CUMULATIVE IMPACT & CARRYING CAPACITY STUDY (CIA&CCS) OF BEAS SUB BASIN IN HIMACHAL PRADESH

FINAL REPORT

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EXECUTIVE SUMMARY

1 BACKGROUND

Directorate of Energy, Government of Himachal Pradesh undertook the task of conducting Cumulative Environmental Impact Assessment (CEIA) Study for Beas river basin in Himachal Pradesh with an objective to assess the cumulative impacts of hydropower development in the basin. In the meantime, MoEF&CC has taken over all the river basin/carrying capacity studies being conducted by Central/State agencies and therefore, all reports were submitted directly to MoEF&CC. RS Envirolink Technologies Pvt. Ltd. (RSET), Gurgaon has been awarded the study based on techno-commercial bidding. Expert Appraisal Committee (EAC) for River Valley and Hydroelectric Projects of Ministry of Environment & Forests (MoEF&CC) approved the Terms of Reference (TOR) for the study. The study was initiated during February 2016, an inception report was submitted in June 2016 to capture the progress made during first four months of the study period and a Rapid CIA report was submitted in November 2016, which captured progress in first 8 months. The draft report was discussed and appraised in 4th meeting of the Expert Appraisal Committee for River Valley and Hydroelectric Projects held on 12th April 2017, wherein a visit to the study area by a sub-committee of EAC was suggested, which was made during April 2018 and post visit the outcome was discussed in EAC meeting during the same month. Recommendations were discussed in detail and it was decided to share the recommendations with the state government and thereafter the final report will be discussed in EAC. Directorate of Energy, Government of Himachal Pradesh, on receipt of recommendations, has shared their views/observations on the recommendations and made a presentation during EAC meeting of June 2018. During presentation, EAC sought further information from state government to justify their observations and matter was discussed in subsequent EAC meetings of October and November 2018. EAC finally concluded all the discussions on Beas River Basin study and directed the Consultant to update/finalize the basin study report, keeping in view the matter discussed and recorded in various EAC meetings. The present report is the final report prepared by incorporating recommendations finalised by EAC in consultation with state government of Himachal Pradesh.

2 HYDROPOWER PROJECTS IN BEAS BASIN

Beas Basin in Himachal Pradesh has 4877.70 MW of power potential (for > 5 MW projects), distributed among 51 hydropower projects spread throughout the basin (**Table 1 and Figure 1**). Out of these 51 projects, 22 projects are commissioned (total installed capacity 2820.90 MW), 5 are under construction (total installed capacity 947 MW), 20 are at various stages of investigations (total installed capacity 1028.90 MW) and 4 are yet to be allotted.

Out of proposed 24 projects, many of which are under different stages of survey and investigation, only 4 projects have installed capacity of more than 50 MW i.e. requiring environment clearance as category “A” projects; two are with installed capacity greater than 25 MW but less than 50 MW i.e. environment clearance is applicable under category “B” and remaining 18 projects are less than 25 MW of installed capacity i.e. environment clearance is not applicable.

Table 1: Hydropower Projects in Beas Basin

S. No.	Name of Project	Capacity (MW)	Developer	Status	Year of Commiss-ioning
1	Beas Sutlej Link	990	Bhakra Beas Management Board	Commissioned	1977
2	Parbati-III HEP	520	NHPC Limited	Commissioned	2014
3	Pong Dam	396	Bhakra Beas Management Board	Commissioned	1978-83
4	Allain Duhangan HEP	192	AD Hydro Power Ltd.	Commissioned	2010
5	Larji HEP	126	HPPCL	Commissioned	2006
6	Uhl-I (Shanan) HEP	110	Punjab State Power Corporation	Commissioned	1923
7	Malana-II HEP	100	Everest Power Pvt. Ltd.	Commissioned	2012
8	Sainj HEP	100	HPPCL	Commissioned	2017
9	Malana-I HEP	86	Malana Power Company Ltd.	Commissioned	2001
10	Uhl-II (Bassi) HEP	66	HPSEB	Commissioned	1970-81
11	Baragaon SHEP	24	Kanchanjunga Hydro Power Ltd.	Commissioned	2015
12	Patikari SHEP	16	Patikari Hydro Electric Project Ltd.	Commissioned	2008
13	Neugal SHEP	15	Om Hydropower Ltd.	Commissioned	2013
14	Baner SHEP	12	HPSEB	Commissioned	1996
15	Khauli SHEP	12	HPSEB	Commissioned	2007
16	Gaj SHEP	10.5	HPSEB	Commissioned	1996
17	Toss SHEP	10	Toss Mini Hydel Power Project	Commissioned	2008
18	Beas Kund SHEP	9	Kapil Mohan and Associates	Commissioned	2012
19	Binwa SHEP	6	HPSEB	Commissioned	1984
20	Baner-II SHEP	6	Podigy Hydro Power Pvt. Ltd.	Commissioned	2015
21	Sarbari-II SHEP	5.4	DSL Hydrowatt Ltd.	Commissioned	2010
22	Balargha SHEP	9	Sandhya Hydro Power Projects	Commissioned	2018
23	Parbati-II HEP	800	NHPC Limited	Under Construction	
24	Uhl III HEP	100	HPSEB	Under Construction	
25	Lambadug HEP	25	KU Hydro Power Pvt. Ltd.	Under Construction	
26	Lower Uhl SHEP	13	Trident Power Systems Ltd.	Under Construction	
27	Fozal SHEP	9	Fozal Power Pvt. Ltd.	Under Construction	
28	Nakthan HEP	460	HPPCL	Under S&I	
29	Thana Plaun HEP	191	HPPCL	Under S&I	
30	Triveni Mahadev HEP	96	HPPCL	Under S&I	
31	Dhaulasidh HEP	66	Satluj Jal Vidyut Nigam Ltd.	Under S&I	
32	Malana-III HEP	30	BMD Pvt. Ltd.	Under S&I	
33	Raison SHEP	18	HPSEB	Under S&I	
34	Uhl SHEP	14	Puri Oil Mills Ltd.	Under S&I	
35	Uhl Khad SHEP	14	Kharnal Hydro Electric Project P Ltd.	Under S&I	
36	Parbati SHEP	12	Manimahesh Power Private Ltd.	Under S&I	
37	Jari SHEP	12	WIL Power Projects Ltd.	Under S&I	
38	Jobrie SHEP	12	Green Infra Limited	Under S&I	
39	Sharni SHEP	9.6	Sharni Hydro Power Pvt. Ltd.	Under S&I	
40	Sarsadi SHEP	9.6	Himshakti Power Pvt. Ltd.	Under S&I	
41	Hurla-I SHEP	9.4	Hurla Valley Power Pvt. Ltd.	Under S&I	
42	Sarsadi-II SHEP	9	Aroma Colonisers Pvt. Ltd.	Under S&I	
43	Palchan Bhang SHEP	9	Palchan Bhang Power Pvt. Ltd.	Under S&I	
44	Bhang SHEP	9	Bhang Hydel Power L.L.P.	Under S&I	
45	Kilhi Bahl SHEP	7.5	Puri Oil Mills Ltd.	Under S&I	
46	Makori	20.80	Sai Engineering Foundation	Under S&I	
47	Bhujling	20.00	Sai Engineering Foundation	Under S&I	
48	Kanda Pattan	40.00		Yet to be allotted	
49	Manalsu	21.90		Yet to be allotted	
50	Seri Rawla	13.00		Yet to be allotted	
51	Khauli II	6.00		Yet to be allotted	
Total		**4877.70**			

Figure 1: Map showing locations of Hydro-power Projects in Beas Basin

3 STUDY METHODOLOGY

To undertake Cumulative Impact Assessment and Carrying Capacity Study (CIA&CCS) of Beas river basin vis-à-vis proposed hydropower development in Himachal Pradesh, it was essential to establish the present environment setting in the basin on which impacts of development can be predicted and strategy for sustainable development can be formulated. Scoping for the study has set the requirement of extensive baseline data to be collected. Extensive baseline surveys were carried out for data collection, sampling and analysis. Additionally, data was collected from secondary sources, collated and analyzed. Entire data collection and analysis work was undertaken scientifically based on the pre-defined methodology and following the terms of reference issued by the department. The data on baseline status of various environmental parameters in the study area was collected through primary surveys for three seasons as specified in the approved TOR. Baseline data collection, compilation and analysis was followed by cumulative impact assessment and formulation of recommendation for sustainable hydropower development in the basin. Environmental flow release assessment was another major component of the scope and based on the hydro-meteorological assessment of the basin in general and for the locations of hydropower projects in particular, the exercise was undertaken using hydro-dynamic modelling for hydropower projects locations.

4 BASIN CHARACTERISTICS

More than 90% of the drainage system of Himachal Pradesh is a part of Indus river system with Jhelum, Chenab, Ravi, Beas and Sutlej its tributaries. Beas basin in comprised of Beas river drainage catchment in Himachal Pradesh. Beas happens to be a principal tributary of Sutlej river in India. Beas basin is flanked in the north by drainage catchment of Ravi and Chenab rivers and in the south by Sutlej river. Beas river originates from Beas Kund at Rohtang Pass at an elevation of 13,050 feet (3,978 m) and flows for a length of about 470 km before joining the Sutlej River at Harike Pattan south of Amritsar in Punjab. After the confluence of two source streams viz. Beas Kund and Beas Rishi at Palchan village, the river is known as Beas. The river after passing through Manali town traverses dense evergreen forested slopes and enters the town of Kullu. At Bhuntar Beas river is joined by Parbati river on its left bank which is a major tributary. The river flows in north-south direction up to Larji and then turns west up to Pandoh diversion dam. It is fed by number of streams in this stretch up to Pandoh. In addition to Parbati river major tributaries of Beas River upstream of Pandoh are Sainj, Tirthan river and Bakhli Khad joining from the east; Sanjoin, Manalsu, Fozal and Sarbari from the west. After Pandoh, Beas river flows in northerly direction and is joined by Uhl river on its right bank along its course. After this it again turns westward up to Mandi where it takes northerly turn again to be joined by Rana Khad on its right bank. It then enters Kangra valley near Sandhol. In Kangra valley Binwa, Neugal, Banganga, Gaj and Dehar are the major streams joining from the north and Kunah, Maseh, Son, Khairan Man from south. The northern and eastern tributaries of the Beas receive water from the melting snow and are perennial whereas the southern tributaries are seasonal. After leaving Himachal Pradesh the river enters plains of Punjab at Talwara and joins Sutlej at Harike Pattan.

The Study Area covered as a part of the Beas Basin is comprised of part of Beas river catchment falling within Himachal Pradesh i.e. Beas river catchment from its origin at Rohtang Pass up to Pong Dam at the inter-state boundary with Punjab. The total catchment area of Beas river in Himachal Pradesh is about 12591 sq km and its length in the study area is about 274 km. Drainage map of the study area i.e. Beas river basin in Himachal Pradesh was prepared from Survey of India Toposheets at 1:50000 scale as base map along with satellite data.

Beas basin is characterized by rugged topography with high ridges and peaks, with higher reaches covered with glaciers, and massive ice and snowfields. The elevation in the basin varies from high of 6619m to a low of 325m. In order to understand the relief profile of the basin it has been divided into 600m elevation zones. In order to understand the terrain morphology Digital Elevation Model (DEM) of the basin was prepared from SRTM 30m data. More than 70% of the catchment area lies below elevation of 3000 m and about 21% of the area lies between 3000 and 4800m elevation zone. Slope map of the basin was also generated using SRTM 30m data. First of all, a Digital Terrain Model (DTM) of the area was prepared, which was then used to generate a slope map. More than 32% of Beas river basin area in Himachal Pradesh is characterized by steep slopes while around 33% area is having moderately steep slopes. Soil map of the study area has been produced using soil maps collected from National Bureau of Soil Survey & Land use Planning (NBSS & LUP), Nagpur.

For the convenience of study and analysis of various physical and biological parameters and their interpretation, entire Beas basin in India has been delineated into 11 sub-basins comprised of major tributaries and covering varied domains as well as hydroelectric projects as given in **Table 2**.

Table 2: Characteristics of Sub-basins of Beas river basin

No	Sub-basin	Altitudinal Range (m)	Projects	Status	River/Stream	Area (sq km)
1	Beas I Sub-basin	1671-6002	Beas Kund	Commissioned	Beas Kund Nala	**618.35**
			Palchan Bhang	Proposed	Kothi Nala	
			Bhang	Proposed	Beas River	
			Jobrie	Proposed	Jobrie & Allain Nala	
			Allain Duhangan	Commissioned	Allain & Duhangan Nala	
2	Beas II Sub-basin	1168-4927	Baragaon	Commissioned	Sanjoin & Bijara Nala	**798.21**
			Fozal	Under Construction	Fozal Nala	
			Raison	Proposed	Beas	
			Sarbari II	Commissioned	Sarbari Khad	
3	Malana Sub-basin	1427-5756	Malana I	Commissioned	Malana Nala	**158.04**
			Malana II	Commissioned	Malana Nala	
			Malana III	Proposed	Malana Nala	
4	Parbati Upper Sub-basin	1427-6619	Nakthan	Proposed	Tosh Nala & Parbati River	**1437.11**
			Toss	Commissioned	Tosh Nala	
			Jari	Proposed	Parbati River	
			Balargha	Commissioned	Parbati River	
			Parbati II	Under Construction	Parbati River	
			Parbati	Proposed	Parbati River	
5	Parbati Lower Sub-basin	1168-3721	Sharni	Proposed	Parbati River	**137.02**
			Sarsadi	Proposed	Parbati River	
			Sarsadi II	Proposed	Parbati River	

No	Sub-basin	Altitudinal Range (m)	Projects	Status	River/Stream	Area (sq km)
6	Sainj Sub-basin	1168-5673	Sainj	Under Construction	Sainj River	**1108.37**
			Parbati III	Commissioned	Sainj River	
			Hurla I	Proposed	Hurla Nala	
7	Tirthan Sub-basin	1168-5201	-	-	-	**685.25**
8	Beas III Sub-basin	798-3346	Patikari	Commissioned	Bakhli Khad	**703.44**
			Pandoh	Commissioned	Beas River	
			Larji	Commissioned	Beas River	
9	Uhl Sub-basin	657-5171	Lambadug	Under Construction	Lambadug Khad	**1711.71**
			Uhl	Proposed	Uhl River	
			Uhl I (Shanan)	Commissioned	Uhl River	
			Uhl II (Bassi)	Commissioned	Rana & Neri Khad	
			Uhl III	Under Construction	Rana & Neri Khad	
			Lower Uhl	Under Construction	Uhl River	
			Uhl Khad	Proposed	Uhl River	
10	Beas IV Sub-basin	414-4907	Gaj	Commissioned	Gaj Khad	**3644.10**
			Khauli	Commissioned	Khauli Khad	
			Baner	Commissioned	Baner Khad	
			Neugal	Commissioned	Neugal Nala	
			Baner II	Commissioned	Baner Khad	
			Binwa	Commissioned	Binwa Khad	
			Kilhi Bahl	Proposed	Binwa & Awa Nala	
			Pong Dam	Commissioned	Beas River	
11	Beas V Sub-basin	325-2039	Triveni Mahadev	Proposed	Beas River	**1589.19**
			Dhaulasidh	Proposed	Beas River	
			Thana Plaun	Proposed	Beas River	

5 HYDROMETEOROLOGY

For hydro meteorological assessment of the Beas basin, data pertaining to rainfall and discharge was collected from various secondary sources. Project specific water availability information was collected from various project developers through Directorate of Energy, Government of Himachal Pradesh. Data was used for hydro-dynamic modelling carried out for project specific environment flow assessment.

6 TERRESTRIAL BIODIVERSITY

6.1 Forest Cover in Beas Basin

Major part of Beas river basin is comprised of the Beas river system traversing the districts of Kullu, Mandi, Hamirpur and Kangra of Himachal Pradesh. According to total forest cover as per Forest Survey of India (2015) Mandi has the maximum forest cover (42.43%), while Kangra has 36.03%.

According to forest cover map of the basin non-forest constitutes main land use in the basin and accounts for more than 60.60% of the entire Beas basin area. Very Dense forest constitutes 9.31% while Moderately Dense forest covers 17.79% of the total area.

6.2 Forest Types

The forests in the Beas basin, the study area are covered under four administrative Circles viz. Kullu, Hamirpur, Dharamshala and Mandi. Entire study area falls under 11 Forest Divisions with Kullu and Parbati Forest Divisions under Kullu Circle; Suket, Mandi, Nachan and Joginder Nagar under Mandi Circle, Dharamshala, Nurpur and Palampur under Dharamshala Circle and Dehra under Hamirpur Circle.

According to 'A Revised Survey of the Forest Types of India' by Champion and Seth (1968) forests in the basin are represented by 7 major Groups and 22 forest types viz. **5B/C2** Northern Dry Mixed Deciduous forest, **9C1a:** Himalayan sub-tropical pine forest **9/C1b:** Upper or Himalayan Chir Pine Forest **9/ C1/DS1:** Himalayan sub-tropical scrub **9/C1/DS2:** Sub tropical *Euphorbia* scrub **10/C1a** *Olea cuspidata* Scrub forest **12/C1a**: Ban Oak Forests (*Quercus incana*) **12/C1b**: Moru Oak Forest (*Q. dilatata*) **12/C1b**: (a, b) DS1/Oak scrub **12/C1c**: Moist Deodar Forests **12/C1d**: Western Mix Coniferous Forest **12/C1e**: Moist Temperate deciduous forests **12/C1f**: Low-level blue pine forest (*Pinus wallichiana*) **12/C2a**: Kharsu Oak forest (*Quercus semecarpifolia*) **12/C2b**: Himalayan upper oak-fir forest **12/DS1:** Montane Bamboo brakes **12/DS3**: Himalayan Temperate pastures **12/C1/DS2**: Himalayan temperate secondary scrub **14/C1a**: West Himalayan Sub Alpine fir forest **14C1b**: West Himalayan Sub Alpine Birch/fir forests 15C1: **Birch-Rhododendron scrub forest** 15/C3**: Alpine Pasture** 16C1**: Dry alpine scrub.**

6.3 Floristics

Bio-geographically, the study area i.e. Beas basin is situated in the Biogeographic zone- 2A of North West Himalaya (Rodgers *et al.*, 1988). The entire area is comprised of complex hill system with elevation ranging from 325 m to about 6620 m, traversed throughout by several rivers and rivulets.

The flora of the study area covers the vast canvas of Himalayan ecosystem along an altitudinal gradient, a meeting ground of cold deserts of trans Himalayan region to the temperate and alpine Himalayan flora. At lower altitudes, there are forests of pine and at higher altitudes the presence of oak-rhododendron forests with horse chestnuts and maples. The temperate zone has coniferous forest of cedar, fir and spruce. The alpine areas harbor herbaceous flora like species of *Aconitum, Corydalis, Delphinium, Gentiana, Meconopsis, Pedicularis, Primula, Saxifraga*, etc. At higher elevations, the flora is of the cold desert type with prominence of species of *Astragalus, Caragana, Ephedra, Juniperus* and stunted *Hippophae* and rhododendrons. In the present study 1727 species of plants have been documented from the study area. A brief overview of number of plant species in various taxonomic groups.

GROUP	Families	Genera	Species	Total no. of species
Angiosperms				
Dicots	133	600	1263	
Monocots	29	165	318	
Total	**162**	**765**	**1581**	**1727**
Gymnosperms	3	7	14	
Pteridophytes	18	36	113	
Bryophytes	11	12	19	

6.4 Rare, Endangered, Threatened (RET) and Endemic Plant Species

In Beas basin, there are 14 plant species that are under different threat categories as per Red Data Book of Plants published by Botanical Survey of India. According to Red-list Status of candidate species as per Shimla Conservation Assessment Management Prioritisation (CAMP) December, 2010 by Foundation for Revitalisation of Local Health Traditions (FRLHT), 41 species are found in Beas basin. However according to IUCN (Ver. 2017-2) only 107 species have been assessed for their conservation status globally and most of them are listed in 'Least Concern' category and only 8 are in VU category, 2 in Near Threatened, 4 each in Critically Endangered and Endangered category.

Of 84 plant species endemic to North West Himalaya (Included here are the Himalaya above about 1000 m in the area westward of the Kali Gandaki River Gorge in Central Nepal – Jain & Rao, 1983; Kanai, 1963; Rau, 1974) and Himachal Pradesh (Chaudhery, 1999) 64 species are reported from Beas basin.

6.5 Medicinal & Economically Important Plants

This region harbours a wide range of medicinal plants used in Ayurvedic, Homoeopathic and Unani medicines or used by the local people. In the present study 146 plant species have been documented which are used for various medicinal purposes in the basin.

6.6 Floristic Profile across the Basin

To understand the vegetation profile across the basin i.e. in different sub-basins species richness was documented. According to this species richness ranges from 94 to 171 with maximum in the Parbati Upper sub-basin and minimum in Beas I. Important trees of this basin are *Taxus wallichiana, Cedrus deodara, Pinus wallichiana, Picea smithiana, Abies pindrow*. It is home to large number of medicinal plants also. Uhl sub-basin is another biodiversity rich due to diverse habitats congenial for growth of different species. Dominant trees of Uhl sub-basin are *Aegle marmelos, Bauhinia variegata, Cinnamomum tamala, Neolitsea umbrosa, Mallotus philippensis* and *Sapium insigne*. At lower to mid elevations *Pinus roxburghii* is a very common species. However, with the increasing altitude montane Himalayan species become more prominent and lowland species are rare or absent. Beas I and Beas II sub-basins located in the high altitudinal zone are mainly comprised of coniferous species like *Abies pindrow, Cedrus deodara, Picea smithiana* and *Pinus wallichiana*.

As already discussed in previous section on medicinal plants large number of medicinal plants are found in the basin owing diverse habitats and elevation range. Some of the important medicinal plants like *Aconitum chasmanthum, A. heterophyllum, Arnebia benthami, Dactylorhiza hatagirea, Dioscorea deltoidea, Ephedra gerardiana, Ferula jaeschkeana, Nardostachys grandiflora, Picrorhiza kurroa, Rheum australe*, etc. are found in higher altitude areas of Beas I, Beas II, Parbati Upper, Sainj and Tirthan sub-basins.

6.7 Community Structure

The phytosociological studies were carried out for the analysis of community structure coverings all three season (pre-monsoon, monsoon and winter). The sampling for the same was conducted at the 60 locations.

6.7.1 Density of Trees

Upper catchment of Beas basin (Manali-Kullu) is comprised of temperate forest. *Pinus wallichiana, Cedrus deodara, Picea smithiana* and *Corylus colurna* were dominant tree species in these forests and are found in association with *Aesculus indica, Acer caesium, Alnus nepalensis, Celtis australis, Ulmus villosa, Fraxinus floribundus, Populus ciliata, Juglans regia, Quercus semecarpifolia, Salix fragilis, Salix tetrasperma, Ilex dipyrena* and *Betula utilis.*

In the middle stretch covering area between Kullu to Mandi forest is comprised of temperate to sub-tropical forest type. *Pinus wallichiana, Cedrus deodara Quercus semecarpifolia, Salix fragilis* and *Betula alnoides* are dominant at higher elevations in temperate areas, while at lower elevations *Adina cordifolia, Bauhinia variegata, Bombax ceiba, Celtis australis, Dalbergia sissoo, Mallotus philippensis, Rhus succedanea, Ficus palmata, Grewia optiva, Morus alba, Toona hexandra, Albizia* sp., *Boehmeria rugulosa, Phoebe lanceolata, Populus ciliata,* etc. are common.

The area downstream of Mandi up to Pong Dam forest is generally classified under tropical forest type. Tree component is mainly comprised mainly of *Syzygium cumini, Albizia lebbeck, Albizia chinensis, Boehmeria rugulosa, Delonix regia, Dalbergia sissoo, Sapium insigne, Bombax ceiba, Adina cordifolia, Eucalyptus citriodora, Mallotus philippensis, Lannea grandis, Bombax ceiba, Azadirachta indica,* etc.

The density of trees varied from site to site. The overall tree density throughout the study area ranged from minimum of 120 number of trees/ha to maximum of 530 trees/ha. Highest tree density was recorded at sampling site located near diversion site of Fozal HEP (left bank of Fozal Nala) and Sampling site located near the Diversion weir of Khauli Khad HEP, where *Pinus roxburghii, Quercus* spp. and *Bauhinia variegata* are the dominant species followed by sampling site located upstream of Uhl-I HEP barrage site (Right Bank of Ulh river) and lowest density of tree species were recorded at sampling site located in proposed project area of Jobrie HEP (right bank of Allain Nala).

Dominance

Among the trees *Pinus wallichiana, Cedrus deodara, Picea smithiana* and *Fraxinus floribunda* are the most frequent occurring species. *Cedrus deodara* was the most dominant species in temperate zone covering area of Upper catchment of Beas river up to Kulu, Malana Nala, Parbati river, Upper catchment of Uhl river areas. Pure stands of *Cedrus deodara* were recorded with high IVI values at most of the sites. *Pinus wallichiana* were the other dominant trees of the forests in this region. However, *Juglans regia* and *Picea smithiana* were also found dominant at some places. While at lower elevation comprising of temperate and sub-tropical region *Pinus wallichiana* was more commonly found at higher elevation ridges while species of *Quercus*, *Pinus roxburghii*, *Alnus nepalensis*, *Celtis australis* are dominant in tropical forests. In the tropical region of Beas basin *Dalbergia sissoo, Populus ciliata, Adina cordifolia, Bombax ceiba, Albizia* spp., *Eucalyptus citriodora, Mallotus philippensis, Lannea grandis* show frequent distribution with high IVI value. In all 91 species of trees were recorded from different sites.

During the field surveys 128 species of shrubs were recorded, species like *Rhododendron anthopogon, Rosa webbiana,* and *Juniperus communis* with other species like *Ephedra vulgaris, Cotoneaster bacillaris, Sorbaria tomentosa, Berberis jaeschkeana, Berberis lycium, Artemisia nilagirica* and *Berberis aristata*, were the most dominant shrub species in temperate region of Beas basin. *Sorbaria tomentosa, Artemisia nilagirica* and *Berberis aristata* were dominant at sites located at lower elevations in all seasons whereas *Rosa webbiana, Berberis lycium* and *Rhododendron campanulatum* were dominant at sites located at higher elevations.

In the middle stretch of Beas basin where vegetation is of temperate and sub-tropical forest type *Berberis aristata, Debregeasia longifolia, Boehmeria platyphylla, Leucosceptrum canum, Maesa chisia, Melocalamus compactiflorus, Oxyspora paniculata, Sarcococca saligna, Colebrookea oppositifolia Indigofera gerardiana Debregeasia longifolia* are the dominant shrub species with IVI values more than 50. At the lower elevations comprised of sub-tropical and tropical forest type *Lantana camara, Murraya koenigii* and *Justicia adhatoda* are the dominant shrub species with high IVI values. Predominant shrub species recorded from the study are in the lower catchment of Beas river are *Boehmeria macrophylla, Caryopteris odorata, Debregeasia salicifolia, Urtica dioica, Desmodium elegans, Woodfordia fruticosa,* etc.

In all 250 species of herbs were recorded during field surveys. *Gentiana kurroo*, *Iris kemaonesis*, *Poa alpina, Dactylis glomerata, Thymus serpyllum, Bistorta macrophylla, Axyris hybrida, Senecio chrysanthemoides, Origanum vulgare, Ageratum conyzoides, Artemisia nilagirica, Argemone mexicana, Achyranthes aspera, Anaphalis contorta, Nepeta ciliaris, Urena lobata, Datura stramonium, Fragaria vesca, Micromeria biflora, Mentha longifolia, Eragrostis pilosa, Buddleja asiatica, Curcuma aromatica, Parthenium hysterophorus, Cyperus rotundus* and *Chrysopogon fulvus* were found dominant at different sampling sites with each of them having IVI of more than 30. In general species like *Artemisia maritima*, *Gentiana kurroo, Ageratum conyzoides* and *Argemone mexicana* were the most dominant species at most of the sites during the surveys.

6.7.2 Species Diversity

To understand the species richness Shannon Weiner Diversity was calculated for trees, shrubs and herbs. Amongst trees the diversity Index ranged from low of 1.17 at sampling site V22 located near power house site of Sarbari II HEP to highest at sampling site V54 at sampling site located at left bank of Pong dam reservoir (2.82).

Among shrubs, highest diversity Index was recorded at sampling site V31 in the downstream of Dam site of Parbati III HEP (3.14) followed by sampling site V28 (3.13) in the Upstream of Sainj HEP Dam site and lowest at sampling site V4 located near proposed project area of Jobrie HEP (left bank of Alain Nala) (1.37).

