I	R	LC	0	0	1	1

FS: Aq–Aquatic Feeder, C–Carnivores, F–Frugivore, G–Granivore, I–Insectivore, N–Nectarivore, Nc–Nucivore, O–Omnivore, P–Piscivore; MS–Migratory Status–BV–Breeding Visitor, IR–Isolated Record, R–Resident, WV–Winter Visitor; CS–Conservation status–IUCN Red List and WPA–1972 Schedule: VU–Vulnerable, LC–Least Concern; PM–Post monsoon, M–Monsoon, W–Winter

Appendix II. 3.184: List of possible mammalian fauna of the Tawang region and the Mago chu HEP area

Sl. No.	Common name	Scientific name	SPA	Conservation status	
				IUCN	WPA
	Primates				
1	Arunachal macaque	*Macaca munzala*		EN	–
2	Assamese macaque	*M. assamensis*		NT	II
3	Capped langur	*Trachypithecus pileatus*		VU	I
4	Slow loris	*Nycticebus coucang*		VU	I
	Ungulates				
5	Barking deer	*Muntiacus muntjak*	*	LC	III
6	Bharal	*Pseudois nayaur*		LC	I
7	Chinese goral	*Nemorhaedus caudatus*		VU	III
8	Himalayan goral	*N. goral*	*	NT	III
9	Musk deer	*Mos chus* sp.		EN	–
10	Sambar	*Cervus unicolor*		VU	III
11	Serow	*N. sumatraensis*			
12	Wild pig	*Sus scrofa*	*	LC	III
	Carnivores				
13	Common leopard	*Panthera pardus*		NT	I
14	Jungle Cat	*Felis Chaus*	*	LC	II
15	Dhole	*Cuon alpinus*		EN	II
16	Himalayan black bear	*Ursus thibetanus*		VU	II
17	Himalayan palm civet	*Paguma larvata*	*	LC	II
18	Leopard cat	*Prionailurus bengalensis*		LC	–
19	Otter	*Lutra* sp.		VU	–
20	Red panda	*Ailurus fulgens*		VU	I
21	Snow leopard	*Uncia uncia*		EN	I
22	Yellow–throated marten	*Martes flavigula*	*	LC	II
	Rodents				
23	Hairy–footed flying squirrel	*Belomys pearsonii*		DD	II
24	Himalayan marmot	*Marmota himalayana*		LC	II
25	Himalayan striped squirrel	*Tamiops macclellandi*	*	LC	–
26	Orange–bellied Himalayan squirrel	*Dremomys lokriah*	*	LC	–
	*Hoary–bellied Himalayan Squirrel	*Callosciurus pygerythrus*	*	LC	–
27	Porcupine	*Hystrix* sp.		LC	IV
	*Chesnut rat	*Niviventer fluvescens*	*	LC	V
	Lagomorphs				
28	Large–eared pika	*Ochotona macrotis*		LC	–
29	Moupin pika	*Ochotona thibetana*		LC	–
	29 species		10 species R% 34.48%		

Data Source: 1–Mishra *et al.* 2006, SPA–Species of Project Area, * Additional species reported during the study

Appendix II. 3.185: Status of birds at Mago chu barrage site

Sl. No.	Family and species name	Common name	FS	MS	CS	Total
1	**Apodidae**					
1	*Aerodramus brevirostris*	Himalayan Swiftlet	I	R	LC	78
2	**Bucerotidae**					
2	*Aceros nipalensis*	Rufous–necked Hornbill	F	R	VU	1
3	**Cinclidae**					
3	*Cinclus cinclus*	White–throated Dipper	I	R	LC	2
4	**Cuculidae**					
4	*Chrysococcyx maculatus*	Asian Emerald Cuckoo	I	BV	LC	2
5	**Dicruridae**					
5	*Dicrurus leucophaeus*	Ashy Drongo	O	WV	LC	1
6	**Fringillidae**					
6	*Pyrrhula erythrocephala*	Red–headed Bullfinch	G	R	LC	7
7	**Hirundinidae**					
7	*Delichon nipalense*	Nepal House–martin	I	R	LC	30
8	**Leiothrichidae**					
8	*Heterophasia capistrata*	Rufous Sibia	O	R	LC	4
9	**Motacillidae**					
9	*Anthus hodgsoni hodgsoni*	Olive–backed Pipit	I	R	LC	2
10	**Muscicapidae**					
10	*Phoenicurus frontalis*	Blue–fronted Redstart	I	BV	LC	1
11	*Chaimarrornis leucocephalus*	White–capped River–chat	I	R	LC	1
12	*Enicurus scouleri*	Little Forktail	I	R	LC	1
13	*Rhyacornis fuliginosa*	Plumbeous Water–redstart	I	R	LC	7
11	**Nectariniidae**					

Sl. No.	Family and species name	Common name	FS	MS	CS	Total
14	*Aethopyga nipalensis*	Green–tailed Sunbird	N	R	LC	3
12	**Paridae**					
15	*Parus spilonotus*	Black–spotted Yellow Tit	I	R	LC	2
16	*Parus ater*	Coal Tit	I	R	LC	2
17	*Parus dichrous*	Grey–crested Tit	I	R	LC	2
18	*Parus monticolus*	Green–backed Tit	I	R	LC	6
13	**Pycnonotidae**					
19	*Hypsipetes leucocephalus*	Himalayan Black Bulbul	O	R	LC	7
14	**Stenostiridae**					
20	*Culicicapa ceylonensis*	Grey–headed Canary–flycatcher	I	BV	LC	1
15	**Sylviidae**					
21	*Orthotomus cuculatus*	Mountain Tailorbird	I	R	LC	2
22	*Phylloscopus reguloides*	Blyth's Leaf–warbler	I	WV	LC	2
23	*Phylloscopus xanthoschistos*	Grey–hooded Warbler	I	R	LC	2
16	**Tichodromidae**					
24	*Tichodroma muraria*	Wallcreeper	I	WV	LC	2
17	**Timaliidae**					
25	*Yuhina flavicollis*	Whiskered Yuhina	I	R	LC	5
18	**Turdidae**					
26	*Myophonus caeruleus*	Blue Whistling–thrush	I	R	LC	3
27	*Turdus atrogularis*	Black–throated Thrush	I	WV	LC	1

Fs–Foraging Status, F–Frugivore, G–Granivore, I–Insectivore, N–Nectarivore, O–Omnivore, MS–Migratory Status–BV–Breeding Visitor, , R–Resident, WV–Winter Visitor; CS–Conservation status–IUCN Red List and WPA–1972 Schedule: VU–Vulnerable LC–Least Concern;

Appendix II. 3.186: Status of birds at Mago chu powerhouse site

Sl. No.	Family and species name	Common name	FS	MS	CS	No. of birds recorded
1	**Accipitridae**					
1	*Elanus caeruleus*	Black–winged Kite	C	R	LC	5
2	*Gyps fulvus*	Griffon Vulture	C	WV	LC	3
3	*Nisaetus nipalensis*	Mountain–hawk Eagle	C	R	LC	3
2	**Aegithalidae**					
4	*Aegithalos concinnus*	Red–headed Tit	I	R	LC	5
3	**Apodidae**					
5	*Apus pacificus*	Pacific Swift	I	BV	LC	2
4	**Campephagidae**					
6	*Pericrocotus speciosus*	Scarlet Minivet	I	R	LC	4
5	**Cinclidae**					
7	*Cinclus cinclus*	White–throated Dipper	I	R	LC	1
6	**Cisticolidae**					
8	*Prinia crinigera*	Striated Prinia	I	R	LC	15
9	*Prinia hodgsonii*	Grey–breasted Prinia	I	R	LC	2
7	**Cuculidae**					
10	*Chrysococcyx maculatus*	Asian Emerald Cuckoo	I	BV	LC	1
11	*Hierococcyx sparverioides*	Large Hawk–cuckoo	I	BV	LC	1
12	*Phaenicophaeus tristis*	Green–billed Malkoha	O	R	LC	2
8	**Dicruridae**					
13	*Dicrurus leucophaeus*	Ashy Drongo	O	WV	LC	3
9	**Emberizidae**					
14	*Emberiza pusilla*	Little Bunting	G	WV	LC	4
10	**Fringillidae**					
15	*Carpodacus pulcherrimus*	Himalayan Beautiful Rosefinch	G	WV	LC	6
16	*Carduelis spinoides*	Himalayan Greenfinch	G	WV	LC	25
11	**Hirundinidae**					
17	*Delichon nipalense*	Nepal House Martin	I	R	LC	12
12	**Laniidae**					
18	*Lanius schach tricolor*	Black–headed' Long–tailed Shrike	I	BV	LC	2
13	**Leiothrichidae**					
19	*Heterophasia capistrata*	Rufous Sibia	O	R	LC	2
14	**Megalaimidae**					
20	*Megalaima asiatica*	Blue–throated Barbet	F	R	LC	7
21	*Megalaima franklinii*	Golden–throated Barbet	F	R	LC	1
22	*Megalaima virens*	Great Barbet	F	R	LC	6
15	**Motacillidae**					
23	*Anthus hodgsoni hodgsoni*	Olive–backed Pipit	I	R	LC	2
16	**Muscicapidae**					
24	*Enicurus leschenaulti*	White–crowned Forktail	I	R	LC	5
25	*Muscicapa ferruginea*	Ferruginous Flycatcher	I	BV	LC	2

Sl. No.	Family and species name	Common name	FS	MS	CS	No. of birds recorded
26	*Niltava (vivda) catesi*	Vivid Niltava	I	BV	LC	2
27	*Niltava sundara*	Rufous–bellied Niltava	I	BV	LC	1
28	*Phoenicurus frontalis*	Blue–fronted Redstart	I	BV	LC	1
29	*Rhyacornis fuliginosa*	Plumbeous Water–redstart	I	R	LC	3
30	*Saxicola ferreus*	Grey Bushchat	I	R	LC	2
17	**Paridae**					
31	*Parus ater*	Coal Tit	I	R	LC	2
32	*Parus dichrous*	Grey–crested Tit	I	R	LC	2
33	*Parus monticolus*	Green–backed Tit	I	R	LC	2
18	**Picidae**					
34	*Dendrocopos canicapillus*	Grey–capped Pygmy Woodpecker	I	R	LC	2
35	*Picus flavinucha*	Greater Yellownape	I	R	LC	2
19	**Prunellidae**					
36	*Prunella rubeculoides*	Robin Accentor	O	R	LC	24
20	**Rhipiduridae**					
37	*Rhipidura albicollis*	White–throated Fantail	I	R	LC	1
21	**Stenostiridae**					
38	*Chelidorhynx hypoxantha*	Yellow–bellied Fantail	I	R	LC	6
22	**Sylviidae**					
39	*Abroscopus schisticeps*	Black–faced Warbler	I	R	LC	5
40	*Phylloscopus chloronotus*	Lemon–rumped Leaf Warbler	I	BV	LC	1
41	*Phylloscopus inornatus*	Yellow–browed Leaf–warbler	I	WV	LC	4
42	*Phylloscopus maculipennis*	Ashy–throated Warbler	I	R	LC	1
43	*Phylloscopus maculipennis*	Grey–faced Leaf–warbler	I	R	LC	2
44	*Phylloscopus pulcher*	Orange–barred Leaf–warbler	I	WV	LC	2
45	*Seicercus burkii*	Green–crowned Warbler	I	BV	LC	4
46	*Seicercus castaniceps*	Chestnut–crowned Warbler	I	BV	LC	3
47	*Seicercus poliogenys*	Grey–cheeked Warbler	I	R	LC	4
23	**Timaliidae**					
48	*Alcippe nipalensis*	Nepal Fulvetta	I	R	LC	3
49	*Leiothrix lutea*	Red–billed Leiothrix	O	R	LC	4
50	*Trachalopteron erthrocephalum*	Red–headed Launghingthrush	I	R	LC	16
51	*Yuhina occipitalis*	Rufous–vented Yuhina	I	R	LC	4
24	**Troglodytidae**					
52	*Troglodytes troglodytes*	Winter Wren	I	R	LC	1
25	**Turdidae**					
53	*Turdus albocinctus*	White–collared Blackbird	I	R	LC	2
26	**Zosteropidae**					
54	*Zosterops palpebrosus*	Oriental White–eye	I	R	LC	1

FS–Foraging Status, F–Frugivore, G–Granivore, I–Insectivore, O–Omnivore, MS–Migratory Status–BV–Breeding Visitor, R–Resident, WV–Winter Visitor; CS–Conservation status–IUCN Red List and WPA–1972 Schedule: LC–Least Concern

Appendix II. 3.187: Ecological status of birds recorded in the Nykcharong chu HEP area

Sl. No.	Family and species name	Common name	FS	MS	CS	PM	M	W	Overall
1	**Accipitridae**								
1	*Hieraaetus fasciatus*	Bonelli's Eagle	C	R	LC	0	1	0	1
2	*Buteo rufinus*	Long–legged Buzzard	C	WV	LC	0	1	0	1
2	**Aegithalidae**								
3	*Aegithalos concinnus*	Red–headed Tit	I	R	LC	0	0	11	11
3	**Apodidae**								
4	*Aerodramus brevirostris*	Himalayan Swiftlet	I	R	LC	0	138	5	143
5	*Apus pacificus*	Pacific Swift	I	BV	LC	5	0	0	5
4	**Campephagidae**								
6	*Pericrocotus ethologus*	Long–tailed Minvet	I	BV	LC	0	0	4	4
7	*Hemipus picatus*	Pied Flycatcher–shrike	I	R	LC	14	0	0	14
8	*Pericrocotus speciosus*	Scarlet Minivet	I	R	R	0	9	0	9
5	**Certhiidae**								
9	*Certhia discolor*	Brown–throated Treecreeper	I	R	LC	0	0	2	2
10	*Certhia familiaris mandellii*	Eurasian Treecreeper	I	R	LC	0	2	0	2
11	*Certhia nepalensis*	Rusty–flanked Treecreeper	I	R	LC	0	0	14	14
6	**Cinclidae**								
12	*Cinclus pallasii*	Brown Dipper	Aq	R	LC	1	0	0	1
13	*Cinclus cinclus*	White–throated Dipper	I	R	LC	0	0	4	4
7	**Columbidae**								
14	*Ducula badia*	Mountain Imperial–pigeon	G	R	LC	6	0	1	7
15	*Streptopelia orientalis*	Oriental Turtle–dove	G	WV	LC	0	2	3	5
8	**Corvidae**								

Sl. No.	Family and species name	Common name	FS	MS	CS	PM	M	W	Overall
16	*Corvus culminatus*	Large–billed Crow	O	R	LC	0	0	3	3
17	*Nucifraga caryocatactes*	Spotted Nutcracker	Nu	R	LC	0	0	2	2
9	**Cuculidae**								
18	*Chrysococcyx maculatus*	Asian Emerald Cuckoo	I	BV	LC	1	0	0	1
19	*Cuculus poliocephalus*	Small Cuckoo	I	BV	LC	0	0	1	1
10	**Dicaeidae**								
20	*Dicaeum ignipectus*	Fire–breasted Flowerpecker	N	R	LC	11	3	3	17
21	*Dicaeum minullum*	Plain Flowerpecker	N	R	LC	0	4	0	4
22	*Dicaeum melanoxanthum*	Yellow–bellied Flowerpecker	N	R	LC	0	0	2	2
23	*Dicaeum chrysorrheum*	Yellow–vented Flowerpecker	N	R	LC	0	3	0	3
11	**Dicruridae**								
24	*Dicrurus leucophaeus*	Ashy Drongo	O	WV	LC	17	1	0	18
25	*Dicrurus macrocercus*	Black Drongo	O	R	LC	20	0	0	20
12	**Falconidae**								
26	*Falco tinnunculus*	Common Kestrel	C	WV	LC	0	0	1	1
13	**Fringillidae**								
27	*Fringilla montifringilla*	Brambling	I	IR	LC	0	0	7	7
28	*Haematospiza sipahi*	Scarlet Finch	G	R	LC	0	10	0	10
14	**Hirundinidae**								
29	*Delichon dasypus*	Asian House Martin	I	BV	LC	0	0	6	6
30	*Delichon nipalense*	Nepal House–martin	I	R	LC	0	77	33	110
15	**Laniidae**								
31	*Lanius cristatus*	Brown Shrike	I	WV	LC	0	2	0	2
16	**Leiothrichidae**								
32	*Heterophasia capistrata*	Rufous Sibia	O	R	LC	25	37	15	77
17	**Motacillidae**								
33	*Anthus hodgsoni hodgsoni*	Olive–backed Pipit	I	R	LC	0	2	0	2
18	**Muscicapidae**								
34	*Phoenicurus ochruros*	Black Redstart	I	WV	LC	0	0	1	1
35	*Phoenicurus frontalis*	Blue–fronted Redstart	I	BV	LC	0	0	8	8
36	*Cyornis rubeculoides*	Blue–throated Flycatcher	I	BV	LC	0	0	1	1
37	*Muscicapa sibirica*	Dark–sided Flycatcher	I	BV	LC	0	3	0	3
38	*Phoenicurus hodgsoni*	Hodgson's Redstart	I	WV	LC	0	0	1	1
39	*Niltava grandis*	Large Niltava	I	R	LC	0	1	0	1
40	*Enicurus scouleri*	Little Forktail	I	R	LC	0	0	1	1
41	*Ficidula strophiata*	Orange–gorgeted Flycatcher	I	R	LC	0	3	2	5
42	*Copsy chus saularis*	Oriental Magpie–robin	I	R	LC	0	0	1	1
43	*Cymrnis poliogenys*	Pale–chinned Flychatcher	I	R	LC	0	0	2	2
44	*Rhyacornis fuliginosa*	Plumbeous Water–redstart	I	R	LC	24	14	3	41
45	*Muscicapella hodgsoni*	Pygmy Blue Flycatcher	I	R	LC	0	0	1	1
46	*Niltava sundara*	Rufous–bellied Niltava	I	BV	LC	0	3	0	3
47	*Ficedula tricolor*	Slaty–blue Flycatcher	I	BV	LC	0	1	0	1
48	*Ficedula superciliaris*	Ultramarine Flycatcher	I	BV	LC	0	2	0	2
49	*Chaimarrornis leucocephalus*	White–capped River–chat	I	R	LC	19	8	1	28
50	*Myiomela leucura*	White–tailed Blue Robin	I	R	LC	7	0	0	7
51	*Myiomela leucura*	White–tailed Blue Robin	I	R	LC	4	0	0	4
19	**Nectariniidae**								
52	*Aethopyga saturata*	Black–breasted Sunbird	N	R	LC	0	0	1	1
53	*Aethopyga nipalensis*	Green–tailed Sunbird	N	R	LC	14	14	9	37
20	**Oriolidae**								
54	*Oriolus tenuirostris*	Slender–billed Oriole	O	R	LC	6	0	0	6
21	**Paridae**								
55	*Parus ater*	Coal Tit	I	R	LC	0	0	3	3
56	*Parus monticolus*	Green–backed Tit	I	R	LC	20	13	15	48
57	*Parus dichrous*	Grey–crested Tit	I	R	LC	14	0	0	14
58	*Melanochlora sultanea*	Sultan Tit	I	R	LC	2	0	0	2
59	*Sylviparus modestus*	Yellow–browed Tit	I	R	LC	0	0	10	10
22	**Passeridae**								
60	*Passer montanus*	Eurasian Tree Sparrow	G	R	LC	0	0	2	2
23	**Prunellidae**								
61	*Prunella collaris*	Alpine Accentor	I	WV	LC	0	0	1	1
62	*Prunella immaculata*	Maroon–backed Accentor	I	WV	LC	0	0	9	9
63	*Prunella strophiata*	Rufous–breasted Accentor	I	R	LC	0	0	1	1
24	**Pycnonotidae**								
64	*Hemixos flavala*	Ashy Bulbul	O	R	LC	6	0	0	6
65	*Hypsipetes leucocephalus*	Himalayan Black Bulbul	O	R	LC	75	0	0	75
66	*Hypsipetes mcclellandi*	Mountain Bulbul	O	R	LC	0	2	0	2
67	*Pycnonotus cafer*	Red–vented Bulbul	O	R	LC	0	0	2	2

Sl. No.	Family and species name	Common name	FS	MS	CS	PM	M	W	Overall
25	**Sittidae**								
68	*Sitta himalayensis*	White–tailed Nuthatch	I	R	LC	15	1	2	18
26	**Stenostiridae**								
69	*Culicicapa ceylonensis*	Grey–headed Canary–flycatcher	I	BV	LC	20	4	0	24
70	*Chelidorhynx hypoxantha*	Yellow–bellied Fantail	I	R	LC	0	21	2	23
27	**Sylviidae**								
71	*Abroscopus schisticeps*	Black–faced Warbler	I	R	LC	0	9	0	9
72	*Phylloscopus reguloides*	Blyth's Leaf–Warbler	I	WV	LC	15	14	4	33
73	*Phylloscopus pulcher*	Buff–barred Warbler	I	BV	LC	0	11	0	11
74	*Seicercus castaniceps*	Chestnut–crowned Warbler	I	BV	LC	0	5	0	5
75	*Tesia castaneocoronata*	Chestnut–headed Tesia	I	R	LC	0	2	0	2
76	*Phylloscopus coronatus*	Eastern Crowned Warbler	I	WV	LC	19	1	0	20
77	*Seicercus burkii*	Green–crowned Warbler	I	BV	LC	0	5	0	5
78	*Phylloscopus trochiloides*	Greenish Warbler	I	WV	LC	20	10	0	30
79	*Seicercus poliogenys*	Grey–cheeked Warbler	I	R	LC	0	3	0	3
80	*Phylloscopus maculipennis*	Grey–faced Leaf–warbler	I	R	LC	0	10	5	15
81	*Phylloscopus xanthoschistos*	Grey–hooded Warbler	I	R	LC	20	5	9	34
82	*Phylloscopus chloronotus*	Lemon–rumped Leaf Warbler	I	BV	LC	0	11	0	11
83	*Orthotomus cuculatus*	Mountain Tailorbird	I	R	LC	0	0	1	1
84	*Phylloscopus fuligiventer*	Smoky Leaf–warbler	I	WV	LC	0	1	0	1
85	*Cettia fortipes*	Strong–footed Bush–warbler	I	R	LC	0	5	0	5
86	*Phylloscopus inornatus*	Yellow–browed Leaf–warbler	I	WV	LC	0	0	1	1
28	**Tichodromidae**								
87	*Tichodroma muraria*	Wallcreeper	I	WV	LC	0	0	2	2
29	**Timaliidae**								
88	*Trochalopteron imbricatum*	Bhutan Laughingthrush	I	R	LC	0	14	39	53
89	*Yuhina nigrimenta*	Black–chinned Yuhina	I	R	LC	0	4	0	4
90	*Trochalopteron affine*	Black–faced Laughingthrush	I	R	LC	0	0	15	15
91	*Trochalopteron squamatum*	Blue–winged Laughingthrush	I	R	LC	0	0	5	5
92	*Alcippe nipalensis*	Nepal Fulvetta	I	R	LC	0	3	0	3
93	*Leiothrix lutea*	Red–billed Leiothrix	O	R	LC	0	4	0	4
94	*Trachalopteron erthrocephalum*	Red–headed Launghingthrush	I	R	LC	20	28	8	56
95	*Ianthocincla rufogularis*	Rufous–chinned Laughingthrush	I	R	LC	14	0	0	14
96	*Yuhina occipitalis*	Rufous–vented Yuhina	I	R	LC	0	14	3	17
97	*Actinodura waldeni*	Streak–throated Barwing	I	R	LC	9	0	0	9
98	*Yuhina gularis*	Stripe–throated Yuhina	O	R	LC	0	4	0	4
99	*Yuhina flavicollis*	Whiskered Yuhina	I	R	LC	15	9	6	30
100	*Garrulax albogularis*	White–throated Laughingthrush	I	R	LC	9	0	0	9
30	**Troglodytidae**								
101	*Troglodytes troglodytes*	Winter Wren	I	R	LC	0	0	2	2
31	**Turdidae**								
102	*Myophonus caeruleus*	Blue Whistling–thrush	I	R	LC	24	9	5	38
103	*Monticola cinclorhyn chus*	Blue–headed Rock–thrush	I	BV	LC	22	0	0	22
104	*Monticola rufiventris*	Chestnut–bellied Rock Thrush	I	R	LC	2	0	0	2
105	*Turdus albocinctus*	White–collared Blackbird	I	R	LC	0	0	9	9
32	**Zosteropidae**								
106	*Zosterops palpebrosus*	Oriental White–eye	I	R	LC	0	3	1	4

FS: Aq–Aquatic Feeder, C–Carnivores, F–Frugivore, G–Granivore, I–Insectivore, N–Nectarivore, Nc–Nucivore, O–Omnivore, P–Piscivore; MS–Migratory Status–BV–Breeding Visitor, IR–Isolated Record, R–Resident, WV–Winter Visitor; CS–Conservation status–IUCN Red List and WPA–1972 Schedule: VU–Vulnerable, LC–Least Concern; PM–Post monsoon, M–Monsoon, W–Winter

Appendix II. 3.188: List of possible mammalian fauna of the Tawang region and contribution of species reported in the Nykcharong chu HEP area

Sl. No.	Common name	Scientific name	SPA	Conservation status	
				IUCN	WPA
	Primates				
1	Arunachal macaque	*Macaca munzala*	*	EN	–
2	Assamese macaque	*M. assamensis*		NT	II
3	Capped langur	*Trachypithecus pileatus*		VU	I
4	Slow loris	*Nycticebus coucang*		VU	I
	Ungulates				
5	Barking deer	*Muntiacus muntjak*	*	LC	III
6	Bharal	*Pseudois nayaur*		LC	I
7	Chinese goral	*Nemorhaedus caudatus*		VU	III
8	Himalayan goral	*N. goral*	*	NT	III
9	Musk deer	*Mos chus* sp.		EN	–
10	Sambar	*Cervus unicolor*		VU	III