Diversity of herb species shows seasonal variation in the study area. Maximum Diversity for herbs was recorded during monsoon season varied from lowest 2.27 at sampling site V-14 located near to the proposed Dam site of Nakthan HEP and highest value of diversity was recorded from sampling site V59 (3.17) located near to the proposed Dam site of Dhaulasidh HEP. During pre-monsoon season sampling, species diversity of herbs varied from lowest 1.75 at sampling site V14 (Near proposed power site of Nakthan HEP) and highest 2.98 at sampling site (Site V35) located near to the diversion site of proposed Uhl HEP. During winter season sampling the Diversity Index ranged from lowest of 1.91 (at Site V1) to highest of 2.83 (at Site V59).

6.8 Faunal Resources

6.8.1 Mammals

According to data compiled from secondary sources like published literature and Forest Working Plans and Wildlife management plan of Protected Areas and the forest and wildlife divisions, 40 mammalian species are reportedly found in the Beas basin. Family Bovidae is the largest family represented by 6 species while Viverridae is represented by 4 species, Felidae, Muridae, Mustelidae, Cervidae and Cercoitecidae having 3 species.

6.8.1.1 Conservation Status

According to IWPA (1972) Nine species of mammals are included in Schedule-I according to WPA 1972, 14 species in Schedule-II and rest of the species are either under Schedule- III, IV or V species. Six species have restricted distribution inhabiting higher elevations of the basin.

According to IUCN Red List (2017-2), 11 species are listed under different threat categories of which 2 species are under Endangered category viz. *Panthera uncia* and *Moschus chrysogaster* (*Moschus moschiferus*), 4 are under Vulnerable category viz. *Panthera pardus*, *Capricornis sumatraensis*, *Rusa unicolor* and *Ursus thibetanus* while 5 species are listed as Near Threatened category. Rest of the 29 species of mammals reported from the basin are under Least Concern (LC) category.

Among these threatened species Snow Leopard, Musk Deer, Serow, and Himalayan tahr are confined to upper reaches of the basin.

6.8.1.2 Sub-basin-wise Mammals Distribution

Species richness in different sub-basins ranges from 30 to 36 species with maximum in sub-basin Beas IV and minimum in sub-basin Beas I (refer **Table 3**). There is not much variation in the species richness along the elevational gradient, however it is slightly higher at middle elevations i.e. between 1800 and 2100 m. The sub-basins in lower reaches like Beas IV, Beas V, Uhl, etc. harbour more species as compared to the sub-basins located in upper reaches like Beas I, Beas II, Malana and Parbati. The species like Rhesus Macaque (*Macaca mulatta*), Common Leopard (*Pathera pardus*), Jungle Cat (*Felis chaus*), Jackal (*Canis aureus*) and Common Otter (*Lutra lutra*) are widely distributed throughout the basin. Upper reaches of the basin harbour species with relatively restricted distribution and threatened species. The species confined to the upper reaches are Snow Leopard (*Panthera uncia*), Brown Bear (*Ursus arctos*), Blue Sheep (*Pseudois nayur*), Siberian Ibex (*Capra sibirica*), Himalayan Tahr (*Hemitragus jemlahicus*) and Musk Deer (*Moschus chrysogaster*). All species are categorised either under IUCN Redlist (2017-2) or Schedule I category or under both categories.

Mammalian species confined to the foothills and lower reaches include Indian Fox (*Vulpes bengalensis*), Hyaena (*Hyaena hyaena*), Common Mongoose (*Herpestes edwardsii*), Commom Palm Civet (*Paradoxurus hermaphrodites*), and Sambar (*Cervus unicolor*).

Table 3: Sub-basin wise mammalian species richness

Sub-basins	Total species richness	No. of RET species	No. of Schedule I species
Beas I	30	8	6
Beas II	33	7	6
Malana	31	8	7
Parbati Upper	31	9	8
Parbati Lower	32	8	8
Sainj	33	8	8
Tirthan	33	8	8
Beas III	31	8	5
Uhl	35	8	8
Beas IV	36	8	7
Beas V	33	5	4

6.8.2 Birds in Beas Basin

In the present study **625 species** of birds belonging to 23 Orders and **96 families** have been documented from the basin.

According to this list, Muscicapidae with 53 species is the largest family in the basin followed by Accipitridae with 44 species and Anatidae with 24 species of birds.

Out of 625 species of birds 64 species have not been evaluated by IUCN Redlist (2017-2) while 511 have been listed in Least Concern category. Fifty species have been listed under different threat categories of IUCN (2017-2) and WPA Schedules. Five species have been listed as Critically Endangered category (White-rumped Vulture, Slender-billed Vulture, Red-headed Vulture, Sociable Lapwing and Great Indian Bustard) while 6 species (Steppe Eagle, Egyptian Vulture, Greater Adjutant, Saker Falcon, Red-necked Falcon and Lesser Florican) are listed as Endangered in IUCN Redlist.

According to WPA (1972) 22 species have been listed as Schedule-I species and 8 species are endemic to Himalaya are reported from the basin.

Pong Dam lake is the richest area in terms of bird species diversity where 415 species of birds have been reported and is home to number of wintering species.

Species richness in different sub-basins ranges from 117 to 418 with minimum in Beas sub-basin I and maximum in Beas sub-basin IV (refer **Table 4**). Maximum number of bird species reported from Beas IV sub-basin is owing to the presence of Pong Dam Lake which is a suitable wintering habitat for migratory birds. Bar-headed geese is one of the most dominant waterfowl species that is found in Pong Dam lake. Majority of the species are generalists while a few of them are confined to upper reaches (Himalayan Snowcock - *Tetraogallus himalayensis*, Monal Pheasant - *Lophophorus impejanus*, Horned Lark - *Eremophila alpestris*, Himalayan Yellow-billed Chough-*Pyrrhocorax graculus*, Himalayan Red-billed Chough - *Pyrrhocorax pyrrhocorax*, Western Greenish Leaf-Warbler - *Phylloscopus trochiloides*, etc. and lower reaches (Grebs, Herons, Storks, Egrets, Ducks, etc). In general, species richness decreases along the elevational gradients, the sub-basin extends from lower reaches harbour relatively high species richness.

Considerably high species richness in Beas sub-basin IV is attributed to the presence of a large wetland – Pong dam reservoir which is home of many aquatic bird species.

Table 4: Sub-basin wise bird species richness

Sub-basins	Total species richness	No. of threatened species	No. of Schedule I species
Beas I	117	4	7
Beas II	123	4	7
Malana	121	4	7
Parbati Upper	120	4	7
Parbati Lower	123	4	7
Sainj Khad	123	4	7
Tirthan	123	4	6
Beas III	136	7	7
Uhl	137	7	7
Beas IV	418	21	5
Beas V	145	3	1

Endemic Species

The species that are endemic to Western Himalaya and found in Beas basin are White-throated Tit (*Aegithalos niveogularis*), Western Tragopan (*Tragopan melanocephalus*), Cheer Pheasant (*Catreus wallichi*), Spectacled finch (*Callacanthis burtoni*), Orange Bullfinch (*Pyrrhula aurantiaca*), Kashmir flycatcher (*Ficedula subrubra*), Kashmir nuthatch (*Sitta cashmirensis*), Tytlers' leaf warbler (*Phylloscopus tytleri*) and Brooks's Leaf-Warbler (*Phylloscopus subviridis*).

Nearly 66% of the total bird species in Beas basin are residents. Of the total resident bird 14.5% species perform local movement and 13.5% are seasonal migrants. About 25% of the total bird species are summer and winter visitors, which perform their movement for breeding purpose. The passage migrant species include Pale Grasshopper-Warbler, Lesser Whitethroat, Yellow Wagtail, Brambling, Black-headed Bunting and Red-headed Bunting.

The wetland of Pong dam reservoir (Pong Dam Lake Wildlife Sanctuary) in the basin (Beas sub-basin IV) provides a good niche for the migratory birds. As many as 418 bird species have been recorded from the Pong dam reservoir area only according to Status Paper on Pong Wetland published by Randhawa (2014) under HP State Centre on Climate Change. Many migratory birds like Bar Headed Geese (*Anser indicus*), Northern Pintail (*Anas acuta*), Common Pochard (*Aythya farina*), Red Necked Grebe (*Podiceps grseigena*), Mallard (*Anas platyrhynchos*), etc. visit this site in winter from trans-Himalayan region.

6.8.3 Butterflies

Total 150 species of butterflies in the Beas river basin have been documented. Species richness in different sub-basins ranges from 76 to 137 with minimum in Beas sub-basin I and maximum in Beas sub-basin IV (refer **Table 5**). Majority of the species are common in distribution in all sub-basin while a few of them are restricted to upper reaches (Red Apollo - *Parnassius charltonius*, Common Blue Apollo - *Parnassius hardwickei*, Painted Lady- *Vanessa cardui*, Mountain Argus - *Erebia shallada*) and lower reaches (Spangle-*Papilio protenor*, Tawny Mime-*Chilasa agestor*, Psyche - *Leptosia nina nina*, Common Jezebel - *Delias eucharis*, Pale Hedge Blue - *Udara dilecta*, Purple Hedge Blue - *Heliophorus epicles*, Common Baron - *Euthalia* *aconthea*, Common Jester - *Symbrenthia hippoclus*, Common Bush Brown - *Mycalesis perseus*, Dark Blue Tiger - *Tirumala septentrionis* etc).

Table 5: Sub-basin wise number of butterfly species richness

Sub-basins	Total species richness	No. of Threatened species	No. of Schedule I species
Beas I	76	0	0
Beas II	79	0	0
Malana	84	0	0
Parbati Upper	84	0	0
Parbati II	82	0	0
Sainj Khad	84	0	0
Tirthan	84	0	0
Beas III	135	0	1
Uhl	137	0	1
Beas IV	136	0	1
Beas V	120	0	1

Conservation Status: Out of 150 species inventoried for Beas river basin, only 5 species, viz. Bath White (*Pontia daplidice*), Small Grass Yellow (*Eurema brigitta*), Peacock Pansy (*Junonia almanac*), Yellow Pansy (*Junonia hierta*) and Common Crow (*Euploea core*) are assessed under the IUCN Redlist (2017-2) and listed under 'Least Concern' category. Similarly, only a few species are included in the list of scheduled species as per IWPA (1972). Only one species – Common Pierrot (*Castalius rosimon*) in Beas river basin is included in Schedule I. A total of 8 species like Common Yellow Swallowtail (*Papilio machaon*), Regal Apollo (*Parnassius charltonius*), Common Onyx (*Horaga onyx*), Pea Blue (*Lampides boeticus*), Common Beak (*Libythea lepita*), Danaid Eggfly (*Hypolimnas misippus*), Veined Labyrinth (*Lethe pulaha*), Common Fiorester (*Lethe insana insane*) are listed in Schedule II.

6.8.4 Herpetofauna

Total 59 species are reported from the Beas basin of which 51 species are of reptiles and 8 species are of amphibians (**Table 6**).

6.8.4.1 Reptiles

Reptilian fauna is comprised of 51 species belonging to 12 families. Colubridae is the largest family represented by sixteen species followed by Agamidae, Scincidae and Geoemydidae with 5 species each. IUCN Red List (2017-2) has kept Indian Rock Python (*Python molurus*), Spotted Pond Turtle (*Geoclemys hamiltonii*) and Gangetic Soft-shell Turtle (*Nilssonia gangetica*) under Vulnerable category. Eleven species are under Least Concern category and rest of the species are yet not evaluated under IUCN Red List (2017-2).

6.8.4.2 Amphibia

From the Beas basin 8 species of Amphibians are reported which belong to 4 families, which comprises of toads and frogs. Bufonidae is the largest family with 3 species.

Table 6: Sub-basin wise herpetofaunal species richness in Beas river basin

Sub-basins	Total species richness	No. of Threatened species	No. of Schedule I species
Beas I	26	1	0
Beas II	28	1	0
Malana	27	1	0
Parbati Upper	27	1	0
Parbati Lower	28	1	0
Sainj Khad	29	1	0
Tirthan	29	1	0
Beas III	32	2	1
Uhl	32	2	1
Beas IV	38	4	2
Beas V	30	4	2

Conservation Status: Most of the assessed species are listed in 'Least Concern' category. Only Tiny Frog is categorised under 'Vulnerable' category. Tiny Frog is widely distributed in the basin. Under the Schedule list of IWPA (1972) only Indian Flapshell Turtle are included under Schedule I. It is confined to the Shivalik hills (Beas IV and V) of the basin.

6.9 Protected Areas

There are 10 Wildlife Sanctuaries and 3 National Parks in the basin covering an area of 3236 sq km (**Table 7**).

Table 7: List of Protected Areas located within Beas Basin and status of ESZ Notifications*

S. No.	PROTECTED AREAS	Area (Sq km)	Status of ESZ Notification
Wildlife Sanctuaries			
1	Dhauladhar Wildlife Sanctuary	982.86	Draft Notification (13/01/2016)
2	Kanawar Wildlife Sanctuary	107.29	Draft Notification (28/04/2016)
3	Khokhan Wildlife Sanctuary	14.94	Draft Notification (04/03/2016)
4	Manali Wildlife Sanctuary	29.00	Draft Notification (04/03/2016)
5	Sainj Wildlife Sanctuary**	90.00	-
6	Pong Dam Lake Wildlife Sanctuary	207.59	Draft Notification (17/11/2016)
7	Tirthan Wildlife Sanctuary**	61.00	-
8	Shikari Devi Wildlife Sanctuary	29.94	Draft Notification (04/03/2016)
9	Nargu Wildlife Sanctuary	132.37	Draft Notification (08/03/2016)
10	Kais Wildlife Sanctuary	12.61	Draft Notification (24/04/2016)
National Parks			
11	Great Himalayan National Park**	754.40	-
12	Khirganga National Park**	710.00	Draft Notification (25/07/2016)
13	Indrakilla National Park	104.00	Final Notification Issued (17.01.2018)
Great Himalayan National Park Conservation Area (GHNPCA)**		1615.40	Draft Notification (22/08/2016)

*http://envfor.nic.in/content/esz-notifications

*** Great Himalayan National Park Conservation Area includes Sainj WLS, Tirthan WLS, Great Himalayan National Park and Khirganga National park*

6.10 Important Birding Areas

BirdLife International is the world's largest nature conservation partnership. It identifies Important Birding Areas worldwide for conservation action. The Bombay Natural History Society (BNHS) is the BirdLife Partner for India and is responsible for coordinating the IBA programme in the country. Of the 467 IBAs identified so far in India, 191 are Wildlife Sanctuaries, 52 are National Parks, 23 are Tiger Reserves and one is a Conservation Reserve (Birdlife International, 2017). India's IBAs are host to 75 species of globally threatened birds of which eight are Critically Endangered, 10 are Endangered and 57 are Vulnerable. A total of 199 IBAs (almost 43%) are located outside the Protected Area Network (PAN) and have no official protection. In Himachal Pradesh 27 IBAs have been and of these 24 are sanctuaries and 2 are national parks and only one is non-protected area (Islam and Rahmani, 2004). In Beas basin 9 IBAs have been identified based upon the criteria defined by Birdlife International. Most of the IBAs harbor critically endangered Western tragopan and Vulnerable Cheer pheasant.

Table 8: List of IBAs identified in Beas basin

IBA Site Code	IBAs	Criteria	Important Species*
IN-HP-04	Dhauladhar Wildlife Sanctuary	A1, A2	Western tragopan
IN-HP-08	Great Himalayan National Park	A1, A2	Western tragopan, Cheer pheasant
IN-HP-09	Kais Wildlife Sanctuary	A1, A2	Western tragopan, Cheer pheasant
IN-HP-11	Kanawar Wildlife Sanctuary	A1, A2	Western tragopan, Cheer pheasant
IN-HP-16	Manali Wildlife Sanctuary	A1, A2, A3	Western tragopan, Cheer pheasant
IN-HP-17	Nargu Wildlife Sanctuary	A3	-
IN-HP-19	Pong Dam Lake Wildlife Sanctuary	A1, A4iii	White-rumped vulture, Slender-billed vulture
IN-HP-24	Shikari Devi Wildlife Sanctuary	A1, A2, A3	Cheer pheasant
IN-HP-27	Tirthan Wildlife Sanctuary	A1, A2, A3	Western tragopan

**Western tragopan, White-rumped vulture and Slender-billed vulture are Critically Endangered; Cheer pheasant is Vulnerable*

Owing to rich avi-faunal diversity Pong dam reservoir has been declared as Ramsar site in 2002 spread over an area of 156.62 sq km. Pong dam lake is an important wintering ground for waterfowl. IBA report on Himachal Pradesh states that concentration of wintering waterfowl population has sharply increased over the years especially the populations of Northern Pintail, Bar-headed Geese, Common Teal, Eurasian Wigeon, Common Pochard and Great Cormorant. The report also says that almost 20% of Bar-headed Geese population occurs in Pong Dam only. No other IBA site in India holds such a large population of this species. The status paper on Pong dam has reported 415 species of birds from the Pong Dam lake. Pong Dam Lake also known as Maharana Pratap Sagar was declared Ramsar site on 19.8.2002 by Ramsar Convention.

7 AQUATIC ECOLOGY

7.1 Water Quality Assessment

Both physico-chemical and biological water quality of Beas river and its major tributaries was assessed at 59 locations in the entire Beas basin.

7.1.1 *Physico-chemical Water Quality*

The analysis of most of the physico-chemical parameters in general revealed that there is hardly any significant variation in most of the parameters most of them are within prescribed CPCB standards. The absence of heavy metals is mainly attributed to absence of heavy industries in the basin except for medium and small enterprises in towns like Kullu, Mandi and Kangra comprising mainly of Agro and Food Processing, mechanical and engineering based, wood, woollen items, and wooden based industries and main exportable items are fabric and ayurvedic medicines (Source: Industrial Profile of Kullu, Mandi and Kangra towns). Main economic activities are comprised of tourism and its related activities. Being hilly and mountainous region industries have not developed in the basin. The heavy metals in Beas river and its tributary streams are either Not Detectable or Below Detectable Limits.

In order to make an overall assessment of water quality of Beas river and its tributary streams water quality indices like WQI (Water Quality Index) based upon 9 different water quality parameters was used. WQI at majority of sampling sites in different sub-basins during all seasons ranges from Good to Excellent as the values in general range between 70 and 94 which indicates that water quality based upon above parameters is largely Good or Excellent. Only at some of the sampling sites in Parbati Lower (Parbati, Sharni and Sarsadi HE projects areas is in Medium category. It was also seen that BOD values were higher than the normal range and Total Coliforms were also on high side presumably due to discharge of untreated discharge of domestic sewage directly into Beas river where towns like Manali, Kullu and Mandi.

7.1.2 *Biological Water Quality*

For assessing biological water quality an index of BMWP (Biological Monitoring Working Party) was used which is indicative of biological richness of a particular river/stream based upon type of Macro-invertebrates inhabiting the particular stream.

BMWP score varied from lowest value of 24 to highest value of 144. Water quality during monsoon in general was Poor to Good in most of water sampling sites in Parbati Lower, Uhl, Sainj, Beas III, Beas IV and Beas V sub-basins. Water quality however was in Good category during winters at all the above sites. Water quality scenario was almost similar to winters in pre-monsoon season at all these sites. At majority of the sampling sites water quality is in 'Very Good' category at sampling sites located in Parbati Upper and Parbati Lower sub-basins especially during pre-monsoon and winters.

7.2 Fishes

Beas drainage system in Himachal Pradesh is spread over a length of more than 900 km, which is comprised of 274 km of Beas river and about 626 km of tributaries (Sehgal, 1983). Important from view point of fishes are Baner, Binwa, Neugal, Dehar, Awa, Banganga, Gaj, Manuni, Parbati, Patlikuhl, Sainj, Suketi, Tirthan and Uhl. Northern and eastern tributaries are perennial, and snow fed while southern tributaries are seasonal. Coldwater streams are characterized by high transparency and dissolved oxygen. Major cold-water fishes belong to Cyprinidae, Cobitidae and Sisoridae and these fishes are small in size. Most of the hill stream fishes live at the bottom or on the banks due to low water current than the main Beas river.

Fishes living in torrential tributary streams have special organs for attachment. These fishes thrive in the hilly streams and have bottom dwelling habits.

Based upon the data compiled various secondary sources cited above fish fauna in the Beas basin is comprised of 84 species belonging to 14 families. Cyprinidae is the largest family represented by 43 species followed by Cobitidae and Sisoridae with 11 species each. As many as 57 species have been reported from Pong Dam reservoir itself. The conservation status of fish species was assessed with the help of IUCN Redlist, Conservation Assessment and Management Plan (CAMP) Workshops Report (1998) and Threatened Freshwater Fishes of India by National Bureau of Fish Genetic Resources, Lucknow (NBFGR, 2010) (refer **Table 9**).

Out of 84 species 77 are native/indigenous while remaining 7 fish viz. *Amblypharyngodon mola* (Mola Carplet), *Hypophthalmichthys molitrix* (Silver Carp), *Ctenopharyngodon idella* (Grass carp), *Carassius auratus* (Gold Fish), *Cyprinus carpio* (Common Carp), *Salmo trutta fario* (Brown Trout) and *Oncorhynchus mykiss* (Rainbow Trout) are exotic. Fish diversity decreases along the elevational gradient, thus lower reaches of basin/sub-basins harbour relatively high species richness.

Rich fish fauna of Beas IV sub-basin can be attributed to the presence of Pong Dam reservoir at the foot of the basin and many perennial tributaries like Baner Khad, Gaj Khad and Dehar Khad. These tributaries are considered as sanctuaries of fish. Baner is one of the known spawning ground of *Tor putitora* (Golden Mahseer). The seeds of Golden mahseer had been collected by Joshi (1980) from Baner Khad successfully. The sub-basins like Uhl, Beas III and Beas IV extend in lower reaches are dominated by carp fishes like *Labeo* spp., *Tor putitora*, *Catla catla* (Main river) and minor carp like *Barilius* spp., *Puntius* spp., *Nemacheilus* spp., etc. (in tributaries). Sub-basins in upper reaches like Beas I, Beas II, Sainj Khad, Tirthan, Parbati I, Parbati II and Malana II are dominated by Snow Trout (*Schizothorax richardsonii*). However, due to regular introduction of Brown Trout (*Salmo trutta fario* and Rainbow Trout (*Onchorhynchus myskiss*), the native populations have been adversely affected and some of the river stretches are dominated by these exotic trout.

Table 9: Distribution of fish species in Beas Basin and their conservation status

Sub-basin	Projects	River/Stream	No. of Fish species	No of RET Species	
				IUCN	CAMP
Beas I	Beas Kund	Beas Kund Nala	11	1	3
	Palchan Bhang	Kothi Nala/Beas river			
	Bhang	Beas River			
	Jobrie	Jobrie & Allain Nala			
	Allain Duhangan	Allain & Duhangan Nala			
Beas II	Baragaon	Sanjoin & Bijara Nala	22	1	5
	Fozal	Fozal Nala			
	Raison	Beas			
	Sarbari II	Sarbari Khad			
Malana	Malana I	Malana Nala	17	1	3
	Malana II	Malana Nala			
	Malana III	Malana Nala			
	Nakthan	Tosh Nala & Parbati	12		

Parbati Upper	Tosh	Tosh Nala		1	3
	Jari	Parbati			
	Balargha	Parbati			
	Parbati II	Parbati			
	Parbati	Parbati			
Parbati Lower	Sharni	Parbati	20	1	3
	Sarsadi	Parbati			
	Sarsadi II	Parbati			
Sainj	Sainj	Sainj	20	1	4
	Parbati III	Sainj			
	Hurla I	Hurla Nala			
Tirthan	-	Tirthan	18	1	4
Beas III	Patikari	Bakhli Khad	22	2	13
	Pandoh	Beas			
	Larji	Beas			
Uhl	Lambadug	Lambadug Khad	24	2	13
	Uhl	Uhl			
	Uhl I (Shanan)	Uhl			
	Uhl II (Bassi)	Rana & Neri Khad			
	Uhl III	Rana & Neri Khad			
	Lower Uhl	Uhl			
	Uhl Khad	Uhl			
Beas IV	Gaj	Gaj Khad	57	2	22
	Khauli	Khauli Khad			
	Baner	Baner Khad			
	Neugal	Neugal Khad			
	Baner II	Baner Khad			
	Binwa	Binwa Khad			
	Kilhi Bahl	Binwa & Awa Nala			
	Pong Dam	Beas			
Beas V	Triveni Mahadev	Beas	41	2	17
	Dhaulasidh	Beas			
	Thana Plaun	Beas			

7.2.1 Conservation Status

Out of 84 fish species reported from the basin, 70 species have been evaluated by IUCN Redlist and 59 species are under Least Concern category. Under the IUCN redlist 8 species have been included in different threat categories. Only one species *Tor putitora* is listed as Endangered, 4 species are listed as Near Threatened viz. *Bagarius bagarius, Hypophthalmichthys molitrix*, *Tor tor* and *Wallagu attu*. CAMP (1998) have evaluated 63 species and a total of 29 species are categorised as 'Vulnerable', 'Endangered' and 'Critically Endangered' species out of which 6 are Endangered and 21 are under 'Vulnerable' category. Two species namely *Glyptothorax garhwali* and *Glyptothorax stolickae* are listed as Critically Endangered and are confined to the lower reaches of Beas basin and prefer to inhabit lower reaches of Beas river tributaries. Fifteen species have been included in list of frsehwater threatened fishspecies of India by NBFGR, out of which 4 are listed as Endangered while 11 species are listed under Vulnerable category. *Amblyceps mangois, Tor mosal, Tor putitora* and *Tor tor* have been listed as Endangered species.

7.2.2 Fish Migration & Spawning

The migration of fish in Himalayan rivers are generally attributed to their spawning habit. In Beas basin, two species viz. *Tor putitora* and *Tor tor* are relatively long-distance migratory species, which ascend and spawn in tributaries. *Tor putitora* is periodic and specific in migration and spawning and span in tributaries of mid elevations while *Tor tor* spawns in low land tributaries. Sehgal (1990) stated that prior to construction of Pandoh dam, *Tor putitora* used to migrate in Beas river up to Sultanpur and Kullu but Pandoh dam has hampered its migration and presently it is restricted to downstream of Pandoh dam only.

Clupisoma garua is another long-distance migratory fish. It performs upstream migration during July to September and downstream migration in October-November.

Labeo dero and *Schizothorax richardsonii* (Snow trout) are medium distance migratory species. *Labeo dero* is known to migrate upstream from March to August and it comes down in September. Snow trout performs upstream migration from March to May and moves downstream during November-December.

7.2.3 Existing and Potential Streams for Spawning and Breeding in Beas basin

Snow trout in Beas river migrates upstream during breeding where the temperature is less. It is known to breed twice, in the summer (May-June) and in (July-October), in the shallow water along the bank of the streams (Sharma, 2010) up to November. Juni stream (a left bank tributary of Beas, upstream of Pandoh dam) once was one of the potential spawning ground of *Tor putitora* but due to construction of Pandoh dam, the population of Golden mahseer has disappeared from this tributary.

Existing Trout Streams

Barot is one of the important areas in Beas basin where trout farming is done. Some of the finest fishing spots are located at Luhandi, Puran hatchery, Lachkkandi, Tikkar, Balh and Kamand in this sub-basin. Besides Barot the entire stretch of Beas river from Pandoh Dam to Aut on the Mandi-Manali national highway is also considered good for trout fishing.

Tributaries like **Sarbari, Sanjoin and Phojal** offers ideal habitats for trout and provides ample opportunities for fishing. Sainj and Tirthan rivers which form a tri-junction with Beas river about 100m downstream near Larji are also known trout streams.

Beas river from Manali to Bhuntar provides some excellent pools for fishing especially at Patlikuhl, Katrain and Raison. Trout hatcheries have also been developed at Patlikuhl and Bathad.

Parbati river another large tributary is also suitable habitat for trout in Parbati Lower sub-basin and is famous for trout fishing at places like **Kasol**.

Potential Trout Sites

- i) **Uhl Khad (1500 m)**
- ii) **Khauli (1160 m)**
- iii) **Arnodi Khad (1090 m)**
- iv) **Sukhad Khad (975 m)**
- v) **Khoti Nala (990 m)**

vi) **Poon Nala (990 m)**

All the above-mentioned streams can be classified as Type-A streams and harbor good populations of snow trouts.

The streams with lot of shaded area with dense vegetation are favorable for the breeding of trout fish. Highly oxygenated water i.e. high DO values and rapid current are pre-requisite for the fish. It has been found that an alkaline pH, high DO with water velocity more than 1.8 m/s is the most suitable habitats for snow trout.

Existing Mahseer Streams

a) ***Sari Marog***
b) ***The stretch between Harsi Pattan and Nadaun***
c) ***Kuru***
d) ***Dehra and Pong Dam Reservoir***
e) ***Larji***

Potential Mahseer Sites

vii) **Binwa Khad (810 m)**
viii) **Rana Khad (860 m)**

Himachal Government has specifically declared Tirthan river as an angling reserve and not to allow any hydropower project on this river as well as its tributaries in order to maintain its aquatic biodiversity. Every year fingerlings of brown as well as rainbow trout are stocked in this river by the department.

8 CUMULATIVE IMPACT ASSESSMENT

As Beas basin harbours rich biodiversity, for Cumulative Impact assessment, the biologically rich areas were spatially identified for the purpose of conservation and saving the existing gene pool from extinction. It is evident from the fact that more than 48% of the basin area is under Very High and High Richness Index category. These areas are mainly located in upper Beas catchment, Parbati, Sainj and Tirthan river catchments and higher elevations in catchments of Baner Khad, Neugal Khad, Binwa Khad, Uhl river which drain the southern slopes of Dhauladhar range.

In addition to Biological Richness Index, Fragmentation Index map as well as Disturbance Index maps of the basin were also prepared to delineate areas with where landscape fragmentation has occurred over the years due to various developmental activities and urbanisation. Biotic disturbance attributes like proximity to roads and human settlements along with landscape parameters are combined to generate Disturbance Index.

For overall CIA Forest cover change, type of forest encountered, Fragmentation Index and Disturbance Index categories in different sub-basins, along with ecological attributes of floral and faunal elements both terrestrial as well as aquatic, sub-basin wise ecological assessment of all the above parameters was made.

9 ENVIRONMENTAL FLOWS

For establishing environment flow requirement of the rivers, habitat simulations or micro-habitat modeling methodologies has been used. Flow regime was established by dividing annual occurrence into three distinct seasons/periods i.e. Peak, lean and remaining/other months. Flow simulation study was carried out using one dimensional mathematical model **MIKE 11** developed by Danish Hydraulic Institute of Denmark.

There are 51 hydro projects in the Beas river basin, out of which 19 projects are with installed capacity of 25 MW or more i.e. projects which are covered under EIA notification and can be studied for environment flow assessment by habitat simulation and hydraulic modelling. Smaller projects (less than 25 MW installed capacity) do not give good results when subjected to modelling and therefore for all such projects environment flow is recommended based on present norms of EAC/MoEF&CC. Out of 19 projects, considered for modelling study, 10 are commissioned projects, 3 are under construction, 5 are under different stages of survey & investigations and one, Kanda Pattan, is a newly identified and yet to be allotted project. Downstream of Pong dam is outside the study area and therefore it was not considered for environment flow assessment. Similarly, Uhl II (Basi) is tailrace development of Uhl I without any additional diversion and therefore, the water release from Uhl I will remain in Uhl river and no additional release is considered from Uhl II. For Uhl III, in the absence of discharge data, assessment could not be carried out. Similarly, for Kanda Pattan, no discharge data is available and therefore, modeling could not be carried out.

Flow simulations have been carried out for 10%, 15%, 20%, 25%, 30%, 40%, 50% and 100% releases of the average discharge for each of above three scenarios for the identified projects. Various key parameters for establishing habitat requirement have been calculated which include water depth, flow velocity and top width of waterway. Average discharge values for each study period was derived from 90% dependable year discharge series at each location, as discussed under hydro-meteorology section. Initial critical stretch of the river, immediate downstream of diversion structure is represented by 8-10 cross sections for each project and used in the modeling exercise. Manning's roughness coefficient for different type of channels as suggested by Chow, 1959, was used.

Output data was analysed for environmental flow assessment with a view to meet the needs of dominant fish species with larger habitat requirement. A minimum depth requirement of 40 cm and 50 cm is considered for trout and mahseer zones respectively to assess the environmental flow requirement in lean season. Higher depth is considered for intermediate period and monsoon period to ensure mimicking of natural discharge pattern. For intermediate period in Mahseer zone, a depth range of 60-75 cm is considered and for monsoon season a depth range of 85-100 cm is considered. Similarly, for intermediate period in trout zone, a depth range of 55-65 cm is considered and for monsoon season in trout zone, a depth range of 70-80 cm is considered as minimum requirement. However, some exceptions are considered, as many of the times, in small tributaries even in natural conditions such depths are not available. In such cases, recommendations are made to ensure that even during lower discharges giving lower depths and widths of water in the rivers, a part of it is maintained in the river as environment flow in such a manner that reduction in depth is restricted to about 50% of the natural river depth.

Keeping in view the EAC/MoEF&CC's requirement of minimum release in lean season as 20%, monsoon/peak season as 20-30% and other months also as 20-25%; calculated based on average discharge in four leanest months in 90% dependable year, the same is considered as the overriding criteria even if the modeling exercise is suggesting that a lower discharge can meet the depth requirement. For Dam Toe power houses, where intermediate river stretch is very small, continuous release from the turbines can be used as the contribution towards environmental flow.

Based on the above criteria, environmental flow requirements are established for each project separately and final recommendations for the projects assessed by modeling exercise is tabulated below (**Table 10**). Values are given in percentage as per the prevalent norms, however, for the purpose of implementation absolute values (in cumec) should be used wherever, there is discrepancy.

For Uhl III and Kanda Pattan, in the absence of discharge data, assessment could not be carried out, therefore, it is recommended that Uhl III and Kanda Pattan maintains 20%, 30% and 25% of the average respective values of their 90% dependable year discharge (Year should be picked up from approved DPR used for project design) for lean, monsoon and other months as defined in the table.

For remaining 32 projects i.e. projects with less than 25 MW installed capacity, environment flow should be maintained based on the percentage of average values of discharge in lean, monsoon and other months based on 90% dependable year discharge series (year should be picked up from approved DPR used for project design) and following recommendations should be adopted:

- Lean Season (December to March) : 20% of average discharge in lean season in 90% DY
- Monsoon/Peak Season (June to September): 30% of average discharge in monsoon/peak season in 90% DY
- Remaining 4 months (October, November, April and May): 25% of average discharge in these months in 90% DY

Table 10: Environment Flow Release Recommendation

S. No.	Project	River (Affected Stretch)	Recommended E-flow as % of average discharge in 90% DY			Recommended E-flow (cumec)		
			Lean Season	Peak Season	Other Months	Lean Season	Peak Season	Other Months
1	Beas Satlej Link	Beas River (25 km)	20	15	15	18.99	64.72	25.74
2	Parbati-III	Sainj River (13.7 Km)	20	15	15	1.51	8.46	2.83
3	Allain Duhangan	Allain (9.2 Km)	20	15	15	0.42	2.43	0.85
		Duhangan (5 Km)	20	15	20	0.15	0.96	0.4
4	Larji	Beas River (5.65 Km)	20	15	15	11.42	64.06	21.45
5	Uhl-I	Uhl River (40 Km)	20	15	15	0.44	2.37	1.11
6	Malana-II	Malana Nala (5.2 Km)	20	15	15	0.52	2.56	1.20
7	Sainj	Sainj River (9 Km)	20	15	15	0.71	3.34	1.61
8	Malana-I	Malana Nala (2.32 Km)	20	15	15	0.49	3.32	1.24
9	Uhl II	Tailrace of Uhl I	-	-	-	-	-	-
10	Pong Dam	Beas	-	-	-	-	-	-
11	Parbati-II	Parbati River (5.28 Km)	20	15	15	2.99	16.3	3.79
		Jigrai Nala (0.8 Km)	20	30	25	0.2	1.16	0.54
		Jiwa Nala (8.2 Km)	20	30	25	1.19	6.2	2.53
		Hurla Nala (12 Km)	20	30	25	0.57	3.12	1.28
12	Lambadug	Lambadug (6.3 Km)	20	15	15	0.25	1.28	0.6
13	Uhl III*	Rana Khad	20	30	25			
		Neri Khad	20	30	25			
14	Nakthan	Tosh (4.4 Km)	25	20	20	0.93	5.24	1.99
		Parbati (8.9 Km)	25	20	20	1.42	7.84	2.94
15	Thana Plaun	Beas River (12.7 Km)	20	15	15	5.05	46.62	11.64
16	Triveni Mahadev	Beas River (5.5 Km)	20	15	15	5.62	54.05	14.49
		Binwa Khad (3.2 Km)	20	15	15	0.93	4.6	1.5
17	Malana-III	Malana Nala (3.35 Km)	20	15	15	0.31	2.02	0.94
18	Dhaulasidh	Beas River (37 Km)	20	30	20	6.24	90.79	8.10
19	Kanda Pattan	Beas River (8 Km)	20	30	25			

10 CONCLUSIONS AND RECOMMENDATIONS

Recommendations made on the draft report were reviewed by EAC during visit to Beas basin on April 12-14, 2018. Post visit, the basin study report was discussed in detail during the 13th EAC meeting held on April 27, 2018 where EAC concluded that MoEF&CC will discuss the report with state government of Himachal Pradesh and thereafter the final report will be discussed in EAC again for final appraisal and recommendation. After receiving the output of Beas basin study and minutes of 13th EAC meeting, Directorate of Energy, Government of Himachal Pradesh attended the 15th EAC meeting and inter-alia, made a detailed presentation on the recommendation of the study report. EAC sought additional information from GoHP and matter was further discussed in EAC in 19th and 20th meeting, held during October and November 2018 respectively. Thereafter, Beas basin study has been updated, incorporating all the discussions and recommendations made by EAC and the additional data submitted by Government of Himachal Pradesh. The final set of recommendations are:

1. Jobrie HEP (12 MW) will be developed as two independent projects – one with diversion on Allain Nala and will be of 6 MW installed capacity and another with diversion on Jobrie Nala and will be of 2 MW installed capacity. All the components including pondage for both the projects will be outside the boundary of Inderkilla WLS and its Eco-sensitive Zone (ESZ) with the exception of 2 MW project on Jobrie Nala, which can be developed in ESZ only if permitted by the ESZ notification.

2. Manalsu HEP (21.9 MW) falling within Manali WLS will undergo Wildlife Clearance as per Wildlife Protection Act. Based on the assessment by the State Board of Wildlife that whether the portion of the project coming in the WLS is a permissible activity and accordingly, Wildlife Clearance should be obtained from the Standing Committee on National Board of Wildlife.

3. Bujling HEP (20 MW) – Location of Bujling HEP will be changed/project component revised to ensure that all the components including pondage will be outside the boundary of Dhauladhar WLS as well as ESZ of Dhauladhar WLS as and when it is notified.

4. Makori HEP (20.8 MW) – Project is recommended for dropping and therefore the allotment of project will be cancelled.

5. Palchan Bhang HEP (9 MW), Bhang HEP (9 MW), Seri Rawla (7 MW), Raison (18 MW) will be developed as planned.

6. Four projects on Parbati River viz. Parbati HEP (12 MW), Sharni HEP (9.6 MW), Sarsadi HEP (9.60 MW) & Sarsadi-II HEP (9 MW) are dropped. The stretch of Parbati river from the confluence of Malana Nala with Parbati up to confluence of Parbati river with Beas river, will have only two projects – HEP I (15 MW) and HEP II (20 MW). These projects will be so located to ensure that a minimum of 1 Km of river stretch will flow free between FRL and TWL of projects in cascade. As the both the projects are less than 25 MW installed capacity, environment flow release will be maintained as 20% in lean season, 30% in peak season and 25% in remaining months. Percentage calculations will be made based on the 90% dependable year discharge data used for the project design/power potential calculation in DPR.

7. Nakthan HEP (460 MW) will be re-designed with diversion on Parbati river only. Tip of the submergence of revised Nakthan HEP will be outside the Eco-Sensitive Zone of Khirganga National Park.

8. Installed capacity of present Tosh HEP will be increased from 10 MW to 20 MW and it will be termed as Tosh I HEP. Upstream of Tosh I HEP, Tosh II HEP and Tosh III HEP can be developed, however, it is to be ensured that:
   a. TWL of Tosh II HEP will be at least 1 Km upstream of FRL of Tosh I HEP and
   b. TWL of Tosh III HEP will be at least 1 Km upstream of FRL of Tosh II HEP and
   c. FRL of Tosh III HEP will be outside the ESZ of Khirganga National Park and
   d. All three projects will follow environment flow release norms i.e. 20% in lean season, 30% in peak season and 25% in remaining months. Percentage calculations will be made based on the 90% dependable year discharge data used for the project design/power potential calculation in DPR.

9. Kanda Pattan HEP will be developed on Beas river between Thana Plaun HEP and Triveni Mahadev HEP, however it is to be ensured that:
   a. FRL of Kanda Pattan on Beas river will be at least 1 Km downstream of TWL of Thana Plaun HEP and
   b. TWL of Kanda Pattan on Beas Rvier will be at least 1 Km upstream of FRL of Triveni Mahadev HEP and
   c. the project will follow environment flow release norms i.e. 20% in lean season, 30% in peak season and 25% in remaining months. Percentage calculations will be made based on the 90% dependable year discharge data used for the project design/power potential calculation in DPR.

10. Environment Flow Release Recommendations

    Environment flow release recommendations will be implemented for all the projects i.e. operational projects, under construction projects and projects being planned/designed or are under survey & investigation stage.

    E-flow is recommended for 19 projects as given in **Table 10** shall be adopted. For remaining projects, i.e. projects with less than 25 MW installed capacity, irrespective of their stage of implementation environment flow release recommendations shall be 20% in lean season, 30% in peak season and 25% in other months.

    Calculations for environment flow release in lean season should be based on average of 4-6 leanest months discharge in 90% dependable year. Calculations for environment flow release in peak season should be based on average peak season discharge for 4 months in 90% dependable year i.e. June to September. Calculations for environment flow release remaining 2-4 months (non-peak and non-lean period) should be based on average discharge in 90% dependable year in remaining months.

CHAPTER-1

INTRODUCTION

1.1 BACKGROUND

Directorate of Energy, Government of Himachal Pradesh undertook the task of conducting Cumulative Environmental Impact Assessment (CEIA) Study for Beas river basin in Himachal Pradesh with an objective to assess the cumulative impacts of hydropower development in the basin. In the mean time, MoEF&CC has taken over all the river basin/carrying capacity studies being conducted by Central/State agencies and therefore, all reports were submitted directly to MoEF&CC. RS Envirolink Technologies Pvt. Ltd. (RSET), Gurgaon has been awarded the study based on techno-commercial bidding. Expert Appraisal Committee (EAC) for River Valley and Hydroelectric Projects of Ministry of Environment & Forests (MoEF&CC) approved the Terms of Reference (TOR) for the study. The study was initiated during February 2016 and was scheduled to be completed in 15 months time with the draft report due in 8 months and the draft final report in 15 months from the issue date of work order i.e. 22/02/2016. (As per revised time frame approved in 93rd Meeting of the Expert Appraisal Committee (EAC) for River Valley and Hydroelectric Projects held on 2nd May, 2016). An inception report was submitted in June 2016 to capture the progress made during first four months of the study period. The report focused on proposed approach and methodology to be adopted for the study so that it can be reviewed for its content and direction; and correction can be applied, if required. Thereafter Rapid CIA report was submitted in November 2016, which captured progress in first 8 months. The report covered primary & secondary data collection on various environmental attributes along with description of basin characteristics and planned hydro development etc. The same was discussed and appraised in 4th meeting of the Expert Appraisal Committee for River Valley and Hydroelectric Projects held on 12th April, 2017, wherein a visit to the study area by a sub-committee of EAC was suggested. A visit to Beas basin was made by a sub-committee of EAC during April 2018 and post visit the outcome was discussed in EAC meeting during the same month. Recommendations were discussed in detail and it was decided to share the recommendations with the state government and thereafter the final report will be discussed in EAC. Directorate of Energy, Government of Himachal Pradesh, on receipt of recommendations, has shared their views/observations on the recommendations and made a presentation during EAC meeting of June 2018. During presentation, EAC sought further information from state government to justify their observations and matter was discussed in subsequent EAC meetings of October and November 2018. EAC finally concluded all the discussions on Beas River Basin study and directed the Consultant to update/finalize the basin study report, keeping in view the matter discussed and recorded in various EAC meetings. The final Beas RBS report shall be placed again in the EAC meeting/s for finalization of the various recommendations therein.

1.2 SCOPE OF WORK

The basin study envisages providing optimum support for various natural processes and allowing sustainable development undertaken by its inhabitants. The same is determined in terms of the following:

- Inventorisation and analysis of the existing resource base and its production, consumption and conservation levels.
- Determination of regional ecological fragility/sensitivity based on geo-physical, biological, socio economic and cultural attributes.
- Review of existing and planned developments as per various developmental plans and records.
- Evaluation of impacts on various facets of environment due to existing and planned hydro power project developmental activities vis-à-vis development activities other than hydro.
- Suggest a road map of sustainable way of development of various projects & HEPs in the basin.

The basin study also envisages a broad framework of environmental action plan to mitigate the adverse impacts on environment, which is in the form of:
- Preclusion of an activity
- Infrastructure development
- Modification in the planned activity
- Implementation of set of measures for amelioration of adverse impacts.

The basin study is a step beyond the EIA, as it incorporates an integrated approach to assess the impacts due to various developmental projects.

The scope of work has been defined by Directorate of Energy based on approved Terms of Reference by EAC and same is being followed for the study. The Study Area to be covered as a part of the Basin falling in the State of Himachal Pradesh from its origin at Beas Kund near Rothang Pass up-to upstream of Pong Dam. The study area is comprised of area from Beas Kund HEP to Pong Dam at the inter-state boundary.

1.2.1 Baseline Data

The study is based on secondary as well as primary data collection, as discussed below:

Secondary Data

Environmental Component	Source	Parameters for Data Collection
Meteorology	IMD	• Rainfall, temperature wind, humidity etc.
Water Resources	Directorate of Energy, HPPCL, CWC, Water Availability Studies, Other studies/reports	• Drainage characteristics of the basin • Water sharing agreements • Sediment load • Perennial sources of water and their designated usages
Water Quality	State Government/Municipalities	• Water quality, human settlement, sewage generated and mode of collection, conveyance treatment and disposal of sewage
Flora	Working Plans of Forest Divisions, Forest Department, Published Reports, Literature, Research articles/other studies and reports, Red Data Book	• Forest types • General vegetation pattern and floral diversity • Economically important species • Rare, Endangered and Threatened floral species • Endemic floral species, if any • Location of wildlife sanctuaries, national parks, biosphere reserves if any, in the study area

Environmental Component	Source	Parameters for Data Collection
	(IUCN)	
Fauna	Forest Department, Literature study/other studies and reports, Red Data list published by International Union for Conservation of Nature (IUCN)	• Inventory of Birds (residents, migratory), land animals including mammals, reptiles, amphibians, fishes etc • RET faunal species as per the categorization of IUCN Red Data list and Indian Wildlife Protection Act, 1972. • Endemic faunal species • Existence of barriers and corridors for wild animals, if any
Fish	Fisheries Department, other studies and reports	• Presence of major fish species • Inventory of migratory fish species & migratory routes of various fish species • Presence of major breeding and spawning sites.

Primary Data

Environmental Component	Sampling Frequency	No. of Samples	Parameters for Data Collection
Water Quality	Once per month for 12 months	59	• pH, Dissolved Oxygen (DO), Electrical Conductivity (EC), Total Suspended Solids (TSS), Total Dissolved Solids (TDS), Total Alkalinity, Total Hardness, Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand(COD), Nitrates, Chlorides, Sulphates, Phosphates, Sodium, Calcium, Magnesium, Potassium, Iron, Manganese, Zinc, Cadmium, Lead, Copper, Mercury, Chromium, Total Coliform
Flora	Mapping for 3 seasons (pre-monsoon, monsoon and post-monsoon)	60	• Forest type and density, bio-diversity in the study area. • Comprehensive checklist of flora (Angiosperms, Gymnosperms, Lichens, Pteridophytes, Bryophytes, Fungi, Algae etc.) with Botanical and local name. • Importance Value Index of the dominant species at various sampling locations. • Frequency, Abundance and Density of each species of Trees, Shrubs and Herbs at representative sampling sites • Listing of plants of genetically, biologically, economical and medicinal importance. • Major forest produce, if any, and dependence of locals on the same in the forests observed in the study area.
Fauna	Simultaneously with ecological survey	60	• Identification of faunal species by indirect observations of mammals - tracks, droppings (scale), claw marks and calls, etc. and also by direct observation techniques
Aquatic Flora and Fauna	Once per month for 12 months	59	• Assessment of biotic resources with special reference to primary productivity, zooplanktons, phytoplanktons, benthos, macrophytes, macro-invertebrates and fishes in the study area. • Population densities and diversities of phytoplanktons, zooplanktons, benthos, macrophytes, macro-invertebrates and fish

Environmental Component	Sampling Frequency	No. of Samples	Parameters for Data Collection
			shall be estimated. • Diversity indices of these ecological groups should also be calculated separately.
Aquatic Flora and Fauna	Once per month for 12 months	59	• Fish composition • Migratory route of migratory fishes • Spawning & breeding grounds of fish species, if any, should be identified.

Projects' Data

As discussed above, primary and secondary data on environmental component are collected, collated and analysed as part of the scope. Directorate of Energy, Government of Himachal Pradesh has provided basic information and data about the existing, under execution and planned projects in the Beas basin in Himachal Pradesh. During the period the study, more project specific information was collected from individual project developers and list is updated wherever required. Updated list of projects and their status is discussed in next chapter.

1.2.2 Impact Assessment

The key aspects to be covered are listed below:

- Modification in hydrologic regime due to diversion of water for hydropower generation.
- Depth of water available in river stretches during lean season and its assessment of its adequacy vis-a-vis various fish species.
- Length of river stretches with normal flow due to commissioning of various hydroelectric projects due to diversion of flow for hydropower generation.
- Impacts on discharge in river stretches during monsoon and lean seasons due to diversion of flow for hydropower generation.
- Impacts on water users in terms of water availability and quality
- Impacts on aquatic ecology including riverine fisheries as a result of diversion of flow for hydropower generation.
- Assessment of maintaining minimum releases of water during lean season to sustain riverine ecology, maintain water quality and meet water requirement of downstream users.
- Impact due to loss of forests
- Impact on RET species & impacts on economically important plant species.
- Impacts due to increased human interference
- Impacts due to agricultural practices.
- Study the impact of cascade development and make recommendations on the requirement of free flowing stretch between two projects. Ecological inventory and geomorphology for different stretches of river to be delineated.
- Information on river stretch affected and forest area affected by each project needs to be modified to include additional details of catchment area; total forest area of the sub basin and the area getting affected and total river length, stretch affected and free flowing.
- Undertake environmental flow release assessment for the entire year i.e. covering lean, non-lean non- monsoon and monsoon periods, based on methodology such as BBM and make recommendations for each stretch.

- Hydro Dynamic Study for assessment of Environmental flow release should be linked with the fauna, habitat requirement for assessment of environmental flow releases for entire year.
- Modelling study carried out to assess the impact of peaking discharge should be concluded with recommendations for mitigation of such impacts.
- Sampling sites, forest cover and forest type should be listed and illustrated sub-basin wise. Endemic species of fishes in the sub basin may be tabulated.
- Downstream impact study shall be done up to the end of the Study Area.
- Impact of sand mining, boulder mining, etc. need to be included in the study.
- Impact on overall balance of sediment due to construction of a number of projects needs to be included in the report.
- The main objective of the study is to bring out the impacts of dams being planned on the main river and its tributaries. At the end of the Report there shall be a separate Chapter synthesizing the results of each component so that a holistic picture of impacts could be emerged which should lead to Recommendations.
- Impact assessment shall also include "Impacts due to construction of approach roads for the HEPs".
- Source of secondary information used in the report/to be used in the report shall be revealed and credit given accordingly.
- Detailed maps of each Sub-Basin have to be provided separately for each parameter such as forest cover, forest type, vegetation, location of sampling sites, etc. For each forest type it will be appropriate to give altitudinal range (for some it is given), its location in Beas Sub-Basin in separate maps.
- For betterment of analysis, it may be appropriate to categorize dams as Operational/ Under Construction/ EC, Scoping, Not Allotted yet, this will facilitate decision making on dropping of any dam, if it is required from environmental angle.

1.3 OUTCOME OF THE STUDY

The key outcomes of the study would be to:

- Provide sustainable and optimal ways of hydropower development of Beas River, keeping in view of the environmental setting of the basin.
- Assess requirement of environmental flow for the entire year i.e. covering lean, non-lean non- monsoon and monsoon periods with actual flow, depth and velocity at different levels.
- Management of impact and mitigation measures.
- Recommend preclusion of HEPs found expedient for safeguard of riverine ecology.

Study would cover the following aspects and explore issues mentioned below:

- Flow Regime
- Flood Plain including wetlands
- Aquatic ecology
- River Morphology
- Sediment Transportation/erosion and deposition
- Impact on human activities and livelihood

- Considering the total length of the main river in the basin and the HEPs already existing and planned for future development, how many more HEPs may be allowed to come up? In other words, how much of the total length of the river that may be tunnelled inclusive of the tunnelling requirement of all the projects that have been planned for development so that the integrity of the river is not grossly undermined.

- Downstream impact and what may be criteria for downstream impact study for individual HEP in terms of length of the river downstream to the tail water discharge point and what may be the parameters of such a study.

- What criteria the EAC may adopt in restricting the river reach for hydropower development. Alternatively, what should be the clear river length of uninterrupted flow between the reservoir tip at FRL of a downstream Project and the tail water discharge point of the immediate upstream project

- Scientific assessment of the e-flow for 3 different seasons that must be maintained in the downstream of a dam /barrage and based on such a procedure. The exercise, following techniques such as BBM or equivalent may be worked-out for all HEPs.

- For peaking power generation, what extent of diurnal flow variation may be considered safe for the aquatic life. There are examples where the release is drastically reduced during the long time for reservoir filling and the huge discharge flows through the river during the few hours of peak power generation. This is detrimental to the aquatic environment of the downstream stretch of the river. This aspect is to be analysed and suitable approach be recommended.

- What are the design/feature modification required for existing/operating plans to make them environmentally & ecologically sustainable

- The status of compliance of Environmental Clearance condition with respect to sanctioned Projects may have to brought-out in the report.

1.4 BROAD WORK PLAN & APPROACH

As the basin level environmental impact assessment study of Beas basin in Himachal Pradesh, needs to be completed in 15 months time frame, work plan has been prepared to ensure several activities progress simultaneously. Primary data collected for terrestrial and aquatic flora and fauna cannot be representative especially for short term studies; therefore, stress has also been placed on collection of secondary data on these components, wherever available; to be augmented by the primary data collected in different seasons. Following major tasks have been identified to complete the work in time:

- Secondary data collection from Directorate of Energy, Government of Himachal Pradesh, Himachal Pradesh Power Corporation Ltd. (HPPCL), Indian Meteorological Department (IMD), Central Water Commission (CWC), Forest and Fisheries Department. This included data on precipitation, flow and sediment, status of planned and allotted projects in the basin, forest working plans, wildlife sanctuaries/national parks and other protected areas in the basin and their management plans, fish fauna.

- Secondary data was collected from different published sources and literature survey. This included forest types, flora, fauna and fisheries; their conservation status i.e. Rare, Endangered & Threatened (RET), Schedule species as per Indian Wildlife (Protection) Act (WPA), etc.
- Procured satellite data from NASA portals, forest cover from Forest Survey of India (FSI) data, Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) Global Digital Elevation Model (GDEM) Version 2 data and digital maps; to prepare base maps, longitudinal sections of river stretches, slope maps, drainage maps, forest cover maps, etc.
- Primary Data collection was done as per the pre-defined frequency. Study teams collected data on various parameters viz. water quality, flora, fauna, fisheries, aquatic ecology, etc. at different sampling locations.
- Environmental flow requirement was assessed using standard methodologies like hydrological or habitat simulation and hydro-dynamic modelling or holistic approach depending upon the suitability and requirement. To assess environmental flow requirements for different projects' stretches, a flow simulation studies were carried out using 10 daily flow series (CWC approved wherever applicable) in one dimensional mathematical model MIKE 11. Flow simulations to be carried out for 10%, 15%, 20%, 25%, 30%, 40%, 50% and 100% releases of the average discharge in 90% dependable year flow series of the respective hydro electric projects.
- Provide sustainable and optimal ways of hydropower development of Beas River, keeping in view of the environmental setting of the basin.