Sl. No.	Common name	Scientific name	SPA	Conservation status	
11	Serow	*N. sumatraensis*			
12	Wild pig	*Sus scrofa*	*	LC	III
	Carnivores				
13	Common leopard	*Panthera pardus*	*	NT	I
14	Jungle Cat	*Felis Chaus*	*	LC	II
15	Dhole	*Cuon alpinus*	*	EN	II
16	Himalayan black bear	*Ursus thibetanus*		VU	II
17	Himalayan palm civet	*Paguma larvata*		LC	II
18	Leopard cat	*Prionailurus bengalensis*	*	LC	–
19	Otter	*Lutra* sp.		VU	–
20	Red panda	*Ailurus fulgens*		VU	I
21	Snow leopard	*Uncia uncia*		EN	I
22	Yellow–throated marten	*Martes flavigula*	*	LC	II
	Rodents				
23	Hairy–footed flying squirrel	*Belomys pearsonii*		DD	II
24	Himalayan marmot	*Marmota himalayana*		LC	II
25	Himalayan striped squirrel	*Tamiops macclellandi*	*	LC	–
26	Orange–bellied Himalayan squirrel	*Dremomys lokriah*	*	LC	–
	*Hoary–bellied Himalayan Squirrel	*Callosciurus pygerythrus*	*	LC	–
27	Porcupine	*Hystrix* sp.	*	LC	IV
	*Chesnut rat	*Niviventer fluvescens*		LC	V
	Lagomorphs				
28	Large–eared pika	*Ochotona macrotis*		LC	–
29	Moupin pika	*Ochotona thibetana*		LC	–
	29 species		**13 species R% 44.82%**		

Data Source: 1–Mishra et al 2006, SPA–Species of Project Area. * Additional species reported during the study

Appendix II. 3.189: Status of birds at Nykcharong chu barrage site

Sl. No.	Family and species name	Common name	FS	MS	CS	No. of birds recorded
1	**Apodidae**					
1	*Aerodramus brevirostris*	Himalayan Swiftlet	I	R	LC	5
2	**Certhiidae**					
2	*Certhia nepalensis*	Rusty–flanked Treecreeper	I	R	LC	10
3	**Dicaeidae**					
3	*Dicaeum ignipectus*	Fire–breasted Flowerpecker	N	R	LC	2
4	**Dicruridae**					
4	*Dicrurus leucophaeus*	Ashy Drongo	O	WV	LC	5
5	*Dicrurus macrocercus*	Black Drongo	O	R	LC	2
5	**Fringillidae**					
6	*Fringilla montifringilla*	Brambling	I	IR	LC	4
6	**Hirundinidae**					
7	*Delichon dasypus*	Asian House Martin	I	BV	LC	3
8	*Delichon nipalense*	Nepal House Martin	I	R	LC	8
7	**Leiothrichidae**					
9	*Heterophasia capistrata*	Rufous Sibia	O	R	LC	4
8	**Muscicapidae**					
10	*Enicurus scouleri*	Little Forktail	G	WV	LC	1
11	*Phoenicurus frontalis*	Blue–fronted Redstart	I	BV	LC	4
12	*Phoenicurus hodgsoni*	Hodgson's Redstart	I	WV	LC	1
9	**Nectariniidae**					
13	*Aethopyga nipalensis*	Green–tailed Sunbird	N	R	LC	5
10	**Paridae**					
14	*Melanochlora sultanea*	Sultan Tit	I	R	LC	2
15	*Parus dichrous*	Grey–crested Tit	I	R	LC	2
16	*Parus monticolus*	Green–backed Tit	I	R	LC	4
17	*Sylviparus modestus*	Yellow–browed Tit	I	R	LC	3
11	**Prunellidae**					
18	*Prunella immaculata*	Maroon–backed Accentor	I	WV	LC	9
12	**Pycnonotidae**					
19	*Hemixos flavala*	Ashy Bulbul	O	R	LC	1
20	*Hypsipetes leucocephalus*	Himalayan Black Bulbul	O	R	LC	2
13	**Stenostiridae**					
21	*Culicicapa ceylonensis*	Grey–headed Canary–flycatcher	I	BV	LC	3
14	**Sylviidae**					
22	*Phylloscopus coronatus*	Eastern Crowned Warbler	I	WV	LC	3
23	*Phylloscopus maculipennis*	Ashy–throated Warbler	I	R	LC	2

Sl. No.	Family and species name	Common name	FS	MS	CS	No. of birds recorded
24	*Phylloscopus reguloides*	Blyth's Leaf–warbler	I	WV	LC	2
25	*Phylloscopus trochiloides*	Greenish Warbler	I	WV	LC	3
26	*Phylloscopus xanthoschistos*	Grey–hooded Warbler	I	R	LC	5
15	**Timaliidae**					
27	*Trochalopteron affine*	Black–faced Laughingthrush	I	R	LC	3
28	*Trochalopteron imbricatum*	Bhutan Laughing Thrush	I	R	LC	5
29	*Trachalopteron erthrocephalum*	Red–headed Launghingthrush	I	R	LC	3
16	**Turdidae**					
30	*Monticola cinclorhyn chus*	Blue–headed Rock–thrush	I	BV	LC	2
31	*Myophonus caeruleus*	Blue Whistling–thrush	I	R	LC	4

FS: Foraging Status, G–Granivore, I–Insectivore, N–Nectarivore, O–Omnivore, MS–Migratory Status–BV–Breeding Visitor, IR–Isolated Record, R–Resident, WV–Winter Visitor; CS–Conservation status–IUCN Red List and WPA–1972 Schedule: LC–Least Concern;

Appendix II. 3.190: Status of birds at Nykcharong chu powerhouse site

Sl. No.	Family and species name	Common name	FS	MS	CS	No. of birds recorded
1	**Accipitridae**					
1	*Elanus caeruleus*	Black–winged Kite	C	R	LC	5
2	*Gyps fulvus*	Griffon Vulture	C	WV	LC	3
3	*Nisaetus nipalensis*	Mountain–hawk Eagle	C	R	LC	3
2	**Aegithalidae**					
4	*Aegithalos concinnus*	Red–headed Tit	I	R	LC	5
3	**Apodidae**					
5	*Apus pacificus*	Pacific Swift	I	BV	LC	2
4	**Campephagidae**					
6	*Pericrocotus speciosus*	Scarlet Minivet	I	R	LC	4
5	**Cinclidae**					
7	*Cinclus cinclus*	White–throated Dipper	I	R	LC	1
6	**Cisticolidae**					
8	*Prinia crinigera*	Striated Prinia	I	R	LC	15
9	*Prinia hodgsonii*	Grey–breasted Prinia	I	R	LC	2
7	**Cuculidae**					
10	*Chrysococcyx maculatus*	Asian Emerald Cuckoo	I	BV	LC	1
11	*Hierococcyx sparverioides*	Large Hawk–cuckoo	I	BV	LC	1
12	*Phaenicophaeus tristis*	Green–billed Malkoha	O	R	LC	2
8	**Dicruridae**					
13	*Dicrurus leucophaeus*	Ashy Drongo	O	WV	LC	3
9	**Emberizidae**					
14	*Emberiza pusilla*	Little Bunting	G	WV	LC	4
10	**Fringillidae**					
15	*Carpodacus pulcherrimus*	Himalayan Beautiful Rosefinch	G	WV	LC	6
16	*Carduelis spinoides*	Himalayan Greenfinch	G	WV	LC	25
11	**Hirundinidae**					
17	*Delichon nipalense*	Nepal House Martin	I	R	LC	12
12	**Laniidae**					
18	*Lanius schach tricolor*	Black–headed' Long–tailed Shrike	I	BV	LC	2
13	**Leiothrichidae**					
19	*Heterophasia capistrata*	Rufous Sibia	O	R	LC	2
14	**Megalaimidae**					
20	*Megalaima asiatica*	Blue–throated Barbet	F	R	LC	7
21	*Megalaima franklinii*	Golden–throated Barbet	F	R	LC	1
22	*Megalaima virens*	Great Barbet	F	R	LC	6
15	**Motacillidae**					
23	*Anthus hodgsoni hodgsoni*	Olive–backed Pipit	I	R	LC	2
16	**Muscicapidae**					
24	*Enicurus leschenaulti*	White–crowned Forktail	I	R	LC	5
25	*Muscicapa ferruginea*	Ferruginous Flycatcher	I	BV	LC	2
26	*Niltava (vivda) catesi*	Vivid Niltava	I	BV	LC	2
27	*Niltava sundara*	Rufous–bellied Niltava	I	BV	LC	1
28	*Phoenicurus frontalis*	Blue–fronted Redstart	I	BV	LC	1
29	*Rhyacornis fuliginosa*	Plumbeous Water–redstart	I	R	LC	3
30	*Saxicola ferreus*	Grey Bushchat	I	R	LC	2
17	**Paridae**					
31	*Parus ater*	Coal Tit	I	R	LC	2
32	*Parus dichrous*	Grey–crested Tit	I	R	LC	2
33	*Parus monticolus*	Green–backed Tit	I	R	LC	2
18	**Picidae**					

Sl. No.	Family and species name	Common name	FS	MS	CS	No. of birds recorded
34	*Dendrocopos canicapillus*	Grey–capped Pygmy Woodpecker	I	R	LC	2
35	*Picus flavinucha*	Greater Yellownape	I	R	LC	2
19	**Prunellidae**					
36	*Prunella rubeculoides*	Robin Accentor	O	R	LC	24
20	**Rhipiduridae**					
37	*Rhipidura albicollis*	White–throated Fantail	I	R	LC	1
21	**Stenostiridae**					
38	*Chelidorhynx hypoxantha*	Yellow–bellied Fantail	I	R	LC	6
22	**Sylviidae**					
39	*Abroscopus schisticeps*	Black–faced Warbler	I	R	LC	5
40	*Phylloscopus chloronotus*	Lemon–rumped Leaf Warbler	I	BV	LC	1
41	*Phylloscopus inornatus*	Yellow–browed Leaf–warbler	I	WV	LC	4
42	*Phylloscopus maculipennis*	Ashy–throated Warbler	I	R	LC	1
43	*Phylloscopus maculipennis*	Grey–faced Leaf–warbler	I	R	LC	2
44	*Phylloscopus pulcher*	Orange–barred Leaf–warbler	I	WV	LC	2
45	*Seicercus burkii*	Green–crowned Warbler	I	BV	LC	4
46	*Seicercus castaniceps*	Chestnut–crowned Warbler	I	BV	LC	3
47	*Seicercus poliogenys*	Grey–cheeked Warbler	I	R	LC	4
23	**Timaliidae**					
48	*Alcippe nipalensis*	Nepal Fulvetta	I	R	LC	3
49	*Leiothrix lutea*	Red–billed Leiothrix	O	R	LC	4
50	*Trachalopteron erthrocephalum*	Red–headed Launghingthrush	I	R	LC	16
51	*Yuhina occipitalis*	Rufous–vented Yuhina	I	R	LC	4
24	**Troglodytidae**					
52	*Troglodytes troglodytes*	Winter Wren	I	R	LC	1
25	**Turdidae**					
53	*Turdus albocinctus*	White–collared Blackbird	I	R	LC	2
26	**Zosteropidae**					
54	*Zosterops palpebrosus*	Oriental White–eye	I	R	LC	1

FS–Foraging Status, F–Frugivore, G–Granivore, I–Insectivore, O–Omnivore, MS–Migratory Status–BV–Breeding Visitor, R–Resident, WV–Winter Visitor; CS–Conservation status–IUCN Red List and WPA–1972 Schedule: LC–Least Concern

Appendix II. 3.191: Ecological status of bird species recorded in the Rho HEP area

Sl. No.	Family and species name	Common name	FS	MS	CS	PM	M	W	Overall
1	**Accipitridae**								
1	*Hieraaetus fasciatus*	Bonelli's Eagle	C	R	LC	0	1	0	1
2	*Gyps himalayensis*	Himalayan Vulture	C	WV	LC	0	0	1	1
3	*Buteo rufinus*	Long–legged Buzzard	C	WV	LC	0	1	0	1
2	**Apodidae**								
4	*Aerodramus brevirostris*	Himalayan Swiftlet	I	R	LC	18	88	0	106
3	**Campephagidae**								
5	*Pericrocotus ethologus*	Long–tailed Minvet	I	BV	LC	0	0	2	2
6	*Pericrocotus speciosus*	Scarlet Minivet	I	R	R	0	11	0	11
4	**Certhiidae**								
7	*Certhia familiaris mandellii*	Eurasian Treecreeper	I	R	LC	0	2	0	2
8	*Certhia nepalensis*	Rusty–flanked Treecreeper	I	R	LC	0	0	1	1
5	**Charadriidae**								
9	*Charadrius placidus*	Long–billed Plover	I	WV	LC	0	2	0	2
6	**Cinclidae**								
10	*Cinclus pallasii*	Brown Dipper	Aq	R	LC	1	0	0	1
11	*Cinclus cinclus*	White–throated Dipper	I	R	LC	0	0	6	6
7	**Columbidae**								
12	*Streptopelia orientalis*	Oriental Turtle–dove	G	WV	LC	0	3	3	6
13	*Treron sphenurus*	Wedge–tailed Green–pigeon	G	R	LC	21	0	0	21
8	**Corvidae**								
14	*Dendrocitta formosae*	Grey Treepie	O	R	LC	0	0	5	5
15	*Corvus culminatus*	Large–billed Crow	O	R	LC	0	0	4	4
16	*Nucifraga caryocatactes*	Spotted Nutcracker	Nu	R	LC	0	0	3	3
9	**Cuculidae**								
17	*Chrysococcyx maculatus*	Asian Emerald Cuckoo	I	BV	LC	3	0	0	3
18	*Hierococcyx sparverioides*	Large Hawk–cuckoo	I	BV	LC	11	0	0	11
19	*Cuculus poliocephalus*	Small Cuckoo	I	BV	LC	0	0	1	1
10	**Dicaeidae**								
20	*Dicaeum ignipectus*	Fire–breasted Flowerpecker	N	R	LC	12	0	2	14
21	*Dicaeum minullum*	Plain Flowerpecker	N	R	LC	0	4	0	4
22	*Dicrurus leucophaeus*	Ashy Drongo	O	WV	LC	18	1	0	19
11	**Dicruridae**								

Sl. No.	Family and species name	Common name	FS	MS	CS	PM	M	W	Overall
23	*Dicrurus macrocercus*	Black Drongo	O	R	LC	16	0	0	16
24	*Dicrurus aeneus*	Bronzed Drongo	O	R	LC	21	0	0	21
12	**Fringillidae**								
25	*Carpodacus nepalensis*	Dark–breasted Rosefinch	G	R	LC	0	0	9	9
26	*Carpodacus edwardsii*	Dark–rumped Rosefinch	G	R	LC	0	0	16	16
27	*Haematospiza sipahi*	Scarlet Finch	G	R	LC	0	6	0	6
28	*Mycerobas melanozanthos*	Spot–winged Grosbeak	G	R	LC	0	2	0	2
29	*Mycerobas carnipes*	White–winged Grosbeak	G	R	LC	0	0	3	3
13	**Halcyonidae**								
30	*Halcyon smyrnensis*	White–throated Kingfisher	P	R	LC	2	0	0	2
14	**Hirundinidae**								
31	*Delichon nipalense*	Nepal House–martin	I	R	LC	14	27	0	41
15	**Laniidae**								
32	*Lanius schach tricolor*	Black–headed' Long–tailed Shrike	I	BV	LC	0	0	1	1
16	**Leiothrichidae**								
33	*Heterophasia capistrata*	Rufous Sibia	O	R	LC	22	60	13	95
17	**Megalaimidae**								
34	*Megalaima virens*	Great Barbet	F	R	LC	12	0	0	12
18	**Motacillidae**								
35	*Motacilla cinerea*	Grey Wagtail	I	WV	LC	0	2	0	2
36	*Anthus hodgsoni hodgsoni*	Olive–backed Pipit	I	R	LC	0	9	0	9
37	*Motacilla alba alboides*	White Wagtail	I	WV	LC	13	0	0	13
19	**Muscicapidae**								
38	*Phoenicurus frontalis*	Blue–fronted Redstart	I	BV	LC	0	0	4	4
39	*Cyornis rubeculoides*	Blue–throated Flycatcher	I	BV	LC	0	0	1	1
40	*Muscicapa sibirica*	Dark–sided Flycatcher	I	BV	LC	0	2	0	2
41	*Niltava grandis*	Large Niltava	I	R	LC	0	1	0	1
42	*Ficidula strophiata*	Orange–gorgeted Flycatcher	I	R	LC	0	2	0	2
43	*Copsy chus saularis*	Oriental Magpie–robin	I	R	LC	0	0	3	3
44	*Rhyacornis fuliginosa*	Plumbeous Water–redstart	I	R	LC	24	16	5	45
45	*Niltava sundara*	Rufous–bellied Niltava	I	BV	LC	0	3	0	3
46	*Ficedula superciliaris*	Ultramarine Flycatcher	I	BV	LC	8	0	0	8
47	*Eumyias thalassinus*	Verditer Flycatcher	I	BV	LC	18	4	0	22
48	*Chaimarrornis leucocephalus*	White–capped River–chat	I	R	LC	18	8	3	29
20	**Nectariniidae**								
49	*Aethopyga saturata*	Black–breasted Sunbird	N	R	LC	8	0	1	9
50	*Aethopyga ignicauda*	Fire–tailed Sunbird	N	R	LC	0	0	1	1
51	*Aethopyga nipalensis*	Green–tailed Sunbird	N	R	LC	12	5	2	19
21	**Paradoxornithidae**								
52	*Paradoxornis nipalensis*	Black–throated Parrotbill	G	R	LC	0	0	21	21
22	**Paridae**								
53	*Parus spilonotus*	Black–spotted Yellow Tit	I	R	LC	11	0	0	11
54	*Parus ater*	Coal Tit	I	R	LC	8	0	2	10
55	*Parus monticolus*	Green–backed Tit	I	R	LC	0	9	12	21
56	*Parus dichrous*	Grey–crested Tit	I	R	LC	11	0	0	11
57	*Melanochlora sultanea*	Sultan Tit	I	R	LC	3	0	0	3
58	*Sylviparus modestus*	Yellow–browed Tit	I	R	LC	0	0	2	2
23	**Passeridae**								
59	*Passer rutilans*	Cinnamon Sparrow	G	R	LC	15	0	0	15
60	*Passer montanus*	Eurasian Tree Sparrow	G	R	LC	0	0	7	7
24	**Picidae**								
61	*Blythipicus pyrrhotis*	Bay Woodpecker	I	R	LC	0	1	0	1
62	*Dendrocopos canicapillus*	Grey–capped Pygmy Woodpecker	I	R	LC	0	0	2	2
25	**Prunellidae**								
63	*Prunella collaris*	Alpine Accentor	I	WV	LC	0	0	2	2
64	*Prunella rubeculoides*	Robin Accentor	I	WV	LC	0	0	3	3
65	*Prunella strophiata*	Rufous–breasted Accentor	I	R	LC	0	0	2	2
26	**Pycnonotidae**								
66	*Hemixos flavala*	Ashy Bulbul	O	R	LC	3	0	0	3
67	*Hypsipetes leucocephalus*	Himalayan Black Bulbul	O	R	LC	52	0	0	52
68	*Pycnonotus cafer*	Red–vented Bulbul	O	R	LC	0	3	4	7
27	**Sittidae**								
69	*Sitta himalayensis*	White–tailed Nuthatch	I	R	LC	11	2	0	13
28	**Stenostiridae**								
70	*Culicicapa ceylonensis*	Grey–headed Canary–flycatcher	I	BV	LC	18	4	0	22
71	*Chelidorhynx hypoxantha*	Yellow–bellied Fantail	I	R	LC	0	9	0	9
29	**Sylviidae**								
72	*Abroscopus schisticeps*	Black–faced Warbler	I	R	LC	0	5	0	5

Sl. No.	Family and species name	Common name	FS	MS	CS	PM	M	W	Overall
73	*Phylloscopus reguloides*	Blyth's Leaf–Warbler	I	WV	LC	0	7	1	8
74	*Phylloscopus pulcher*	Buff–barred Warbler	I	BV	LC	0	6	0	6
75	*Seicercus castaniceps*	Chestnut–crowned Warbler	I	BV	LC	0	3	0	3
76	*Tesia castaneocoronata*	Chestnut–headed Tesia	I	R	LC	0	2	0	2
77	*Orthotomus sutorius*	Common Tailorbird	I	R	LC	0	0	3	3
78	*Seicercus burkii*	Green–crowned Warbler	I	BV	LC	0	4	0	4
79	*Phylloscopus trochiloides*	Greenish Warbler	I	WV	LC	0	12	0	12
80	*Seicercus poliogenys*	Grey–cheeked Warbler	I	R	LC	0	2	0	2
81	*Phylloscopus maculipennis*	Grey–faced Leaf–warbler	I	R	LC	0	11	2	13
82	*Phylloscopus xanthoschistos*	Grey–hooded Warbler	I	R	LC	17	11	0	28
83	*Phylloscopus chloronotus*	Lemon–rumped Leaf Warbler	I	BV	LC	0	10	0	10
84	*Cettia fortipes*	Strong–footed Bush–warbler	I	R	LC	0	8	0	8
85	*Phylloscopus inornatus*	Yellow–browed Leaf–warbler	I	WV	LC	0	0	1	1
30	**Tichodromidae**								
86	*Tichodroma muraria*	Wallcreeper	I	WV	LC	0	0	2	2
31	**Timaliidae**								
87	*Trochalopteron imbricatum*	Bhutan Laughingthrush	I	R	LC	0	10	33	43
88	*Trochalopteron affine*	Black–faced Laughingthrush	I	R	LC	0	0	5	5
89	*Trochalopteron squamatum*	Blue–winged Laughingthrush	I	R	LC	0	0	5	5
90	*Dryonastes caerulatus*	Grey–sided Laughingthrush	I	R	LC	0	3	0	3
91	*Stachyris nigriceps*	Grey–throated Babbler	I	R	LC	0	0	7	7
92	*Alcippe nipalensis*	Nepal Fulvetta	I	R	LC	0	8	0	8
93	*Pellorneum ruficeps*	Puff–throated Babbler	I	R	LC	4	0	0	4
94	*Leiothrix lutea*	Red–billed Leiothrix	O	R	LC	0	4	0	4
95	*Trachalopteron erthrocephalum*	Red–headed Launghingthrush	I	R	LC	0	22	12	34
96	*Minla ignotincta*	Red–tailed Minla	I	R	LC	0	0	5	5
97	*Ianthocincla rufogularis*	Rufous–chinned Laughingthrush	I	R	LC	11	0	0	11
98	*Yuhina occipitalis*	Rufous–vented Yuhina	I	R	LC	0	13	12	25
99	*Lanthocincla ocellata*	Spotted Laughingthrush	I	R	LC	0	2	0	2
100	*Pomatorhinus ruficollis*	Streak–breasted Scimitar–babbler	I	R	LC	0	0	2	2
101	*Actinodura waldeni*	Streak–throated Barwing	I	R	LC	6	0	0	6
102	*Yuhina gularis*	Stripe–throated Yuhina	O	R	LC	11	0	0	11
103	*Yuhina flavicollis*	Whiskered Yuhina	I	R	LC	12	6	7	25
104	*Pomatorhinus schisticeps*	White–browed Scimitar–babbler	I	R	LC	0	0	2	2
105	*Garrulax albogularis*	White–throated Laughingthrush	I	R	LC	7	0	0	7
32	**Troglodytidae**								
106	*Troglodytes troglodytes*	Winter Wren	I	R	LC	0	0	2	2
33	**Turdidae**								
107	*Myophonus caeruleus*	Blue Whistling–thrush	I	R	LC	22	13	7	42
108	*Zoothera dixoni*	Long–tailed Thrush	I	BV	LC	0	1	1	2
109	*Turdus albocinctus*	White–collared Blackbird	I	R	LC	0	0	10	10
34	**Zosteropidae**								
110	*Zosterops palpebrosus*	Oriental White–eye	I	R	LC	0	0	4	4

FS: Aq–Aquatic Feeder, C–Carnivores, F–Frugivore, G–Granivore, I–Insectivore, N–Nectarivore, Nc–Nucivore, O–Omnivore, P–Piscivore; MS–Migratory Status–BV–Breeding Visitor, IR–Isolated Record, R–Resident, WV–Winter Visitor; CS–Conservation status–IUCN Red List and WPA–1972 Schedule: VU–Vulnerable, LC–Least Concern; PM–Post monsoon, M–Monsoon, W–Winter

Appendix II. 3.192: List of possible mammalian fauna of the Tawang region and Rho HEP area

Sl. No.	Common name	Scientific name	SPA	Conservation status	
				IUCN	WPA
	Primates				
1	Arunachal macaque	*Macaca munzala*	*	EN	–
2	Assamese macaque	*M. assamensis*		NT	II
3	Capped langur	*Trachypithecus pileatus*		VU	I
4	Slow loris	*Nycticebus coucang*		VU	I
	Ungulates				
5	Barking deer	*Muntiacus muntjak*	*	LC	III
6	Bharal	*Pseudois nayaur*		LC	I
7	Chinese goral	*Nemorhaedus caudatus*		VU	III
8	Himalayan goral	*N. goral*	*	NT	III
9	Musk deer	*Mos chus* sp.		EN	–
10	Sambar	*Cervus unicolor*		VU	III
11	Serow	*N. sumatraensis*			
12	Wild pig	*Sus scrofa*	*	LC	III
	Carnivores				
13	Common leopard	*Panthera pardus*		NT	I