1.5 OUTLINE OF PRESENT REPORT

CIA report has been presented in following sections. Briefly, these sections cover following:

Chapter 1: Introduction; covers general introduction of the study, outcomes expected outcomes of the study, study area and brief work approach and plan.

Chapter 2: Hydropower Development in Beas Basin; provides information of existing, under construction and planned hydro power development in Beas river basin of Himachal Pradesh.

Chapter 3: Methodology adopted for generating baseline data on various terrestrial as well as aquatic environmental parameters and description of sampling locations for terrestrial and aquatic ecology and analysis of each environmental parameter.

Chapter 4: Basin Characteristics; defines catchment characteristics of the study area supplemented by primary survey data gathered during field survey in study area, details of sub-basin wise base data, thematic layers produced etc.

Chapter 5**:** Hydro-meteorology provides data on flows and meteorological observations with the help of primary as well as secondary level information.

Chapter 6**:** Environmental baseline data for terrestrial ecology covers information on forest types, floristic and faunal diversity of study area through secondary sources and primary survey data

***Chapter 7*:** Environmental baseline data for aquatic ecology covers physico-chemical and biological characteristics as well as information of fish and fisheries from primary and secondary sources

***Chapter 8*:** Environmental flow analysis: This chapter covers literature survey for different available methodologies nationally or internationally for environmental flow assessment and outcomes of hydro-dynamic modelling in respect of various projects.

***Chapter 9*:** Cumulative Impact Assessment

***Chapter 10*:** Conclusions & Recommendations

Chapter-2

HYDROPOWER DEVELOPMENT IN BEAS BASIN

2.1 HYDROPOWER POTENTIAL

Himachal Pradesh, with five major rivers flowing through the state, has about a quarter of India's total potential hydropower resources. These five major rivers are Beas, Ravi, Satluj, Yamuna and Chenab. Total identified hydropower potential in the state is 27436 MW; out of which 10460.47 MW is under operation, 2438.24 MW is under construction; 9510.70 MW is under various stages of survey & investigation; and remaining 5026.59 MW is yet to be taken up (source: Directorate of Energy, Government of HP, abstract of Power as updated on June 2017).

History of hydropower development in Beas basin goes way back to 1923 when Shanan Power station (Uhl I – 110 MW) was commissioned as first megawatt scale project of country and later Uhl II (60 MW) got commissioned during 1970-71. Largest project of the basin i.e. Pandoh Dam, commonly known as Beas Satluj link project of 990 MW was commissioned in 1977. Another major project of the basin, Pong Dam (396 MW) was conceived way back in 1927, however after final design approval, construction work started in 1961 and project got commissioned during 1978-83 period.

77.25% of hydropower potential of the Beas basin has already been established through operational (57.83%) and under construction projects (19.42%); the cumulative impact assessment study has kept this in view along with the impacts of proposed future development in the basin. The basin study is aimed at assessing the cumulative or aggregate ecological impact of all the HEPs planned or under execution on aquatic fauna and flora, biodiversity of the riverine ecosystem and surrounding areas and ecological integrity.

2.2 HYDROPOWER PROJECTS IN BEAS BASIN

Directorate of Energy, Government of Himachal Pradesh has assessed the total potential of Beas basin as 4099.60 MW as given in Table 1 of TOR and same is reproduced as **Table 2.1** below. In addition, they have also mentioned 5 projects at Table 8 of the TOR, which were under allotment at that time.

Table 2.1: Total Hydropower Potential of Beas Basin

Sr. No.	HEP Category	No. of Projects	Capacity (MW)
1	Commissioned HEPs	19	2718.50
2	Under Construction HEPs	07	1068.00
3	Under Clearance HEPs	12	888.20
4	Under Investigation HEPs	05	70.90
5	Foregone HEPs	03	354.00
Total		**46**	**4099.60**

During the study period, the information/status of hydropower projects was updated and the final list of 51 projects (> 5 MW) were prepared as the total hydropower potential of the Beas basin. The same is given at **Table 2.2** below. Projects locations are shown in **Figure 2.1**.

Beas Basin in Himachal Pradesh has 4877.70 MW of power potential (for > 5 MW projects), distributed among 51 hydropower projects spread throughout the basin. Out of these 51 projects, 22 projects are commissioned (total installed capacity 2820.90 MW), 5 are under construction (total installed capacity 947 MW), 20 are at various stages of investigations (total installed capacity 1028.90 MW) and 4 are yet to be allotted.

Out of proposed 24 projects, many of which are under different stages of survey and investigation, only 4 projects have installed capacity of more than 50 MW i.e. requiring environment clearance as category “A” projects; two are with installed capacity greater than 25 MW but less than 50 MW i.e. environment clearance is applicable under category “B” and remaining 18 projects are less than 25 MW of installed capacity i.e. environment clearance is not applicable.

Table 2.2: Hydropower Projects in Beas Basin

S. No.	Name of Project	Capacity (MW)	Developer	Status	Year of Commiss-ioning
1	Beas Satluj Link	990	Bhakra Beas Management Board	Commissioned	1977
2	Parbati-III HEP	520	NHPC Limited	Commissioned	2014
3	Pong Dam	396	Bhakra Beas Management Board	Commissioned	1978-83
4	Allain Duhangan HEP	192	AD Hydro Power Ltd.	Commissioned	2010
5	Larji HEP	126	Himachal Pradesh State Electricity Board	Commissioned	2006
6	Uhl-I (Shanan) HEP	110	Punjab State Power Corporation Limited	Commissioned	1923
7	Malana-II HEP	100	Everest Power Pvt. Ltd.	Commissioned	2012
8	Sainj HEP	100	HPPCL	Commissioned	2017
9	Malana-I HEP	86	Malana Power Company Ltd.	Commissioned	2001
10	Uhl-II (Bassi) HEP	66	Himachal Pradesh State Electricity Board	Commissioned	1970-81
11	Baragaon SHEP	24	Kanchanjunga Hydro Power Ltd.	Commissioned	2015
12	Patikari SHEP	16	Patikari Hydro Electric Project Ltd.	Commissioned	2008
13	Neogal SHEP	15	Om Hydropower Ltd.	Commissioned	2013
14	Baner SHEP	12	Himachal Pradesh State Electricity Board	Commissioned	1996
15	Khauli SHEP	12	Himachal Pradesh State Electricity Board	Commissioned	2007
16	Gaj SHEP	10.5	Himachal Pradesh State Electricity Board	Commissioned	1996
17	Toss SHEP	10	Toss Mini Hydel Power Project	Commissioned	2008
18	Beas Kund SHEP	9	Kapil Mohan and Associates	Commissioned	2012
19	Binwa SHEP	6	Himachal Pradesh State Electricity Board	Commissioned	1984
20	Baner-II SHEP	6	Podigy Hydro Power Pvt. Ltd.	Commissioned	2015

S. No.	Name of Project	Capacity (MW)	Developer	Status	Year of Commiss-ioning
21	Sarbari-II SHEP	5.4	DSL Hydrowatt Ltd.	Commissioned	2010
22	Balargha SHEP	9	Sandhya Hydro Power Projects Balargha	Commissioned	2018
23	Parbati-II HEP	800	NHPC Limited	Under Construction	
24	Uhl III HEP	100	Himachal Pradesh State Electricity Board	Under Construction	
25	Lambadug HEP	25	KU Hydro Power Pvt. Ltd.	Under Construction	
26	Lower Uhl SHEP	13	Trident Power Systems Ltd.	Under Construction	
27	Fozal SHEP	9	Fozal Power Pvt. Ltd.	Under Construction	
28	Nakhtan HEP	460	HPPCL	Under S&I	
29	Thana Plaun HEP	191	HPPCL	Under S&I	
30	Triveni Mahadev HEP	96	HPPCL	Under S&I	
31	Dhaulasidh HEP	66	Satluj Jal Vidyut Nigam Ltd.	Under S&I	
32	Malana-III HEP	30	BMD Pvt. Ltd.	Under S&I	
33	Raison SHEP	18	Himachal Pradesh State Electricity Board	Under S&I	
34	Uhl SHEP	14	Puri Oil Mills Ltd.	Under S&I	
35	Uhl Khad SHEP	14	Kharnal Hydro Electric Project Pvt. Ltd.	Under S&I	
36	Parbati SHEP	12	Manimahesh Power Private Ltd.	Under S&I	
37	Jari SHEP	12	WIL Power Projects Ltd.	Under S&I	
38	Jobrie SHEP	12	Green Infra Limited	Under S&I	
39	Sharni SHEP	9.6	Sharni Hydro Power Pvt. Ltd.	Under S&I	
40	Sarsadi SHEP	9.6	Himshakti Power Pvt. Ltd.	Under S&I	
41	Hurla-I SHEP	9.4	Hurla Valley Power Pvt. Ltd.	Under S&I	
42	Sarsadi-II SHEP	9	Aroma Colonisers Pvt. Ltd.	Under S&I	
43	Palchan Bhang SHEP	9	Palchan Bhang Power Pvt. Ltd.	Under S&I	
44	Bhang SHEP	9	Bhang Hydel Power L.L.P.	Under S&I	
45	Kilhi Bahl SHEP	7.5	Puri Oil Mills Ltd.	Under S&I	
46	Makori	20.80	Sai Engineering Foundation	Under S&I	
47	Bhujling	20.00	Sai Engineering Foundation	Under S&I	
48	Kanda Pattan	40.00		Yet to be allotted	
49	Manalsu	21.90		Yet to be allotted	
50	Seri Rawla	13.00		Yet to be allotted	
51	Khauli II	6.00		Yet to be allotted	
Total		**4877.70**			

Figure 2.1: Map showing locations of Hydro-power Projects in Beas Basin

2.3 ENVIRONMENT CLEARANCE STATUS

As can be seen from the above discussion and **Table 2.2**; there are only six projects left in the entire basin which require environment clearance under EIA Notification. Out of total 51 Projects, 19 projects are with installed capacity of 25 MW or greater which get covered under EIA notification. Out of these 10 projects are commissioned, 3 projects are under construction viz., Parbati II, Uhl III and Lambadug an remaining 6 projects are under various stages of survey and investigation.

Status of environment clearance of under-construction and proposed projects was reviewed and is given at **Table 2.3**.

Table 2.3: Status of Environment Clearance

Project		Status of Environment Clearance
Parbati II HEP (800 MW)	Under Construction	EC granted vide letter No. J-12011/34/2001-IA-I dated 04/06/2001
Uhl III (100 MW)	Under Construction	EC granted vide letter No. J-12011/19/2002-IA-I dated 15/11/2002
Lambadug (25 MW)	Under Construction	• EC letter Not Available in Public Domain; neither shared by developer • Discussed in EAC meeting on 16/08/2007 and 21-22/08/2008; project was recommended for EC subject to submission of certain information. • No further details/copy of EC letter is available for review; however it is clear that EC letter must have been issued under EIA notification of 2006 with 10 years validity and would have required extension in 2018.
Nakhtan (460 MW)	Under S&I	Discussed for Environment Clearance in 91st meeting of EAC held on 8-9/02/2016. Diversion of Tosh Nalla have been objected to by the Toss Mini Hydel Power Project, developer of commissioned Tosh HEP and the matter is sub-judice. EAC recorded that "***the matter is Sub-judice, a decision in this regard shall be taken only after the Courts Directions***". Project is being re-configured and may have to go for fresh/amendment of scope and environment clearance.
Thana Plaun (191 MW)	Under S&I	Project was presented for environment clearance before EAC during June 2018; however, EAC noted that the baseline data is more than 3 years old, therefore recommended collection of one season fresh baseline data before the project can be considered for environment clearance.
Triveni Mahadev (96 MW)	Under S&I	Scoping Clearance issued for 78 MW installed capacity vide letter No. J-12011/12/2011-IA-I dated 29.11.2012. Scoping for enhanced capacity of 96 MW is yet to be

Project		Status of Environment Clearance
		applied for.
Dhaulasidh (66 MW)	Under S&I	EC granted vide MoEF&CC Letter No. J-12011/15/2010-IA-I dated 21/02/2013
Kanda Pattan	Yet to be allotted	
Malana-III (30 MW)	Under S&I	Scoping Clearance approved by SEIAA in its 15th meeting held on May 21, 2013. Letter/further information not available.

2.4 PROJECTS DESCRIPTION

Efforts have been made to collect the data of all the projects in the basin. Data have been sourced from Directorate of Energy as well as by contacting project promoters so that all the relevant information required to make basin level impact assessment can be compiled for data analysis. In addition, minutes of meeting of Expert Appraisal Committee (EAC) of Ministry of Environment, Forest & Climate Change (MOEF&CC) or State Expert Appraisal Committee (SEAC) of Himachal Pradesh have also been referred to for the meetings where Beas projects have been considered for TOR or EC.

Project descriptions compiled in the form of salient features have been collected for Malana-I, Tosh, Allain Duhangan, Sarbari-II, Beas Kund, Malana-II, Neogal, Parbati III, Baragaon, Baner-II, Pong Dam, Beas Satluj Link (Pandoh), Sainj, Fozal, Lambadug, Lower Uhl, Parbati II, Balargha, Uhl, Sarsadi II, Palchan Bhang, Uhl Khad, Bhang, Sharni, Sarsadi, Nakhtan, Thana Plaun, Triveni Mahadev, Dhaulasidh, Parbati, Hurla-I, Jari, Raison, Kilhi Bahl, Malana III and Jobrie SHEPs. Information collected is compiled in the form of Salient Features of each project and is given from **Table 2.4** to **2.42**. For the remaining projects, locations and proposed installed capacities are available; this data was used during basin wise impact assessment, however their salient features could not be made available by the concerned agencies.

Table 2.4: Salient Features of Malana I (86 MW)

LOCATION	
District	Kullu
Name of River	Malana Nala
HYDROLOGY	
Catchment area at diversion site (km^2)	178.50
Design Discharge (m^3/s)	21
DIVERSION STRUCTURE	
Type	Barrage
FRL (masl)	1893
MDDL (masl)	1879
Average Bed level (masl)	1889
Live Storage (ha-m)	24.9
HEADRACE TUNNEL	
Type	D Shaped, Concrete Lined
Diameter (m)	2.85
Length (km)	2.80
Number	1
SURGE SHAFT	
Type	Open at Top, Restricted Orifice
Diameter (m)	5
Height (m)	72
PENSTOCK	
Type	Surface
Number	1
Diameter (m)	2.2 (1.5m beyond bifurcation)
Length (m)	580 (8m beyond bifurcation)
POWERHOUSE	
Type	Surface
Installed Capacity (MW)	86
Rated Head (m)	480
Tail water level (masl)	1385.5
TURBINE	
Type	Pelton, Vertical Axis
Numbers	Two
Rated Output	43 MW each
POWER BENEFITS	
90% Dependable Energy (GWh)	370.93
PROJECT COST	
Capital Cost (US$)	70 million
Year of Commissioning/ Completion	
Commercial Operation Date (COD)	05-07-2001

Table 2.5: Salient Features of Tosh (20 MW)

LOCATION	
District	Kullu
Name of River	Tosh Nala
HYDROLOGY	
Catchment area at diversion site (km^2)	382.00
Design Discharge (m^3/s)	15
DIVERSION STRUCTURE	
Type	Trench Weir
FSL (masl)	2480
HFL (masl)	2483.5
HEADRACE TUNNEL-I (From Weir to Intake Tank)	
Type	D Shaped
Diameter (m)	3.6
Length (m)	135.63
HEADRACE TUNNEL-II (From Shingle Flushing)	
Type	Circular
Diameter (m)	1.8
Length (m)	130.04
HEADRACE TUNNEL-III	
Type	D Shaped
Diameter (m)	3
Length (m)	33.17
HEADRACE TUNNEL-IV (From Balancing Reservoir to Surge Shaft)	
Type	Circular
Diameter (m)	2
Length (m)	157.75
SURGE SHAFT	
Type	Circular
Diameter (m)	5.4
Depth (m)	13.9
PENSTOCK	
Number	Two
Diameter (m)	1.5 (Main), 1.2 (After Bifurcation)
Total Length (m)	900
POWERHOUSE	
Type	Surface
Installed Capacity (MW)	20MW
Designed Net Head (m)	173.75
Tail water level (masl)	2284
TURBINE	
Type	4 Jet Vertical Shaft Pelton
Numbers	Four
Rated Output	5 MW each
POWER BENEFITS	
75% Dependable Energy (MU)	117.1
PROJECT COST	
Capital Cost (Rs)	88.197 Crore

Table 2.6: Salient Features of Allain Duhangan (192 MW)

LOCATION		
District	Kullu	
Name of River	Allain Nala	Duhangan Nala
HYDROLOGY		
Catchment area at diversion site (km^2)	128.90	66.2
Design Discharge (m^3/s)	18.9	7.9
DIVERSION STRUCTURE		
Type	Barrage	Trench Weir
Maximum Water Level (masl)	2747	2787
Average Bed level (masl)	2740	2782
HEADRACE TUNNEL		
Type	D Shaped, Concrete Lined	D Shaped, Concrete Lined
Size (m)	3.4 (W) x 3.4 (H)	3.4 (W) x 3.4 (H)
Length (m)	3690.00	4565
PRESSURE SHAFT		
Type	Steel lined, back filled with concrete	
Diameter	2800 mm internal dia. Bifurcating 50 m upstream of power house cavern into two branches each of 2000 mm internal dia.	
Length (m)	1750 (including length after bifurcation)	
POWERHOUSE		
Type	Underground	
Installed Capacity (MW)	192	
Gross Head (m)	851	
Tail water level (masl)	1862.9	
TURBINE		
Type	Vertical Pelton	
Numbers	Two	
Rated Output	96 MW each	
POWER BENEFITS		
90% Dependable Energy (GWh)	678.18	
Year of Commissioning/ Completion		
Unit I	17-07-2010	
Unit II	16-09-2010	

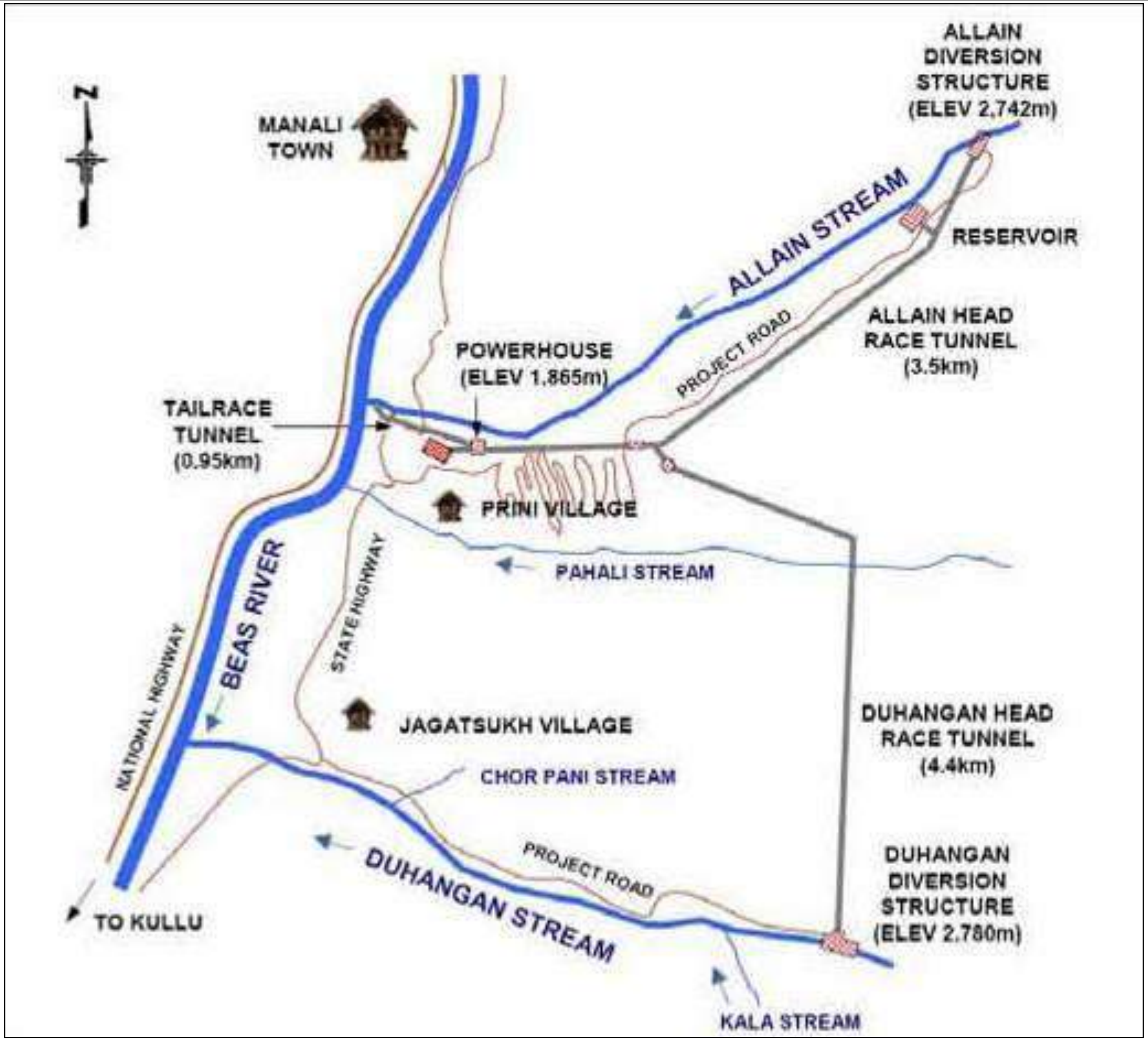


Figure 2.2: Layout Plan of Allain Duhangan HEP

Table 2.7: Salient Features of Sarbari-II (5.4 MW)

LOCATION	
District	Kullu
Name of River	Sarbari Khad
HYDROLOGY	
Catchment area at diversion site (km^2)	86
Design Discharge (m^3/s)	3.65
DIVERSION STRUCTURE	
Type	Aqueduct (Cascading development)
FRL (masl)	1625.45
INTAKE STRUCTURE	
Type	R.C.C. structure
Shape	Rectangular
Size (m)	21 x 8.50 x 5.50
WATER CONDUCTOR SYSTEM (From Tail Race Channel of Sarbari I to Intake)	
Shape	Circular
Diameter (m)	1.6
Length (m)	58.42
HEAD RACE TUNNEL	
Type	D Shaped pressurized flow tunnel
Diameter (m)	1.8
Length (m)	3514.6
PENSTOCK	
Number	One
Diameter (m)	1.25
Diameter after bifurcation (m)	1
Length (m)	0.37
Length of bifurcation at lower end (m)	10 (each penstock liner)
POWERHOUSE	
Type	Surface
Installed Capacity (MW)	5.4
Designed Net Head (m)	188.36
Tail water level (masl)	1418
TURBINE	
Type	Horizontal axis Pelton
Numbers	Two
Rated Output	2.70 MW each
Year of Commissioning/ Completion	
Commercial Operation Date (COD)	25-08-2010

Table 2.8: Salient Features of Beas Kund (9 MW)

LOCATION	
District	Kullu
Name of River	Beas Kund Nala
HYDROLOGY	
Catchment area at diversion site (km^2)	115.25
Design Discharge (m^3/s)	9.09
DIVERSION STRUCTURE	
Type	Trench Weir
FRL (masl)	2423.5
INTAKE STRUCTURE	
Type	R.C.C. structure
Shape	Rectangular
Size (m)	5.30 x 4 x 5.20
HEAD RACE TUNNEL	
Shape	Horse Shoe
Diameter (m)	2.5
Length (m)	1512
SURGE SHAFT	
Type	Cylindrical Underground
Diameter (m)	6
Height (m)	35
PENSTOCK	
Type	Steel IS:2002 Gr.-B or ASTM A-285 Gr. C
Number	One (Main), Three (Branches)
Diameter (m)	2.0 (Main)
Length (m)	435.0 (Main), 15 (each branch)
POWERHOUSE	
Type	Surface
Installed Capacity (MW)	9
Net Head (m)	119
Tail water level (masl)	2294
TURBINE	
Type	Horizontal axis Francis
Numbers	Three
Rated Output	3.0 MW each
Year of Commissioning/ Completion	
Unit I	07-06-2012
Unit II	19-03-2012
Unit III	07-06-2012

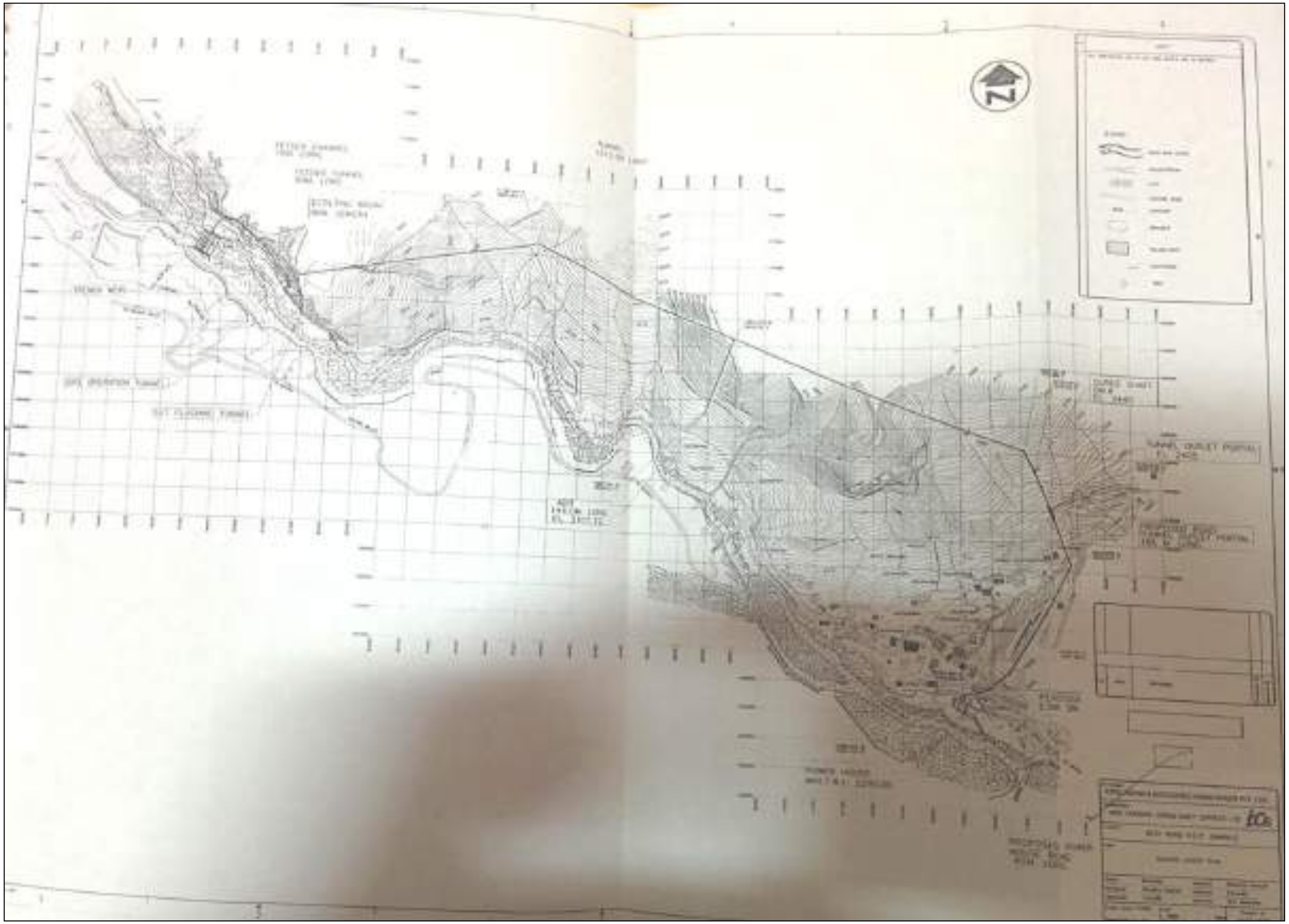


Figure 2.3: General Layout Plan of Beas Kund SHEP

Table 2.9: Salient Features of Malana II (100 MW)

LOCATION	
District	Kullu
Name of River	Malana Nala
HYDROLOGY	
Catchment area at diversion site (km^2)	158.00
Design Discharge (m^3/s)	18.65
DIVERSION STRUCTURE	
Type	Concrete Gravity Dam
Height from river bed (m)	45
Top of Structure (masl)	2545
FRL (masl)	2543
MDDL (masl)	2528
Average Bed level (masl)	2500
Live Storage (Mcum)	0.2875
HEADRACE TUNNEL	
Type	D Shaped, Concrete Lined
Size (m)	3.0 x 2.75
Length (km)	4.85
SURGE SHAFT	
Type	Underground, Simple Surge Shaft
Diameter (m)	6
Height (m)	90
PRESSURE SHAFT	
Type	Underground
Diameter (m)	2.5
Length (m)	666
POWERHOUSE	
Type	Underground
Installed Capacity (MW)	100
Rated Net Head (m)	608
Tail water level (masl)	1913
TURBINE	
Type	Vertical Axis Pelton Wheel
Numbers	Two
Rated Output	50 MW each
POWER BENEFITS	
90% Dependable Energy (M Kwh)	428
PROJECT COST	
Capital Cost (Rs)	63347 lakh
Year of Commissioning/ Completion	
Commercial Operation Date (COD)	12-07-2012

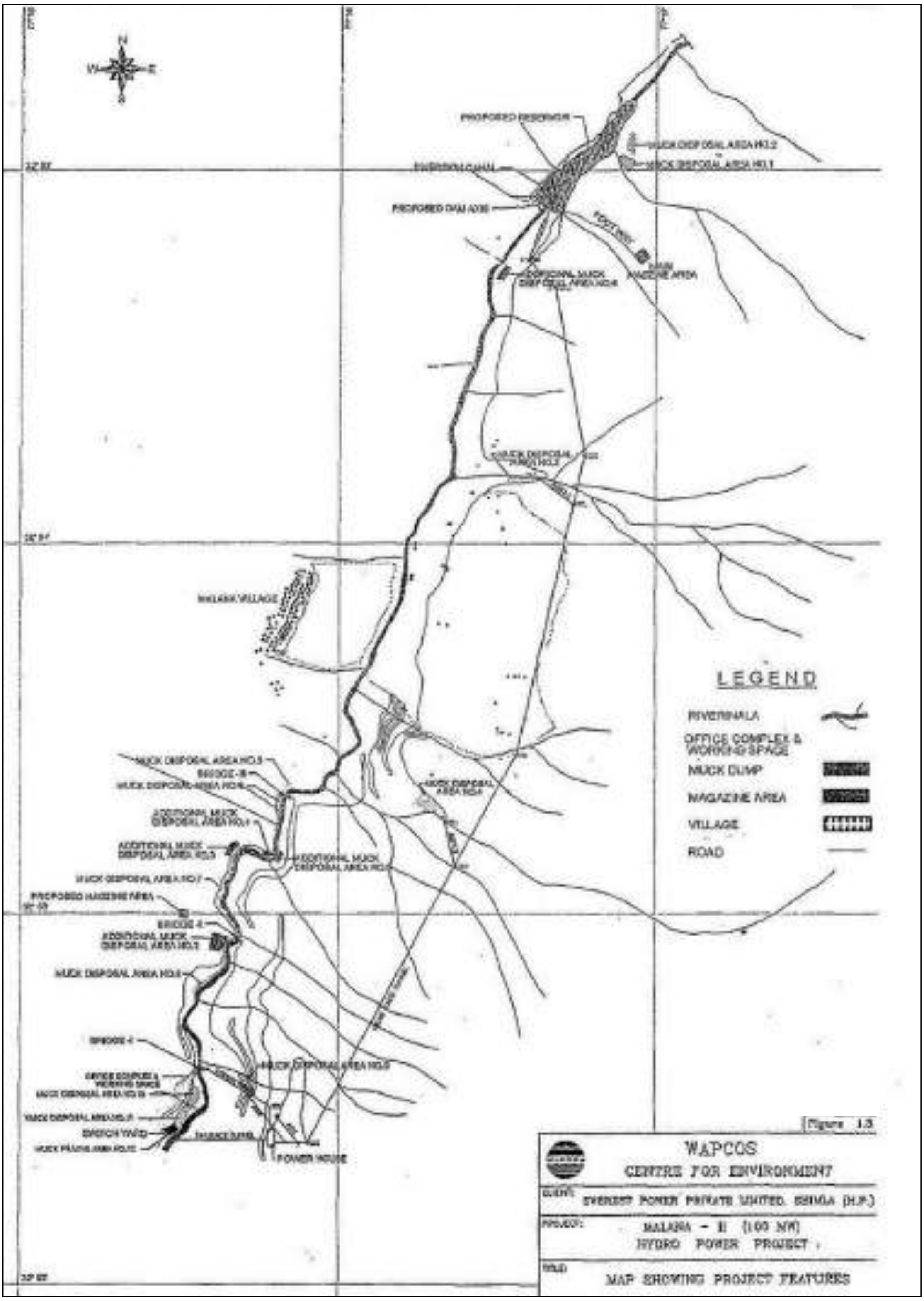


Figure 2.4: Layout Plan of Malana II HEP

Table 2.10: Salient Features of Neugal (15 MW)

LOCATION	
District	Kangra
Name of River	Neugal Nala
HYDROLOGY	
Catchment area at diversion site (km^2)	32.20
Design Discharge (m^3/s)	4.6
DIVERSION STRUCTURE	
Type	Ogee Weir
River Bed level (masl)	1905.3
High Flood level (masl)	1931.1
Top Level of Structure (masl)	1932.1
Trash Rack Level (masl)	1931.9
HEAD RACE TUNNEL	
Type	D Shaped Pressure Flow
Size (m)	2.25 x 2.25
Length (m)	3178
PENSTOCK	
Type	Surface Circular Steel
Number	One (Main), Two (Branches)
Diameter (m)	1.30 (Main), 0.92 (Each Branch)
Length (m)	664.00 (Main)
POWERHOUSE	
Type	Surface
Installed Capacity (MW)	15
Net Head (m)	392
Tail water level (masl)	1509.5
TURBINE	
Type	Pelton Horizontal Axis
Numbers	Two
Rated Output	7.5 MW each
POWER BENEFITS	
50% Dependable Energy (MU)	76.17
90% Dependable Energy (MU)	70.43
PROJECT COST	
Total Cost (Rs)	8161 lakh
Year of Commissioning/ Completion	
Commercial Operation Date (COD)	06-05-2013

Table 2.11: Salient Features of Parbati III (520 MW)

LOCATION	
District	Kullu
Name of River	Sainj River
HYDROLOGY	
Catchment area at diversion site (km^2)	
Design Discharge (cumec)	
DIVERSION STRUCTURE	
Type	Rock fill
Height from river bed (m)	43
FRL (masl)	1330
MDDL (masl)	
Live Storage (10^6 m^3)	
HEADRACE TUNNEL	
Type	Concrete lined
Diameter (m)	7.25
Length (m)	7.875
Number	
SURGE SHAFT	
Type	
Diameter (m)	20
Height (m)	133.75
PRESSURE SHAFT	
Type	Steel lined
Number	2
Diameter (m)	4.50 each bifurcating into two 3.0m dia penstocks
Length (m)	510 & 460
POWERHOUSE	
Type	Underground
Installed Capacity (MW)	520
Net Design Head (m)	
Minimum Tail water level (masl)	
TURBINE	
Type	Vertical axis Francis
Numbers	4
Rated Output	130 MW each

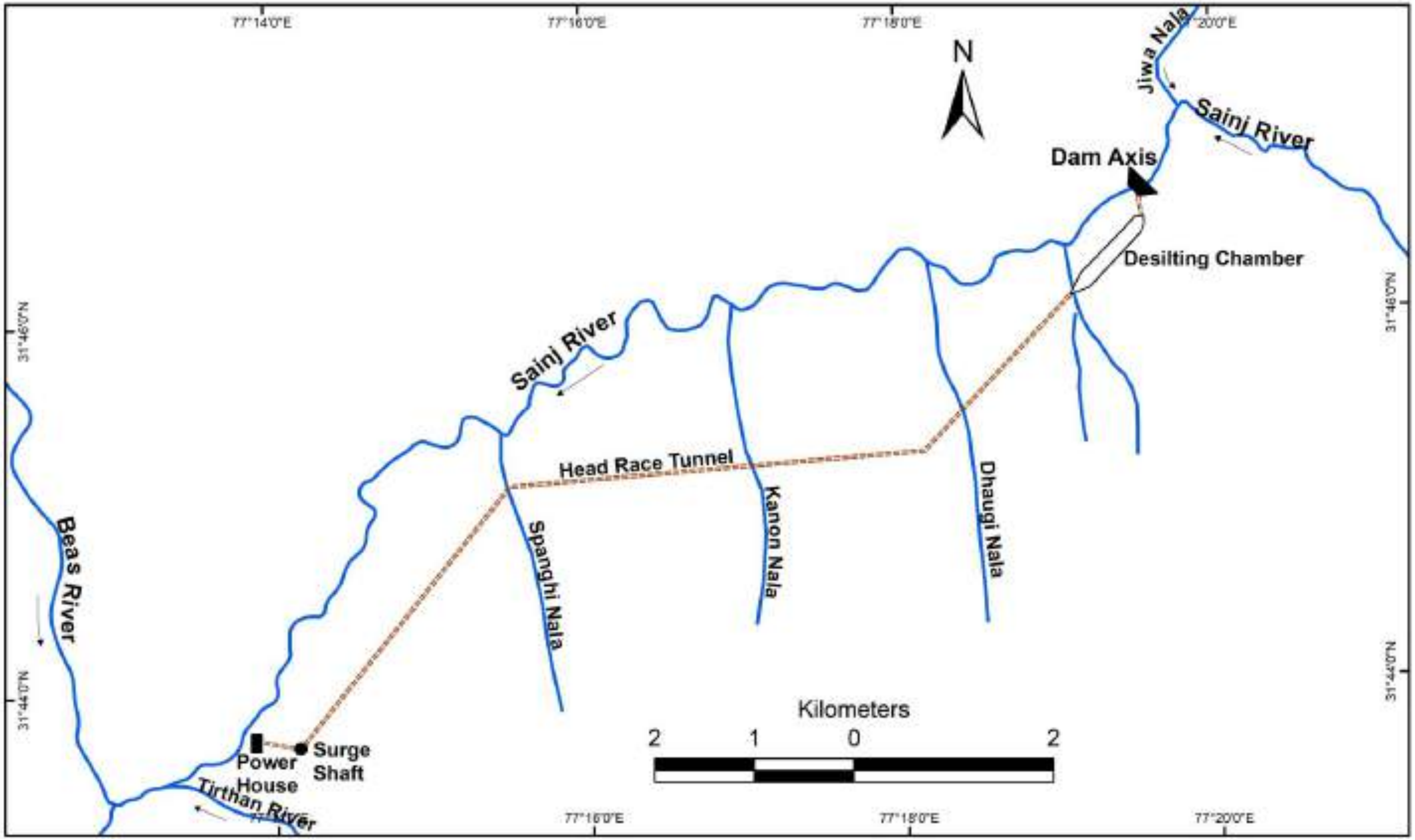


Figure 2.5: General Layout plan of Parbati III HEP

Table 2.12: Salient Features of Baragaon (24 MW)

LOCATION		
District	Kullu	
Name of River	Sanjoin Nala	Bijara Nala
HYDROLOGY		
Catchment area at diversion site (km^2)	26.00	13
Design Discharge (m^3/s)	5.652	5.652
DIVERSION STRUCTURE		
Type	Trench Weir	Trench Weir
Top of Structure (masl)	2396	2385
HFL (masl)	2398.34	2387.213
HEADRACE TUNNEL		
Type	D Shaped lined upto Springing Level	D Shaped Fully Lined
Size (m)	1.80 x 2.25	1.80 x 2.25
Length (m)	128.00	1934
SURGE SHAFT		
Type	Vertical, Circular and Lined	
Diameter	4	
Height (m)	28	
PENSTOCK		
Type	Steel Liner	
Number	One (Main), Three (Unit)	
Diameter (m)	1.35 (Main), 0.80 (Unit)	
Length (m)	1480 (Main), 12 (2 Units) and 6 (1 Unit)	
POWERHOUSE		
Type	Surface	
Installed Capacity (MW)	24	
Gross Head (m)	608	
Tail water level (masl)	1770	
TURBINE		
Type	Horizontal Axis Pelton Turbine	
Numbers	Three	
Rated Output	8 MW each	
Year of Commissioning/ Completion		
Unit I	24-03-2014	
Unit II	30-03-2014	
Unit III	25-05-2014	

Table 2.13: Salient Features of Patikari (16 MW)

LOCATION	
District	Mandi
Name of River	Bakhli Khad, a tributary of Beas River
HYDROLOGY	
Catchment area at diversion site (km^2)	214
Design Discharge (m^3/s)	5.83
DIVERSION STRUCTURE	
Type	Ogee
FRL (masl)	1394.4
Average Bed level (masl)	1388.76
HEAD RACE TUNNEL	
Length (m)	3614
Diameter	1.80m D-section (2.1m high)
Surge Shaft	
Diameter	3.0m
Full Supply level (FSL)	1396.9m
Min. Draw Down Level (MDDL)	1385.75
Min. water seal above MDDL	1.5m
PENSTOCK	
Type	Surface
Number	One
Diameter (m)	1.30m
Length (m)	677.065m
POWERHOUSE	
Type	Surface power house. Reinforced concrete substructure with reinforced concrete columns and beams and masonry walls above. Roof of GCI sheets on tabular trusses.
Installed Capacity (MW)	16
Rated Net Head (m)	356.3
TURBINE	
Type	Pelton, Horizontal axis
Numbers	2
Rated Output	8

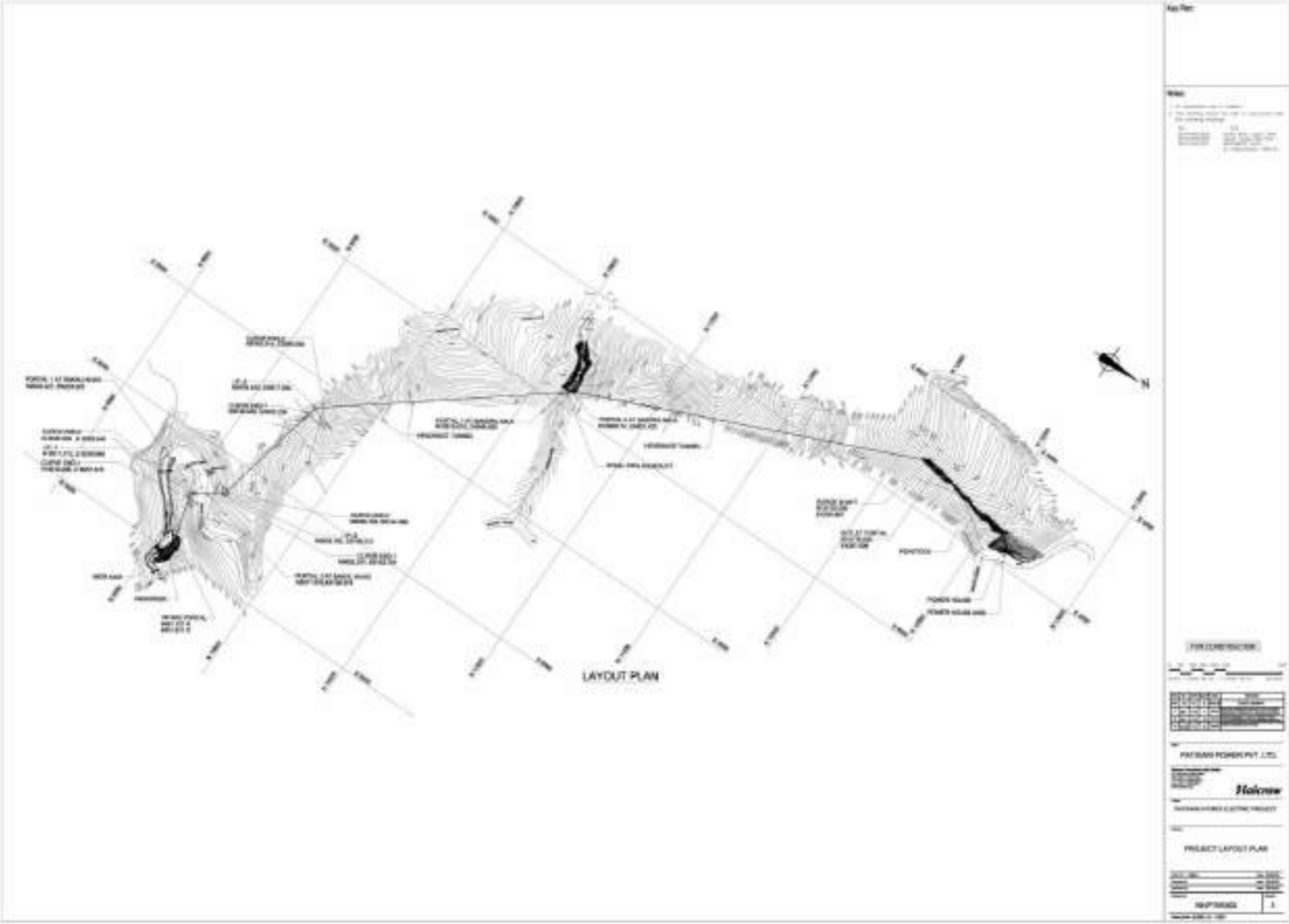


Figure 2.6: General Layout plan of Patikari SHEP

Table 2.14: Salient Features of Baner-II (6 MW)

LOCATION	
District	Kangra
Name of River	Baner Khad
HYDROLOGY	
Catchment area at diversion site (km^2)	42
Design Discharge (m^3/s)	5.54
DIVERSION STRUCTURE	
Type	Trench Weir
FSL (masl)	1342
HFL (masl)	1343.75
Average Bed level (masl)	1342
FEEDER CHANNEL	
Type	Trapezoidal
Size (m)	1.00 (bottom) x 3.00 (top) x 3.00 (height)
Length (m)	19
FOREBAY TANK	
Type	RCC Rectangular Tank
Size (m)	165 (L) x 35 (W) x 7 (D)
Storage Capacity (cum)	28800
Top Level of structure (m)	1343.5
MDDL (m)	1337.6
Penstock Entry Level (m)	1335.3
PENSTOCK	
Type	Surface Circular Steel
Number	One (Main), Two (Branches)
Diameter (m)	1.6 (Main), 0.90 (Each Branch)
Length (m)	1980 (Main), 50 (Each Branch)
POWERHOUSE	
Type	Surface
Installed Capacity (MW)	6
Rated Net Head (m)	130
Tail water level (masl)	1387
TURBINE	
Type	Horizontal axis Francis
Numbers	Two
Rated Output	3.0 MW each
Year of Commissioning/ Completion	
Commercial Operation Date (COD)	27-06-2015

Table 2.15: Salient Features of Pong Dam (396 MW)

LOCATION	
District	Kangra, Hamirpur
Name of River	Beas River
HYDROLOGY	
Catchment area at diversion site (km^2)	12,560
Design Discharge (cumec)	
DIVERSION STRUCTURE	
Type	Earth core gravel shell
Height from river bed (m)	100.58
FRL (masl)	433.12
RBL (masl)	335.28
Live Storage (10^6 m^3)	5966
HEADRACE TUNNEL	
Type	
Diameter (m)	
Length (m)	
Number	
SURGE SHAFT	
Type	
Diameter (m)	
Height (m)	
PENSTOCK	
Type	Steel
Number	3
Diameter (m)	9.14 each
Length (m)	
POWERHOUSE	
Type	Underground
Installed Capacity (MW)	396
Net Design Head (m)	
Minimum Tail water level (masl)	
TURBINE	
Type	Vertical shaft, Francis Type
Numbers	6
Rated Output	66 MW each

Table 2.16: Salient Features of Beas Satluj Link (990 MW)

LOCATION	
District	Mandi
Name of River	Beas and Satluj
HYDROLOGY	
Catchment area at diversion site (km^2)	
Design Discharge (cumec)	
DIVERSION STRUCTURE	
Type	Earth-cum-rock fill
Height from river bed (m)	76.25
FRL (masl)	896.42
RBL (masl)	838.16
Storage (m^3)	1580000
HEADRACE TUNNEL	
Pandoh Baggi Tunnel	7.62 m dia, 13.11 km long
Sundernagar Hydel Channel	11.8 km long open channel
Sundarnagar Dehar Tunnel	8.53 m dia, 12.53 km long
SURGE SHAFT	
Type	
Diameter (m)	22.86
Height (m)	125
PENSTOCK	
Type	
Number	Three 4.877 m dia split to six 3.353 m dia
Diameter (m)	
Length (m)	
POWERHOUSE	
Type	Surface, on Right Bank of Satluj River
Installed Capacity (MW)	990
Net Design Head (m)	
Minimum Tail water level (masl)	
TURBINE	
Type	
Numbers	6
Rated Output	165 MW each

Table 2.17: Salient Features of Sainj (100 MW)

LOCATION	
District	Kullu
Name of River	Sainj River
HYDROLOGY	
Catchment area at diversion site (km^2)	434.33
Design Discharge (cumec)	28.7
DIVERSION STRUCTURE	
Type	Gated Barrage
Height from river bed (m)	25
FRL (masl)	1752
MDDL (masl)	1738.5
Live Storage (10^6 m^3)	38.41
HEADRACE TUNNEL	
Type	Circular, Concrete Lined
Diameter (m)	3.85
Length (m)	6360.75
Number	1
SURGE SHAFT	
Type	Underground, Restricted Orifice
Diameter (m)	9
Height (m)	75.80m above top of orifice slab
PRESSURE SHAFT	
Type	Underground, Steel Lined
Number	One (Main), Two (Branches)
Diameter (m)	2.75 (Main), 1.95 (Each Branch)
Length (m)	±640 (Main); 32.71 and 28.32 (Branches)
POWERHOUSE	
Type	Underground
Installed Capacity (MW)	100
Net Design Head (m)	395.96
Minimum Tail water level (masl)	1333.21
TURBINE	
Type	Pelton, Vertical Axis
Numbers	Two
Rated Output	50 MW each

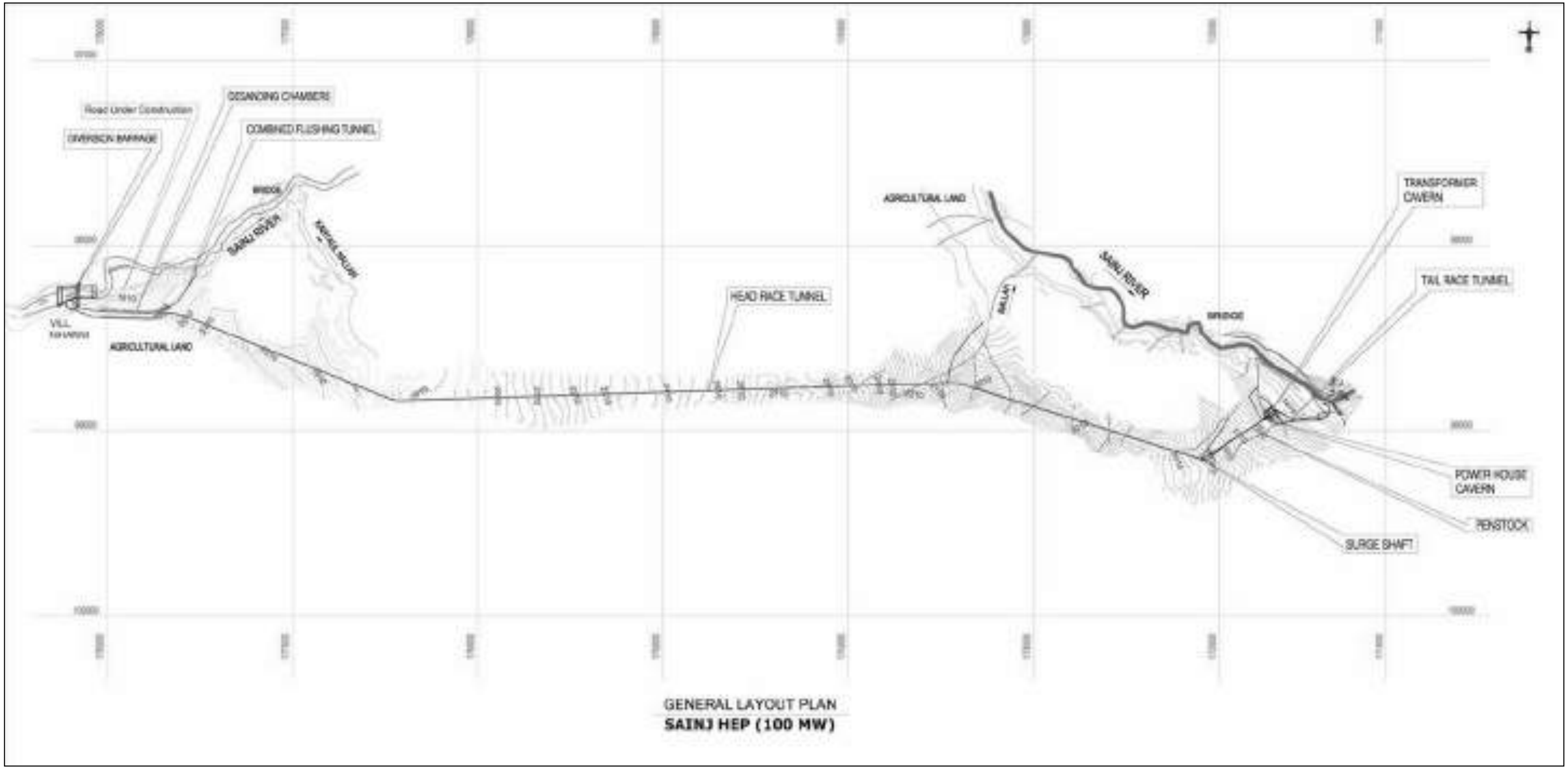


Figure 2.7: General Layout plan of Sainj HEP

Table 2.18: Salient Features of Fozal (6 MW)

LOCATION	
District	Kullu
Name of River	Fozal Nala
Coordinates - Diversion Site	32° 00' 29.79" N, 77° 17' 23.84" E
Coordinates - Powerhouse	32° 00' 15.99" N, 77° 15' 05.42" E
HYDROLOGY	
Catchment area at diversion site (km^2)	108.5
Design Discharge (cumec)	7.33
DIVERSION STRUCTURE	
Type	Trench Weir
Height from river bed (m)	9.4
Top of Structure (masl)	1594.5
Trash Rack Level (masl)	1590
FSL (masl)	1589.2
MDDL (masl)	1585.2
Average Bed level (masl)	1585.1
Capacity (cumec	30000
HEAD RACE TUNNEL (Desilting Tank to Tunnel Inlet)	
Type	RCC Channel, Square Box Section
Size (m)	3.50 x 3.50 i/c 0.60m freeboard
Length (m)	255.23
POWER CHANNEL	
Type	Open Channel
Size (m)	1.95 x 1.95
Length (m)	2300
FOREBAY	
Type	Oval Shaped
MDDL (masl)	1578.75
FSL (masl)	1580.25
C/L of Penstock (masl)	1576.65
PENSTOCK	
Type	Surface Circular Steel
Number	One (Main), Three (Branches)
Diameter (m)	1.40 (Main), 0.85 (Each Branch)
Length (m)	176.00 (Main), 2.00 (Each Branch)
POWERHOUSE	
Type	Surface
Installed Capacity (MW)	6
Net Head (m)	97
Tail water level (masl)	1478.5
TURBINE	
Type	Francis Horizontal Axis
Numbers	Three
Rated Output	2.00 MW Each
POWER GENERATION	
75% Dependable Energy (GWH)	34.43
PROJECT COST	
Net Cost (Rs)	3098 lakh

Table 2.19: Salient Features of Lambadug (25 MW)

LOCATION	
District	Kangra
Name of River	Lambadug Khad
HYDROLOGY	
Catchment area at diversion site (km^2)	197
Design Discharge (m^3/s)	12.75
DIVERSION STRUCTURE	
Type	Drop Type Trench Weir
FRL (masl)	2082
HEAD RACE TUNNEL	
Type	D Shaped, Concrete Lined
Equivalent Radius (m)	3.7
Length (m)	4150
PENSTOCK	
Type	Surface
Diameter (m)	2
Length (m)	550
POWERHOUSE	
Installed Capacity (MW)	25
Net Head (m)	221.71
Tail water level (masl)	1836
TURBINE	
Type	Vertical Francis
Numbers	Two
Rated Output	12.5 MW each
POWER BENEFITS	
75% Dependable Net Energy (MU)	105.36
50% Dependable Net Energy (MU)	130.92
PROJECT COST	
Cost per MW (Rs)	4.90 Crore