Sl. No.	Common name	Scientific name	SPA	Conservation status	
14	Jungle Cat	*Felis Chaus*	*	LC	II
15	Dhole	*Cuon alpinus*		EN	II
16	Himalayan black bear	*Ursus thibetanus*		VU	II
17	Himalayan palm civet	*Paguma larvata*		LC	II
18	Leopard cat	*Prionailurus bengalensis*		LC	–
19	Otter	*Lutra* sp.		VU	–
20	Red panda	*Ailurus fulgens*		VU	I
21	Snow leopard	*Uncia uncia*		EN	I
22	Yellow–throated marten	*Martes flavigula*	*	LC	II
	Rodents				
23	Hairy–footed flying squirrel	*Belomys pearsonii*		DD	II
24	Himalayan marmot	*Marmota himalayana*		LC	II
25	Himalayan striped squirrel	*Tamiops macclellandi*	*	LC	–
26	Orange–bellied Himalayan squirrel	*Dremomys lokriah*		LC	–
	*Hoary–bellied Himalayan Squirrel	*Callosciurus pygerythrus*	*	LC	–
27	Porcupine	*Hystrix* sp.		LC	IV
	*Chesnut rat	*Niviventer fluvescens*		LC	V
	Lagomorphs				
28	Large–eared pika	*Ochotona macrotis*		LC	–
29	Moupin pika	*Ochotona thibetana*		LC	–
	29 species		**8 species R% 27.58%**		

Data source: 1–Mishra et al. 2006, SPA–Species of Project Area, * Additional species reported during the study

Appendix II. 3.193: Status of birds at Rho barrage site

Sl. No.	Family and species name	Common name	FS	MS	CS	No. of birds recorded
1	**Accipitridae**					
1	*Hieraaetus fasciatus*	Bonelli's Eagle	C	R	LC	1
2	**Apodidae**					
2	*Aerodramus brevirostris*	Himalayan Swiftlet	I	R	LC	5
3	**Certhiidae**					
3	*Certhia nepalensis*	Rusty–flanked Treecreeper	I	R	LC	1
4	**Cinclidae**					
4	*Cinclus cinclus*	White–throated Dipper	I	R	LC	2
5	**Columbidae**					
5	*Streptopelia orientalis*	Oriental Turtle–dove	G	WV	LC	2
6	*Treron sphenurus*	Wedge–tailed Green–pigeon	G	R	LC	4
6	**Cuculidae**					
7	*Cuculus poliocephalus*	Small Cuckoo	I	BV	LC	1
7	**Dicaeidae**					
8	*Dicaeum ignipectus*	Fire–breasted Flowerpecker	N	R	LC	4
8	**Fringillidae**					
9	*Carpodacus edwardsii*	Dark–rumped Rosefinch	G	R	LC	13
10	*Haematospiza sipahi*	Scarlet Finch	G	R	LC	2
9	**Hirundinidae**					
11	*Delichon nipalense*	Nepal House Martin	I	R	LC	15
10	**Leiothrichidae**					
12	*Heterophasia capistrata*	Rufous Sibia	O	R	LC	9
11	**Megalaimidae**					
13	*Megalaima virens*	Great Barbet	F	R	LC	2
12	**Muscicapidae**					
14	*Chaimarrornis leucocephalus*	White–capped River–chat	I	R	LC	7
15	*Ficedula superciliaris*	Ultramarine Flycatcher	I	BV	LC	2
16	*Muscicapa sibirica*	Dark–sided Flycatcher	I	BV	LC	1
17	*Phoenicurus frontalis*	Blue–fronted Redstart	I	BV	LC	1
18	*Rhyacornis fuliginosa*	Plumbeous Water–redstart	I	R	LC	11
13	**Nectariniidae**					
19	*Aethopyga nipalensis*	Green–tailed Sunbird	N	R	LC	2
14	**Paridae**					
20	*Parus monticolus*	Green–backed Tit	I	R	LC	1
21	*Sylviparus modestus*	Yellow–browed Tit	I	R	LC	2
15	**Prunellidae**					
22	*Prunella rubeculoides*	Robin Accentor	O	R	LC	1
16	**Pycnonotidae**					
23	*Hypsipetes leucocephalus*	Himalayan Black Bulbul	O	R	LC	7
17	**Sittidae**					
24	*Sitta himalayensis*	White–tailed Nuthatch	I	R	LC	2

Sl. No.	Family and species name	Common name	FS	MS	CS	No. of birds recorded
18	**Stenostiridae**					
25	*Culicicapa ceylonensis*	Grey–headed Canary–flycatcher	I	BV	LC	1
19	**Sylviidae**					
26	*Phylloscopus inornatus*	Yellow–browed Leaf–warbler	I	WV	LC	1
27	*Phylloscopus maculipennis*	Grey–faced Leaf–warbler	I	R	LC	2
28	*Phylloscopus reguloides*	Blyth's Leaf–warbler	I	WV	LC	1
29	*Phylloscopus trochiloides*	Greenish Warbler	I	WV	LC	1
30	*Phylloscopus xanthoschistos*	Grey–hooded Warbler	I	R	LC	4
31	*Tesia castaneocoronata*	Chestnut–headed Tesia	I	R	LC	2
20	**Timaliidae**					
32	*Ianthocincla rufogularis*	Rufous–chinned Laughingthrush	I	R	LC	3
33	*Trachalopteron erthrocephalum*	Red–headed Launghingthrush	I	R	LC	4
34	*Trochalopteron imbricatum*	Bhutan Laughing Thrush	I	R	LC	3
35	*Trochalopteron squamatum*	Blue–winged Laughingthrush	I	R	LC	5
36	*Yuhina flavicollis*	Whiskered Yuhina	I	R	LC	3
37	*Yuhina gularis*	Stripe–throated Yuhina	O	R	LC	4
21	**Turdidae**					
38	*Monticola solitarius*	Blue Rock–thrush	I	WV	LC	1
39	*Myophonus caeruleus*	Blue Whistling–thrush	I	R	LC	2

FS–Foraging status, Aq–Aquatic Feeder, C–Carnivores, F–Frugivore, G–Granivore, I–Insectivore, N–Nectarivore, O–Omnivore, MS–Migratory Status–BV–Breeding Visitor, R–Resident, WV–Winter Visitor; CS–Conservation status–IUCN Red List and WPA–1972 Schedule: LC–Least Concern;

Appendix II. 3.194: Status of birds at Rho powerhouse site

Sl. No.	Genus/Family/Species	Common name	FS	MS	CS	No. of birds recorded
1	**Apodidae**					
1	*Aerodramus brevirostris*	Himalayan Swiftlet	I	WV	LC	8
2	**Columbidae**					
2	*Streptopelia orientalis*	Oriental Turtle–dove	G	WV	LC	3
3	**Corvidae**					
3	*Corvus culminatus*	Large–billed Crow	O	R	LC	2
4	**Dicaeidae**					
4	*Dicaeum ignipectus*	Fire–breasted Flowerpecker	N	R	LC	3
5	**Dicruridae**					
5	*Dicrurus aeneus*	Bronzed Drongo	O	R	LC	6
6	*Dicrurus leucophaeus*	Ashy Drongo	O	WV	LC	3
7	*Dicrurus macrocercus*	Black Drongo	O	R	LC	1
6	**Leiothrichidae**					
8	*Heterophasia capistrata*	Rufous Sibia	O	R	LC	7
7	**Megalaimidae**					
9	*Megalaima virens*	Great Barbet	F	R	LC	2
8	**Motacillidae**					
10	*Anthus hodgsoni hodgsoni*	Olive–backed Pipit	I	R	LC	5
11	*Motacilla cinerea*	Grey Wagtail	I	WV	LC	2
9	**Muscicapidae**					
12	*Rhyacornis fuliginosa*	Plumbeous Water–redstart	I	R	LC	6
10	**Paridae**					
13	*Parus ater*	Coal Tit	I	R	LC	2
14	*Parus monticolus*	Green–backed Tit	I	R	LC	2
11	**Pycnonotidae**					
15	*Hemixos flavala*	Ashy Bulbul	O	R	LC	1
16	*Hypsipetes leucocephalus*	Himalayan Black Bulbul	C	R	LC	7
12	**Stenostiridae**					
17	*Culicicapa ceylonensis*	Grey–headed Canary–flycatcher	I	BV	LC	2
13	**Sylviidae**					
18	*Phylloscopus trochiloides*	Greenish Warbler	I	WV	LC	2
19	*Phylloscopus xanthoschistos*	Grey–hooded Warbler	I	R	LC	1
14	**Timaliidae**					
20	*Dryonastes caerulatus*	Grey–sided Laughingthrush	I	R	LC	3
21	*Lanthocincla ocellata*	Spotted Laughingthrush	I	R	LC	2
22	*Trachalopteron erthrocephalum*	Red–headed Launghingthrush	I	R	LC	6
23	*Trochalopteron imbricatum*	Bhutan Laughing Thrush	I	R	LC	3
15	**Turdidae**					
24	*Myophonus caeruleus*	Blue Whistling–thrush	I	R	LC	3
25	*Turdus albocinctus*	White–collared Blackbird	I	R	LC	2

Sl. No.	Genus/Family/Species	Common name	FS	MS	CS	No. of birds recorded
26	*Zoothera dixoni*	Long–tailed Thrush	I	BV	LC	1

FS–Foraging status: C–Carnivores, F–Frugivore, G–Granivore, I–Insectivore, N–Nectarivore, O–Omnivore, MS–Migratory Status–BV–Breeding Visitor, R–Resident, WV–Winter Visitor; CS–Conservation status–IUCN Red List and WPA–1972 Schedule: LC–Least Concern

Appendix II. 3.1 95: Check list and ecological status of birds recorded in the proposed Tawang–I HEP area

Sl. No.	Species	Common name	FS	MS	CS	PM	M	W	Overall
1	**Accipitridae**								
1	*Gypaetusbarbatus*	Bearded Vulture	C	R	LC	1	0	0	1
2	*Accipiter nisus*	Eurasian Sparrowhawk	C	R	LC	0	1	0	1
3	*Circus cyaneus*	Hen Harrier	C	WV	LC	0	0	1	1
4	*Accipiter gentilis*	Northern Goshawk	C	WV	LC	0	3	0	3
2	**Aegithinidae**								
5	*Aegithinatiphia*	Common Iora	I	R	LC	13	0	0	13
3	**Apodidae**								
6	*Aerodramusbrevirostris*	Himalayan Swiftlet	I	R	LC	17	1	1	19
4	**Certhiidae**								
7	*Certhiafamiliarismandellii*	Eurasian Treecreeper	I	R	LC	0	2	1	3
8	*Certhia nepalensis*	Rusty–flanked Treecreeper	I	R	LC	0	4	0	4
5	**Chloropseidae**								
9	*Chloropsis hardwickii*	Orange–bellied Leafbird	I	R	LC	0	4	0	4
6	**Cisticolidae**								
10	*Priniaatrogularis*	Black–throated Prinia	I	R	LC	0	6	2	8
11	*Priniahodgsonii*	Grey–breasted Prinia	I	R	LC	0	0	2	2
12	*Priniacrinigera*	Striated Prinia	I	R	LC	0	5	0	5
7	**Columbidae**								
13	*Duculabadia*	Mountain Imperial–pigeon	G	R	LC	0	0	3	3
14	*Streptopelia orientalis*	Oriental Turtle–dove	G	WV	LC	25	6	3	34
15	*Columba leuconota*	Snow Pigeon	G	R	LC	14	6	0	20
16	*Spilopelia chinensis*	Spotted Dove	G	R	LC	0	1	0	1
17	*Treronsphenurus*	Wedge–tailed Green–pigeon	G	R	LC	0	8	3	11
8	**Corvidae**								
18	*Dendrocittaformosae*	Grey Treepie	O	R	LC	0	9	0	9
19	*Corvusculminatus*	Large–billed Crow	O	R	LC	0	7	1	8
20	*Dendrocittavagabunda*	Rufous Treepie	O	R	LC	0	2	0	2
21	*Urocissaflavirostris*	Yellow–bellied Blue Magpie	C	R	LC	0	3	0	3
9	**Cuculidae**								
22	*Hierococcyxvarius*	Common Hawk–cuckoo	I	R	LC	19	0	0	19
23	*Phaenicophaeustristis*	Green–billed Malkoha	O	R	LC	0	1	0	1
24	*Hierococcyxsparverioides*	Large Hawk–cuckoo	I	BV	LC	12	0	0	12
25	*Cacomantismerulinus*	Plaintive Cuckoo	I	R	LC	0	5	3	8
26	*Cuculuspoliocephalus*	Small Cuckoo	I	BV	LC	0	4	1	5
10	**Dicaeidae**								
27	*Dicaeumignipectus*	Fire–breasted Flowerpecker	N	R	LC	15	2	6	23
11	**Dicruridae**								
28	*Dicrurusleucophaeus*	Ashy Drongo	O	WV	LC	0	4	0	4
29	*Dicrurusmacrocercus*	Black Drongo	O	R	LC	19	0	0	19
12	**Emberizidae**								
30	*Melophuslathami*	Crested Bunting	G	R	LC	25	0	1	26
31	*Emberizagodlewskii*	Godlewski's Bunting	G	R	LC	0	0	4	4
32	*Emberizapusilla*	Little Bunting	G	WV	LC	0	2	1	3
13	**Estrildidae**								
33	*Lon churapunctulata*	Scaly–breasted Munia	G	R	LC	0	3	0	3
14	**Fringillidae**								
34	*Fringillamontifringilla*	Brambling	I	IR	LC	24	0	0	24
35	*Carpodacus nepalensis*	Dark–breasted Rosefinch	G	R	LC	0	0	2	2
36	*Pyrrhulaerythrocephala*	Red–headed Bullfinch	G	R	LC	20	7	6	33
37	*Haematospizasipahi*	Scarlet Finch	G	R	LC	17	3	0	20
38	*Mycerobascarnipes*	White–winged Grosbeak	G	R	LC	0	1	0	1
15	**Halcyonidae**								
39	*Halcyon smyrnensis*	White–throated Kingfisher	P	R	LC	10	0	0	10
16	**Hirundinidae**								
40	*Delichondasypus*	Asian House Martin	I	BV	LC	0	14	0	14
41	*Delichonnipalense*	Nepal House–martin	I	R	LC	0	1	0	1
17	**Laniidae**								
42	*Laniusschachtricolor*	Black–headed' Long–tailed Shrike	I	BV	LC	16	0	1	17
18	**Megalaimidae**								
43	*Megalaimafranklinii*	Golden–throated Barbet	F	R	LC	13	1	0	14
44	*Megalaimavirens*	Great Barbet	F	R	LC	0	2	0	2

Sl. No.	Species	Common name	FS	MS	CS	PM	M	W	Overall
19	**Motacillidae**								
45	*Anthushodgsonihodgsoni*	Olive–backed Pipit	I	R	LC	3	0	0	3
20	**Muscicapidae**								
46	*Phoenicurusochruros*	Black Redstart	I	WV	LC	0	0	4	4
47	*Phoenicurusfrontalis*	Blue–fronted Redstart	I	BV	LC	0	0	1	1
48	*Muscicapasibirica*	Dark–sided Flycatcher	I	BV	LC	0	1	0	1
49	*Muscicapaferruginea*	Ferruginous Flycatcher	I	BV	LC	0	2	0	2
50	*Saxicolaferreus*	Grey Bushchat	I	R	LC	0	2	3	5
51	*Tarsigerrufilatus*	Himalayan Red–flanked Bush Robin	I	R	LC	20	86	20	126
52	*Enicurusscouleri*	Little Forktail	I	R	LC	8	0	0	8
53	*Ficidulastrophiata*	Orange–gorgeted Flycatcher	I	R	LC	14	0	2	16
54	*Copsy chussaularis*	Oriental Magpie–robin	I	R	LC	0	1	0	1
55	*Cymrnispoliogenys*	Pale–chinned Flychatcher	I	R	LC	13	0	0	13
56	*Muscicapellahodgsoni*	Pygmy Blue Flycatcher	I	R	LC	14	0	0	14
57	*Niltavasundara*	Rufous–bellied Niltava	I	BV	LC	0	2	0	2
58	*Ficedulahodgsonii*	Slaty–backed Flycatcher	I	WV	LC	0	0	1	1
59	*Ficedulatricolor*	Slaty–blue Flycatcher	I	BV	LC	9	0	1	10
60	*Ficedulasuperciliaris*	Ultramarine Flycatcher	I	BV	LC	0	8	0	8
61	*Tarsigerindicus*	White–browed Bush–robin	I	R	LC	0	0	3	3
62	*Chaimarrornisleucocephalus*	White–capped River–chat	I	R	LC	15	0	2	17
63	*Enicurusleschenaulti*	White–crowned Forktail	I	R	LC	7	1	0	8
64	*Myiomelaleucura*	White–tailed Blue Robin	I	R	LC	1	0	0	1
65	*Phoenicurusschisticeps*	White–throated Redstart	I	R	LC	0	0	3	3
21	**Nectariniidae**								
66	*Aethopygasaturata*	Black–breasted Sunbird	N	R	LC	0	3	0	3
67	*Aethopyganipalensis*	Green–tailed Sunbird	N	R	LC	15	8	2	25
68	*Aethopygagoulgiae*	Mrs Gould's Sunbird	N	R	LC	25	0	0	25
22	**Paridae**								
69	*Parusdichrous*	Grey–crested Tit	I	R	LC	0	5	0	5
70	*Parusrubidiventris*	Rufous–vented Tit	I	R	LC	0	9	0	9
71	*Melanochlorasultanea*	Sultan Tit	I	R	LC	0	7	0	7
23	**Passeridae**								
72	*Passer montanus*	Eurasian Tree Sparrow	G	R	LC	21	2	6	29
24	**Phasianidae**								
73	*Lophuraleucomelanos*	Kaleej Pheasant	O	R	LC	0	1	0	1
25	**Picidae**								
74	*Dryocopusmartius*	Black Woodpecker	I	R	LC	0	1	0	1
75	*Picusflavinucha*	Greater Yellownape	I	R	LC	0	11	4	15
76	*Dendrocoposcanicapillus*	Grey–capped Pygmy Woodpecker	I	R	LC	0	1	0	1
26	**Prunellidae**								
77	*Prunellarubeculoides*	Robin Accentor	I	WV	LC	21	61	12	94
27	**Pycnonotidae**								
78	*Hypsipetesleucocephalus*	Himalayan Black Bulbul	O	R	LC	12	0	0	12
79	*Pycnonotuscafer*	Red–vented Bulbul	O	R	LC	0	0	2	2
28	**Stenostiridae**								
80	*Culicicapaceylonensis*	Grey–headed Canary–flycatcher	I	BV	LC	0	23	8	31
29	**Sylviidae**								
81	*Phylloscopusreguloides*	Blyth's Leaf–Warbler	I	WV	LC	0	11	1	12
82	*Phylloscopuspulcher*	Buff–barred Warbler	I	BV	LC	0	7	0	7
83	*Orthotomussutorius*	Common Tailorbird	I	R	LC	0	0	3	3
84	*Seicercusburkii*	Green–crowned Warbler	I	BV	LC	0	24	0	24
85	*Phylloscopustrochiloides*	Greenish Warbler	I	WV	LC	0	6	1	7
86	*Phylloscopusmaculipennis*	Grey–faced Leaf–warbler	I	R	LC	13	8	0	21
87	*Phylloscopusxanthoschistos*	Grey–hooded Warbler	I	R	LC	12	0	0	12
88	*Cettiaflavolivacea*	Himalayan' Aberrant Bush–warbler	I	WV	LC	86	8	0	94
89	*Cettiabrunnescens*	Hume's Bush–warbler	I	R	LC	11	0	0	11
90	*Cettia major*	Large/Chest–crowned Bush Warbler	I	BV	LC	25	0	3	28
30	**Tichodromidae**								
91	*Tichodromamuraria*	Wallcreeper	I	WV	LC	23	0	0	23
31	**Timaliidae**								
92	*Minlastrigula*	Bar–throated Minla	I	R	LC	0	5	0	5
93	*Trochalopteronimbricatum*	Bhutan Laughingthrush	I	R	LC	0	2	21	23
94	*Pellomeumtickelli*	Buff–breasted Babbler	I	R	LC	0	0	1	1
95	*Stachyrisnigriceps*	Grey–throated Babbler	I	R	LC	17	0	0	17
96	*Pomatorhinushypoleucos*	Large Scimitar–babbler	I	R	LC	0	4	0	4
97	*Alcippenipalensis*	Nepal Fulvetta	I	R	LC	15	25	40	80
98	*Trachalopteronerthrocephalum*	Red–headed Laughingthrush	I	R	LC	0	3	0	3
99	*Minlaignotincta*	Red–tailed Minla	I	R	LC	25	16	23	64

Sl. No.	Species	Common name	FS	MS	CS	PM	M	W	Overall
100	*Ianthocinclarufogularis*	Rufous–chinned Laughingthrush	I	R	LC	15	0	0	15
101	*Lanthocinclaocellata*	Spotted Laughingthrush	I	R	LC	7	0	1	8
102	*Grammatoptilastriatus*	Striated Laughingthrush	I	R	LC	25	0	0	25
103	*Yuhinagularis*	Stripe–throated Yuhina	O	R	LC	8	4	0	12
104	*Yuhinaflavicollis*	Whiskered Yuhina	I	R	LC	0	3	2	5
105	*Erporniszantholeuca*	White–bellied Erpornis	I	R	LC	0	0	2	2
106	*Pomatorhinusschisticeps*	White–browed Scimitar–babbler	I	R	LC	0	4	0	4
107	*Pteruthiusflaviscapis*	White–browed Shrike–babbler	I	R	LC	20	3	4	27
32	**Turdidae**								
108	*Monticolasolitarius*	Blue Rock–thrush	I	WV	LC	14	0	0	14
109	*Myophonuscaeruleus*	Blue Whistling–thrush	I	R	LC	25	9	10	44
110	*Monticolacinclorhyn chus*	Blue–headed Rock–thrush	I	BV	LC	21	1	0	22
111	*Turdusboulboul*	Grey–winged Blackbird	I	R	LC	19	0	0	19
112	*Turdusalbocinctus*	White–collared Blackbird	I	R	LC	0	1	0	1
33	**Upupidae**								
113	*Upupaepops*	Common Hoopoe	I	WV	LC	5	0	0	5
34	**Zosteropidae**								
114	*Zosteropspalpebrosus*	Oriental White–eye	I	R	LC	0	11	0	11

FS: Aq–Aquatic Feeder, C–Carnivores, F–Frugivore, G–Granivore, I–Insectivore, N–Nectarivore, Nc–Nucivore, O–Omnivore, P–Piscivore; MS–Migratory Status–BV–Breeding Visitor, IR–Isolated Record, R–Resident, WV–Winter Visitor; CS–Conservation status–IUCN Red List and WPA–1972 Schedule: VU–Vulnerable, LC–Least Concern; PM–Post monsoon, M–Monsoon, W–Winter

Appendix II. 3.196: List of possible mammalian fauna of Tawang region and Tawang–I HEP area

Sl. No.	Common name	Scientific name	SPA	Conservation status	
				IUCN	**WPA**
	Primates				
1	Arunachal macaque	*Macaca munzala*	*	EN	–
2	Assamese macaque	*M. assamensis*		NT	II
3	Capped langur	*Trachypithecus pileatus*		VU	I
4	Slow loris	*Nycticebuscoucang*		VU	I
	Ungulates				
5	Barking deer	*Muntiacusmuntjak*	*	LC	III
6	Bharal	*Pseudoisnayaur*		LC	I
7	Chinese goral	*Nemorhaedus caudatus*		VU	III
8	Himalayan goral	*N. goral*		NT	III
9	Musk deer	*Mos chus* sp.		EN	–
10	Sambar	*Cervus unicolor*		VU	III
11	Serow	*N. sumatraensis*			
12	Wild pig	*Sus scrofa*	*	LC	III
	Carnivores				
13	Common leopard	*Panthera pardus*		NT	I
14	Jungle Cat	*FelisChaus*	*	LC	II
15	Dhole	*Cuon alpinus*		EN	II
16	Himalayan black bear	*Ursus thibetanus*		VU	II
17	Himalayan palm civet	*Pagumalarvata*	*	LC	II
18	Leopard cat	*Prionailurusbengalensis*	*	LC	–
19	Otter	*Lutra*sp.		VU	–
20	Red panda	*Ailurusfulgens*		VU	I
21	Snow leopard	*Uncia uncia*		EN	I
22	Yellow–throated marten	*Martesflavigula*	*	LC	II
	Rodents				
23	Hairy–footed flying squirrel	*Belomyspearsonii*		DD	II
24	Himalayan marmot	*Marmotahimalayana*		LC	II
25	Himalayan striped squirrel	*Tamiopsmacclellandi*	*	LC	–
26	Orange–bellied Himalayan squirrel	*Dremomyslokriah*		LC	–
	*Hoary–bellied Himalayan Squirrel	*Callosciuruspygerythrus*	*	LC	–
27	Porcupine	*Hystrix*sp.		LC	IV
	*Chesnut rat	*Niviventerfluvescens*		LC	V
	Lagomorphs				
28	Large–eared pika	*Ochotonamacrotis*		LC	–
29	Moupinpika	*Ochotonathibetana*		LC	–
	29 species		**8 species R% 27.58**		

Data Source: 1–Mishra et al 2006, SPA–Species of Project Area, * Additional species reported during the study