Figure 2.8: General Layout of Lambadug HEP

Table 2.20: Salient Features of Lower Uhl (13 MW)

LOCATION	
District	Mandi
Name of River	Uhl River
Coordinates - Diversion Site	31° 49' 50" N, 76° 58' 34" E
HYDROLOGY	
Catchment area at diversion site (km^2)	365.00 at Barot and 606.09 at Riagri
Design Discharge (cumec)	15.72
DIVERSION STRUCTURE	
Type	Barrage
Height from deepest river bed level (m)	10.76
Top of Structure (masl)	1075
FRL (masl)	1068.38
Deepest River Bed Level (masl)	1064.24
HEAD RACE TUNNEL	
Type	D Shaped with CC Lining
Diameter (m)	3.6
Length (m)	3802.56
FOREBAY TANK	
Type	Surface
Size (m)	65.00 x 12.00
Live Storage Capacity (cum)	3120
FSL (m)	1064
MDDL (m)	1060
Penstock Entry Level (m)	1056.945
PENSTOCK	
Type	Circular, Burried
Number	One (Main), Two (Branches)
Diameter (m)	2.20 (Main), 1.55 (Each Branch)
Length (m)	197.50 (Main), 26.50 (Each Branch)
POWERHOUSE	
Type	Surface
Installed Capacity (MW)	13
Rated Net Head (m)	99.17
Tail water level (masl)	965.4
TURBINE	
Type	Horizontal Francis
Numbers	Two
Rated Output	6.50 MW Each
ENERGY GENERATION	
75% Dependable Energy (Mu)	60.19

Table 2.21: Salient Features of Parbati II (800 MW)

LOCATION				
District	Kullu			
Name of River	Parbati River	Jigrai Nala	Hurla Nala	Jiwa Nala
HYDROLOGY				
Catchment area at diversion site (km^2)	1155	44	67	120
Design Discharge (cumec)	87	3.60	9.0	16.50
DIVERSION STRUCTURE				
Type	Concrete Gravity Dam	Trench Weir	Trench Weir	Trench Weir
Height from river bed (m)	83.7			
FRL (masl)	2197		2221 (top)	2220 (top)
MDDL (masl)	2189	2207.3 (sill)	2218 (crest)	2216.87 (crest)
RBL (m)	2128			
Gross Storage (10^6 m^3)	655			
HEADRACE TUNNEL				
Type	Concrete lined			
Diameter (m)	6			
Length (m)	31.23			
Number	1			
SURGE SHAFT				
Type	Orifice			
Diameter (m)	17			
Height (m)	116			
PRESSURE SHAFT				
Type				
Number				
Diameter (m)				
Length (m)				
POWERHOUSE				
Type	Surface			
Installed Capacity (MW)	800			
Design Head (m)	788			
Minimum Tail water level (masl)				
TURBINE				
Type	Pelton, vertical axis			
Numbers	4			
Rated Output	200 MW each			

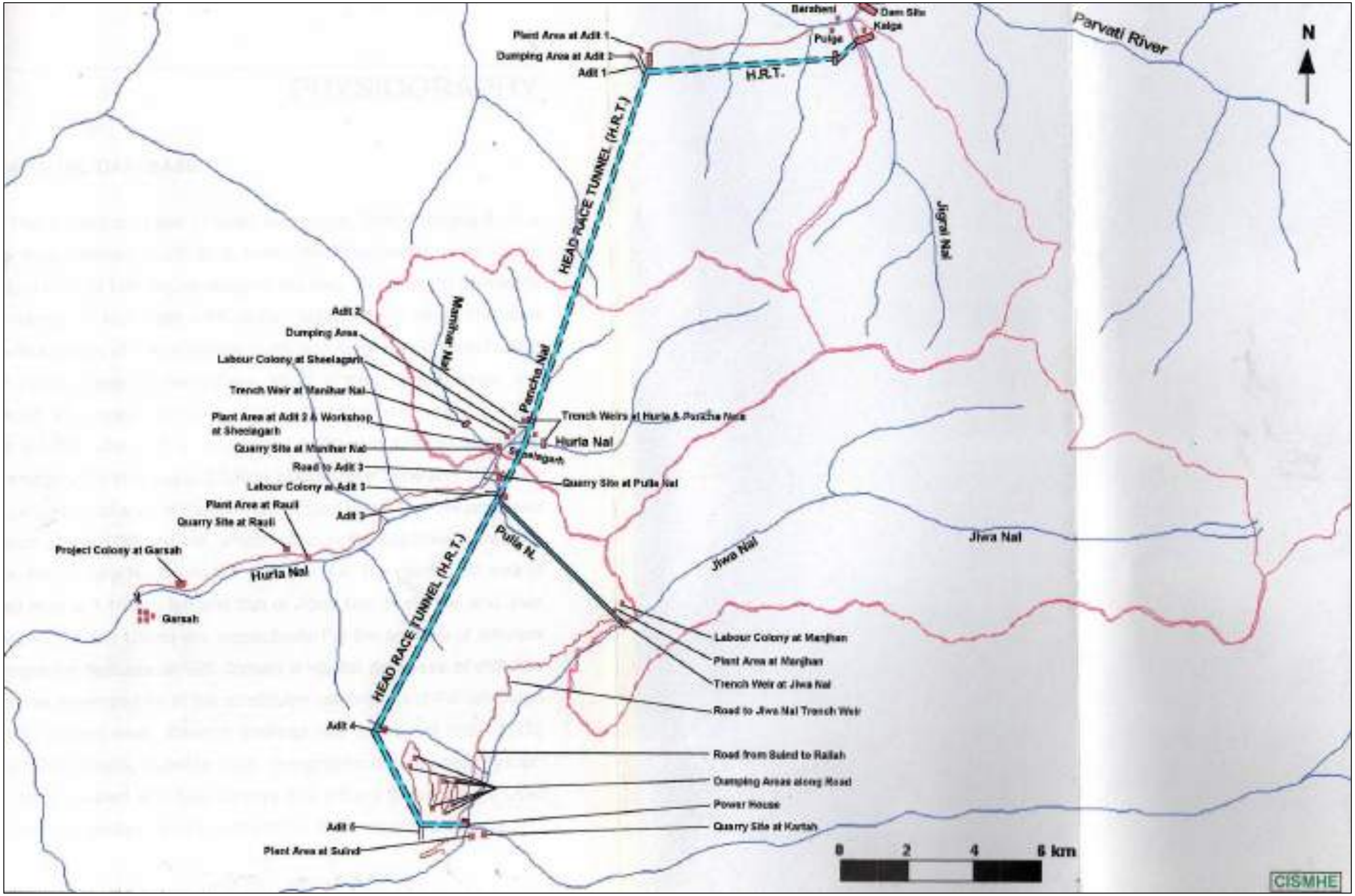


Figure 2.9: General Layout plan of Parbati II HEP

Table 2.22: Salient Features of Uhl-III (100 MW)

LOCATION			
District	Mandi		
Name of River	Neri Khad	Bassi PH tail race junction	Rana Khad
HYDROLOGY			
Catchment area at diversion site (km^2)	16.00		98.90
Design Discharge (m^3/s)			
DIVERSION STRUCTURE			
Type			
Crest level	894.50	889.75	897.65
POWER CHANNEL			
Length (m)	1250		1970
STORAGE RESERVOIR	At Khuddar		
Type	Surface Trapezoidal shape		
Live Storage Capacity m^3	176000		
FRL (m)	890.90		
MDDL (m)	882.00		
HEAD RACE TUNNEL			
Type	Circular shape		
Diameter (m)	4.15		
Length (m)	8275		
Design Discharge m^3	41.30		
SURGE SHAFT			
Shape	Restricted orifice open to sky		
Diameter (m)	13 and 9 riser		
Height (m)	45 and 12 riser		
Top Level (m)	905		
Bottom Level (m)	848		
Maximum Surge level (m)	903.50		
Maximum Surge level (m)	850.00		
PENSTOCK			
Type	Circular Steel lined		
Diameter (m)	Main (1no.) 3.40 m Branches (2 nos.) 2.40m each		
Length (m)	Main (1773) after bifurcation (80m)		
POWERHOUSE			
Type	Surface		
Installed Capacity (MW)	100		
Design Head (m)	282.90		
Minimum Tail water level (masl)	580		
TURBINE			
Type	P. Francis Vertical Axis		
Numbers	2		
Rated Output	50		

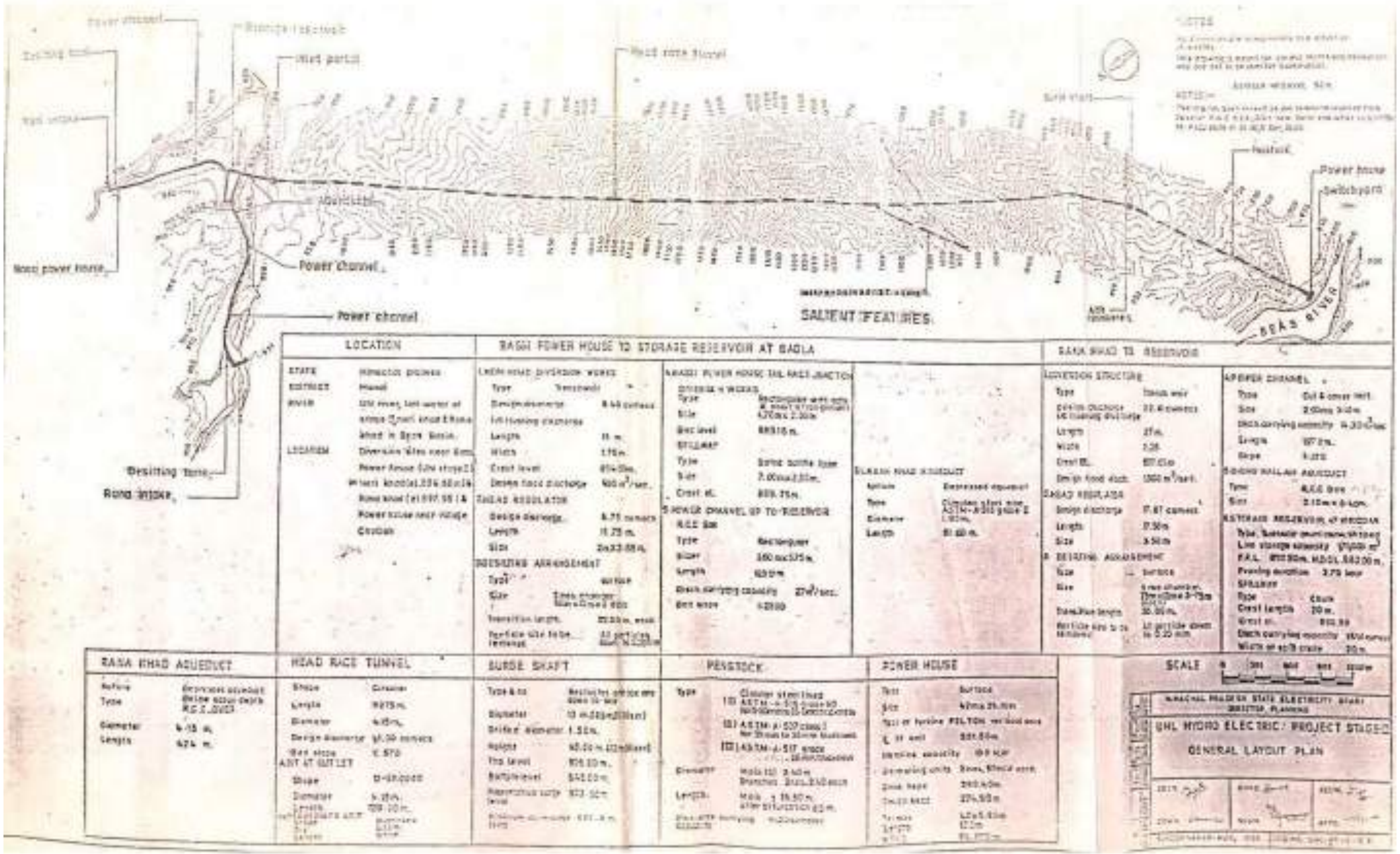


Figure 2.10: General Layout plan of Uhl III HEP

Table 2.23: Salient Features of Balargha (9 MW)

LOCATION	
District	Kullu
Name of River	Parbati River
HYDROLOGY	
Catchment area at diversion site (km^2)	70
Design Discharge (m^3/s)	13.35 i/c overloading discharge
DIVERSION STRUCTURE	
Type	Boulder Weir - Over Flow Type
FRL (masl)	1950
HFL (masl)	1954
Top Deck Level (masl)	1955
HEAD RACE TUNNEL	
Type	D Shaped
Size (m)	2.50 (Wide) x 3.70 (High)
Length (m)	1557
FOREBAY TANK	
Shape	Rectangular
Size (m)	8.00 (Wide) x 50.00 (Long)
Storage Capacity (cum)	1602 for 2 minutes peaking
Maximum Water Level (m)	±1948.90
MDDL (m)	±1944
FRL (m)	1948
Spillway Crest Level (m)	±1948
Normal Water Level (m)	±1948
PENSTOCK	
Number	Three
Diameter (m)	1.45 each
Length (m)	111 each
POWERHOUSE	
Type	Surface
Installed Capacity (MW)	9
Rated Net Head (m)	84
Minimum Tail water level (masl)	1863.5
TURBINE	
Type	Horizontal Axis Francis
Numbers	Three
Rated Output	3.00 MW Each
POWER GENERATION	
75% Dependable Energy (MU)	49.55

Table 2.24: Salient Features of Uhl (14 MW)

LOCATION	
District	Mandi
Name of River	Uhl River
Coordinates - Diversion Site	32° 04' 22.50" N, 76° 04' 38.50" E
Coordinates - Powerhouse	32° 02' 33.40" N, 76° 50' 33.77" E
HYDROLOGY	
Catchment area at diversion site (km^2)	113.369
Design Discharge (cumec)	8.35
DIVERSION STRUCTURE	
Type	Raised Diversion Weir
Crest level (masl)	2085
Depth (m)	12
HFL (masl)	2091.15
HEAD RACE TUNNEL (From Intake to Desilting Tank)	
Type	D Shaped
Size (m)	2.50 x 2.50
Length (m)	10
HEAD RACE TUNNEL (From Desilting Tank to Surge Shaft)	
Type	D Shaped Pressurized Tunnel
Size (m)	2.30 x 2.30
Length (m)	4624.59
SURGE SHAFT	
Type	Underground RCC/ Steel Tank
Diameter (m)	9.5
Depth (m)	30.00 i/c 3.00 m freeboard
PENSTOCK	
Type	Circular boiler quality steel pipe
Number	One (Main), Three (Branches)
Diameter (m)	2.00 (Main), 1.20 (Each Branch)
Length (m)	700.00 (Main), 15.00 (Each Branch)
POWERHOUSE	
Type	Surface
Installed Capacity (MW)	14
Rated Net Head (m)	201.02
Tail water level (masl)	1870.05
TURBINE	
Type	Horizontal Shaft Synchronous
Numbers	Three
Rated Output	4.67 MW each
ENERGY GENERATION	
75% Dependable Energy (Mu)	74.179

Table 2.25: Salient Features of Sarsadi-II (9 MW)

LOCATION	
District	Kullu
Name of River	Parbati River
HYDROLOGY	
Catchment area at diversion site (km^2)	492.50
Design Discharge (m^3/s)	21
DIVERSION STRUCTURE	
Type	Trench Weir
Crest Level of Weir (masl)	1190
HFL (masl)	1197.65
HEADRACE TUNNEL (From Intake to Desilting Tank)	
Shape	D Shaped
Size	4.0 m x 4.0 mm
Length (m)	304.15
HEADRACE TUNNEL (From Desilting Tank to Surge Shaft)	
Shape	D Shaped
Size (m)	3.50 x 3.50
Length (m)	2685.00
SURGE SHAFT	
Type	Partly Underground
Diameter (m)	9
Depth (m)	26
PRESSURE SHAFT	
Type	Underground
Number	One (Main), Two (Branches)
Diameter (m)	2.75 (Main), 1.95 (Each Branch)
Length (m)	550 (Main), 30 (Each Branch)
PENSTOCK	
Diameter (m)	3 (Primary), 2.25 (Branched)
Length (m)	75 (Main), 10 (Branched)
POWERHOUSE	
Type	Surface
Installed Capacity (MW)	9
Rated Designed Net Head (m)	51.1
Tail water level (masl)	1136
TURBINE	
Type	Horizontal Shaft Francis
Numbers	Two
Rated Output	4.5 MW each
POWER BENEFITS	
Energy gneration in 2008on the basis of discharges derived from Malana (MU)	21.75
PROJECT COST	
Capital Cost (Rs)	6350.90 Lakh

Table 2.26: Salient Features of Palchan Bhang (9 MW)

LOCATION	
District	Kullu
Name of River	Kothi Nala
HYDROLOGY	
Catchment area at diversion site (km^2)	64.62
Design Discharge (cumec)	
DIVERSION STRUCTURE	
Type	Drop Type Trench Weir
FRL (masl)	2242
River Bed Level (masl)	2246
WATER CONDUCTING SYSTEM	
Type	D Shaped Tunnel
Size (m)	2.20 x 2.20
Length (m)	3233
FOREBAY TANK	
Type	Surface
Size (m)	65.00 x 8.50 x 2.00
Storage Capacity (cum)	1139
Full Forbay Level (m)	2239
MDDL (m)	2237.9
PENSTOCK	
Type	Circular, Surface Steel
Number	One (Main), Three (Branches)
Diameter (m)	1.25 (Main), 0.85 (Each Branch)
Length (m)	450
POWERHOUSE	
Type	Surface
Installed Capacity (MW)	9
Net Head (m)	198.39
Tail water level (masl)	2035
TURBINE	
Type	Francis
Numbers	Three
Rated Output	3.0 W Each

Table 2.27: Salient Features of Uhl Khad (14 MW)

LOCATION	
District	Mandi
Name of River	Uhl River
HYDROLOGY	
Catchment area at diversion site (km^2)	636.09
Design Discharge (cumec)	17.75
DIVERSION STRUCTURE	
Type	Concrete Trench Weir
River Bed Level (masl)	935.5
WATER CONDUCTING SYSTEM	
Type	D Shaped Tunnel
Size (m)	3.20 x 3.20
Length (m)	3413
SURGE SHAFT	
Type	Underground
Diameter (m)	6.5
Depth (m)	54
PENSTOCK	
Type	Circular, Surface Steel
Number	One (Main), Two (Branches)
Diameter (m)	2.5
Length (m)	160
POWERHOUSE	
Type	Surface
Installed Capacity (MW)	14
Net Head (m)	101.58
Tail water level (masl)	824.61
TURBINE	
Type	Horizontal Shaft Francis
Numbers	Two
Rated Output	7.0 W Each

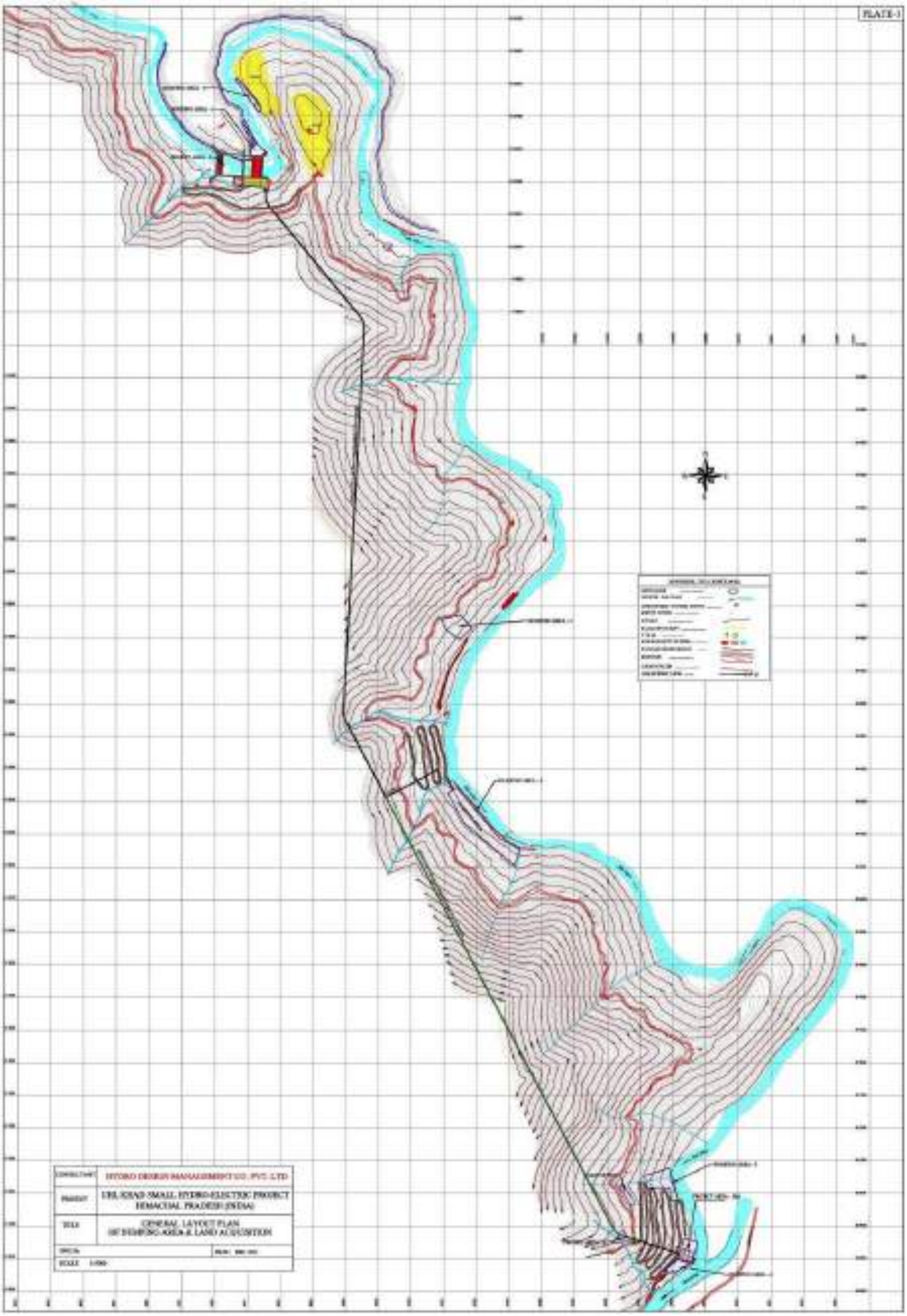


Figure 2.11: General Layout plan of Uhl Khad SHEP

Table 2.28: Salient Features of Bhang (9 MW)

LOCATION	
District	Kullu
Name of River	Beas River
Coordinates - Diversion Site	32° 18' 6.21" N, 77° 10' 57.77" E
Coordinates - Powerhouse	32° 16' 36.61" N, 77° 10' 47.75" E
HYDROLOGY	
Catchment area at diversion site (km^2)	162.75
Design Discharge (cumec)	8.5
DIVERSION STRUCTURE	
Type	Trench Weir
Crest Level (masl)	2240
HFL (masl)	2241.55
POWER CHANNEL (From Intake to Desilting Tank)	
Type	Rectangular Cut and Cover Type
Size (m)	2.80 x 2.80
Length (m)	43.78
FOREBAY TANK	
Type	RCC Hopper, Surface
Size (m)	65.00 (L) x 8.00 (W) x 4.50 (D)
Storage Capacity (cum)	1310
FSL (masl)	2238
MDDL (masl)	2237
Crest Level of Penstock (masl)	2232.65
PENSTOCK	
Type	Boiler Quality Steel
Number	One (Main), Two (Branches)
Diameter (m)	2.0 (Main), 1.35 (Each Branch)
Length (m)	2320.00 (Main), 15.00 (Each Branch)
POWERHOUSE	
Type	Surface
Installed Capacity (MW)	9
Rated Net Head (m)	126
Tail water level (masl)	2104
TURBINE	
Type	Vertical Shaft 6 Jet Pelton
Numbers	Two
Rated Output	4.50 MW Each
POWER GENERATION	
75% Dependable Energy (Mu)	39.571

Table 2.29: Salient Features of Sharni (9.6 MW)

LOCATION	
District	Kullu
Name of River	Parbati River
Coordinates - Diversion Site	31° 58' 42.69" N, 77° 15' 01.61" E
Coordinates - Powerhouse	31° 57' 56.68" N, 77° 13' 42.65" E
HYDROLOGY	
Effective Catchment area at diversion site (km^2)	182
Design Discharge (cumec)	24.15
DIVERSION STRUCTURE	
Type	RCC Barrage Type Weir
FSL(masl)	1310
HFL (masl)	1312.5
HEAD RACE TUNNEL (Tunnel Intake to Surge Shaft)	
Type	D Shaped Pressurised Tunnel
Size (m)	4.10 x 4.10
Length (m)	2738
SURGE SHAFT	
Type	RCC Circular Tank
Diameter (m)	20
Height (m)	24.45
FSL (masl)	1307.4
MDDL (masl)	1303.3
Crest Level of Penstock (masl)	1293.28
PENSTOCK	
Type	Surface Circular Steel
Number	One (Main), Two (Branches)
Diameter (m)	3.30 (Main), 2.30 (Each Branch)
Length (m)	58.66 (Main), 20.00 (Each Branch)
POWERHOUSE	
Type	Surface
Installed Capacity (MW)	9.6
Net Head (m)	47.64
Tail water level (masl)	1254
TURBINE	
Type	Horizontal Shaft Francis
Numbers	Two
Rated Output	4.80 MW Each
POWER GENERATION	
75% Dependable Energy (Mu)	46.4

Table 2.30: Salient Features of Sarsadi (9.6 MW)

LOCATION	
District	Kullu
Name of River	Parbati River
Coordinates - Diversion Site	31° 57' 25" N, 77° 11' 33" E
Coordinates - Powerhouse	31° 56' 38.01" N, 77° 10' 21.48" E
HYDROLOGY	
Effective Catchment area at diversion site (km^2)	188
Design Discharge (cumec)	24.15
DIVERSION STRUCTURE	
Type	RCC Rectangular tank
FSL(masl)	1253.99
Top level of Structure (masl)	1254.29
HEAD RACE TUNNEL (Feeder Channel Outlet to Surge Shaft)	
Type	D Shaped Pressurised Tunnel
Size (m)	4.10 x 4.10
Length (m)	3165
SURGE SHAFT	
Type	RCC Circular Tank
Diameter (m)	20
Height (m)	25.21
FSL (masl)	1251.32
MDDL (masl)	1247.22
Crest Level of Penstock (masl)	1239.98
PENSTOCK	
Type	Surface Circular Steel
Number	One (Main), Two (Branches)
Diameter (m)	58.66 (Main), 20.00 (Each Branch)
Length (m)	58.66 (Main), 20.00 (Each Branch)
POWERHOUSE	
Type	Surface
Installed Capacity (MW)	9.6
Net Head (m)	47.63
Tail water level (masl)	1203
TURBINE	
Type	Horizontal Shaft Francis
Numbers	Two
Rated Output	4.80 MW Each
POWER GENERATION	
75% Dependable Energy (Mu)	46.3

Table 2.31: Salient Features of Nakhtan (460 MW)

LOCATION		
District	Kullu	
Name of River	Parbati River	Tosh Nala
HYDROLOGY		
Catchment area at diversion site (km^2)	687.44	332.67
Design Discharge (m^3/s)	51.85	23.13
DIVERSION STRUCTURE		
Type	Barrage	Barrage
Height from river bed (m)	13	17
Top of Structure (masl)	2977	2977
FRL (masl)	2975	2975
MDDL (masl)	2975	2975
River Bed Level (masl)	2964	2960
Gross Storage (MCM)	0.034	0.03
HEADRACE TUNNEL		
Type	Circular (TBM)	Modified Horse Shoe (DBM)
Number	One	One
Diameter (m)	5.10	3.10
Length (m)	7471.56	2896.22
PRESSURE SHAFT		
Type	Underground	
Number	One (Main), Four (Unit)	
Internal Diameter (m)	4.20 (Main), 2.1 each (Unit)	
Length (m)	1848.38 (Main); 55.72, 34.54, 37.1 and 37.1 (Unit)	
POWERHOUSE		
Type	Underground	
Installed Capacity (MW)	460	
Rated Net Head (m)	678.98	
Tail water level (masl)	2269.62	
TURBINE		
Type	Pelton	
Numbers	Four	
Rated Output	115 MW each	
POWER BENEFITS		
90% Dependable Energy (MU)	1535.11	
CONSTRUCTION PERIOD (Inclusive of Infrastructure Works)	90 months	
PROJECT ESTIMATED COST (Dec. 2014 price level)		
Total Completed Cost (Crore)	Rs. 4693.32	
Cost per MW	Rs. 10.20	
TARIFF		
1st Year Tariff (Rs./ Unit)	7.17	
35 Years Levelized tariff (Rs./ Unit)	6.30	