Appendix II. 3.197: Status of birds at Tawang–I barrage site

Sl. No.	Family and species name	Common name	FS	MS	CS	No. of birds recorded
1	**Accipitridae**					
1	*Accipiter gentilis*	Northern Goshawk	C	WV	LC	1
2	**Apodidae**					
2	*Aerodramusbrevirostris*	Himalayan Swiftlet	I	R	LC	8
3	**Campephagidae**					
3	*Pericrocotusspeciosus*	Scarlet Minivet	I	R	LC	2
4	**Charadriidae**					
4	*Charadriusplacidus*	Long–billed Plover	I	WV	LC	2
5	**Columbidae**					
5	*Streptopelia orientalis*	Oriental Turtle–dove	G	WV	LC	4
6	**Corvidae**					
6	*Corvusculminatus*	Large–billed Crow	O	R	LC	2
7	**Dicaeidae**					
7	*Dicaeumignipectus*	Fire–breasted Flowerpecker	N	R	LC	3
8	**Dicruridae**					
8	*Dicrurusaeneus*	Bronzed Drongo	O	R	LC	6
9	*Dicrurusleucophaeus*	Ashy Drongo	O	WV	LC	3
10	*Dicrurusmacrocercus*	Black Drongo	O	R	LC	1
9	**Leiothrichidae**					
11	*Heterophasiacapistrata*	Rufous Sibia	O	R	LC	21
10	**Megalaimidae**					
12	*Megalaimavirens*	Great Barbet	F	R	LC	2
11	**Motacillidae**					
13	*Anthushodgsonihodgsoni*	Olive–backed Pipit	I	R	LC	3
14	*Motacillacinerea*	Grey Wagtail	I	WV	LC	2
12	**Muscicapidae**					
15	*Chaimarrornisleucocephalus*	White–capped River–chat	I	R	LC	1
16	*Eumyiasthalassinus*	Verditer Flycatcher	I	BV	LC	3
17	*Niltavasundara*	Rufous–bellied Niltava	I	BV	LC	2
18	*Rhyacornisfuliginosa*	Plumbeous Water–redstart	I	R	LC	11
19	*Saxicolaferreus*	Grey Bushchat	I	R	LC	1
13	**Paridae**					
20	*Parusater*	Coal Tit	I	R	LC	2
21	*Parusmonticolus*	Green–backed Tit	I	R	LC	5
14	**Pycnonotidae**					
22	*Hemixosflavala*	Ashy Bulbul	O	R	LC	1
23	*Hypsipetesleucocephalus*	Himalayan Black Bulbul	O	R	LC	7
15	**Stenostiridae**					
24	*Culicicapaceylonensis*	Grey–headed Canary–flycatcher	I	BV	LC	2
16	**Sylviidae**					
25	*Phylloscopusinornatus*	Yellow–browed Leaf–warbler	I	WV	LC	2
26	*Phylloscopustrochiloides*	Greenish Warbler	I	WV	LC	2
27	*Phylloscopusxanthoschistos*	Grey–hooded Warbler	I	R	LC	2
17	**Timaliidae**					
28	*Dryonastescaerulatus*	Grey–sided Laughingthrush	I	R	LC	3
29	*Grammatoptilastriatus*	Striated Laughingthrush	I	R	LC	3
30	*Trachalopteronerthrocephalum*	Red–headed Launghingthrush	I	R	LC	6
31	*Yuhinaflavicollis*	Whiskered Yuhina	I	R	LC	6
32	*Yuhinaoccipitalis*	Rufous–vented Yuhina	I	R	LC	9
18	**Turdidae**					
33	*Myophonuscaeruleus*	Blue Whistling–thrush	I	R	LC	5
34	*Zootheradixoni*	Long–tailed Thrush	I	BV	LC	1

FS–Foraging Status: C–Carnivores, F–Frugivore, G–Granivore, I–Insectivore, N–Nectarivore, O–Omnivore, MS–Migratory Status–BV–Breeding Visitor, R–Resident, WV–Winter Visitor; CS–Conservation status–IUCN Red List and WPA–1972 Schedule: LC–Least Concern

Appendix II. 3.198: Status of birds at Tawang–I powerhouse site

Sl. No.	Family and species name	Common name	FS	MS	CS	No. of birds recorded
1	**Apodidae**					
1	*Aerodramusbrevirostris*	Himalayan Swiftlet	I	R	LC	6
2	**Cisticolidae**					
2	*Priniaatrogularis*	Black–throated Prinia	I	R	LC	5
3	*Priniacrinigera*	Striated Prinia	I	R	LC	1
4	*Prinia sylvatica*	Jungle Prinia	I	R	LC	1
3	**Dicaeidae**					
5	*Dicaeumignipectus*	Fire–breasted Flowerpecker	N	R	LC	2

Sl. No.	Family and species name	Common name	FS	MS	CS	No. of birds recorded
4	**Leiothrichidae**					
6	*Heterophasiacapistrata*	Rufous Sibia	O	R	LC	2
5	**Megalaimidae**					
7	*Megalaimavirens*	Great Barbet	F	R	LC	1
6	**Motacillidae**					
8	*Anthushodgsonihodgsoni*	Olive–backed Pipit	I	R	LC	2
9	*Motacillacinerea*	Grey Wagtail	I	WV	LC	1
7	**Muscicapidae**					
10	*Chaimarrornisleucocephalus*	White–capped River–chat	I	R	LC	3
11	*Eumyiasthalassinus*	Verditer Flycatcher	I	BV	LC	2
12	*Ficidulastrophiata*	Orange–gorgeted Flycatcher	I	R	LC	1
13	*Phoenicurushodgsoni*	Hodgson's Redstart	I	WV	LC	2
14	*Rhyacornisfuliginosa*	Plumbeous Water–redstart	I	R	LC	3
15	*Saxicolaferreus*	Grey Bushchat	I	R	LC	1
8	**Nectariniidae**					
16	*Aethopyganipalensis*	Green–tailed Sunbird	N	R	LC	5
17	*Aethopygasaturata*	Black–breasted Sunbird	N	R	LC	3
9	**Paridae**					
18	*Parusmonticolus*	Green–backed Tit	I	R	LC	2
10	**Picidae**					
19	*Picusflavinucha*	Greater Yellownape	I	R	LC	1
11	**Pycnonotidae**					
20	*Pycnonotuscafer*	Red–vented Bulbul	I	WV	LC	2
12	**Stenostiridae**					
21	*Culicicapaceylonensis*	Grey–headed Canary–flycatcher	I	BV	LC	3
13	**Sylviidae**					
22	*Phylloscopusreguloides*	Blyth's Leaf–warbler	I	WV	LC	2
23	*Phylloscopustrochiloides*	Greenish Warbler	I	WV	LC	7
24	*Phylloscopusxanthoschistos*	Grey–hooded Warbler	I	R	LC	7
14	**Timaliidae**					
25	*Trochalopteronimbricatum*	Bhutan Laughing Thrush	I	R	LC	3
26	*Trachalopteronerthrocephalum*	Red–headed Launghingthrush	I	R	LC	2
27	*Yuhinaflavicollis*	Whiskered Yuhina	I	R	LC	2
28	*Yuhinagularis*	Stripe–throated Yuhina	O	R	LC	3
15	**Turdidae**					
29	*Myophonuscaeruleus*	Blue Whistling–thrush	I	R	LC	7
16	**Zosteropidae**					
30	*Zosteropspalpebrosus*	Oriental White–eye	I	R	LC	5

FS–Foraging Status: F–Frugivore, I–Insectivore, N–Nectarivore, O–Omnivore, MS–Migratory Status–BV–Breeding Visitor, R–Resident, WV–Winter Visitor; CS–Conservation status–IUCN Red List and WPA–1972 Schedule: LC–Least Concern

Appendix II. 3.199: Check list and ecological status of birds recorded in the Tawang–II HEP area

Sl. No.	Family and species name	Common name	FS	MS	CS	PM	M	W	Overall
1	**Accipitridae**								
1	*Gypaetus barbatus*	Bearded Vulture	C	R	LC	0	1	0	1
2	*Ictinaetus malayensis*	Black Eagle	C	R	LC	2	0	0	2
3	*Elanus caeruleus*	Black–winged Kite	C	R	LC	0	0	1	1
4	*Spilornis cheela*	Crested Serpent Eagle	C	R	LC	0	0	2	2
5	*Accipiter nisus*	Eurasian Sparrowhawk	C	R	LC	0	0	1	1
6	*Circus cyaneus*	Hen Harrier	C	WV	LC	0	0	1	1
7	*Buteo burmanicus*	Himalayan Buzzard	C	WV	LC	0	1	2	3
8	*Buteo rufinus*	Long–legged Buzzard	C	WV	LC	0	0	2	2
9	*Nisaetus nipalensis*	Mountain–hawk Eagle	C	R	LC	0	0	1	1
10	*Accipiter badius*	Shikra	C	R	LC	0	0	1	1
2	**Aegithalidae**								
11	*Aegithalos concinnus*	Red–headed Tit	I	R	LC	0	0	8	8
3	**Apodidae**								
12	*Aerodramus brevirostris*	Himalayan Swiftlet	I	R	LC	0	0	40	40
13	*Apus pacificus*	Pacific Swift	I	BV	LC	0	0	4	4
14	*Hirundapus caudacutus*	White–throated Needletail	I	BV	LC	0	0	14	14
4	**Campephagidae**								
15	*Pericrocotus ethologus*	Long–tailed Minvet	I	BV	LC	0	4	0	4
16	*Hemipus picatus*	Pied Flycatcher–shrike	I	R	LC	11	0	0	11
17	*Pericrocotus speciosus*	Scarlet Minivet	I	R	LC	19	0	0	19
5	**Certhiidae**								
18	*Certhia nepalensis*	Rusty–flanked Treecreeper	I	R	LC	0	0	2	2
6	**Cinclidae**								

Sl. No.	Family and species name	Common name	FS	MS	CS	PM	M	W	Overall
19	*Cinclus pallasii*	Brown Dipper	Aq	R	LC	1	0	0	1
7	**Cisticolidae**								
20	*Prinia atrogularis*	Black–throated Prinia	I	R	LC	0	2	2	4
21	*Prinia hodgsonii*	Grey–breasted Prinia	I	R	LC	0	0	6	6
22	*Prinia sylvatica*	Plain Prinia	I	R	LC	0	14	0	14
23	*Prinia inornata*	Plain Prinia	I	R	LC	0	0	2	2
24	*Prinia crinigera*	Striated Prinia	I	R	LC	21	2	10	33
25	*Prinia flaviventris*	Yellow–bellied Prinia	I	R	LC	12	0	0	12
8	**Columbidae**								
26	*Streptopelia orientalis*	Oriental Turtle–dove	G	WV	LC	25	14	13	52
27	*Treron apicauda*	Pin–tailed Green Pigeon	F	R	LC	13	0	0	13
28	*Spilopelia chinensis*	Spotted Dove	G	R	LC	11	0	0	11
29	*Treron sphenurus*	Wedge–tailed Green–pigeon	G	R	LC	21	0	0	21
9	**Corvidae**								
30	*Dendrocitta formosae*	Grey Treepie	O	R	LC	0	8	8	16
31	*Corvus culminatus*	Large–billed Crow	O	R	LC	23	7	4	34
32	*Dendrocitta vagabunda*	Rufous Treepie	O	R	LC	3	0	0	3
33	*Nucifraga caryocatactes*	Spotted Nutcracker	Nu	R	LC	6	0	4	10
10	**Cuculidae**								
34	*Phaenicophaeus tristis*	Green–billed Malkoha	O	R	LC	14	0	0	14
35	*Cuculus micropterus*	Indian Cuckoo	I	BV	LC	14	0	0	14
36	*Cacomantis merulinus*	Plaintive Cuckoo	I	R	LC	19	0	0	19
11	**Dicaeidae**								
37	*Dicaeum ignipectus*	Fire–breasted Flowerpecker	N	R	LC	13	0	28	41
38	*Dicaeum minullum*	Plain Flowerpecker	N	R	LC	13	0	0	13
12	**Dicruridae**								
39	*Dicrurus macrocercus*	Black Drongo	O	R	LC	16	6	0	22
40	*Dicrurus aeneus*	Bronzed Drongo	O	R	LC	22	0	0	22
41	*Dicrurus hottentottus*	Hair–Crested Drongo	O	R	LC	6	0	0	6
13	**Emberizidae**								
42	*Melophus lathami*	Crested Bunting	G	R	LC	23	0	0	23
43	*Emberiza pusilla*	Little Bunting	G	WV	LC	0	0	5	5
14	**Estrildidae**								
44	*Lonchura punctulata*	Scaly–breasted Munia	G	R	LC	15	3	14	32
45	*Lonchura striata*	White–rumped Munia	G	R	LC	0	5	5	10
15	**Falconidae**								
46	*Falco cherug milvipes*	Eastern' Saker Falcon	C	IR	LC	0	0	1	1
16	**Fringillidae**								
47	*Carpodacus nepalensis*	Dark–breasted Rosefinch	G	R	LC	0	0	5	5
48	*Carduelis spinoides*	Himalayan Greenfinch	G	WV	LC	0	4	2	6
49	*Mycerobas melanozanthos*	Spot–winged Grosbeak	G	R	LC	0	0	3	3
17	**Hirundinidae**								
50	*Delichon dasypus*	Asian House Martin	I	BV	LC	0	0	12	12
51	*Delichon nipalense*	Nepal House–martin	I	R	LC	0	0	90	90
18	**Laniidae**								
52	*Lanius schach tricolor*	Black–headed' Long–tailed Shrike	I	BV	LC	17	5	9	31
53	*Lanius cristatus*	Brown Shrike	I	WV	LC	2	0	0	2
54	*Lanius tephronotus*	Grey–backed Shrike	I	BV	LC	0	3	0	3
19	**Leiothrichidae**								
55	*Heterophasia capistrata*	Rufous Sibia	O	R	LC	25	9	12	46
20	**Megalaimidae**								
56	*Megalaima asiatica*	Blue–throated Barbet	F	R	LC	0	0	7	7
57	*Megalaima franklinii*	Golden–throated Barbet	F	R	LC	0	0	9	9
58	*Megalaima virens*	Great Barbet	F	R	LC	11	1	4	16
21	**Motacillidae**								
59	*Anthus hodgsoni hodgsoni*	Olive–backed Pipit	I	R	LC	0	3	1	4
60	*Motacilla alba alboides*	White Wagtail	I	WV	LC	0	12	3	15
22	**Muscicapidae**								
61	*Phoenicurus ochruros*	Black Redstart	I	WV	LC	0	3	2	5
62	*Phoenicurus frontalis*	Blue–fronted Redstart	I	BV	LC	0	0	10	10
63	*Cyornis rubeculoides*	Blue–throated Flycatcher	I	BV	LC	9	0	0	9
64	*Muscicapa sibirica*	Dark–sided Flycatcher	I	BV	LC	0	2	1	3
65	*Phoenicurus hodgsoni*	Daurian Redstart	I	R	LC	1	0	0	1
66	*Muscicapa ferruginea*	Ferruginous Flycatcher	I	BV	LC	0	2	0	2
67	*Saxicola ferreus*	Grey Bushchat	I	R	LC	13	9	16	38
68	*Tarsiger rufilatus*	Himalayan Red–flanked Bush Robin	I	R	LC	0	0	2	2
69	*Phoenicurus hodgsoni*	Hodgson's Redstart	I	WV	LC	0	0	37	37
70	*Ficidula strophiata*	Orange–gorgeted Flycatcher	I	R	LC	0	3	0	3

Sl. No.	Family and species name	Common name	FS	MS	CS	PM	M	W	Overall
71	*Copsychus saularis*	Oriental Magpie–robin	I	R	LC	12	3	5	20
72	*Rhyacornis fuliginosa*	Plumbeous Water–redstart	I	R	LC	0	0	6	6
73	*Ficedula tricolor*	Slaty–blue Flycatcher	I	BV	LC	0	0	3	3
74	*Eumyias thalassinus*	Verditer Flycatcher	I	BV	LC	20	6	0	26
75	*Chaimarrornis leucocephalus*	White–capped River–chat	I	R	LC	0	3	5	8
76	*Phoenicurus schisticeps*	White–throated Redstart	I	R	LC	0	0	2	2
23	**Nectariniidae**								
77	*Aethopyga saturata*	Black–breasted Sunbird	N	R	LC	0	2	0	2
78	*Aethopyga saturata*	Black–throated Sunbird	N	R	LC	0	0	1	1
79	*Aethopyga nipalensis*	Green–tailed Sunbird	N	R	LC	0	7	2	9
24	**Oriolidae**								
80	*Oriolus traillii*	Maroon Oriole	O	R	LC	0	0	3	3
81	*Oriolus tenuirostris*	Slender–billed Oriole	O	R	LC	7	0	4	11
25	**Paridae**								
82	*Parus ater*	Coal Tit	I	R	LC	0	0	15	15
83	*Parus monticolus*	Green–backed Tit	I	R	LC	0	5	22	27
84	*Parus rubidiventris*	Rufous–vented Tit	I	R	LC	0	0	6	6
26	**Passeridae**								
85	*Passer montanus*	Eurasian Tree Sparrow	G	R	LC	24	6	28	58
27	**Phasianidae**								
86	*Lophura leucomelanos*	Kaleej Pheasant	O	R	LC	0	0	7	7
28	**Picidae**								
87	*Dryocopus martius*	Black Woodpecker	I	R	LC	2	0	0	2
88	*Picus flavinucha*	Greater Yellownape	I	R	LC	0	2	0	2
89	*Dendrocopos canicapillus*	Grey–capped Pygmy Woodpecker	I	R	LC	0	0	3	3
29	**Prunellidae**								
90	*Prunella strophiata*	Rufous–breasted Accentor	I	R	LC	3	0	13	16
30	**Pycnonotidae**								
91	*Hypsipetes leucocephalus*	Himalayan Black Bulbul	O	R	LC	92	9	5	106
92	*Pycnonotus leucogenys*	Himalayan Bulbul	O	R	LC	17	19	17	53
93	*Pycnonotus cafer*	Red–vented Bulbul	O	R	LC	24	27	140	191
94	*Pycnonotus striatus*	Striated Bulbul	O	R	LC	0	0	5	5
31	**Stenostiridae**								
95	*Culicicapa ceylonensis*	Grey–headed Canary–flycatcher	I	BV	LC	0	9	2	11
32	**Sylviidae**								
96	*Phylloscopus reguloides*	Blyth's Leaf–Warbler	I	WV	LC	0	2	0	2
97	*Phylloscopus pulcher*	Buff–barred Warbler	I	BV	LC	0	0	4	4
98	*Orthotomus sutorius*	Common Tailorbird	I	R	LC	0	5	24	29
99	*Seicercus burkii*	Green–crowned Warbler	I	BV	LC	5	1	0	6
100	*Phylloscopus trochiloides*	Greenish Warbler	I	WV	LC	19	14	0	33
101	*Phylloscopus maculipennis*	Grey–faced Leaf–warbler	I	R	LC	20	0	5	25
102	*Phylloscopus xanthoschistos*	Grey–hooded Warbler	I	R	LC	20	17	16	53
103	*Cettia brunnifrons*	Grey–sided Bush–Warbler	I	BV	LC	0	0	1	1
104	*Cettia flavolivacea*	Himalayan' Aberrant Bush–warbler	I	WV	LC	0	0	4	4
105	*Phylloscopus chloronotus*	Lemon–rumped Leaf Warbler	I	BV	LC	0	0	2	2
106	*Orthotomus cuculatus*	Mountain Tailorbird	I	R	LC	0	0	2	2
107	*Phylloscopus fuligiventer*	Smoky Leaf–warbler	I	WV	LC	15	2	1	18
108	*Cettia fortipes*	Strong–footed Bush–warbler	I	R	LC	7	0	2	9
109	*Phylloscopus affinis*	Tickell's Leaf–warbler	I	BV	LC	0	0	6	6
110	*Seicercus conspicillata*	White–spectacled Warbler	I	R	LC	12	0	0	12
111	*Abroscopus superciliaris*	Yellow–bellied Warbler	I	R	LC	0	0	2	2
112	*Phylloscopus inornatus*	Yellow–browed Leaf–warbler	I	WV	LC	0	0	3	3
33	**Tephrodornithidae**								
113	*Tephrodornis gularis*	Large Woodshrike	I	R	LC	11	0	0	11
34	**Timaliidae**								
114	*Alcippe dubia*	Rusty–capped Fulvetta	I	R	LC	0	2	0	2
115	*Alcippe nipalensis*	Nepal Fulvetta	I	R	LC	0	0	4	4
116	*Garrulax albogularis*	White–throated Laughingthrush	I	R	LC	8	0	0	8
117	*Leiothrix lutea*	Red–billed Leiothrix	O	R	LC	0	0	4	4
118	*Minla ignotincta*	Red–tailed Minla	I	R	LC	0	0	7	7
119	*Pellorneum ruficeps*	Puff–throated Babbler	I	R	LC	3	0	0	3
120	*Pomatorhinus erythrogenys*	Rusty–cheeked Scimitar–babbler	I	R	LC	14	4	5	23
121	*Pomatorhinus hypoleucos*	Large Scimitar–babbler	I	R	LC	0	3	0	3
122	*Pomatorhinus schisticeps*	White–browed Scimitar–babbler	I	R	LC	0	0	2	2
123	*Trochalopteron erthrocephalum*	Red–headed Launghingthrush	I	R	LC	0	5	4	9
124	*Trochalopteron imbricatum*	Bhutan Laughingthrush	I	R	LC	0	5	5	10
125	*Yuhina flavicollis*	Whiskered Yuhina	I	R	LC	15	2	20	37
126	*Yuhina gularis*	Stripe–throated Yuhina	O	R	LC	0	5	17	22

Sl. No.	Family and species name	Common name	FS	MS	CS	PM	M	W	Overall
127	*Yuhina occipitalis*	Rufous–vented Yuhina	I	R	LC	0	0	23	23
35	**Turdidae**								
128	*Monticola solitarius*	Blue Rock–thrush	I	WV	LC	12	2	0	14
129	*Myophonus caeruleus*	Blue Whistling–thrush	I	R	LC	24	6	6	36
130	*Monticola cinclorhynchus*	Blue–headed Rock–thrush	I	BV	LC	23	2	0	25
131	*Monticola rufiventris*	Chestnut–bellied Rock Thrush	I	R	LC	0	0	2	2
132	*Turdus boulboul*	Grey–winged Blackbird	I	R	LC	19	0	0	19
133	*Zoothera dixoni*	Long–tailed Thrush	I	BV	LC	0	0	1	1
134	*Turdus albocinctus*	White–collared Blackbird	I	R	LC	0	0	4	4
36	**Upupidae**								
135	*Upupa epops*	Common Hoopoe	I	WV	LC	0	3	0	3
37	**Zosteropidae**								
136	*Zosterops palpebrosus*	Oriental White–eye	I	R	LC	24	12	25	61

FS: Aq–Aquatic Feeder, C–Carnivores, F–Frugivore, G–Granivore, I–Insectivore, N–Nectarivore, Nc–Nucivore, O–Omnivore, P–Piscivore; MS–Migratory Status–BV–Breeding Visitor, IR–Isolated Record, R–Resident, WV–Winter Visitor; CS–Conservation status–IUCN Red List and WPA–1972 Schedule: VU–Vulnerable, LC–Least Concern; PM–Post monsoon, M–Monsoon, W–Winter

Appendix II. 3.200 List of possible mammalian fauna of Tawang region and Twang–II HEP area

Sl. No.	Common name	Scientific name	SPA	Conservation status	
				IUCN	**WPA**
	Primates				
1	Arunachal macaque	*Macaca munzala*	*	EN	–
2	Assamese macaque	*M. assamensis*		NT	II
3	Capped langur	*Trachypithecus pileatus*	*	VU	I
4	Slow loris	*Nycticebus coucang*		VU	I
	Ungulates				
5	Barking deer	*Muntiacus muntjak*	*	LC	III
6	Bharal	*Pseudois nayaur*		LC	I
7	Chinese goral	*Nemorhaedus caudatus*		VU	III
8	Himalayan goral	*N. goral*		NT	III
9	Musk deer	*Moschus* sp.		EN	–
10	Sambar	*Cervus unicolor*		VU	III
11	Serow	*N. sumatraensis*			
12	Wild pig	*Sus scrofa*	*	LC	III
	Carnivores				
13	Common leopard	*Panthera pardus*		NT	I
14	Jungle Cat	*Felis Chaus*	*	LC	II
15	Dhole	*Cuon alpinus*	*	EN	II
16	Himalayan black bear	*Ursus thibetanus*	*	VU	II
17	Himalayan palm civet	*Paguma larvata*	*	LC	II
18	Leopard cat	*Prionailurus bengalensis*	*	LC	–
19	Otter	*Lutra* sp.		VU	–
20	Red panda	*Ailurus fulgens*		VU	I
21	Snow leopard	*Uncia uncia*		EN	I
22	Yellow–throated marten	*Martes flavigula*	*	LC	II
	Rodents				
23	Hairy–footed flying squirrel	*Belomys pearsonii*		DD	II
24	Himalayan marmot	*Marmota himalayana*		LC	II
25	Himalayan striped squirrel	*Tamiops macclellandi*	*	LC	–
26	Orange–bellied Himalayan squirrel	*Dremomys lokriah*		LC	–
	*Hoary–bellied Himalayan Squirrel	*Callosciurus pygerythrus*	*	LC	–
27	Porcupine	*Hystrix* sp.		LC	IV
	*Chesnut rat	*Niviventer fluvescens*		LC	V
	Lagomorphs				
28	Large–eared pika	*Ochotona macrotis*		LC	–
29	Moupin pika	*Ochotona thibetana*		LC	–
	29 species		**12 species R% 41.37%**		

Data Source: 1–Mishra et al 2006, SPA–Species of Project Area. * Additional species reported during the study