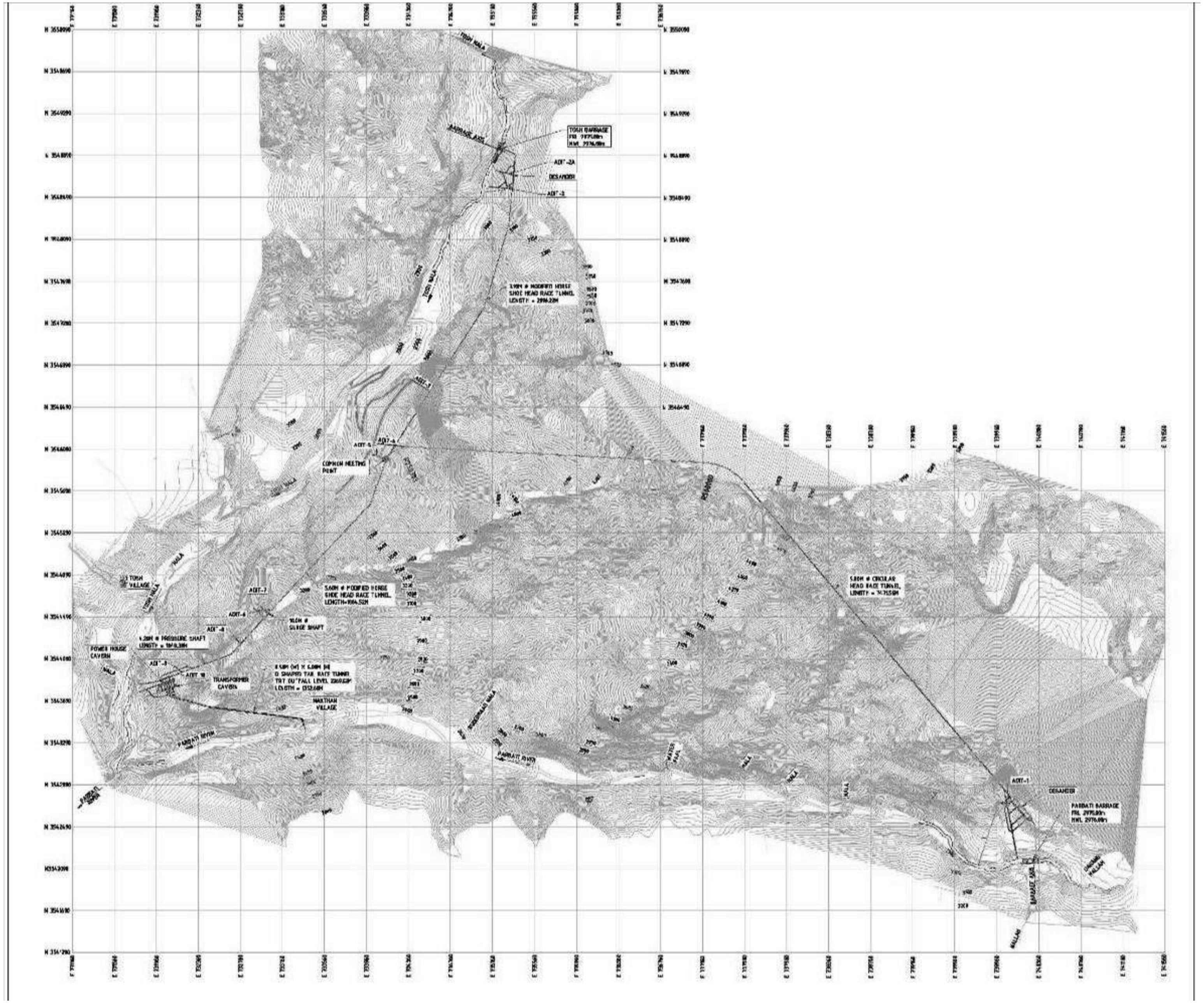


Figure 2.12: General Layout plan of Nakhtan HEP

Table 2.32: Salient Features of Thana Plaun (191 MW)

LOCATION	
District	Mandi
Name of River	Beas River
Coordinates - Diversion Site	31°49'28.22" N, 76°50'20.53" E
HYDROLOGY	
Catchment area at diversion site (km^2)	7378
Average Discharge (cumec)	107.60
DIVERSION STRUCTURE	
Type	RCC Dam
Dam Top level (masl)	719
Height of Dam (m)	85
River Bed level (masl)	634
FRL (masl)	716
MDDL (masl)	697
Live Storage (MCM)	44.93
HEAD RACE TUNNEL	
Type	Horse Shoe
Number	Two
Diameter (m)	6.30 and 7.30
Length (m)	116.30 and 146.40
PENSTOCK/ PRESSURE SHAFT	
Type	Underground
Number	**Pressure Shaft-1:** 5.7 m dia. bifurcating into 2.65 m and 5.00 m dia. which further bifurcates into two branch penstocks of 4.25 m and 2.65 m Dia. **Pressure Shaft-2:** 6.0 m dia. bifurcating into two branch penstocks of 4.25 m Dia. each
Diameter (m)	**Pressure Shaft-1:** 5.7m, 4.25 m and 5.00m and 2.65m **Pressure Shaft-2:** 6.0 m and 4.25 m
Length upto Bifurcation of main pressure shafts (m)	**Pressure Shaft-1 :**92m **Pressure Shaft-2:** 127 m
POWERHOUSE	
Type	Underground
Installed Capacity (MW)	191
Rated Head (m)	72.97
Tail water level (masl)	634 (Monsoon), 632.70 (Lean), 633.30 (Non-Monsoon Peaking Hours), 631.70 (Non-Monsoon Non-Peaking Hours)
TURBINE	
Type	Vertical Francis
Numbers	Five
Rated Output	3 x 50.33 MW and 2 x 20 MW
POWER BENEFITS	
Annual energy in 90% dependable year on 95% machine availability (GWh)	524.91 (Main Units), 143.16 (Environmental Units)
PROJECT COST	
Total Cost (Crore)	Rs. 2007.46
Levelised Tariff at 90% Dependable Year (Rs/KWh)	Rs. 6.70
Levelised Tariff at 50% Dependable Year (Rs/KWh)	Rs. 6.58
CONSTRUCTION PERIOD (excluding 18 months preconstruction activities)	4.5 Years

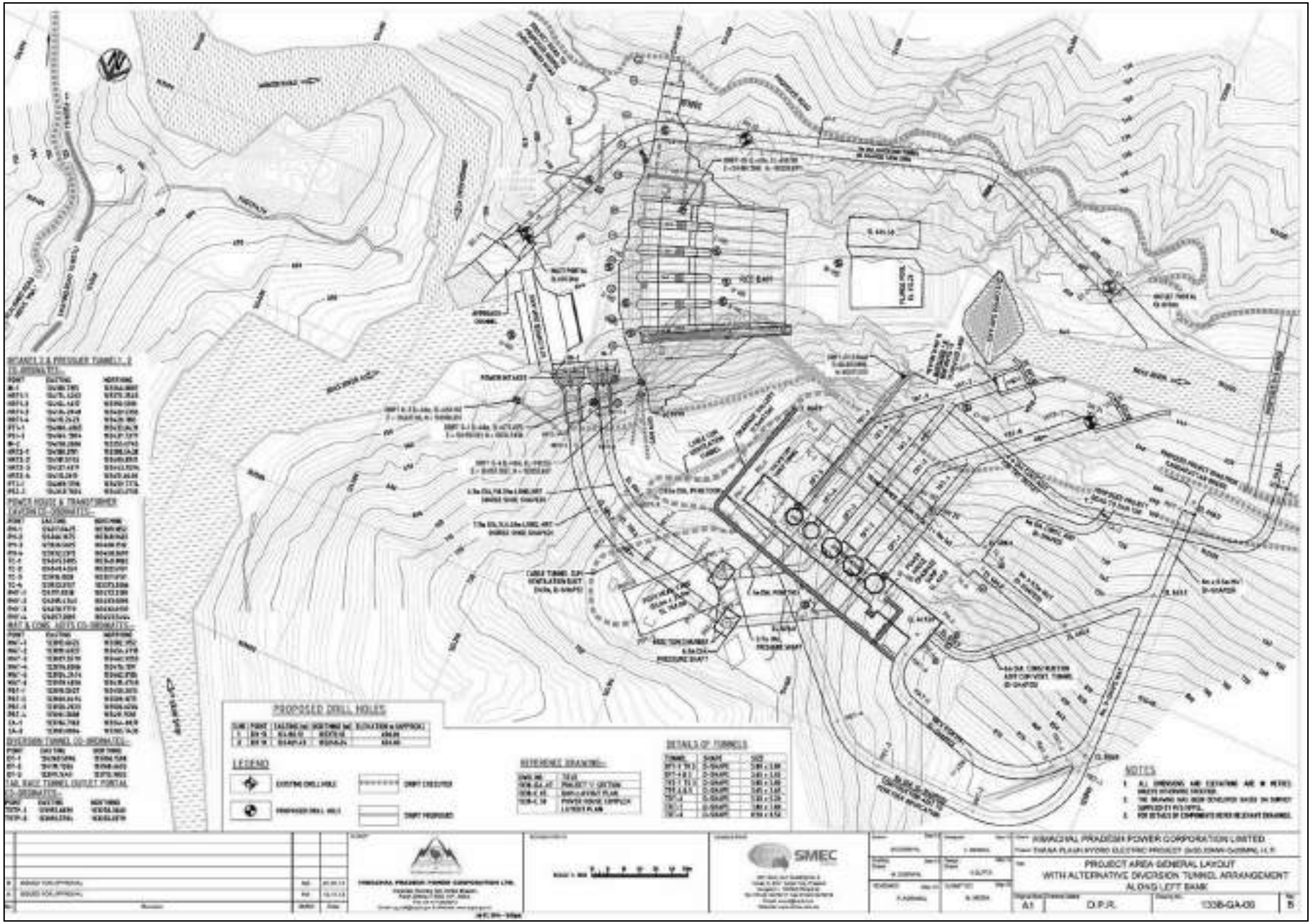


Figure 2.13: General Layout Plan of Thana Plaun HEP

Table 2.33: Salient Features of Triveni Mahadev (96 MW)

LOCATION	
District	Mandi
Name of River	Beas River
HYDROLOGY	
Catchment area at diversion site (km^2)	8155 (7740 of Beas + 415 of Binwa Khad)
Average Discharge (cumec)	250.87
DIVERSION STRUCTURE	
Type	Concrete Gravity Dam
Dam Top level (masl)	595
Height of Dam (m)	31.50
River Bed level (masl)	563.50
FRL (masl)	592
MDDL (masl)	590
Live Storage (MCM)	5.08
Barrage on Binwa Khad to divert water into HRT	15.5 m high
HEAD RACE TUNNEL	
Type	Horse Shoe
Number	One
Diameter (m)	9.50
Length (m)	1850
PENSTOCK/ PRESSURE SHAFT	
Type	Underground/ Surface
Number	Three
Diameter (m)	4.5
Total Length Pressure Shaft/Penstock (m)	169
POWERHOUSE	
Type	Surface (Main including one monsoon unit), Surface (Dam Toe Environmental Releases)
Installed Capacity (MW)	96
Tail water level (masl)	552
TURBINE	
Type	Vertical Kaplan
Numbers	Five
Rated Output	3 x 26.67 MW and 2 x 8.5 MW

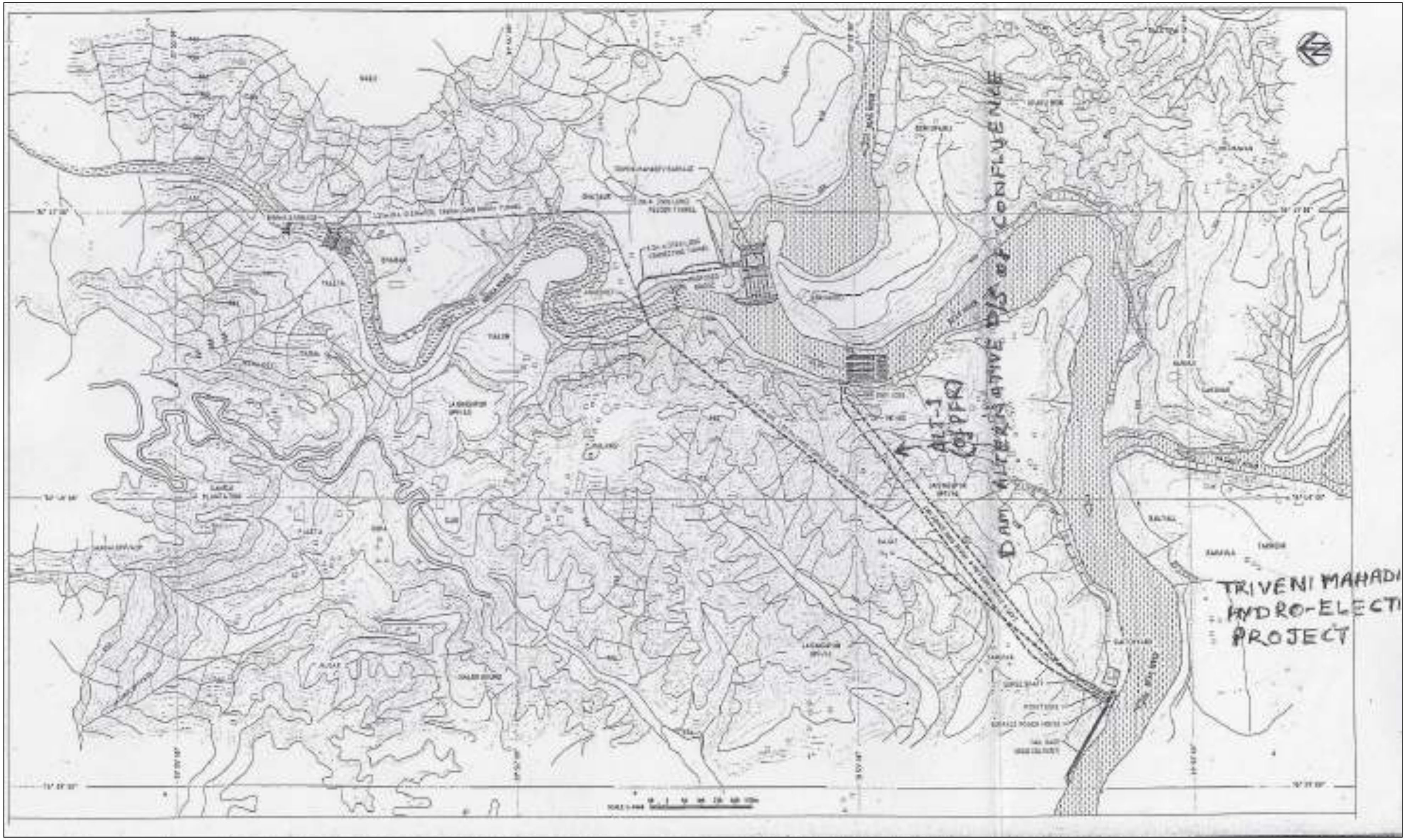


Figure 2.14: General Layout plan of Triveni Mahadev HEP

Table 2.34: Salient Features of Dhaulasidh (66 MW)

LOCATION	
District	Hamirpur
Name of River	Beas River
Coordinates - Diversion Site	31° 48' 23.1" N, 76° 26' 30.7" E
HYDROLOGY	
Catchment area at diversion site (km^2)	9580.00
Design Discharge (m^3/s)	175
DIVERSION STRUCTURE	
Type	Straight Concrete Gravity Dam
Height from river bed (m)	51
Top of Structure (masl)	523
FRL (masl)	520
MDDL (masl)	519
Average Bed level (masl)	472
Live Storage (10^6 m^3)	6.87
PENSTOCK	
Type	Surface
Number	Two
Diameter (m)	4.3
Length (m)	60.50 each
POWERHOUSE	
Type	Dam Toe Surface
Installed Capacity (MW)	66
Rated Head (m)	45.33
Tail water level (masl)	473.3
TURBINE	
Type	Vertical Francis
Numbers	Two
Rated Output	33 MW each
POWER BENEFITS	
90% Dependable Energy (GWh)	257.16
PROJECT COST	
Capital Cost (Rs)	489.74 Crore

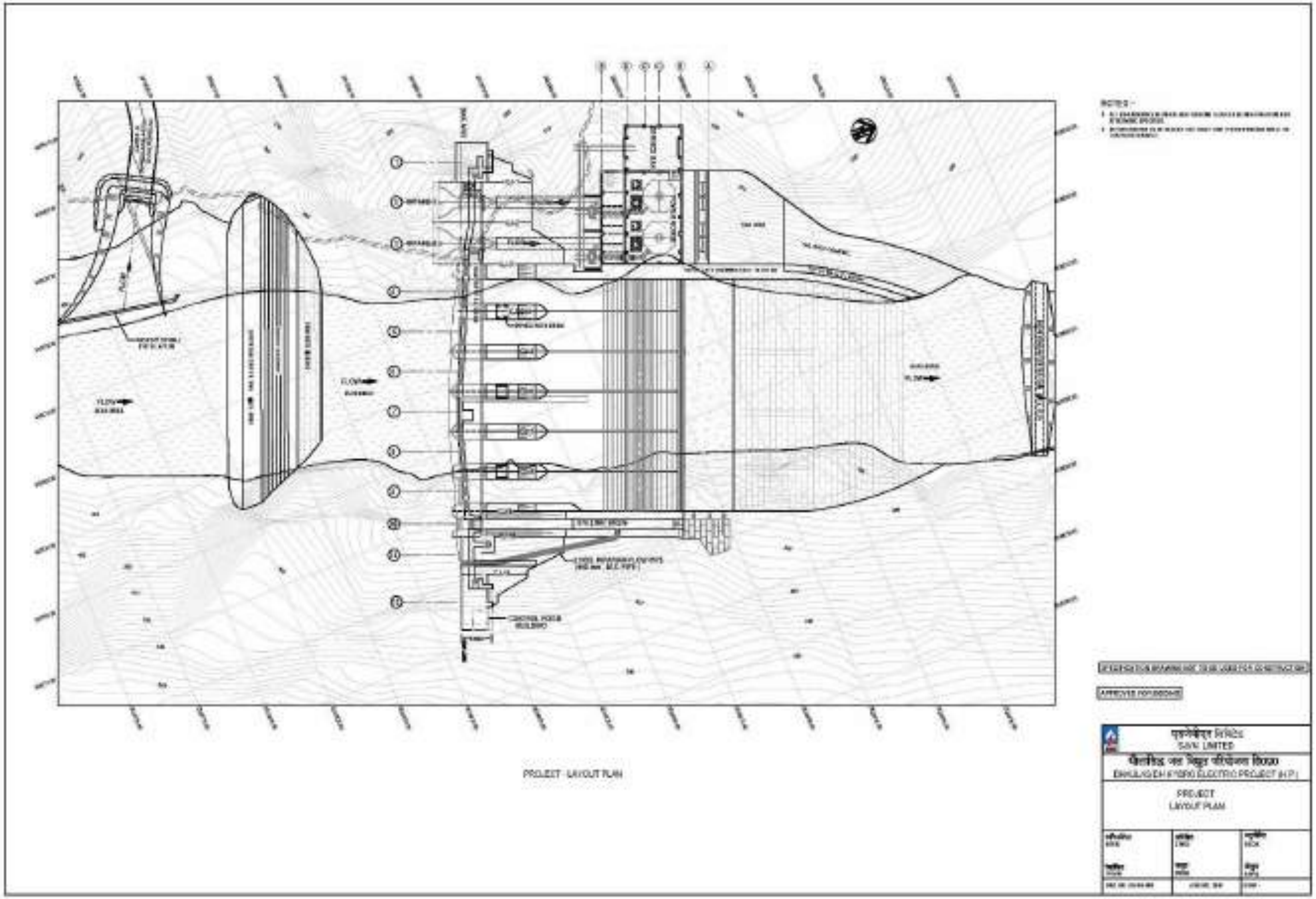


Figure 2.15: General Layout plan of Dhaulasidh HEP

Table 2.35: Salient Features of Parbati (12 MW)

LOCATION	
District	Kullu
Name of River	Parbati River
Coordinates - Diversion Site	32° 4' N, 77° 14' E
Coordinates - Powerhouse	31° 56' N, 77° 6' E
HYDROLOGY	
Catchment area at diversion site (km^2)	Downstream of Tail Race of Malana HEP (86 MW)
Design Discharge (m^3/s)	21.5
DIVERSION STRUCTURE	
Type	Trench Weir
River Bed level (masl)	1391
High Flood level (masl)	1395
Trash Rack Level (masl)	1391
HEAD RACE TUNNEL	
Type	Partial D Shaped
Size (m)	3.75 x 3.75
Length (m)	5250
PENSTOCK	
Type	Surface Circular Steel
Diameter (m)	114 upto bifurcation & 15 including branches
Length (m)	3 upto bifurcation & 2.25 including branches
POWERHOUSE	
Type	Surface
Installed Capacity (MW)	12
Average Net Head (m)	79.89
Average Tail water level (masl)	1312
TURBINE	
Type	Francis
Numbers	Two
Rated Output	6 MW each
POWER BENEFITS	
Annual energy generation in 2008-09 with 20% COL (MU)	51.369
PROJECT COST	
Total Cost (Rs)	7835.217 lakh

Table 2.36: Salient Features of Hurla-I (9.4 MW)

LOCATION	
District	Kullu
Name of River	Hurla Nala
Coordinates - Powerhouse	31° 15' N, 77° 14' E
HYDROLOGY	
Catchment area at diversion site (km^2)	122.4 (Pre Parbati)
	63.2 (Post Parbati)
Design Discharge (m^3/s)	4.67
DIVERSION STRUCTURE	
Type	Trench Weir with Intake Structure of RCC
FRL (masl)	1440
HEAD RACE TUNNEL	
Type	D Shaped
Size (m)	2.0 x 2.5
Length (m)	1831
FOREBAY TANK	
Type	Rectangular RCC
Size (m)	35 (L) x 7.5 (W) x 1.3 (D)
Elevation (masl)	1435
Capacity (cumec)	450
PENSTOCK	
Type	Fabricated from Steel Plate
Number	One
Diameter (m)	1.45
Length (m)	550
POWERHOUSE	
Type	Surface
Installed Capacity (MW)	5.4
Design Head (m)	237
Tail water level (masl)	1185
TURBINE	
Type	Horizontal Francis
Numbers	Two
Rated Output	4.7 MW each
POWER BENEFITS	
95% Dependable Energy (MU)	48.17 (Post Parbati)
	59.69 (Pre Parbati)
PROJECT COST	
Total Cost (Rs)	7121 lakh

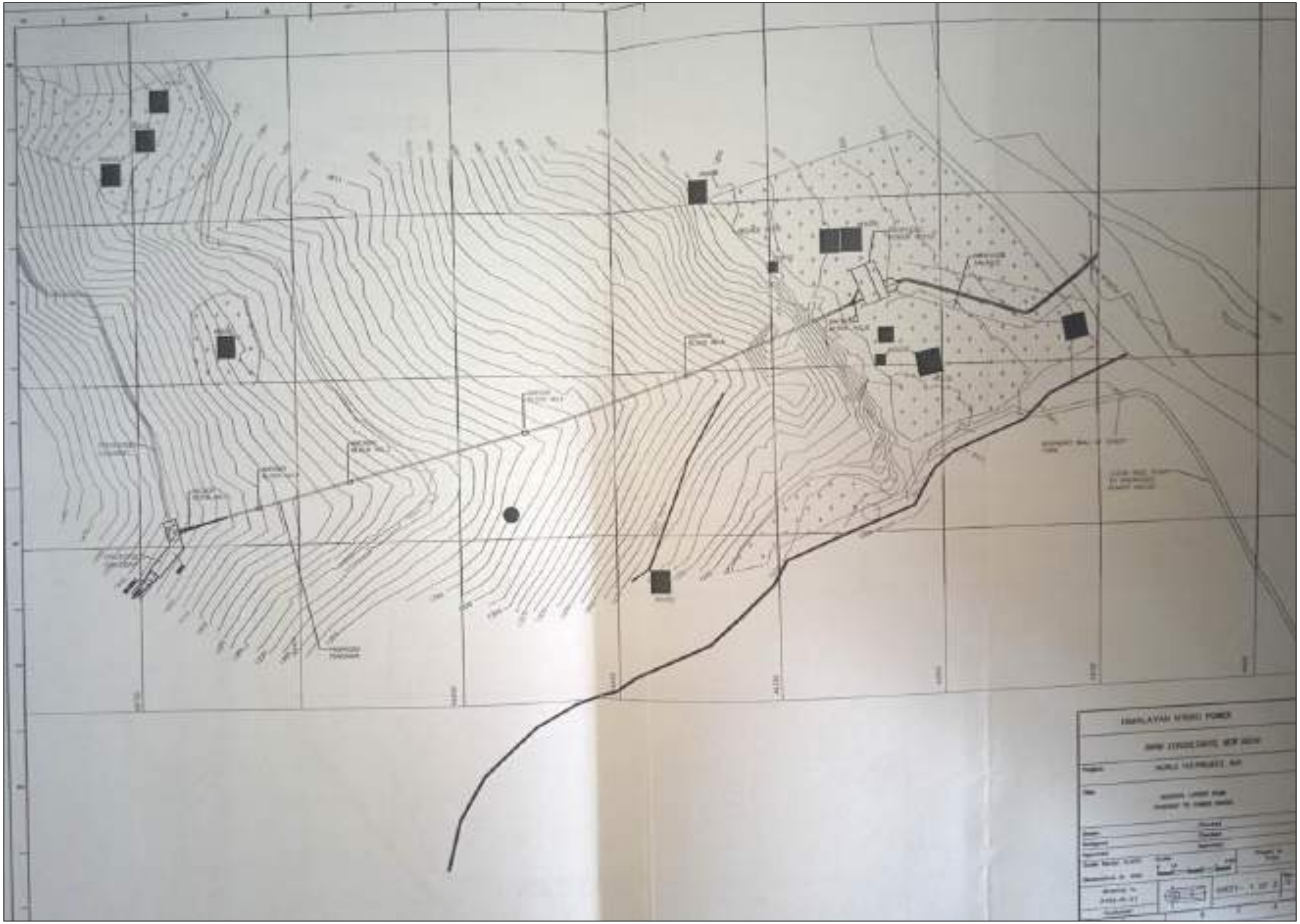


Figure 2.16: General Layout plan of Hurla-I SHEP

Table 2.37: Salient Features of Jari (12 MW)

LOCATION	
District	Kullu
Name of River	Parbati River
Coordinates - Diversion Site	32° 00' 29.79" N, 77° 17' 23.84" E
Coordinates - Powerhouse	32° 00' 15.99" N, 77° 15' 05.42" E
HYDROLOGY	
Effective Catchment area at diversion site (km^2)	182.79
Design Discharge (cumec)	20.35
DIVERSION STRUCTURE	
Type	Concrete Gravity Floor Type Weir
Crest Level of other bay of Weir (masl)	1480
HFL upstream (masl)	1481.43
HEAD RACE TUNNEL (Desilting Tank to Tunnel Inlet)	
Type	RCC Channel, Square Box Section
Size (m)	3.50 x 3.50
Length (m)	255.23
HEAD RACE TUNNEL (Tunnel Inlet to Surge Shaft)	
Type	D Shaped Pressurized Tunnel
Diameter (m)	3.5
Length (m)	3294.54
SURGE SHAFT	
Type	Underground, Steel/RCC
Diameter (m)	3.0 and 10.80
Depth (m)	75.5
Static Water Level (masl)	1480
Operating Water level (masl)	1476.335
Bed Level (masl)	1412.5
Top Level of Tank (masl)	1488
MDDL (masl)	1473.51
PENSTOCK	
Type	Underground Steel
Number	One (Main), Three (Branches)
Diameter (m)	2.50 (Main), 1.60 (Each Branch)
Length (m)	251.30 (Main), 15.00 (Each Branch)
POWERHOUSE	
Type	Surface
Installed Capacity (MW)	12
Net Head (m)	70.3
Tail water level (masl)	1400
TURBINE	
Type	Horizontal Shaft Francis
Numbers	Three
Rated Output	4.00 MW Each
POWER GENERATION	
75% Dependable Energy (Mu)	105.12 (Pre Parvati Stage-II Commissioning) 65.52 (Post Parvati Stage-II Commissioning)
ESTIMATE OF COST	
Total Project Cost (Lakh)	Rs. 10204.70
Cost per MW (Lakh)	Rs. 850
CONSTRUCTION PERIOD	3 Years (after financial closure)