Appendix II. 3.201: Status of birds at Tawang–II barrage site

Sl. No.	Family and species name	Common name	FS	MS	CS	No. of birds recorded
1	**Accipitridae**					
1	*Accipiter badius*	Shikra	C	R	LC	1
2	**Cisticolidae**					
2	*Prinia atrogularis*	Black–throated Prinia	I	R	LC	2
3	*Prinia sylvatica*	Jungle Prinia	I	R	LC	1
3	**Leiothrichidae**					
4	*Heterophasia capistrata*	Rufous Sibia	O	R	LC	4
4	**Megalaimidae**					
5	*Megalaima virens*	Great Barbet	F	R	LC	1
5	**Muscicapidae**					
6	*Chaimarrornis leucocephalus*	White–capped River–chat	I	R	LC	2
7	*Eumyias thalassinus*	Verditer Flycatcher	I	BV	LC	4
8	*Ficidula strophiata*	Orange–gorgeted Flycatcher	I	R	LC	3
9	*Muscicapa ferruginea*	Ferruginous Flycatcher	I	BV	LC	2
10	*Muscicapa sibirica*	Dark–sided Flycatcher	I	BV	LC	2
6	**Nectariniidae**					
11	*Aethopyga nipalensis*	Green–tailed Sunbird	N	R	LC	5
12	*Aethopyga saturata*	Black–breasted Sunbird	N	R	LC	2
7	**Paridae**					
13	*Parus monticolus*	Green–backed Tit	I	R	LC	5
8	**Picidae**					
14	*Picus flavinucha*	Greater Yellownape	I	R	LC	2
9	**Stenostiridae**					
15	*Culicicapa ceylonensis*	Grey–headed Canary–flycatcher	I	BV	LC	8
10	**Sylviidae**					
16	*Phylloscopus fuligiventer*	Smoky Leaf–warbler	I	WV	LC	2
17	*Phylloscopus reguloides*	Blyth's Leaf–warbler	I	WV	LC	2
18	*Phylloscopus trochiloides*	Greenish Warbler	I	WV	LC	13
19	*Phylloscopus xanthoschistos*	Grey–hooded Warbler	I	R	LC	13
11	**Timaliidae**					
20	*Trachalopteron erthrocephalum*	Red–headed Launghingthrush	I	R	LC	2
21	*Yuhina flavicollis*	Whiskered Yuhina	I	R	LC	2
22	*Yuhina gularis*	Stripe–throated Yuhina	O	R	LC	5
12	**Turdidae**					
23	*Monticola cinclorhynchus*	Blue–headed Rock–thrush	I	BV	LC	1
24	*Myophonus caeruleus*	Blue Whistling–thrush	I	R	LC	5
13	**Zosteropidae**					
25	*Zosterops palpebrosus*	Oriental White–eye	I	R	LC	5

FS–Foraging Status: C–Carnivores, F–Frugivore, I–Insectivore, N–Nectarivore, O–Omnivore, MS–Migratory Status–BV–Breeding Visitor, R–Resident, WV–Winter Visitor; CS–Conservation status–IUCN Red List and WPA–1972 Schedule: LC–Least Concern

Appendix II. 3.202: Status of Birds at Tawang–II powerhouse site

Sl. No.	Family and species name	Common name	FS	MS	CS	No. of birds recorded
1	**Campephagidae**					
1	*Pericrocotus ethologus*	Long–tailed Minvet	I	BV	LC	1
2	**Cisticolidae**					
2	*Prinia sylvatica*	Jungle Prinia	I	R	LC	1
3	**Corvidae**					
3	*Dendrocitta formosae*	Grey Treepie	O	R	LC	5
4	*Urocissa flavirostris*	Yellow–bellied Blue Magpie	C	R	LC	1
4	**Fringillidae**					
5	*Carpodacus pulcherrimus*	Himalayan Beautiful Rosefinch	G	WV	LC	3
6	*Leucosticte nemoricola*	Plain Mountain–finch	G	R	LC	16
5	**Motacillidae**					
7	*Anthus rufulus*	Paddyfield Pipit	I	R	LC	9
6	**Muscicapidae**					
8	*Enicurus maculatus*	Spotted Forktail	I	R	LC	2
9	*Phoenicurus frontalis*	Blue–fronted Redstart	I	BV	LC	10
7	**Passeridae**					
10	*Passer montanus*	Eurasian Tree Sparrow	G	R	LC	2
8	**Sylviidae**					
11	*Phylloscopus affinis*	Tickell's Leaf–warbler	I	BV	LC	1
12	*Phylloscopus fuligiventer*	Smoky Leaf–warbler	I	WV	LC	2
13	*Phylloscopus inornatus*	Yellow–browed Leaf–warbler	I	WV	LC	2
14	*Phylloscopus maculipennis*	Grey–faced Leaf–warbler	I	R	LC	3

Sl. No.	Family and species name	Common name	FS	MS	CS	No. of birds recorded
15	*Tesia castaneocoronata*	Chestnut–headed Tesia	I	R	LC	1
9	**Troglodytidae**					
16	*Troglodytes troglodytes*	Winter Wren	I	R	LC	1

FS–Foraging Status: C–Carnivores, I–Insectivore, G–Granivore, O–Omnivore, MS–Migratory Status–BV–Breeding Visitor, R–Resident, WV–Winter Visitor; CS–Conservation status–IUCN Red List and WPA–1972 Schedule: LC–Least Concern;

Appendix II. 3.203: Birds recorded in the Nyamjang chu HEP area

Sl. No.	Family Genera Species	Common name	FS	MS	CS	Overall
1	**Accipitridae**					
1	*Nisaetus nipalensis*	Mountain–hawk Eagle	C	R	LC	1
2	**Apodidae**					
2	*Aerodramus brevirostris*	Himalayan Swiftlet	I	R	LC	1
3	**Campephagidae**					
3	*Pericrocotus ethologus*	Long–tailed Minvet	I	BV	LC	5
4	**Caprimulgidea**					
4	*Caprimulgus jotaka*	Grey Nightjar	I	R	LC	2
5	**Chloropseidae**					
5	*Chloropsis hardwickii*	Orange–bellied Leafbird	I	R	LC	4
6	**Cisticolidae**					
6	*Prinia atrogularis*	Black–throated Prinia	I	R	LC	3
7	*Prinia sylvatica*	Jungle Prinia	I	R	LC	4
8	*Prinia crinigera*	Striated Prinia	I	R	LC	5
7	**Columbidae**					
9	*Streptopelia orientalis*	Oriental Turtle–dove	G	WV	LC	22
10	*Spilopelia chinensis*	Spotted Dove	G	R	LC	8
11	*Treron sphenurus*	Wedge–tailed Green–pigeon	G	R	LC	3
8	**Corvidae**					
12	*Corvus culminatus*	Large–billed Crow	O	R	LC	1
13	*Nucifraga caryocatactes*	Spotted Nutcracker	Nu	R	LC	2
9	**Cuculidae**					
14	*Chrysococcyx maculatus*	Asian Emerald Cuckoo	I	BV	LC	1
15	*Cuculus canorus*	Common Cuckoo	I	BV	LC	3
16	*Surniculus (lugubris) dicruroides*	Fork–tailed' Drongo Cuckoo	I	BV	LC	1
17	*Cuculus micropterus*	Indian Cuckoo	I	BV	LC	1
18	*Hierococcyx sparverioides*	Large Hawk–cuckoo	I	BV	LC	3
10	**Dicaeidae**					
19	*Dicaeum ignipectus*	Fire–breasted Flowerpecker	N	R	LC	14
11	**Dicruridae**					
20	*Dicrurus leucophaeus*	Ashy Drongo	O	WV	LC	8
21	*Dicrurus macrocercus*	Black Drongo	O	R	LC	13
22	*Dicrurus aeneus*	Bronzed Drongo	O	R	LC	4
12	Emberizidae					
23	*Melophus lathami*	Crested Bunting	G	R	LC	8
13	Falconidae					
24	*Falco tinnunculus*	Common Kestrel	C	WV	LC	2
14	**Fringillidae**					
25	*Carduelis spinoides*	Himalayan Greenfinch	G	WV	LC	4
26	*Haematospiza sipahi*	Scarlet Finch	G	R	LC	5
15	**Hirundinidae**					
27	*Delichon dasypus*	Asian House Martin	I	BV	LC	10
16	**Laniidae**					
28	*Lanius schach tricolor*	Black–headed' Long–tailed Shrike	I	BV	LC	14
29	*Lanius cristatus*	Brown Shrike	I	WV	LC	2
30	*Lanius tephronotus*	Grey–backed Shrike	I	BV	LC	1
17	**Leiothrichidae**					
31	*Heterophasia capistrata*	Rufous Sibia	O	R	LC	43
18	**Megalaimidae**					
32	*Megalaima virens*	Great Barbet	F	R	LC	7
19	**Motacillidae**					
33	*Anthus hodgsoni hodgsoni*	Olive–backed Pipit	I	R	LC	3
34	*Anthus rufulus*	Paddyfield Pipit	I	R	LC	6
35	*Motacilla alba alboides*	White Wagtail	I	WV	LC	4
20	**Muscicapidae**					
36	*Phoenicurus ochruros*	Black Redstart	I	WV	LC	3
37	*Muscicapa sibirica*	Dark–sided Flycatcher	I	BV	LC	4
38	*Muscicapa ferruginea*	Ferruginous Flycatcher	I	BV	LC	38
39	*Saxicola ferreus*	Grey Bushchat	I	R	LC	13

Sl. No.	Family Genera Species	Common name	FS	MS	CS	Overall
40	*Ficidula strophiata*	Orange–gorgeted Flycatcher	I	R	LC	1
41	*Copsy chus saularis*	Oriental Magpie–robin	I	R	LC	1
42	*Rhyacornis fuliginosa*	Plumbeous Water–redstart	I	R	LC	9
43	*Ficedula tricolor*	Slaty–blue Flycatcher	I	BV	LC	7
44	*Ficedula superciliaris*	Ultramarine Flycatcher	I	BV	LC	2
45	*Eumyias thalassinus*	Verditer Flycatcher	I	BV	LC	13
46	*Tarsiger indicus*	White–browed Bush–robin	I	R	LC	4
47	*Ficedula monileger*	White–gorgeted Flycatcher	I	R	LC	5
21	**Nectariniidae**					
48	***Aethopyga saturata***	Black–throated Sunbird	N	R	LC	1
49	**Aethopyga goulgiae**	Mrs Gould's Sunbird	N	R	LC	3
22	**Oriolidae**					
50	*Oriolus traillii*	Maroon Oriole	O	R	LC	2
23	**Paridae**					
51	*Parus monticolus*	Green–backed Tit	I	R	LC	19
24	**Passeridae**					
52	*Passer rutilans*	Cinnamon Sparrow	G	R	LC	12
53	*Passer montanus*	Eurasian Tree Sparrow	G	R	LC	5
25	Picidae					
54	*Dendrocopos cathpharius*	Crimson–breasted Pied Woodpecker	I	R	LC	2
26	**Pycnonotidae**					
55	*Hemixos flavala*	Ashy Bulbul	O	R	LC	1
56	*Hypsipetes leucocephalus*	Himalayan Black Bulbul	O	R	LC	70
57	*Pycnonotus leucogenys*	Himalayan Bulbul	O	R	LC	31
58	*Pycnonotus cafer*	Red–vented Bulbul	O	R	LC	43
27	**Sittidae**					
59	*Sitta himalayensis*	White–tailed Nuthatch	I	R	LC	5
28	**Stenostiridae**					
60	*Culicicapa ceylonensis*	Grey–headed Canary–flycatcher	I	BV	LC	1
29	**Sylviidae**					
61	*Abroscopus schisticeps*	Black–faced Warbler	I	R	LC	2
62	*Phylloscopus reguloides*	Blyth's Leaf–Warbler	I	WV	LC	1
63	*Bradypterus luteoventris*	Brown Bush–warbler	I	BV	LC	2
64	*Tesia castaneocoronata*	Chestnut–headed Tesia	I	R	LC	2
65	*Orthotomus sutorius*	Common Tailorbird	I	R	LC	6
66	*Phylloscopus coronatus*	Eastern Crowned Warbler	I	WV	LC	8
67	*Seicercus poliogenys*	Grey–cheeked Warbler	I	R	LC	8
68	*Phylloscopus xanthoschistos*	Grey–hooded Warbler	I	R	LC	6
69	*Orthotomus cuculatus*	Mountain Tailorbird	I	R	LC	2
30	**Timaliidae**					
70	*Trochalopteron imbricatum*	Bhutan Laughingthrush	I	R	LC	31
71	*Alcippe nipalensis*	Nepal Fulvetta	I	R	LC	4
72	*Pellorneum ruficeps*	Puff–throated Babbler	I	R	LC	2
73	*Ianthocincla rufogularis*	Rufous–chinned Laughingthrush	I	R	LC	10
74	*Yuhina occipitalis*	Rufous–vented Yuhina	I	R	LC	4
75	*Alcippe dubia*	Rusty–capped Fulvetta	I	R	LC	2
76	*Pomatorhinus erythrogenys*	Rusty–cheeked Scimitar–babbler	I	R	LC	1
77	*Yuhina gularis*	Stripe–throated Yuhina	O	R	LC	6
78	*Yuhina flavicollis*	Whiskered Yuhina	I	R	LC	12
79	*Pomatorhinus schisticeps*	White–browed Scimitar–babbler	I	R	LC	1
80	*Garrulax albogularis*	White–throated Laughingthrush	I	R	LC	10
31	**Turdidae**					
81	*Monticola solitarius*	Blue Rock–thrush	I	WV	LC	1
82	*Myophonus caeruleus*	Blue Whistling–thrush	I	R	LC	18
83	*Monticola cinclorhyn chus*	Blue–headed Rock–thrush	I	BV	LC	6
84	*Zoothera dixoni*	Long–tailed Thrush	I	BV	LC	2
32	**Upupidae**					
85	*Upupa epops*	Common Hoopoe	I	WV	LC	3
33	**Zosteropidae**					
86	*Zosterops palpebrosus*	Oriental White–eye	I	R	LC	5

FS: C–Carnivores, F–Frugivore, G–Granivore, I–Insectivore, N–Nectarivore, Nc–Nucivore, O–Omnivore; MS–Migratory Status–BV–Breeding Visitor, IR–Isolated Record, R–Resident, WV–Winter Visitor; CS–Conservation status–IUCN Red List and WPA–1972 Schedule: VU–Vulnerable, LC–Least Concern

Appendix II. 3.204: List of possible mammalian fauna of Nyamjang chu HEP area

Sl. No.	Common name	Scientific name	SPA	Conservation status	
				IUCN	WPA
	Primates				
1	Arunachal macaque	*Macaca munzala*	*	EN	–
2	Assamese macaque	*M. assamensis*		NT	II
3	Capped langur	*Trachypithecus pileatus*	*	VU	I
4	Slow loris	*Nycticebus coucang*		VU	I
	Ungulates				
5	Barking deer	*Muntiacus muntjak*	*	LC	III
6	Bharal	*Pseudois nayaur*		LC	I
7	Chinese goral	*Nemorhaedus caudatus*		VU	III
8	Himalayan goral	*N. goral*	*	NT	III
9	Musk deer	*Mos chus* sp.		EN	–
10	Sambar	*Cervus unicolor*		VU	III
11	Serow	*N. sumatraensis*			
12	Wild pig	*Sus scrofa*	*	LC	III
	Carnivores				
13	Common leopard	*Panthera pardus*		NT	I
14	Jungle Cat	*Felis Chaus*	*	LC	II
15	Dhole	*Cuon alpinus*		EN	II
16	Himalayan black bear	*Ursus thibetanus*		VU	II
17	Himalayan palm civet	*Paguma larvata*	*	LC	II
18	Leopard cat	*Prionailurus bengalensis*	*	LC	–
19	Otter	*Lutra* sp.		VU	–
20	Red panda	*Ailurus fulgens*	*	VU	I
21	Snow leopard	*Uncia uncia*		EN	I
22	Yellow–throated marten	*Martes flavigula*	*	LC	II
	Rodents				
23	Hairy–footed flying squirrel	*Belomys pearsonii*		DD	II
24	Himalayan marmot	*Marmota himalayana*		LC	II
25	Himalayan striped squirrel	*Tamiops macclellandi*		LC	–
26	Orange–bellied Himalayan squirrel	*Dremomys lokriah*		LC	–
	*Hoary–bellied Himalayan Squirrel	*Callosciurus pygerythrus*	*	LC	–
27	Porcupine	*Hystrix* sp.	*	LC	IV
	*Chesnut rat	*Niviventer fluvescens*		LC	V
	Lagomorphs				
28	Large–eared pika	*Ochotona macrotis*		LC	–
29	Moupin pika	*Ochotona thibetana*		LC	–
	29 species		**12 species R% 41.37%**		

Data Source: 1–Mishra et al 2006, SPA–Species of Project Area * Additional species reported during the study

Appendix II. 3.205: Status of birds at Nyamjang chu barrage site

Sl. No.	Family and species name	Common name	FS	MS	CS	No. of birds recorded
1	**Apodidae**					
1	*Aerodramus brevirostris*	Himalayan Swiftlet	I	R	LC	1
2	**Campephagidae**					
2	*Pericrocotus ethologus*	Long–tailed Minvet	I	BV	LC	3
3	**Chloropseidae**					
3	*Chloropsis hardwickii*	Orange–bellied Leafbird	I	R	LC	2
4	**Columbidae**					
4	*Spilopelia chinensis*	Spotted Dove	G	R	LC	1
5	*Streptopelia orientalis*	Oriental Turtle–dove	G	WV	LC	10
6	*Treron sphenurus*	Wedge–tailed Green–pigeon	G	R	LC	3
5	**Cuculidae**					
7	*Cuculus canorus*	Common Cuckoo	I	BV	LC	2
8	*Cuculus micropterus*	Indian Cuckoo	I	BV	LC	1
9	*Hierococcyx sparverioides*	Large Hawk–cuckoo	I	BV	LC	1
6	**Dicruridae**					
10	*Dicrurus aeneus*	Bronzed Drongo	O	R	LC	1
11	*Dicrurus leucophaeus*	Ashy Drongo	O	WV	LC	2
7	**Laniidae**					
12	*Lanius schach tricolor*	Black–headed' Long–tailed Shrike	I	BV	LC	4
8	**Leiothrichidae**					
13	*Heterophasia capistrata*	Rufous Sibia	O	R	LC	16
9	**Motacillidae**					
14	*Anthus rufulus*	Paddyfield Pipit	I	R	LC	6
15	*Motacilla alba alboides*	White Wagtail	I	WV	LC	4

Sl. No.	Family and species name	Common name	FS	MS	CS	No. of birds recorded
10	**Muscicapidae**					
16	*Eumyias thalassinus*	Verditer Flycatcher	I	BV	LC	1
17	*Ficedula monileger*	White–gorgeted Flycatcher	I	R	LC	2
18	*Muscicapa ferruginea*	Ferruginous Flycatcher	I	BV	LC	11
19	*Muscicapa sibirica*	Dark–sided Flycatcher	I	BV	LC	2
20	*Rhyacornis fuliginosa*	Plumbeous Water–redstart	I	R	LC	6
21	*Saxicola ferreus*	Grey Bushchat	I	R	LC	1
11	**Oriolidae**					
22	*Oriolus traillii*	Maroon Oriole	O	R	LC	2
12	**Paridae**					
23	*Parus monticolus*	Green–backed Tit	I	R	LC	4
13	**Passeridae**					
24	*Passer montanus*	Eurasian Tree Sparrow	G	R	LC	1
14	**Picidae**					
25	*Dendrocopos cathpharius*	Crimson–breasted Pied Woodpecker	I	R	LC	1
15	**Pycnonotidae**					
26	*Hypsipetes leucocephalus*	Himalayan Black Bulbul	O	R	LC	17
27	*Pycnonotus cafer*	Red–vented Bulbul	O	R	LC	16
28	*Pycnonotus leucogenys*	Himalayan Bulbul	O	R	LC	10
16	**Sittidae**					
29	*Sitta himalayensis*	White–tailed Nuthatch	I	R	LC	2
17	**Sylviidae**					
30	*Abroscopus schisticeps*	Black–faced Warbler	I	R	LC	2
31	*Orthotomus sutorius*	Common Tailorbird	I	R	LC	1
32	*Phylloscopus coronatus*	Eastern Crowned Warbler	I	WV	LC	2
33	*Phylloscopus xanthoschistos*	Grey–hooded Warbler	I	R	LC	1
18	**Timaliidae**					
34	*Garrulax albogularis*	White–throated Laughingthrush	I	R	LC	6
35	*Trochalopteron imbricatum*	Bhutan Laughingthrush	I	R	LC	5
36	*Yuhina flavicollis*	Whiskered Yuhina	I	R	LC	5
19	**Turdidae**					
37	*Myophonus caeruleus*	Blue Whistling–thrush	I	R	LC	4
20	**Zosteropidae**					
38	*Zosterops palpebrosus*	Oriental White–eye	I	R	LC	2

FS–Foraging Status: G–Granivore, I–Insectivore, O–Omnivore; MS–Migratory Status–BV–Breeding Visitor, R–Resident, WV–Winter Visitor; CS–Conservation status–IUCN Red List and WPA–1972 Schedule: LC–Least Concern

Appendix II. 3.206: Status of birds at Nyamjang chu powerhouse site

Sl. No.	Family and species name	Common name	FS	MS	CS	No. of birds recorded
1	**Cisticolidae**					
1	*Prinia crinigera*	Striated Prinia	I	R	LC	9
2	**Columbidae**					
2	*Spilopelia chinensis*	Spotted Dove	G	R	LC	5
3	*Streptopelia orientalis*	Oriental Turtle–dove	G	WV	LC	2
3	**Corvidae**					
4	*Corvus culminatus*	Large–billed Crow	O	R	LC	1
4	**Cuculidae**					
5	*Surniculus (lugubris) dicruroides*	Fork–tailed' Drongo Cuckoo	I	BV	LC	1
5	**Dicaeidae**					
6	*Dicaeum ignipectus*	Fire–breasted Flowerpecker	N	R	LC	2
6	**Dicruridae**					
7	*Dicrurus macrocercus*	Black Drongo	O	R	LC	8
7	**Emberizidae**					
8	*Melophus lathami*	Crested Bunting	G	R	LC	8
8	**Falconidae**					
9	*Falco tinnunculus*	Common Kestrel	C	WV	LC	2
9	**Fringillidae**					
10	*Carduelis spinoides*	Himalayan Greenfinch	G	WV	LC	4
10	**Hirundinidae**					
11	*Delichon dasypus*	Asian House Martin	I	BV	LC	10
11	**Laniidae**					
12	*Lanius cristatus*	Brown Shrike	I	WV	LC	2
13	*Lanius schach tricolor*	Black–headed' Long–tailed Shrike	I	BV	LC	8
12	**Motacillidae**					
14	*Anthus hodgsoni hodgsoni*	Olive–backed Pipit	I	R	LC	3
13	**Muscicapidae**					
15	*Copsy chus saularis*	Oriental Magpie–robin	I	R	LC	1

Sl. No.	Family and species name	Common name	FS	MS	CS	No. of birds recorded
16	*Phoenicurus ochruros*	Black Redstart	I	WV	LC	3
17	*Saxicola ferreus*	Grey Bushchat	I	R	LC	6
18	*Tarsiger indicus*	White–browed Bush–robin	I	R	LC	2
14	**Paradoxornithidae**					
19	*Paradoxornis nipalensis*	Black–throated Parrotbill	G	R	LC	1
15	**Pycnonotidae**					
20	*Hypsipetes leucocephalus*	Himalayan Black Bulbul	O	R	LC	9
22	*Pycnonotus cafer*	Red–vented Bulbul	O	R	LC	18
21	*Pycnonotus leucogenys*	Himalayan Bulbul	O	R	LC	19
16	**Sylviidae**					
23	*Orthotomus sutorius*	Common Tailorbird	I	R	LC	5
24	*Phylloscopus xanthoschistos*	Grey–hooded Warbler	I	R	LC	2
17	**Timaliidae**					
25	*Alcippe dubia*	Rusty–capped Fulvetta	I	R	LC	2
26	*Pomatorhinus erythrogenys*	Rusty–cheeked Scimitar–babbler	I	R	LC	1
18	**Turdidae**					
27	*Monticola cinclorhyn chus*	Blue–headed Rock–thrush	I	BV	LC	3
28	*Myophonus caeruleus*	Blue Whistling–thrush	I	R	LC	1
19	**Upupidae**					
29	*Upupa epops*	Common Hoopoe	I	WV	LC	3

FS–Foraging Status: C–Carnivores, G–Granivore, I–Insectivore, N–Nectarivore, O–Omnivore; MS–Migratory Status–BV–Breeding Visitor, R–Resident, WV–Winter Visitor; CS–Conservation status–IUCN Red List and WPA–1972 Schedule: LC–Least Concern;

Appendix II. 3.207: Ecological status of bird species recorded in the Paikangrong chu HEP area

Sl. No.	Family and species name	Common name	FS	MS	CS	PM	M	W	Overall
1	**Accipitridae**								
1	*Accipiter nisus*	Eurasian Sparrowhawk	C	R	LC	0	0	1	1
2	**Aegithalidae**								
2	*Aegithalos concinnus*	Red–headed Tit	I	R	LC	0	0	10	10
3	**Campephagidae**								
3	*Pericrocotus ethologus*	Long–tailed Minvet	I	BV	LC	0	0	2	2
4	*Pericrocotus speciosus*	Scarlet Minivet	I	R	LC	0	2	0	2
4	**Charadriidae**								
5	*Charadrius placidus*	Long–billed Plover	I	WV	LC	0	2	0	2
5	**Cisticolidae**								
6	*Prinia crinigera*	Striated Prinia	I	R	LC	7	0	0	7
6	**Columbidae**								
7	*Streptopelia orientalis*	Oriental Turtle–dove	G	WV	LC	15	22	0	37
7	**Corvidae**								
8	*Dendrocitta formosae*	Grey Treepie	O	R	LC	0	1	2	3
9	*Corvus culminatus*	Large–billed Crow	O	R	LC	14	0	0	14
10	*Nucifraga caryocatactes*	Spotted Nutcracker	Nu	R	LC	0	9	2	11
11	*Urocissa flavirostris*	Yellow–bellied Blue Magpie	C	R	LC	0	1	0	1
8	**Cuculidae**								
12	*Hierococcyx sparverioides*	Large Hawk–cuckoo	I	BV	LC	9	0	0	9
9	**Dicaeidae**								
13	*Dicaeum ignipectus*	Fire–breasted Flowerpecker	N	R	LC	5	0	0	5
10	**Dicruridae**								
14	*Dicrurus leucophaeus*	Ashy Drongo	O	WV	LC	8	0	0	8
15	*Dicrurus macrocercus*	Black Drongo	O	R	LC	8	0	0	8
11	**Emberizidae**								
16	*Emberiza pusilla*	Little Bunting	G	WV	LC	0	0	2	2
12	**Fringillidae**								
17	*Carpodacus davidianus*	Chinese Beautiful Rosefinch	G	WV	LC	0	2	0	2
18	*Carpodacus nepalensis*	Dark–breasted Rosefinch	G	R	LC	0	0	10	10
19	*Carpodacus edwardsii*	Dark–rumped Rosefinch	G	R	LC	0	0	6	6
20	*Carduelis spinoides*	Himalayan Greenfinch	G	WV	LC	0	48	0	48
21	*Mycerobas melanozanthos*	Spot–winged Grosbeak	G	R	LC	0	2	0	2
13	**Hirundinidae**								
22	*Delichon nipalense*	Nepal House–martin	I	R	LC	13	0	0	13
14	**Leiothrichidae**								
23	*Heterophasia capistrata*	Rufous Sibia	O	R	LC	14	47	8	69
15	**Megalaimidae**								
24	*Megalaima virens*	Great Barbet	F	R	LC	11	0	0	11
16	**Motacillidae**								
25	*Motacilla cinerea*	Grey Wagtail	I	WV	LC	0	2	0	2

Sl. No.	Family and species name	Common name	FS	MS	CS	PM	M	W	Overall
26	*Anthus hodgsoni hodgsoni*	Olive–backed Pipit	I	R	LC	0	21	0	21
27	*Anthus rufulus*	Paddyfield Pipit	I	R	LC	0	1	0	1
17	**Muscicapidae**								
28	*Phoenicurus frontalis*	Blue–fronted Redstart	I	BV	LC	0	0	3	3
29	*Cyornis rubeculoides*	Blue–throated Flycatcher	I	BV	LC	3	0	0	3
30	*Saxicola ferreus*	Grey Bushchat	I	R	LC	0	2	0	2
31	*Phoenicurus hodgsoni*	Hodgson's Redstart	I	WV	LC	0	0	2	2
32	*Rhyacornis fuliginosa*	Plumbeous Water–redstart	I	R	LC	7	4	0	11
33	*Eumyias thalassinus*	Verditer Flycatcher	I	BV	LC	5	4	0	9
34	*Chaimarrornis leucocephalus*	White–capped River–chat	I	R	LC	0	1	0	1
35	*Myiomela leucura*	White–tailed Blue Robin	I	R	LC	2	0	0	2
18	**Nectariniidae**								
36	*Aethopyga saturata*	Black–breasted Sunbird	N	R	LC	4	0	0	4
37	*Aethopyga ignicauda*	Fire–tailed Sunbird	N	R	LC	0	9	2	11
38	*Aethopyga nipalensis*	Green–tailed Sunbird	N	R	LC	9	0	0	9
19	**Paradoxornithidae**								
39	*Paradoxornis nipalensis*	Black–throated Parrotbill	G	R	LC	0	0	21	21
20	**Paridae**								
40	*Parus ater*	Coal Tit	I	R	LC	0	0	2	2
41	*Parus monticolus*	Green–backed Tit	I	R	LC	0	4	6	10
21	**Passeridae**								
42	*Passer rutilans*	Cinnamon Sparrow	G	R	LC	4	0	0	4
22	**Picidae**								
43	*Blythipicus pyrrhotis*	Bay Woodpecker	I	R	LC	0	1	0	1
23	**Prunellidae**								
44	*Prunella collaris*	Alpine Accentor	I	WV	LC	0	0	1	1
45	*Prunella strophiata*	Rufous–breasted Accentor	I	R	LC	0	0	1	1
24	**Pycnonotidae**								
46	*Hypsipetes leucocephalus*	Himalayan Black Bulbul	O	R	LC	33	2	0	35
47	*Hypsipetes mcclellandi*	Mountain Bulbul	O	R	LC	0	0	2	2
48	*Pycnonotus cafer*	Red–vented Bulbul	O	R	LC	0	8	0	8
25	**Rhipiduridae**								
49	*Rhipidura albicollis*	White–throated Fantail	I	R	LC	3	0	0	3
26	**Sittidae**								
50	*Sitta himalayensis*	White–tailed Nuthatch	I	R	LC	0	1	0	1
27	**Stenostiridae**								
51	*Culicicapa ceylonensis*	Grey–headed Canary–flycatcher	I	BV	LC	0	1	0	1
52	*Chelidorhynx hypoxantha*	Yellow–bellied Fantail	I	R	LC	0	1	0	1
28	**Sylviidae**								
53	*Phylloscopus reguloides*	Blyth's Leaf–Warbler	I	WV	LC	9	4	0	13
54	*Phylloscopus pulcher*	Buff–barred Warbler	I	BV	LC	0	8	0	8
55	*Phylloscopus coronatus*	Eastern Crowned Warbler	I	WV	LC	9	0	0	9
56	*Seicercus burkii*	Green–crowned Warbler	I	BV	LC	1	10	0	11
57	*Phylloscopus trochiloides*	Greenish Warbler	I	WV	LC	0	9	0	9
58	*Phylloscopus maculipennis*	Grey–faced Leaf–warbler	I	R	LC	0	4	0	4
59	*Phylloscopus xanthoschistos*	Grey–hooded Warbler	I	R	LC	0	6	0	6
60	*Cettia brunnifrons*	Grey–sided Bush–Warbler	I	BV	LC	7	1	0	8
61	*Cettia brunnescens*	Hume's Bush–warbler	I	R	LC	0	1	0	1
62	*Phylloscopus chloronotus*	Lemon–rumped Leaf Warbler	I	BV	LC	0	9	0	9
63	*Cettia fortipes*	Strong–footed Bush–warbler	I	R	LC	0	3	0	3
29	**Timaliidae**								
64	*Minla strigula*	Bar–throated Minla	I	R	LC	0	16	0	16
65	*Trochalopteron imbricatum*	Bhutan Laughingthrush	I	R	LC	0	5	16	21
66	*Trochalopteron squamatum*	Blue–winged Laughingthrush	I	R	LC	0	9	0	9
67	*Dryonastes caerulatus*	Grey–sided Laughingthrush	I	R	LC	0	3	0	3
68	*Stachyris nigriceps*	Grey–throated Babbler	I	R	LC	0	0	7	7
69	*Pomatorhinus hypoleucos*	Large Scimitar–babbler	I	R	LC	2	0	0	2
70	*Alcippe nipalensis*	Nepal Fulvetta	I	R	LC	0	5	0	5
71	*Pellorneum ruficeps*	Puff–throated Babbler	I	R	LC	3	0	0	3
72	*Leiothrix lutea*	Red–billed Leiothrix	O	R	LC	0	2	0	2
73	*Trachalopteron erthrocephalum*	Red–headed Launghingthrush	I	R	LC	0	3	7	10
74	*Minla ignotincta*	Red–tailed Minla	I	R	LC	0	7	14	21
75	*Yuhina occipitalis*	Rufous–vented Yuhina	I	R	LC	0	40	12	52
76	*Lanthocincla ocellata*	Spotted Laughingthrush	I	R	LC	0	4	0	4
77	*Pomatorhinus ruficollis*	Streak–breasted Scimitar–babbler	I	R	LC	0	0	2	2
78	*Grammatoptila striatus*	Striated Laughingthrush	I	R	LC	14	0	0	14
79	*Yuhina flavicollis*	Whiskered Yuhina	I	R	LC	0	25	10	35
80	*Erpornis zantholeuca*	White–bellied Erpornis	I	R	LC	0	0	4	4

Sl. No.	Family and species name	Common name	FS	MS	CS	PM	M	W	Overall
81	*Pteruthius flaviscapis*	White–browed Shrike–babbler	I	R	LC	0	2	0	2
30	**Troglodytidae**								
82	*Troglodytes troglodytes*	Winter Wren	I	R	LC	2	0	0	2
31	**Turdidae**								
83	*Turdus atrogularis*	Black–throated Thrush	I	WV	LC	0	0	1	1
84	*Myophonus caeruleus*	Blue Whistling–thrush	I	R	LC	11	14	4	29
85	*Zoothera dixoni*	Long–tailed Thrush	I	BV	LC	0	1	1	2
86	*Turdus albocinctus*	White–collared Blackbird	I	R	LC	0	0	5	5

FS: Aq–Aquatic Feeder, C–Carnivores, F–Frugivore, G–Granivore, I–Insectivore, N–Nectarivore, Nc–Nucivore, O–Omnivore, P–Piscivore; MS–Migratory Status–BV–Breeding Visitor, IR–Isolated Record, R–Resident, WV–Winter Visitor; CS–Conservation status–IUCN Red List and WPA–1972 Schedule: VU–Vulnerable, LC–Least Concern; PM–Post monsoon, M–Monsoon, W–Winter

Appendix II. 3.208: List of possible mammalian fauna of the Tawang region and contribution of species reported in the Paikangrong chu HEP area

Sl. No.	Common name	Scientific name	SPA	Conservation status	
				IUCN	WPA
	Primates				
1	Arunachal macaque	*Macaca munzala*	*	EN	–
2	Assamese macaque	*M. assamensis*		NT	II
3	Capped langur	*Trachypithecus pileatus*		VU	I
4	Slow loris	*Nycticebus coucang*		VU	I
	Ungulates				
5	Barking deer	*Muntiacus muntjak*	*	LC	III
6	Bharal	*Pseudois nayaur*		LC	I
7	Chinese goral	*Nemorhaedus caudatus*		VU	III
8	Himalayan goral	*N. goral*	*	NT	III
9	Musk deer	*Moschus* sp.		EN	–
10	Sambar	*Cervus unicolor*		VU	III
11	Serow	*N. sumatraensis*			
12	Wild pig	*Sus scrofa*	*	LC	III
	Carnivores				
13	Common leopard	*Panthera pardus*		NT	I
14	Jungle Cat	*Felis Chaus*	*	LC	II
15	Dhole	*Cuon alpinus*		EN	II
16	Himalayan black bear	*Ursus thibetanus*		VU	II
17	Himalayan palm civet	*Paguma larvata*		LC	II
18	Leopard cat	*Prionailurus bengalensis*		LC	–
19	Otter	*Lutra* sp.		VU	–
20	Red panda	*Ailurus fulgens*		VU	I
21	Snow leopard	*Uncia uncia*		EN	I
22	Yellow–throated marten	*Martes flavigula*		LC	II
	Rodents				
23	Hairy–footed flying squirrel	*Belomys pearsonii*		DD	II
24	Himalayan marmot	*Marmota himalayana*		LC	II
25	Himalayan striped squirrel	*Tamiops macclellandi*		LC	–
26	Orange–bellied Himalayan squirrel	*Dremomys lokriah*	*	LC	–
	*Hoary–bellied Himalayan Squirrel	*Callosciurus pygerythrus*	*	LC	–
27	Porcupine	*Hystrix* sp.		LC	IV
	Chesnut rat	*Niviventer fluvescens*		LC	V
	Lagomorphs				
28	Large–eared pika	*Ochotona macrotis*		LC	–
29	Moupin pika	*Ochotona thibetana*		LC	–
	29 species		7 species R% = 24.13		

Data Source: 1–Mishra et al 2006, SPA–Species of Project Area, * Additional species reported during the study

Appendix II. 3.209: Status of birds at Paikangrong chu barrage and powerhouse site

Sl. No.	Family and species name	Common name	FS	MS	CS	No. of birds recorded
1	**Accipitridae**					
1	*Gyps himalayensis*	Himalayan Vulture	C	WV	LC	2
2	**Aegithalidae**					
2	*Aegithalos concinnus*	Red–headed Tit	I	R	LC	3
3	**Apodidae**					
3	*Aerodramus brevirostris*	Himalayan Swiftlet	I	R	LC	1
4	**Campephagidae**					
4	*Pericrocotus speciosus*	Scarlet Minivet	I	R	LC	3

5	**Certhiidae**					
5	*Certhia familiaris mandellii*	Eurasian Treecreeper	I	R	LC	1
6	**Cinclidae**					
6	*Cinclus pallasii*	Brown Dipper	Aq	R	LC	2
7	**Cuculidae**					
7	*Hierococcyx sparverioides*	Large Hawk–cuckoo	I	BV	LC	2
8	*Phaenicophaeus tristis*	Green–billed Malkoha	O	R	LC	2
8	**Dicruridae**					
9	*Dicrurus leucophaeus*	Ashy Drongo	O	WV	LC	2
10	*Dicrurus macrocercus*	Black Drongo	O	R	LC	2
9	**Emberizidae**					
11	*Emberiza lathami*	Crested Bunting	G	R	LC	2
10	**Hirundinidae**					
12	*Delichon nipalense*	Nepal House Martin	I	R	LC	2
11	**Leiothrichidae**					
13	*Heterophasia capistrata*	Rufous Sibia	O	R	LC	13
12	**Motacillidae**					
14	*Motacilla alba alboides*	White Wagtail	I	WV	LC	1
15	*Motacilla cinerea*	Grey Wagtail	I	WV	LC	1
13	**Muscicapidae**					
16	*Phoenicurus hodgsoni*	Daurian Redstart	I	R	LC	2
14	**Paridae**					
17	*Parus spilonotus*	Black–spotted Yellow Tit	I	R	LC	4
18	*Parus monticolus*	Green–backed Tit	I	R	LC	4
15	**Stenostiridae**					
19	*Chelidorhynx hypoxantha*	Yellow–bellied Fantail	I	R	LC	3
20	*Culicicapa ceylonensis*	Grey–headed Canary–flycatcher	I	BV	LC	1
16	**Sylviidae**					
21	*Phylloscopus affinis*	Tickell's Leaf–warbler	I	BV	LC	2
22	*Phylloscopus chloronotus*	Lemon–rumped Leaf Warbler	I	BV	LC	4
23	*Phylloscopus coronatus*	Eastern Crowned Warbler	I	WV	LC	1
24	*Phylloscopus inornatus*	Yellow–browed Leaf–warbler	I	WV	LC	2
25	*Phylloscopus maculipennis*	Grey–faced Leaf–warbler	I	R	LC	5
26	*Phylloscopus pulcher*	Orange–barred Leaf–warbler	I	WV	LC	5
27	*Phylloscopus reguloides*	Blyth's Leaf–warbler	I	WV	LC	4
28	*Phylloscopus trochiloides*	Greenish Warbler	I	WV	LC	4
29	*Phylloscopus xanthoschistos*	Grey–hooded Warbler	I	R	LC	1
17	**Timaliidae**					
30	*Trachalopteron erthrocephalum*	Red–headed Laughingthrush	I	R	LC	3
31	*Pteruthius flaviscapis*	White–browed Shrike–babbler	I	R	LC	4
32	*Yuhina gularis*	Stripe–throated Yuhina	O	R	LC	2
33	*Yuhina occipitalis*	Rufous–vented Yuhina	I	R	LC	4
18	**Turdidae**					
34	*Myophonus caeruleus*	Blue Whistling–thrush	I	R	LC	3
35	*Turdus boulboul*	Grey–winged Blackbird	I	R	LC	15

FS–Foraging Status, : Aq–Aquatic Feeder, C–Carnivores, G–Granivore, I–Insectivore, O–Omnivore, MS–Migratory Status–BV–Breeding Visitor, R–Resident, WV–Winter Visitor; CS–Conservation status–IUCN Red List and WPA–1972 Schedule: LC–Least Concern

Appendix II. 3.210: Check list and ecological status of bird species recorded in the proposed Jaswantgarh Stage–I HEP area

Sl. No.	Family and species name	Common name	FS	MS	CS	PM	M	W	Overall
1	**Campephagidae**								
1	*Pericrocotus ethologus*	Long–tailed Minvet	I	BV	LC	0	0	2	2
2	**Cisticolidae**								
2	*Prinia crinigera*	Striated Prinia	I	R	LC	14	0	0	14
3	**Columbidae**								
3	*Streptopelia orientalis*	Oriental Turtle–dove	G	WV	LC	6	21	0	27
4	**Corvidae**								
4	*Dendrocitta formosae*	Grey Treepie	O	R	LC	0	1	2	3
5	*Corvus culminatus*	Large–billed Crow	O	R	LC	8	0	0	8
6	*Nucifraga caryocatactes*	Spotted Nutcracker	Nu	R	LC	0	8	6	14
7	*Urocissa flavirostris*	Yellow–bellied Blue Magpie	C	R	LC	0	3	0	3
5	**Cuculidae**								
8	*Hierococcyx sparverioides*	Large Hawk–cuckoo	I	BV	LC	3	1	0	4
6	**Dicaeidae**								
9	*Dicaeum ignipectus*	Fire–breasted Flowerpecker	N	R	LC	8	2	0	10
7	**Dicruridae**								
10	*Dicrurus leucophaeus*	Ashy Drongo	O	WV	LC	3	0	0	3

Sl. No.	Family and species name	Common name	FS	MS	CS	PM	M	W	Overall
11	*Dicrurus macrocercus*	Black Drongo	O	R	LC	8	0	0	8
8	**Fringillidae**								
12	*Carpodacus davidianus*	Chinese Beautiful Rosefinch	G	WV	LC	0	2	0	2
13	*Carpodacus nepalensis*	Dark–breasted Rosefinch	G	R	LC	0	13	10	23
14	*Carpodacus edwardsii*	Dark–rumped Rosefinch	G	R	LC	0	4	0	4
15	*Carduelis spinoides*	Himalayan Greenfinch	G	WV	LC	0	50	0	50
9	**Halcyonidae**								
16	*Halcyon smyrnensis*	White–throated Kingfisher	P	R	LC	1	0	0	1
10	**Leiothrichidae**								
17	*Heterophasia capistrata*	Rufous Sibia	O	R	LC	8	7	4	19
11	**Megalaimidae**								
18	*Megalaima virens*	Great Barbet	F	R	LC	3	0	0	3
12	**Motacillidae**								
19	*Motacilla cinerea*	Grey Wagtail	I	WV	LC	0	2	0	2
20	*Anthus hodgsoni hodgsoni*	Olive–backed Pipit	I	R	LC	0	25	0	25
13	**Muscicapidae**								
21	*Phoenicurus frontalis*	Blue–fronted Redstart	I	BV	LC	0	1	1	2
22	*Saxicola torquatus indicus*	Common Stonechat	I	BV	LC	0	2	0	2
23	*Saxicola ferreus*	Grey Bushchat	I	R	LC	0	2	0	2
24	*Phoenicurus hodgsoni*	Hodgson's Redstart	I	WV	LC	0	0	3	3
25	*Ficidula strophiata*	Orange–gorgeted Flycatcher	I	R	LC	0	3	0	3
26	*Rhyacornis fuliginosa*	Plumbeous Water–redstart	I	R	LC	14	0	0	14
27	*Ficedula hodgsonii*	Slaty–backed Flycatcher	I	WV	LC	0	2	0	2
28	*Eumyias thalassinus*	Verditer Flycatcher	I	BV	LC	7	0	0	7
29	*Chaimarrornis leucocephalus*	White–capped River–chat	I	R	LC	0	6	1	7
30	*Phoenicurus schisticeps*	White–throated Redstart	I	R	LC	0	1	0	1
14	**Nectariniidae**								
31	*Aethopyga saturata*	Black–breasted Sunbird	N	R	LC	2	0	0	2
32	*Aethopyga ignicauda*	Fire–tailed Sunbird	N	R	LC	0	2	1	3
33	*Aethopyga nipalensis*	Green–tailed Sunbird	N	R	LC	2	2	0	4
15	**Paradoxornithidae**								
34	*Paradoxornis nipalensis*	Black–throated Parrotbill	G	R	LC	0	0	21	21
16	**Paridae**								
35	*Parus ater*	Coal Tit	I	R	LC	0	0	2	2
36	*Parus monticolus*	Green–backed Tit	I	R	LC	0	6	2	8
17	**Passeridae**								
37	*Passer rutilans*	Cinnamon Sparrow	G	R	LC	8	0	0	8
18	**Prunellidae**								
38	*Prunella collaris*	Alpine Accentor	I	WV	LC	0	0	2	2
19	**Pycnonotidae**								
39	*Hypsipetes leucocephalus*	Himalayan Black Bulbul	O	R	LC	22	3	0	25
40	*Pycnonotus cafer*	Red–vented Bulbul	O	R	LC	0	8	0	8
20	**Stenostiridae**								
41	*Culicicapa ceylonensis*	Grey–headed Canary–flycatcher	I	BV	LC	0	1	0	1
21	**Sylviidae**								
42	*Phylloscopus reguloides*	Blyth's Leaf–Warbler	I	WV	LC	2	3	0	5
43	*Phylloscopus pulcher*	Buff–barred Warbler	I	BV	LC	0	2	0	2
44	*Phylloscopus coronatus*	Eastern Crowned Warbler	I	WV	LC	5	0	0	5
45	*Seicercus burkii*	Green–crowned Warbler	I	BV	LC	0	6	0	6
46	*Phylloscopus trochiloides*	Greenish Warbler	I	WV	LC	0	13	0	13
47	*Phylloscopus maculipennis*	Grey–faced Leaf–warbler	I	R	LC	0	5	0	5
48	*Phylloscopus xanthoschistos*	Grey–hooded Warbler	I	R	LC	0	3	0	3
49	*Cettia brunnifrons*	Grey–sided Bush–Warbler	I	BV	LC	4	1	0	5
50	*Cettia brunnescens*	Hume's Bush–warbler	I	R	LC	0	1	0	1
51	*Phylloscopus chloronotus*	Lemon–rumped Leaf Warbler	I	BV	LC	0	12	0	12
52	*Cettia fortipes*	Strong–footed Bush–warbler	I	R	LC	0	3	0	3
22	**Timaliidae**								
53	*Minla strigula*	Bar–throated Minla	I	R	LC	0	20	0	20
54	*Trochalopteron imbricatum*	Bhutan Laughingthrush	I	R	LC	0	0	10	10
55	*Trochalopteron squamatum*	Blue–winged Laughingthrush	I	R	LC	0	9	0	9
56	*Dryonastes caerulatus*	Grey–sided Laughingthrush	I	R	LC	0	3	0	3
57	*Stachyris nigriceps*	Grey–throated Babbler	I	R	LC	0	0	7	7
58	*Alcippe nipalensis*	Nepal Fulvetta	I	R	LC	0	9	0	9
59	*Leiothrix lutea*	Red–billed Leiothrix	O	R	LC	0	12	0	12
60	*Trachalopteron erthrocephalum*	Red–headed Laughingthrush	I	R	LC	0	12	5	17
61	*Minla ignotincta*	Red–tailed Minla	I	R	LC	0	10	0	10
62	*Yuhina occipitalis*	Rufous–vented Yuhina	I	R	LC	0	6	12	18
63	*Lanthocincla ocellata*	Spotted Laughingthrush	I	R	LC	0	2	0	2

Sl. No.	Family and species name	Common name	FS	MS	CS	PM	M	W	Overall
64	*Pomatorhinus ruficollis*	Streak–breasted Scimitar–babbler	I	R	LC	0	0	2	2
65	*Grammatoptila striatus*	Striated Laughingthrush	I	R	LC	5	0	0	5
66	*Yuhina gularis*	Stripe–throated Yuhina	O	R	LC	0	12	0	12
67	*Yuhina flavicollis*	Whiskered Yuhina	I	R	LC	0	13	10	23
68	*Pteruthius flaviscapis*	White–browed Shrike–babbler	I	R	LC	0	2	0	2
23	**Troglodytidae**								
69	*Troglodytes troglodytes*	Winter Wren	I	R	LC	1	0	0	1
24	**Turdidae**								
70	*Myophonus caeruleus*	Blue Whistling–thrush	I	R	LC	9	11	2	22
71	*Zoothera dixoni*	Long–tailed Thrush	I	BV	LC	0	1	1	2
72	*Turdus albocinctus*	White–collared Blackbird	I	R	LC	0	1	3	4
25	**Zosteropidae**								
73	*Zosterops palpebrosus*	Oriental White–eye	I	R	LC	0	4	0	4

FS: Aq–Aquatic Feeder, C–Carnivores, F–Frugivore, G–Granivore, I–Insectivore, N–Nectarivore, Nc–Nucivore, O–Omnivore, P–Piscivore; MS–Migratory Status–BV–Breeding Visitor, IR–Isolated Record, R–Resident, WV–Winter Visitor; CS–Conservation status–IUCN Red List and WPA–1972 Schedule: VU–Vulnerable, LC–Least Concern; PM–Post monsoon, M–Monsoon, W–Winter, HEP–Hydro Electric Project

Appendix II. 3.211: List of possible mammalian fauna of the Tawang region and contribution of species reported in the Jaswantgarh Stage–I HEP area

Sl. No.	Common name	Scientific name	SPA	Conservation status	
				IUCN	WPA
	Primates				
1	Arunachal macaque	*Macaca munzala*	*	EN	–
2	Assamese macaque	*M. assamensis*		NT	II
3	Capped langur	*Trachypithecus pileatus*		VU	I
4	Slow loris	*Nycticebus coucang*		VU	I
	Ungulates				
5	Barking deer	*Muntiacus muntjak*		LC	III
6	Bharal	*Pseudois nayaur*		LC	I
7	Chinese goral	*Nemorhaedus caudatus*		VU	III
8	Himalayan goral	*N. goral*		NT	III
9	Musk deer	*Moschus* sp.		EN	–
10	Sambar	*Cervus unicolor*		VU	III
11	Serow	*N. sumatraensis*			
12	Wild pig	*Sus scrofa*	*	LC	III
	Carnivores				
13	Common leopard	*Panthera pardus*		NT	I
14	Jungle Cat	*Felis Chaus*	*	LC	II
15	Dhole	*Cuon alpinus*		EN	II
16	Himalayan black bear	*Ursus thibetanus*		VU	II
17	Himalayan palm civet	*Paguma larvata*		LC	II
18	Leopard cat	*Prionailurus bengalensis*		LC	–
19	Otter	*Lutra* sp.		VU	–
20	Red panda	*Ailurus fulgens*		VU	I
21	Snow leopard	*Uncia uncia*		EN	I
22	Yellow–throated marten	*Martes flavigula*		LC	II
	Rodents				
23	Hairy–footed flying squirrel	*Belomys pearsonii*		DD	II
24	Himalayan marmot	*Marmota himalayana*		LC	II
25	Himalayan striped squirrel	*Tamiops macclellandi*		LC	–
26	Orange–bellied Himalayan squirrel	*Dremomys lokriah*		LC	–
	*Hoary–bellied Himalayan Squirrel	*Callosciurus pygerythrus*	*	LC	–
27	Porcupine	*Hystrix* sp.		LC	IV
	*Chesnut rat	*Niviventer fluvescens*		LC	V
	Lagomorphs				
28	Large–eared pika	*Ochotona macrotis*		LC	–
29	Moupin pika	*Ochotona thibetana*		LC	–
	29 species		4 species R% 13.79		

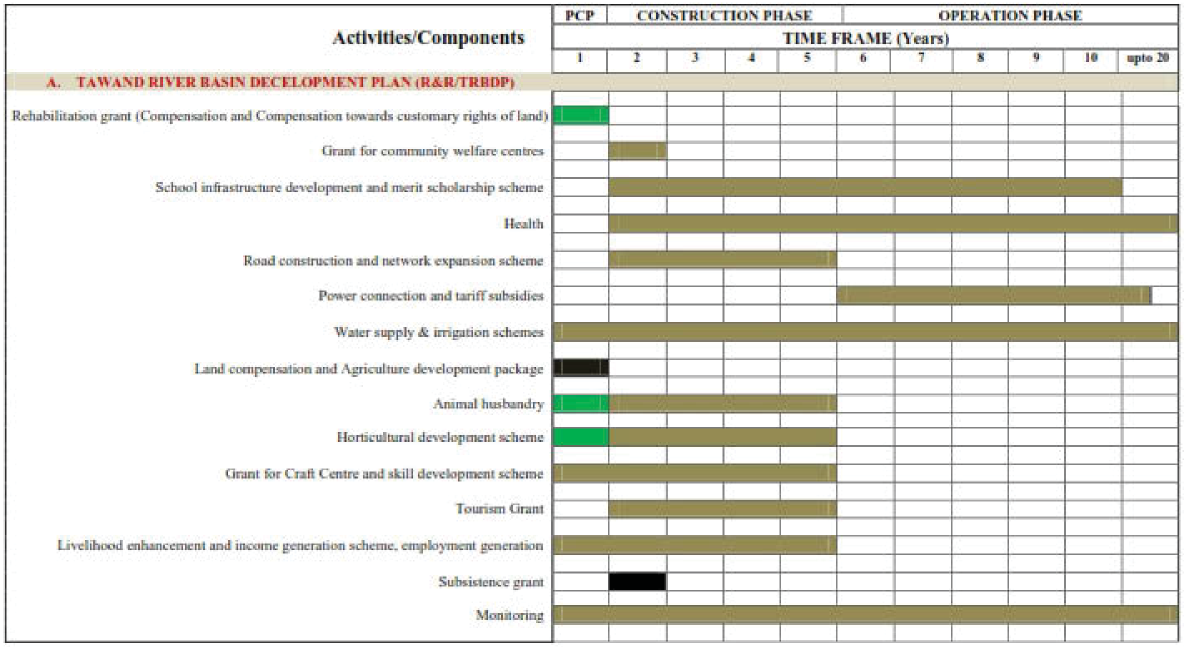
Data Source: 1–Mishra *et al* 2006, SPA–Species of the Project Area, * Additional species reported during the study, HEP–Hydro Electric Project

Appendix II. 3.212: Status of birds at Jaswantgarh Stage–I barrage and powerhouse site

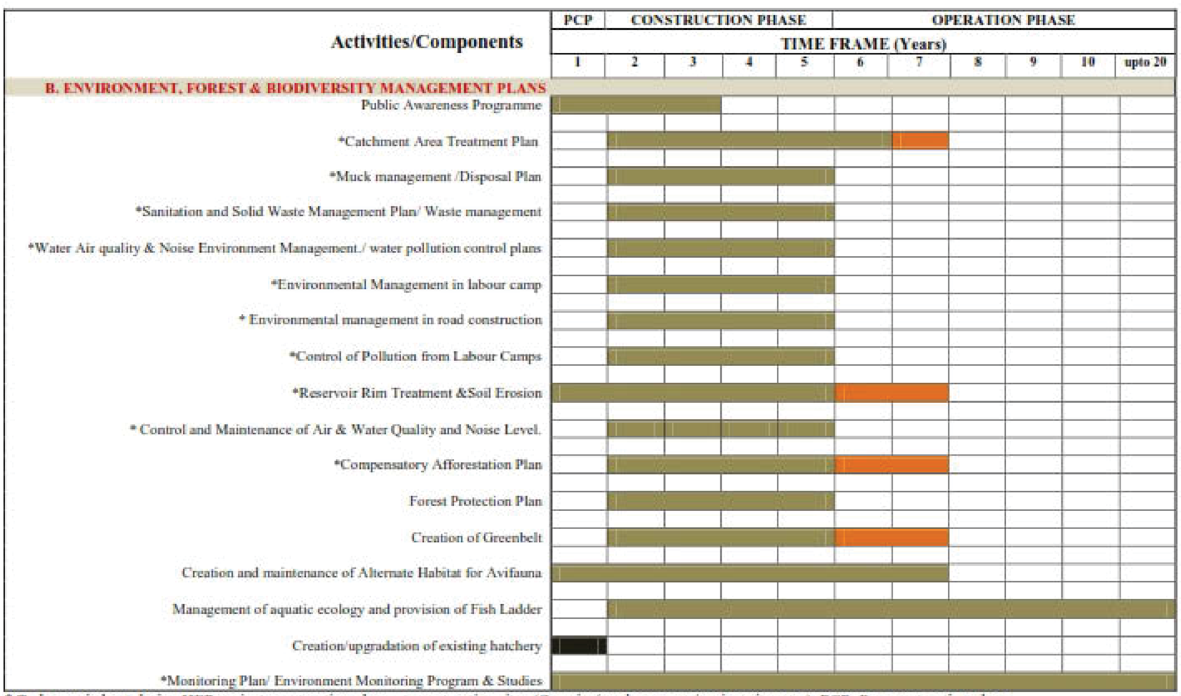
Sl. No.	Family and species name	Common name	FS	MS	CS	No. of birds reported
1	**Aegithalidae**					
1	*Aegithalos concinnus*	Red–headed Tit	I	R	LC	3
2	**Campephagidae**					
2	*Pericrocotus speciosus*	Scarlet Minivet	I	R	LC	3
3	**Certhiidae**					
3	*Certhia familiaris mandellii*	Eurasian Treecreeper	I	R	LC	1
4	**Columbidae**					
4	*Streptopelia orientalis*	Oriental Turtle–dove	G	WV	LC	2
5	**Corvidae**					
5	*Corvus culminatus*	Large–billed Crow	O	R	LC	2
6	**Cuculidae**					
6	*Hierococcyx sparverioides*	Large Hawk–cuckoo	I	BV	LC	1
7	**Dicaeidae**					
7	*Dicaeum ignipectus*	Fire–breasted Flowerpecker	N	R	LC	2
8	**Dicruridae**					
8	*Dicrurus leucophaeus*	Ashy Drongo	O	WV	LC	2
9	*Dicrurus macrocercus*	Black Drongo	O	R	LC	2
9	**Leiothrichidae**					
10	*Heterophasia capistrata*	Rufous Sibia	O	R	LC	16
10	**Megalaimidae**					
11	*Megalaima virens*	Great Barbet	F	R	LC	1
11	**Motacillidae**					
12	*Motacilla alba alboides*	White Wagtail	I	WV	LC	1
13	*Motacilla cinerea*	Grey Wagtail	I	WV	LC	1
12	**Nectariniidae**					
14	*Aethopyga nipalensis*	Green–tailed Sunbird	N	R	LC	2
13	**Paridae**					
15	*Parus monticolus*	Green–backed Tit	I	R	LC	4
14	**Passeridae**					
16	*Passer rutilans*	Cinnamon Sparrow	G	R	LC	2
15	**Pycnonotidae**					
17	*Hypsipetes leucocephalus*	Himalayan Black Bulbul	O	R	LC	15
16	**Stenostiridae**					
18	*Chelidorhynx hypoxantha*	Yellow–bellied Fantail	I	R	LC	3
19	*Culicicapa ceylonensis*	Grey–headed Canary–flycatcher	I	BV	LC	1
17	**Sylviidae**					
20	*Cettia brunnifrons*	Grey–sided Bush–warbler	I	BV	LC	2
21	*Phylloscopus affinis*	Tickell's Leaf–warbler	I	BV	LC	2
22	*Phylloscopus chloronotus*	Lemon–rumped Leaf Warbler	I	BV	LC	4
23	*Phylloscopus coronatus*	Eastern Crowned Warbler	I	WV	LC	2
24	*Phylloscopus inornatus*	Yellow–browed Leaf–warbler	I	WV	LC	2
25	*Phylloscopus maculipennis*	Grey–faced Leaf–warbler	I	R	LC	3
26	*Phylloscopus pulcher*	Orange–barred Leaf–warbler	I	WV	LC	5
27	*Phylloscopus reguloides*	Blyth's Leaf–warbler	I	WV	LC	5
28	*Phylloscopus trochiloides*	Greenish Warbler	I	WV	LC	4
29	*Phylloscopus xanthoschistos*	Grey–hooded Warbler	I	R	LC	1
18	**Timaliidae**					
30	*Pomatorhinus hypoleucos*	Large Scimitar–babbler	I	R	LC	2
31	*Pteruthius flaviscapis*	White–browed Shrike–babbler	I	R	LC	4
32	*Yuhina gularis*	Stripe–throated Yuhina	O	R	LC	2
33	*Yuhina occipitalis*	Rufous–vented Yuhina	I	R	LC	4
19	**Turdidae**					
34	*Myophonus caeruleus*	Blue Whistling–thrush	I	R	LC	6

G–Granivore, I–Insectivore, N–Nectarivore, O–Omnivore, MS–Migratory Status–BV–Breeding Visitor, R–Resident, WV–Winter Visitor; CS–Conservation status–IUCN Red List and WPA–1972 Schedule: LC–Least Concern; HEP–Hydro Electric Project

Appendix VI. 5.1: Suggested activity phasing (indicative only): (A) Tawang River Basin Development Plan (R&R/TRBDP), and (B) Environment, forests and biodiversity management plans in TRB



A



* To be carried out during HEP project construction phase at construction sites (Quarries/workers camp/project sites etc.); PCP=Pre-construction phase

Colour code : Compensation; One time grant/ activity; Creation/Activity/implementation duration; Maintenance duration

B

PHOTOPLATES

PLATE-1: BUTTERFLY SPECIES

Common Bluebottle (*Graphium sarpedon sarpedon*)

Indian Tortoise shell (*Aglais kaschmirensis*)

Common Flash (*Rapala nissa*)

Common Hedgeblue (*Acytolepis puspa*)

Eastern Comma (*Polygonia c-album agnicula*)

Glassy Tiger (*Graphium cloanthus*)

Green Sapphire (*Heliophorus moorei*)

Indian Purple Emperor (*Mimathyma ambica*)

Large Hedgeblue (*Celastrina hugelioreana*)

Lucas' Ace (*Sovia lucasii magna*)

Large Silverstripe (*Argynnis childreni*)

Lucas Ace (*Sovia lucasii magna*)

Spotted Sawtooth (*Prioneris thestylis thestylis*)

Peablue (*Lampides boeticus*)

Scarce Woodbrown (*Lethe sidereal*)

PLATE-2: BIRD SPECIES

Blue-headed Rock-thrush

Rufous Sibia

Green-backed Tit

Oriental White-eye

Verditer Flycatcher

Large-hawk Cuckoo

Jungle Prinia

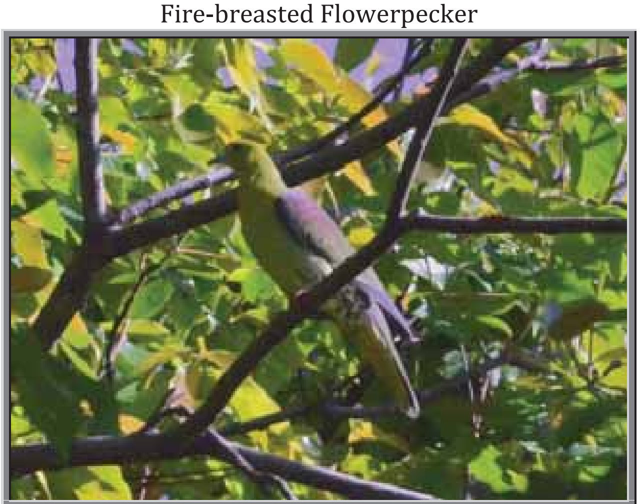
White Wagtail

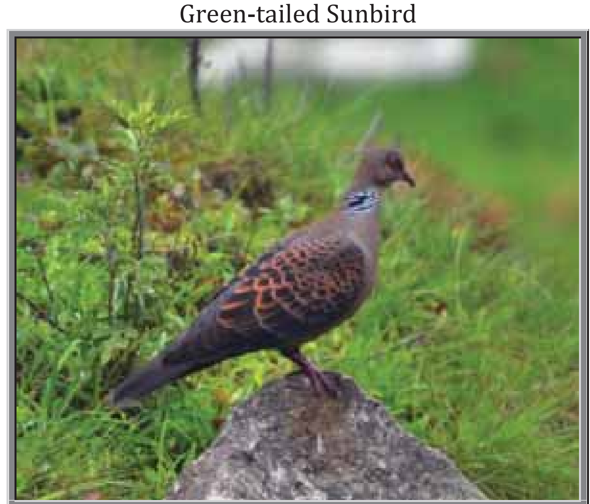

White-collared Blackbird


Himalayan Black Bulbul


Fire-breasted Flowerpecker


Green-tailed Sunbird


Wedge-tailed Green-pigeon


Oriental Turtle-dove


Eurasian Tree Sparrow


Cinnamon Sparrow

PLATE-3: DIRECT AND INDIRECT EVIDENCES OF MAMMALS


Capped Langur


Arunachal Macaque


Goral


Goral Pallet


Dropping of Asiatic Black Bear


Tracks of Himalayan Palm Civet

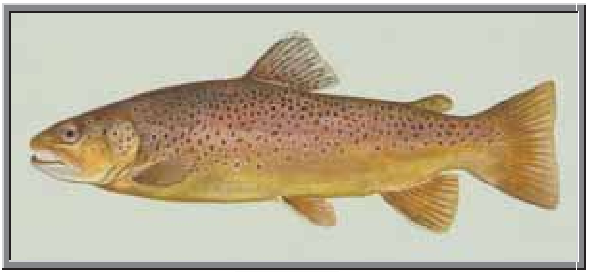

Tracks of Wild Pig


Leopard Scat and Goral Pallet

PLATE-4: FISH FAUNA

Schizothorax richardsonii, (Gray, 1832)
Common snow trout

Schizothorax progastus (McClelland, 1839)
Dinnawah snowtrout



Salmo trutta fario (Linnaeus 1758) Brown trout

Botia rostrata (Günther, 1868)

Syncrossus berdmorei (Blyth, 1860)

Mystus vitatus (Bloch, 1794)

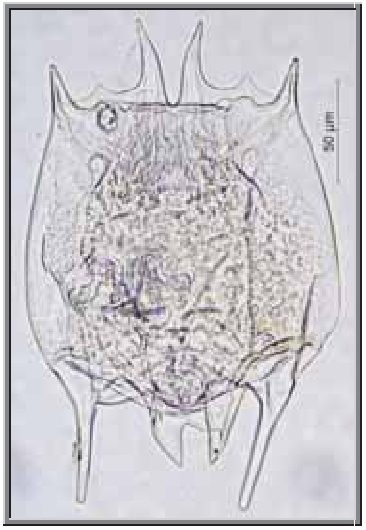
Exostoma berdmorei (Blyth, 1860)

Gagata cenia (Hamilton, 1822)

Amblyceps mangois (Hamilton, 1822)

Erethistoides Montana (Hora, 1950)

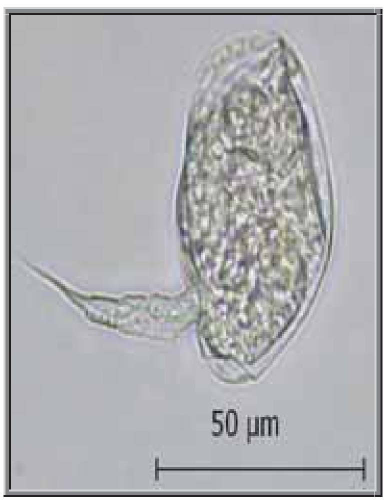
PLATE-5: SPECIES BELONGING TO PHYLUM ROTIFERA AT DIFFERENT HEP SITES OF TAWANG RIVER BASIN



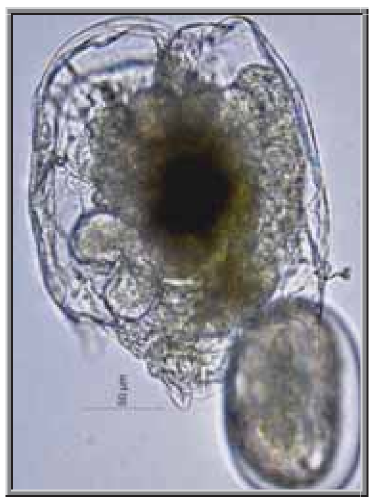
Brachionus quadridentatus

Cephalaodella gibba

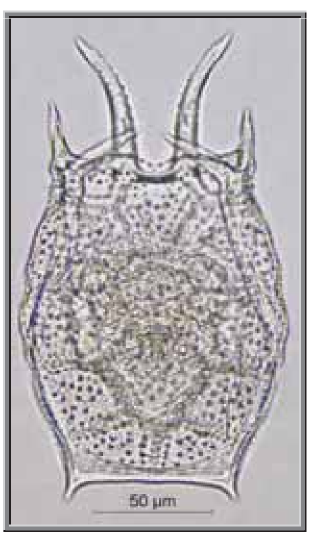

Colurella obtusa



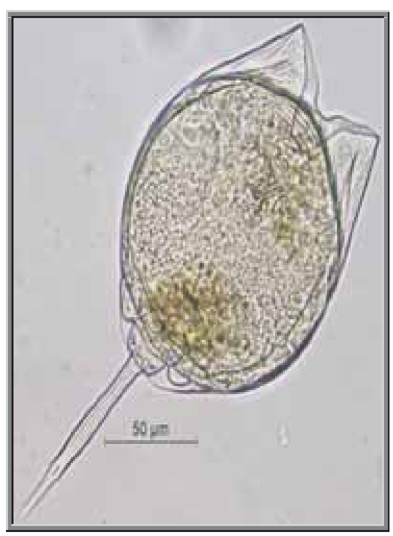
Colurella sulcata


Epiphanes brachionus spinosa


Euchlanis dilatata

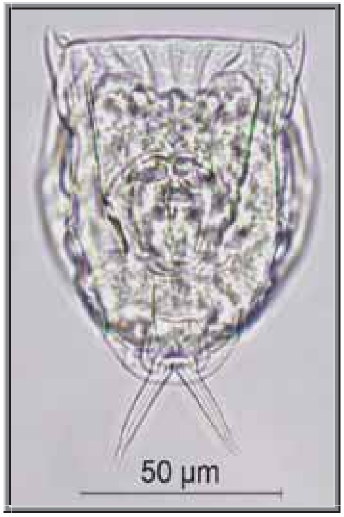


Keratella serrulata

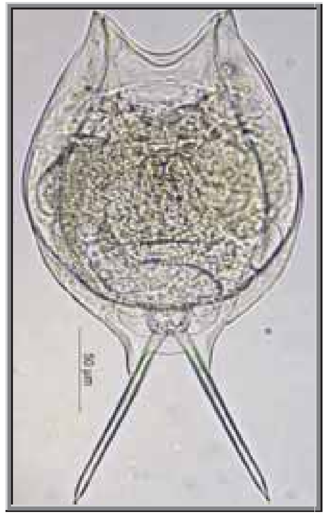


Lecane bulla

Lecane closterocerca



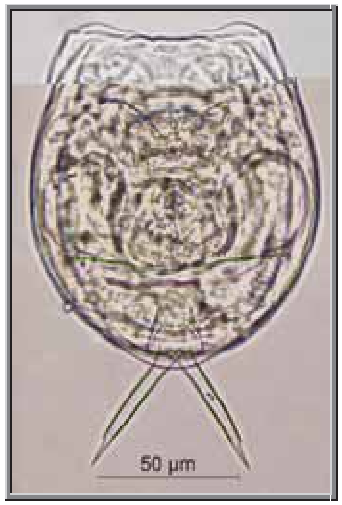
Lecane flexilis



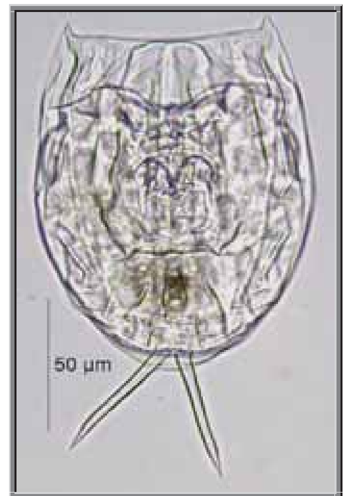
Lecane leontina

Lecane luna

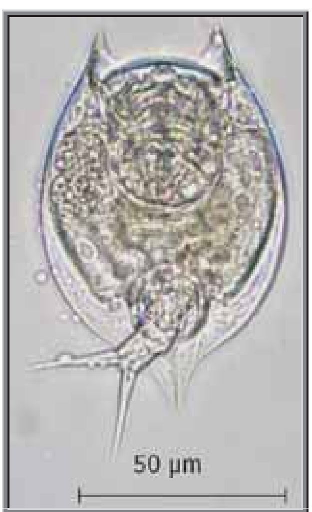
Lecane lunaris



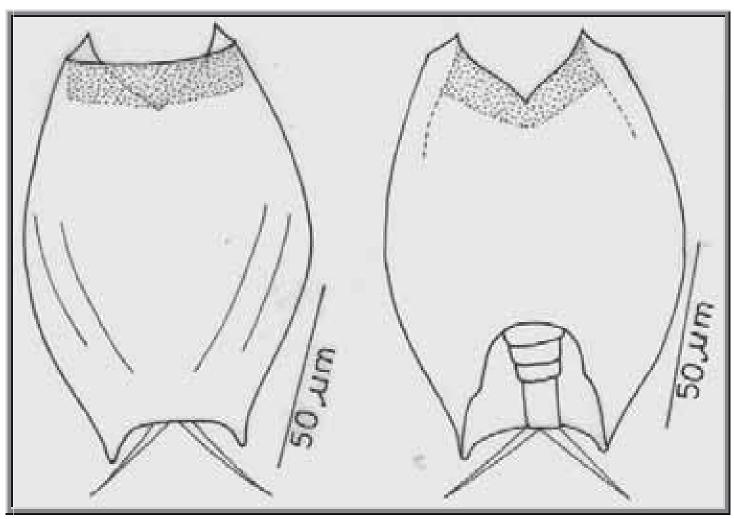
Lecane papuana



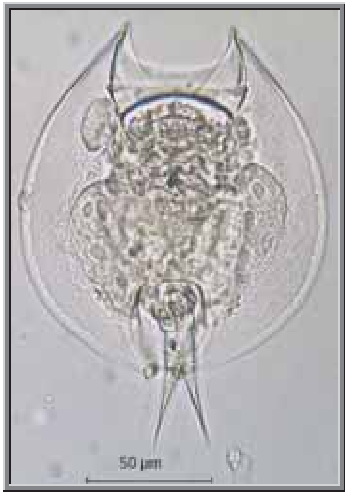
Lecane signifera



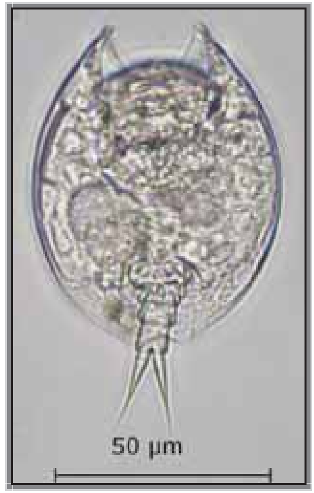
Lepadella acuminata



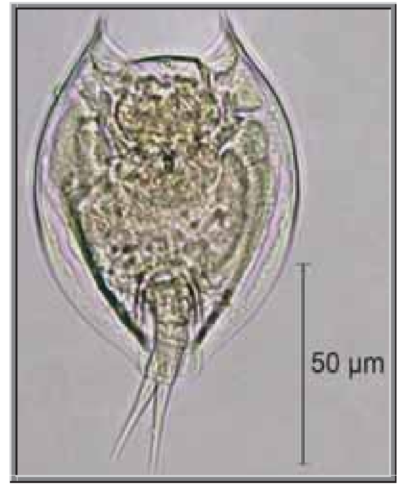
Lepadella nartiangensis



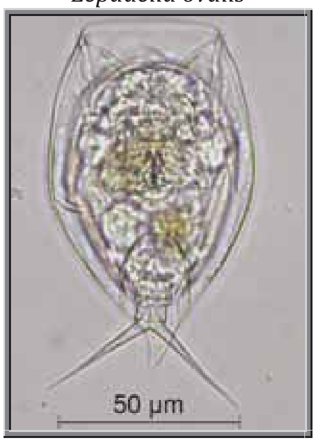
Lepadella ovalis



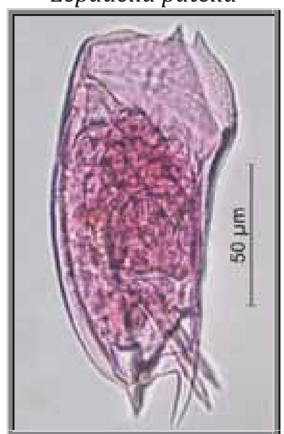
Lepadella patella



Lepadella quadricarinata



Lepadella vandenbrandei



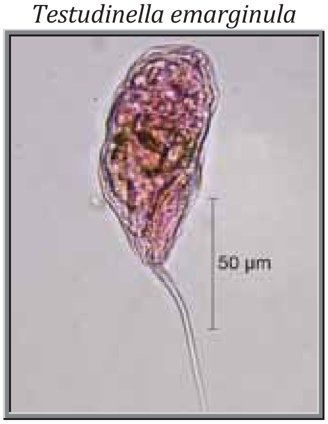
Mytilina ventralis

Notholca squamula

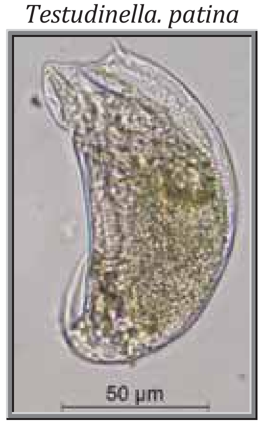
Testudinella emarginula

Testudinella. patina

Trichocerca bidens

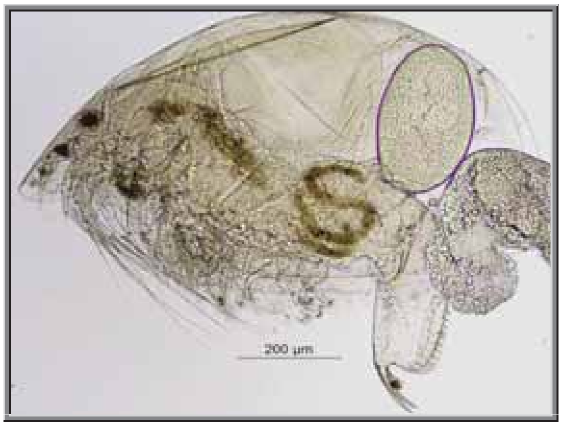


Trichocerca pusilla

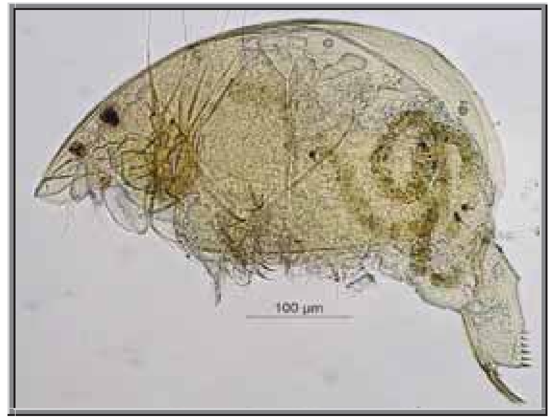


Trichocerca weberi

PLATE-6: SPECIES BELONGING TO ORDER CLADOCERA AT DIFFERENT HEP SITES OF TAWANG RIVER BASIN

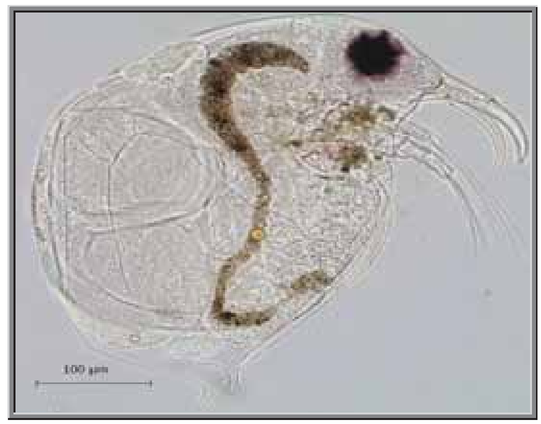


Alona affinis

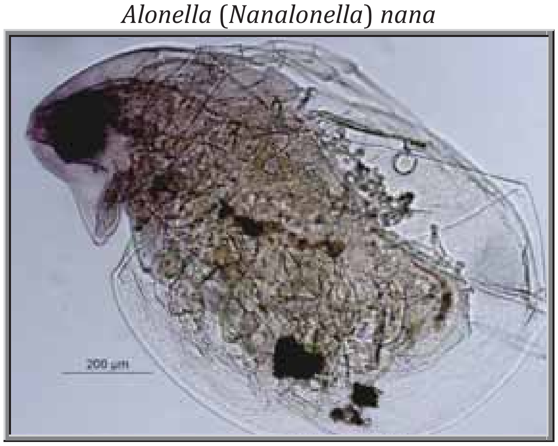


Alona cheni

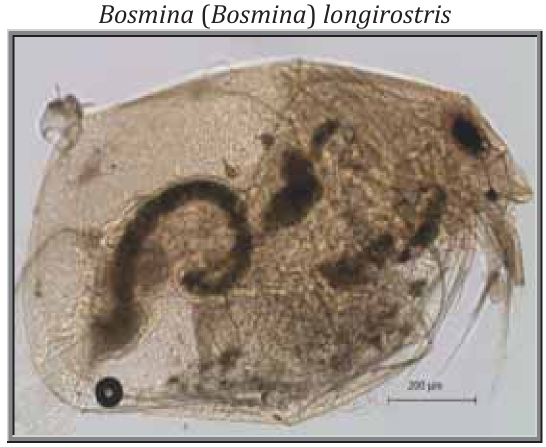
Alonella (*Nanalonella*) *nana*



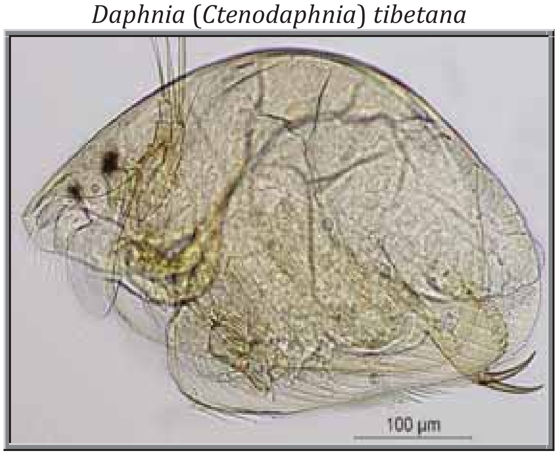
Bosmina (*Bosmina*) *longirostris*



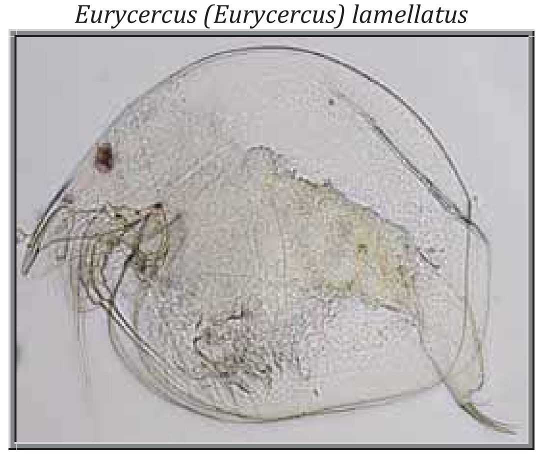
Daphnia (*Ctenodaphnia*) *tibetana*



Eurycercus (Eurycercus) lamellatus



Karualona karua



Leberis diaphanus

PLATE-7: CAMERA TRAP PHOTOS OF ANIMALS OBTAINED DURING THE STUDY AT DIFFERENT HEP SITES

Himalayan Goral

Barking Deer

Arunachal Macaque

Himalayan Crestless Porcupine

Himalayan Black Bear

Himalayan Serow

Golden cat

Serow

Wild Pig

Picture: Sighting of Black-necked crane in Pangchen Valley in December 2013 (WWF India)

PLATE-8: FUNGI COLLECTED FROM DIFFERENT HEP AREAS OF TAWANG RIVER BASIN

Auricularia auricular

Cheilymenia sp.

Cortinarius orichalceus

Cystoderma amianthinum

Dacryopinax spathularia

Daldinia concentrica

Favolus alveolaris

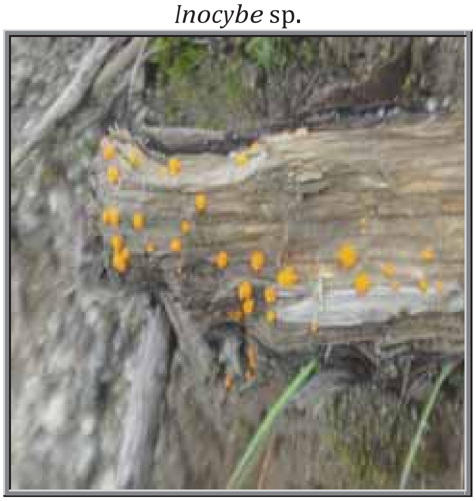
Fomes fomentarius

Fomes ulmarius

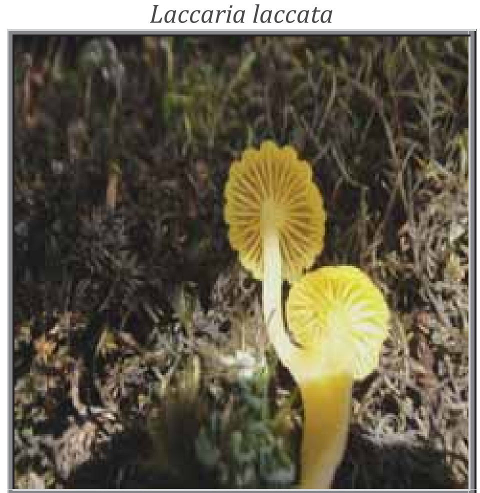
Hygrocybe conica

Inocybe sp.

Laccaria laccata



Nectria cinnabavina coral spot fungus



Omphalina chromacea

Omphalina chrysophylla

Oudemansiella mucida

Panaeolina foenisecii

Panaeolus subbalteatus

Pleurotus ostreatus

Poria eupora

Russula persanguinea

Schizophyllum commune

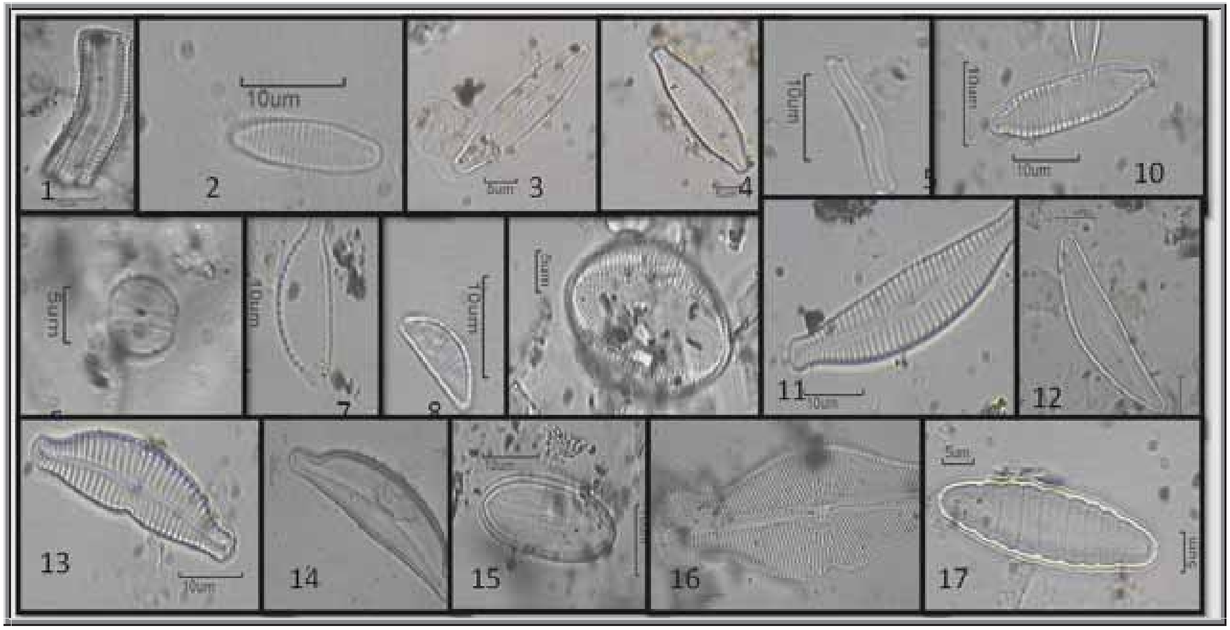
Stereum ostrea

Suillus granulata

Tremella mesenterica

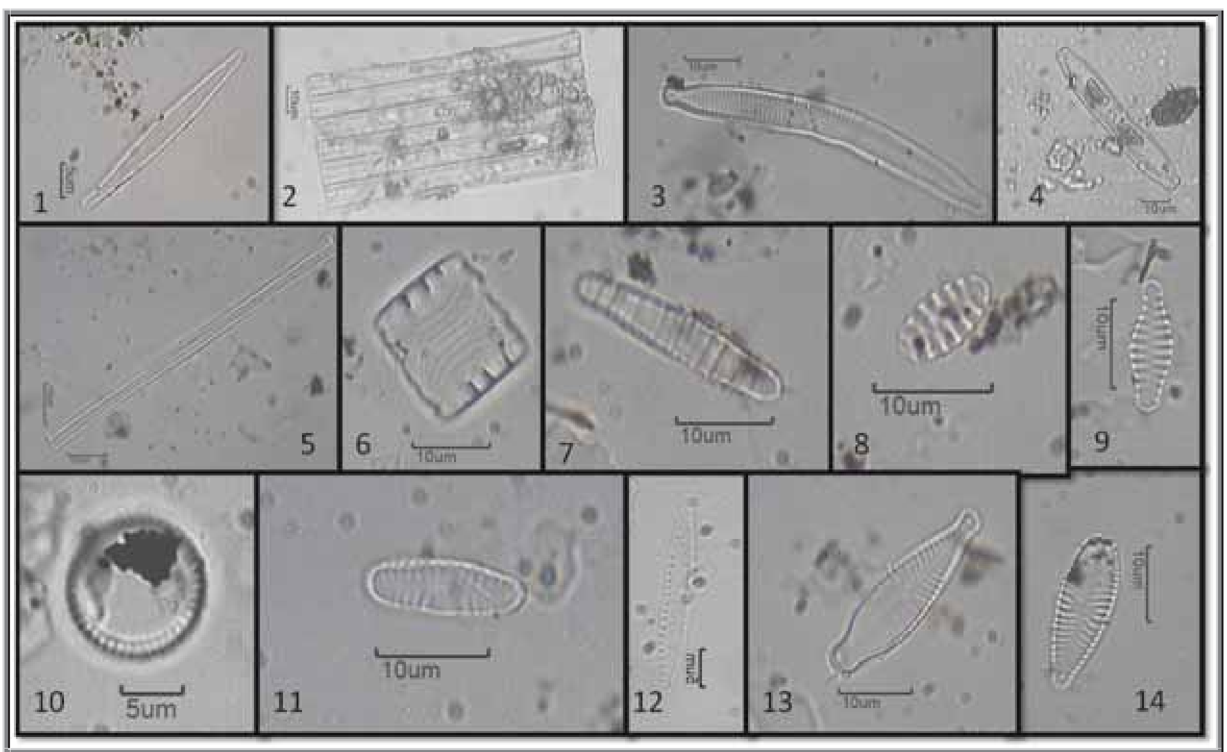
Trametes zonata

PLATE-9: PERIPHYTON SPECIES



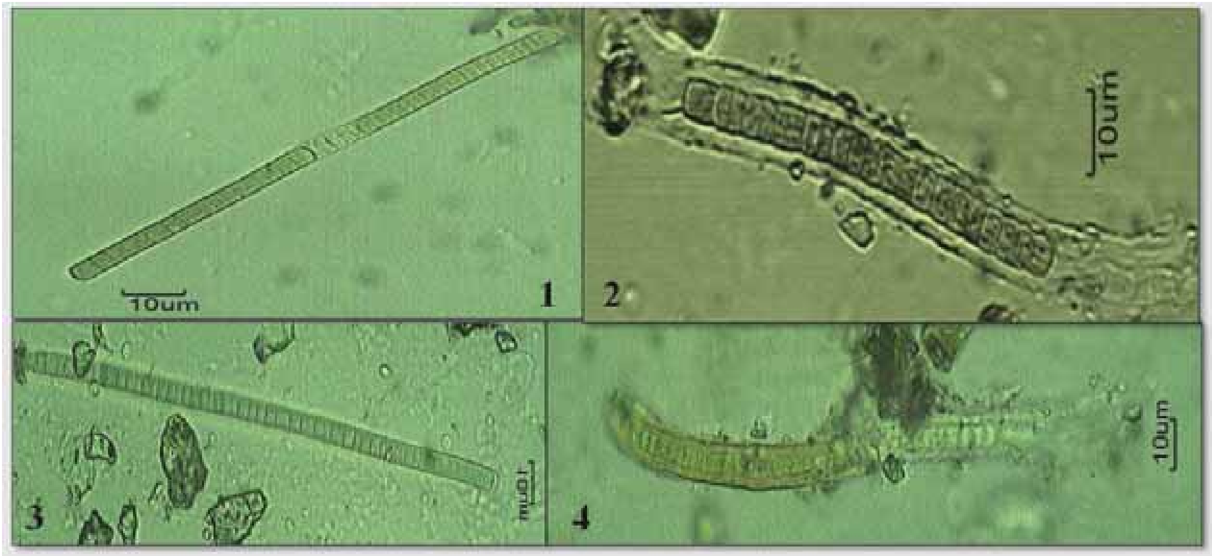
BACILLARIOPHYCEAE FAMILY

1. *Rhoicosphaenia* sp. 2. *Achanthidium pyrenaicium* 3. *Achnanthidium rivulare* 4. *Achnanthes biporoma*
5. *Achnanthidium* sp. 6. *Amphora* sp. 7. *Encyaonema prostatum* 8. *Encyaonema minutum*
9. *Cocconeis* 10. *Caloneis ventrocosa* 11. *Cymbella affinis* 12. *Cymbella delicatula*
13. *Cymbella ermin* 14. *Cymbella tumida* 15. *Cocconeis placentula* 16. *Didymosphenia erminate*
17. *Diatoma* sp.



BACILLARIOPHYCEAE FAMILY

1. *Fragillaria vaucheriae* 2. *Fragillaria bicep* 3. *Eunotia bilunaris* 4. *Hanzchia amphioxys*
5. *Synedra ulna* 6. *Hydrosera* sp. 7. *Meridion circulare* 8. *Opephora* sp.
9. *Pseudostaurosira* sp. 10. *Thallassiosira* sp. 11. *Planothidium frequentissimum* 12. *Nitzchia palea*
13. *Gomphonema olivaceoides* 14. *Gomphonema olivaceum* 15. *Cocconeis placentula* 16. *Didymosphenia erminate*
17. *Diatoma* sp.



CYANOPHYCEAE FAMILY

1. *Phormidium* sp. 2. *Lyngbya* sp. 3. *Oscillatoria* sp. 4. *Calothrix* sp.

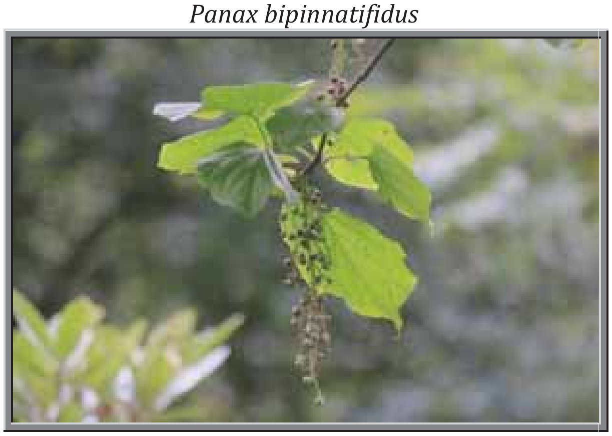
PLATE-10: THREATENED AND ENDEMIC PLANT SPECIES

Acer hookeri

Acer sikkimensis

Panax bipinnatifidus

Taxus wallichiana



Toricillia tiliifolia

Albizia arunachalensis

Paris polyphylla

PLATE-11: FEW PLANT SPECIES OF TAWANG RIVER BASIN

Oberonia sp.

Pteris sp.

Daphne papyracea

Calanthe tricarinata

Polypodium sp.

Clethra delavayi

Delphinium sp.

Aristolochia griffithii

Satyrium nepalense

Actinidia callosa

Dyropteris wallichiana

Aconitum elwesii

Rubus nubicola

Colquhounia coccinea

Ardisia crenata

Benthamia capitata

Bergenia ciliata

Botrychium sp.

Butea buteiformis

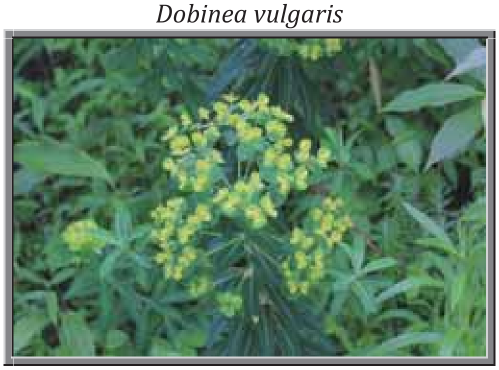
Celastrus paniculatus

Corylus heterophylla

Dipsacus asper

Dobinea vulgaris

Erythrina arborescens



Euphorbia sikkimensis

Verbascum thapsus

Halenia elliptica

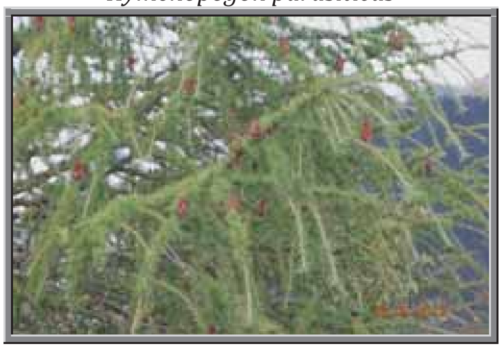
Hedera nepalensis

Herpetospermum pedunculosum

Holboellia latifolia

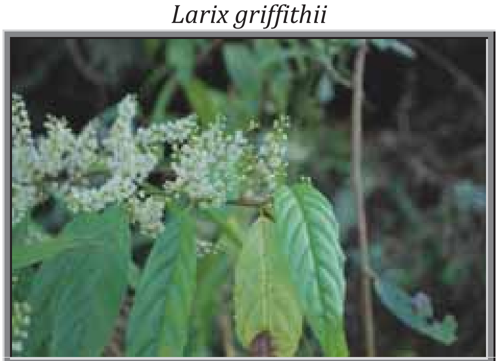
Hymenopogon parasiticus

Iris lactea



Larix griffithii

Leucosceptrum canum



Maesa indica

Codonopsis gracilis

Photinia integrifolia

Ophiopogon intermedius

Valeriana hardwickii

Rhus chinensis

Parochetus communis

Picea spinulosa

Piptanthus nepalensis

Polygala arillata

Prunella vulgaris

Quercus semecarpifolia

Rhododendron arboreum

Thladiantha cordifolia

Clematis montana

Anemone sp.

PLATE-12: NON-TIMBER FOREST PRODUCTS


Edible algae (*Prasiola crispa*)


Cordyceps sinensis

PLATE-13: TRADITIONAL HANDICRAFTS OF MONPA TRIBE IN TAWANG


Traditional crafts


Wooden plunger/butter churner


A collection of traditional masks


Monpa artisan with traditional clay pot


Traditional clay inscription


Locally made religious items

A Monpa weaving traditional craft

Traditional pig feeder

PLATE-14: INTERACTIONS WITH THE VILLAGERS, VILLAGE COUNCILS AND ZILLA PARISHAD OF TAWANG

Mirba village

Seru village

Seru village

Seru village

Shyaro village

Yusum village

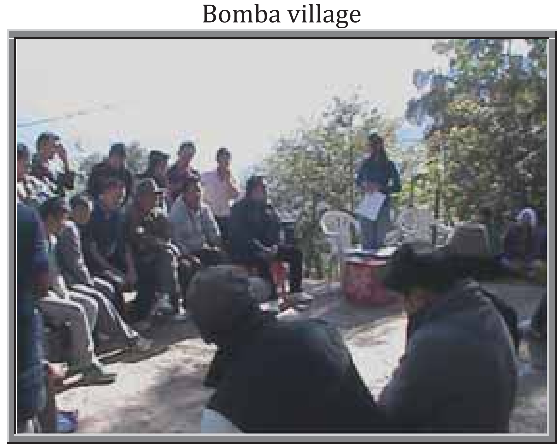

Yusum village


Interactions with Zilla Parishad Chairman

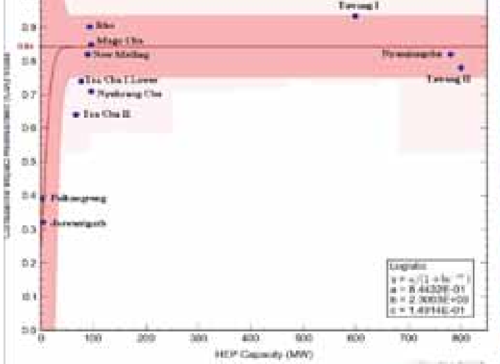

Khet village


Bomba village

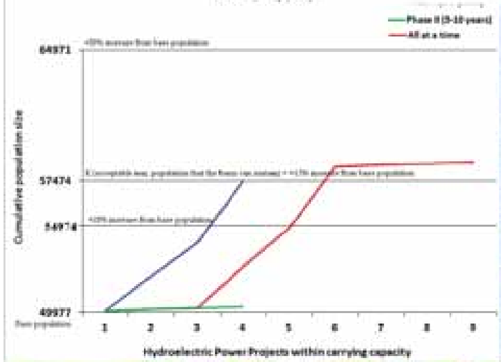

Questionnaire survey at Gomkelling


Yusum village


Interaction with headman at Rho village



Tawang I
Bhu
Nuranang Chu
New Melling
Nyamjangchu
Tawang II
Paikangrong
Logistic
0.0
0.1
0.2
0.3
0.4
0.6
0.7
0.8
0.9
0
100
200
300
400
500
600
700
800
HEP Capacity (MW)



Phase II (5-10 years)
All at a time
64971
57474
54974
49977
Base population
Cumulative population size
1
2
3
4
5
6
7
8
9
Hydroelectric Power Projects within carrying capacity