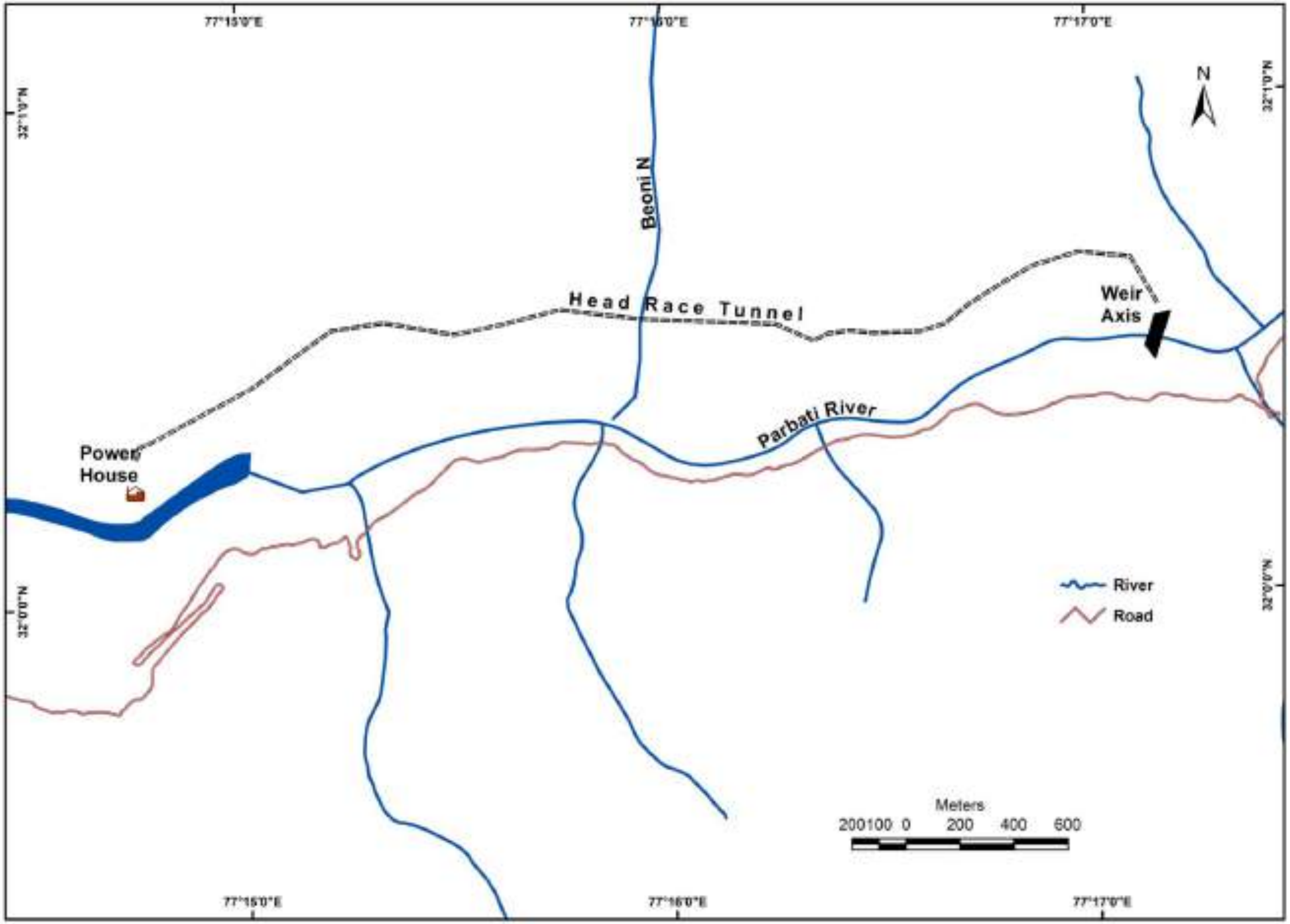


Figure 2.17: General Layout map of Jari SHEP

Table 2.38: Salient Features of Raison (18 MW)

	PROPOSAL-I	TENTATIVE (PROPOSAL-II)
LOCATION		
District	Kullu	Kullu
Name of River	Beas River	Beas River
HYDROLOGY		
Catchment area at diversion site (km^2)	1025	1025
Design Discharge (cumecs)	137.5	137.5
DIVERSION STRUCTURE		
Type	Labyrinth weir Rectangular shaped	Labyrinth weir Rectangular shaped
Crest Elevation (masl)	±1327	±1327
DESILTING TANK		
Type	Surface, central Cunnette type	Surface, central Cunnette type
Size (m)	50x34x4	50x34x4
WATER CONDUCTOR SYSTEM	**POWER CHANNEL CUM FOREBAY**	**POWER CHANNEL**
Size (m)	16m wide, varying height	16m wide, varying height
Length (m)	±430	±235
		PENSTOCK
Type		surface, circular steel penstock
Number		Three
Diameter (m)		3.4 (each)
Length (m)		220 (each)
POWERHOUSE		
Type	Surface	Surface
Installed Capacity (MW)	18	18
Net Head (m)	15	15
Maximum Tail water level (masl)	1311	1311
TURBINE		
Type	Kaplan, horizontal axis	Kaplan, horizontal axis
Numbers	3	3
Rated Output	6 MW each	6 MW each
POWER BENEFITS		
75% Dependable Energy (Gwh)	78.57	78.57
PROJECT ESTIMATED COST (Tentative)		
Total Completed Cost (Crore)	161.39	146.50
Cost per Kwh	3.56	3.23

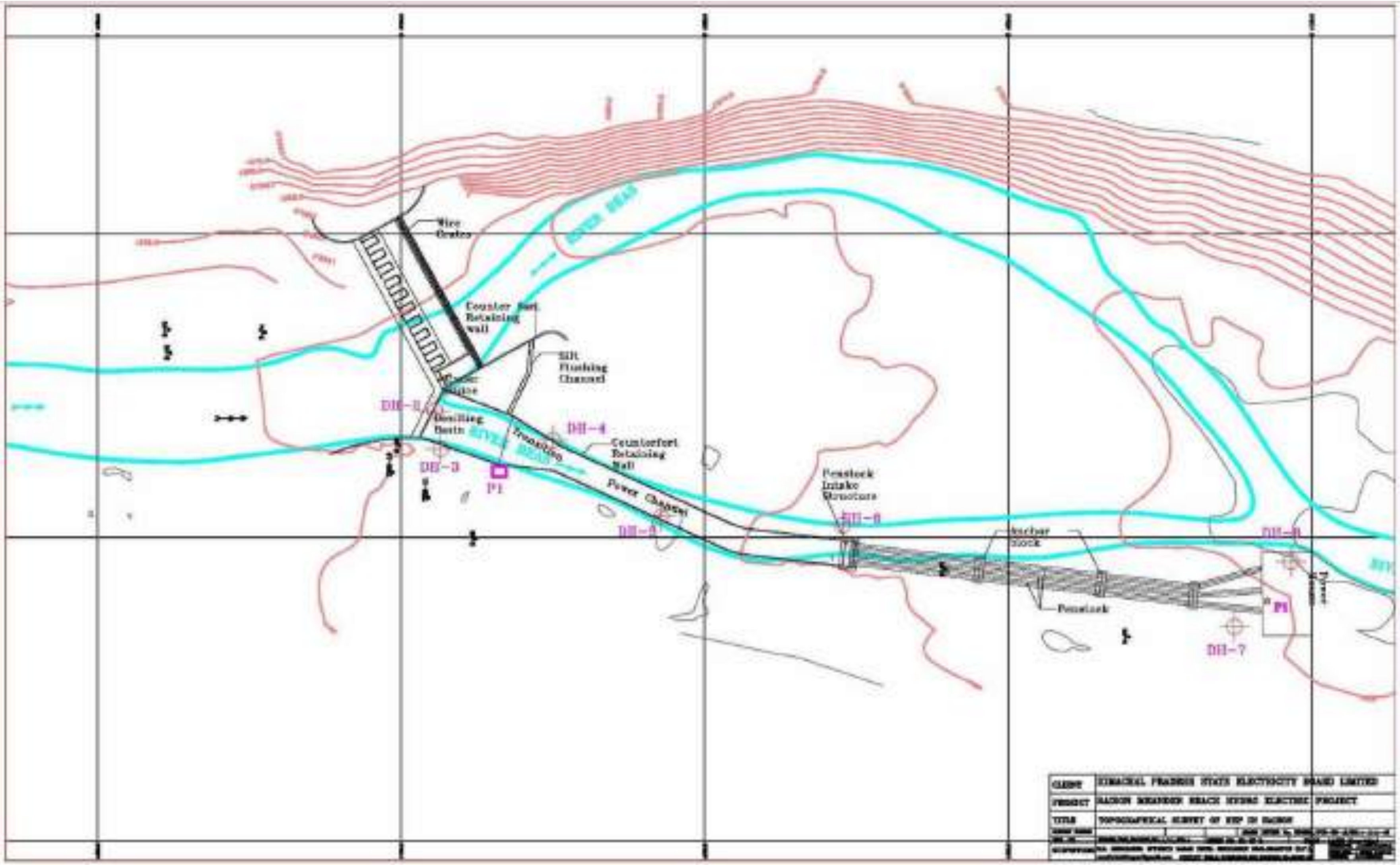


Figure 2.18: General Layout plan of Raison HEP

Table 2.39: Salient Features of Kilhi Bahl (7.5 MW)

LOCATION	
District	Kangra
Name of River	Binwa and Awa Nalas
Coordinates - Diversion Site	32° 00' 40" N, 76° 36' 50" E
Coordinates - Powerhouse	31° 58' 40" N, 76° 37' 15" E
HYDROLOGY	
Catchment area at diversion site (km^2)	282.00
Design Discharge (m^3/s)	10.34
DIVERSION STRUCTURE	
Type	Raised Crested Type Weir
River Bed level (masl)	786
HEAD RACE TUNNEL	
Type	D Shaped
Diameter (m)	2.5
Length (m)	3630
SURGE SHAFT	
Type	Underground
Diameter (m)	6
Height (m)	33
PENSTOCK	
Type	Circular, Underground/ Surface Steel
Diameter (m)	2.2
Length (m)	150
POWERHOUSE	
Type	Surface
Installed Capacity (MW)	7.5
Net Head (m)	86
Tail water level (masl)	690
TURBINE	
Type	Francis
Numbers	Three
Rated Output	7.5 MW each
POWER BENEFITS	
75% Dependable Energy (MU)	46.93
PROJECT COST	
Total Cost (Rs)	7400.65 Lac

Table 2.40: Salient Features of Malana-III (30 MW)

LOCATION	
District	Kullu
Name of River	Malana Nala
Coordinates - Diversion Site	32° 06' 16.35" N, 77° 18' 31.80" E
Coordinates - Powerhouse	32° 5' 4.42" N, 77° 16' 42.24" E
HYDROLOGY	
Catchment area at diversion site (km^2)	124.75
Design Discharge (m^3/s)	14.17 i/c Shingle and Sand flushing discharge
DIVERSION STRUCTURE	
Type	Type Weir
River Bed level (masl)	2895
POWER PIPE	
Type	Circular
Diameter (m)	2
Length (m)	3918
SURGE TANK	
Size (m)	8 (L) x 8 (W) x 6 (H)
Maximum Upsurge level (masl)	2910.35
Minimum Down Surge Level (masl)	2874.75
POWERHOUSE	
Type	Surface
Installed Capacity (MW)	25
Rated Net Head (m)	325.2
Maximum Tail water level (masl)	2550
TURBINE	
Type	Vertical Axis Pelton
Numbers	Two
Rated Output	15 MW each
POWER BENEFITS	
75% Dependable Energy (GWh)	127.64
PROJECT COST	
Total Cost (Rs)	212.66 Crore

Table 2.41: Salient Features of Jobrie (12 MW)

LOCATION		
District	Kullu	
Name of River	Jobrie Nala	Allain Nala
HYDROLOGY		
Catchment area at diversion site (km^2)	66.70	57.3
Design Discharge (m^3/s)	12.53 inclusive of 20% overload during monsoon months	
DIVERSION STRUCTURE		
Type	Raised Crested Boulder Filled Weir	Raised Crested Boulder Filled Weir
FRL (masl)	2965	2965
HFL (masl)	2968.5	2967.5
HEADRACE TUNNEL		
Type	D Shaped, Pressurized	D Shaped, Pressurized
Size (m)	2.0 (W) x 2.5 (H)	2.0 (W) x 2.5 (H)
Length (m)	762.50	2167
PENSTOCK		
Type	Circular, ASTM 285 Grade "C"	
Number	One (Main), Three (Branches)	
Diameter (m)	2.00 (Main), 1.64 (One Branch) and 1.16 (Two Branches Each)	
Length (m)	519.739 (Main), 6.975 (One Branch) and 18.00 (Two Branches Each)	
POWERHOUSE		
Installed Capacity (MW)	18 + 20% Continuous Overload	
Gross Head (m)	205	
Tail water level (masl)	2760.9	
TURBINE		
Type	Horizontal Axis Francis	
Numbers	Three	
Rated Output	6 MW each + 20% Continuous Overload	
POWER BENEFITS		
50% Dependable Energy (MU)	108.74	
75% Dependable Energy MU)	100.69	
90% Dependable Energy (MU)	91.48	
PROJECT COST		
Total Cost (Rs)	15758.11 Lakh	

Table 2.42: Salient Features of Larji (126 MW)

LOCATION	
District	Mandi
Name of River	Beas
HYDROLOGY	
Catchment area at diversion site (km^2)	4921
Design Discharge (cumec)	312.50
DIVERSION STRUCTURE	
Type	Gravity & Masonry
Height from river bed (m)	26.50
Top of Structure (masl)	981.50
River Bed level (masl)	955
Full Reservoir level (masl)	969.50
Minimum Drop Down level (masl)	963.00
Total Volume Content of Dam (TCM)	111.571
HEAD RACE TUNNEL	
Type	Circular
Length (m)	4119.861
Diameter (m)	8.5
PRESSURE SHAFT	
Type	ASTM-A-537
Number	Three
Diameter (m)	4.5 (each)
Length (m)	83.33 (each)
POWERHOUSE	
Type	Underground
Installed Capacity (MW)	126
Net Head (m)	
Tail water level (masl)	899.6
TURBINE	
Type	Kaplan
Numbers	Three
Rated Output	42 MW each
POWER BENEFITS	
50% Dependable Energy (MU)	
90% Dependable Energy (MU)	
PROJECT COST	
Total Cost (Rs)	796.98 Crore
Year of Commissioning/ Completion	
Commercial Operation Date (COD)	Unit I – 19-07-2007
	Unit II – 12-10-2006
	Unit III – 29-09-2006

CHAPTER-3

METHODOLOGY

3.1 GENERAL

To undertake Cumulative Impact Assessment and Carrying Capacity Study (CIA&CCS) of Beas river basin vis-à-vis proposed hydropower development in Himachal Pradesh, it is essential to establish the present environment setting in the basin on which impacts of development can be predicted and strategy for sustainable development can be formulated. Scoping for the study has set the requirement of extensive baseline data to be collected. Extensive baseline surveys were carried out for data collection, sampling and analysis. Additionally, data was collected from secondary sources, collated and analyzed. Entire data collection and analysis work was undertaken scientifically based on the pre-defined methodology, which is discussed in ensuing text. The data on baseline status of various environmental parameters in the study area was collected through primary surveys for three seasons as specified in the approved TOR.

3.2 DATA COLLECTION

3.2.1 Secondary Data Collection

In addition to primary surveys, substantial secondary data was also collected through interaction with various state and project officials. Sources and data so collected have been mentioned below:

- Directorate of Energy, Government of Himachal Pradesh, Himachal Pradesh Power Corporation Ltd. (HPPCL), State Forest Department and State Fisheries Department. This includes status of planned and allotted projects in the basin, Forest Working Plan, Wildlife sanctuaries/National Parks and other protected areas in the basin and their management plans, fish fauna and conservation measures, if any.
- Data collected from published sources and literature survey for forest type, flora, fauna and fishes; their conservation status i.e. Rare, Endangered & Threatened (RET), Scheduled species as per Indian Wildlife (Protection) Act (1972), threatened status according to IUCN Red List, Red Data Books by Botanical Survey of India and conservation of important medicinal plants according to guidelines of CAMP, 2013 (Conservation Assessment and Management Plan) workshops held at Shimla in 2010 and fishes according to CAMP, 1998.
- Procurement of satellite data, Forest Survey of India (FSI) data, Advanced Space borne Thermal Emission and Reflection Radiometer (ASTER) Global Digital Elevation Model (GDEM) Version 2 data and digital maps; used to prepare base maps, longitudinal sections of river stretches, slope maps, drainage maps, forest cover maps, etc.

3.2.2 Primary Data Collection

Primary Data collection has been undertaken for different months and seasons as per the pre-defined TOR. Field surveys were undertaken to collect data on various environmental parameters like water quality, flora, fauna, fisheries, aquatic ecology, etc.

3.3 GENERATION OF THEMATIC LAYERS

The spatial database on physiographic features like drainage, roads, settlements and villages, etc. was created from maps of topographic sheets and satellite data followed by ground truth verification and data analysis with Geographic Information System (GIS) tools. GIS based maps have been provided for the following themes:

- General Features (Villages, roads, tributaries)
- Hydrology: Drainage of Beas river along with their tributaries
- Soil
- Elevation profile
- Slope
- Land use in study area
- Vegetation

A comprehensive list of various thematic data layers prepared and used in the study is given in table below.

Description of the Data Layer	Procedure used in generation
Catchment Boundary (Beas basin in Himachal Pradesh) in ARC and POLYGON shape files	Catchment area in Himachal Pradesh has been delineated using Survey of India 1:50000 topo-sheets and satellite data
Hydro – electric projects in the Beas catchment study area	All hydro projects in Beas basin of Himachal Pradesh have been marked on GIS and data has been taken from Directorate of Energy, Himachal Pradesh as point shapefiles
Main roads passing through the study area	Data related to roads have been picked up from Survey of India 1:50000 topo-sheets and satellite data PWD, BRO and existing published maps. Same has been digitised as GIS layer as polyline shapefile
Other roads in the study area	Data related to roads have been picked up from PWD, BRO and existing published maps. Same has been digitised as GIS layer as polyline shapefile
Rivers, tributaries and drainages in POLYLINE shapes	Small rivers and drainages have been delineated using Survey of India topo-graphical sheets and have been updated using IRS P6, LISS IV satellite data as well as Google Earth. (Polyline shape)
Rivers, tributaries and drainages in POLYGON shapes	Major rivers and drainages have been delineated using Survey of India topo-graphical sheets and have been updated using IRS P6, LISS IV satellite data as well as Google Earth. (Polygon shape)
Soil data layers as per NBSS&LUP, Nagpur	Soil maps have been procured from National Bureau of Soil Survey and Land use Planning, Nagpur in hard copy formats which were geo-referenced and digitized as GIS layer as polygon shapefiles.
Raw satellite data for IRS P6 satellite, LISS III sensor	Raw satellite data for IRS P6, LISS III sensor has also been procured from National Remote Sensing Centre.
Classified data for land cover	Land use and land cover map of the basin was prepared from the data of 2015 was procured from Forest Survey of India (FSI). It was further refined by ground checks carried out during the field surveys. For this purpose FCC of the entire study area was generated from digital satellite data of LISS-III, IRS-P6.
Village level data for all villages in the study area as per latest Census of India	All census data like population, occupational profile, literates, SC/ST population etc. (males/females) have been arranged in EXCEL table.
GIS files for forest data layers as per Forest Survey of India	Forest related data has been procured from Forest Survey of India and forest classification has been done accordingly and has been placed on GIS platform.
Digital Elevation Model of Beas Catchment in Himachal Pradesh (Study Area) showing different elevation ranges	Digital Elevation model for the entire study area has been derived using digitised contours and spot levels from topographical sheets.
Slope Map	Slope map has been derived using digital elevation model of the study area. The entire study area has been divided into different slope classes.

Protected Area National Parks and Wildlife Sanctuaries in the (Beas Catchment) in Himachal Pradesh	Boundary of National Parks and Wildlife Sanctuaries has been marked as GIS layer using Gazette notification.

3.4 STUDY AREA (BEAS BASIN) DEMARCATION

The study area i.e. Beas basin in Himachal Pradesh was delineated using Survey of India toposheets at 1:50000 starting from Rohtang Pass up to Dam site of Pong Dam. The following toposheets were used for delineation.

Survey of India Toposheets : The entire study area is covered in following topographical sheets of Survey of India at 1:50000 scale (**refer Figure 3.1**): 43P15, 43P16, 44M13, 52D3, 52D4, 52D7, 52D8, 52D12, 52D16, 52H3, 52H4, 52H7, 52H8, 52H12, 52H16, 53A1, 53A2, 53A5, 53A6, 53A9, 53A10, 53A13, 53A14, 53A15, 53E1, 53E2, 53E3, 53E5, 53E6, 53E7, 53E9, 53E10, 53E13, 53E14.

Projection and Datum : UTM and WGS 84; 46 North

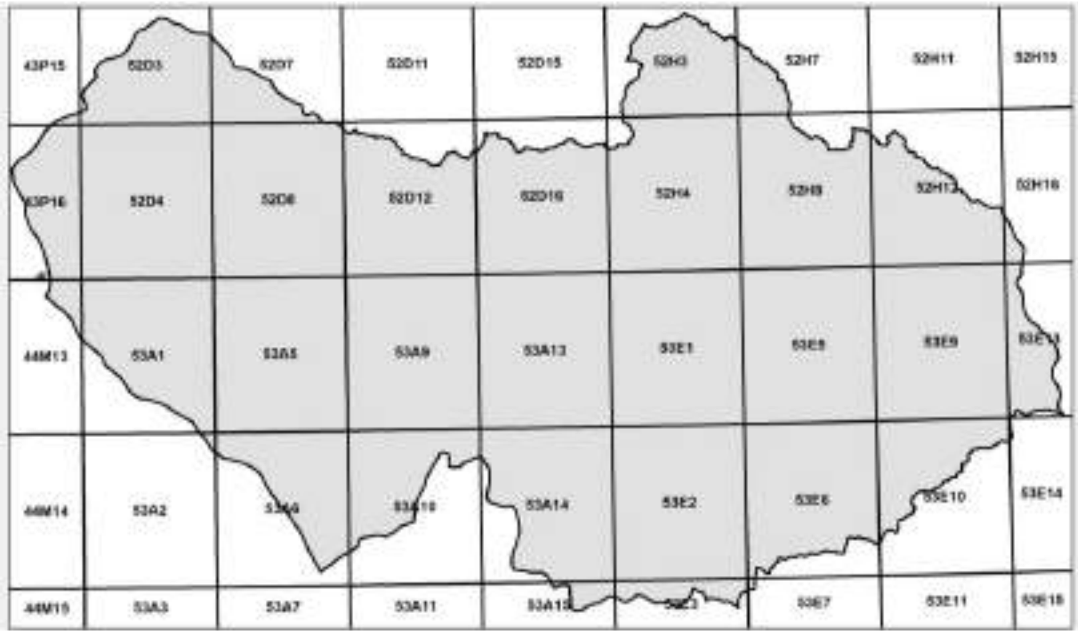


Figure 3.1: Survey of India toposheets at 1:50000 coverage of Beas basin

3.5 LAND USE/ LAND COVER MAPPING

False Color Composite (FCC) of the study area was generated from digital satellite data of LANDSAT ETM+ data downloaded from USGS Earth Explorer portal (https://earthexplorer.usgs.gov/) and is given at **Figure 3.2**. In addition, latest satellite data of Sentinel-2 was also downloaded from USGS portal referred to above. The Sentinel-2 satellite mission was launched by the European Space Agency (ESA) in collaboration with the European Commission, industry, service providers, and data users in June, 2015. Sentinel-2 data is acquired in 13 multispectral bands ranging from Visible and Near-Infrared (VNIR) to Shortwave Infrared (SWIR) wavelengths along a 290-km orbital swath with spectral resolution ranging from 10m to 60m in different bands. Sentinel-2 data of April 2017 was downloaded to generate FCC for visualization purpose mainly. FCC generated from Sentinel-2 is given at **Figure 3.3**.

For the preparation of land use and land cover map of the basin, forest cover data of 2015 was procured from Forest Survey of India (FSI), Dehradun. In addition digital data of 2005 was

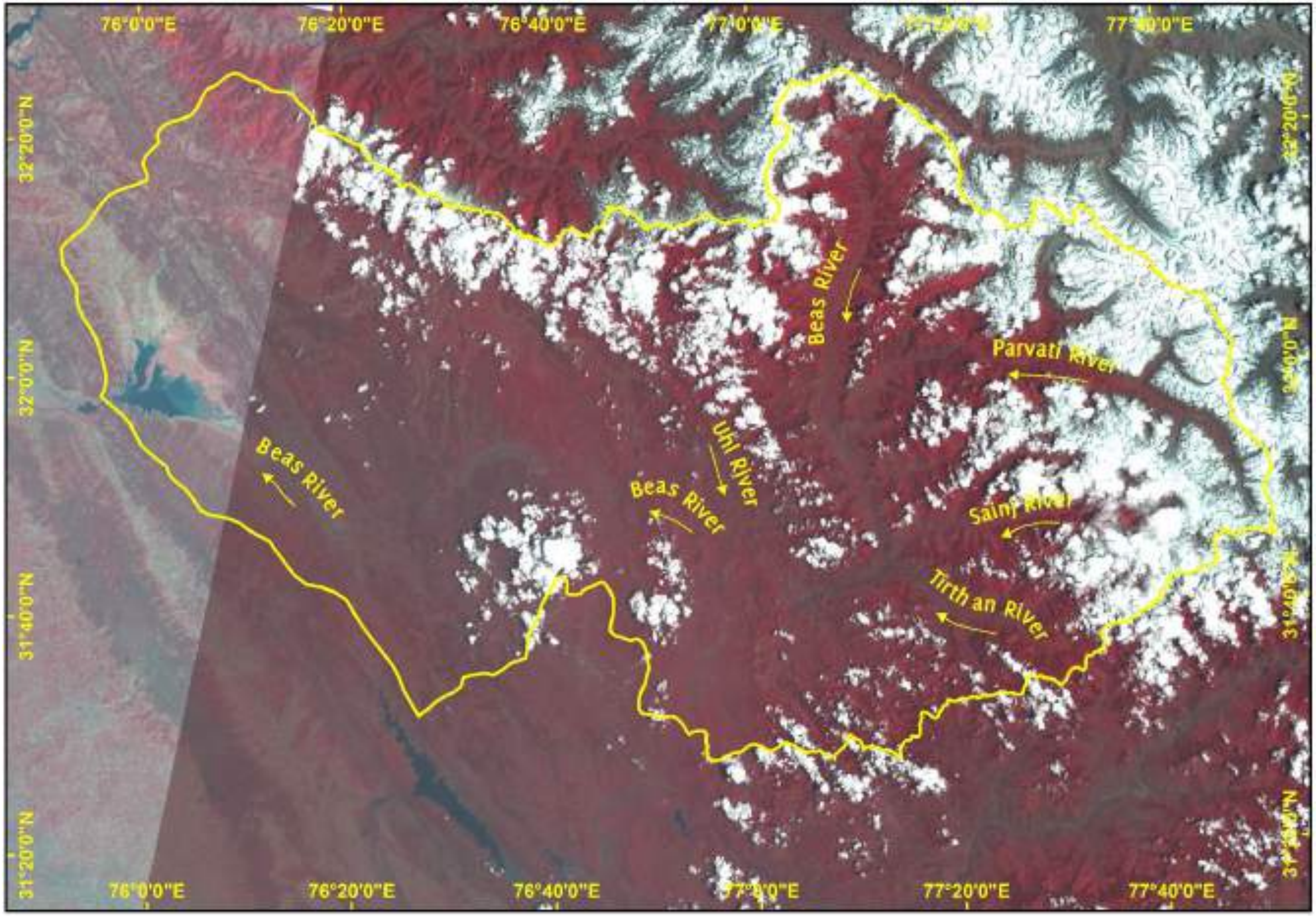


Figure 3.2: FCC generated from Landsat ETM+ data of 2004

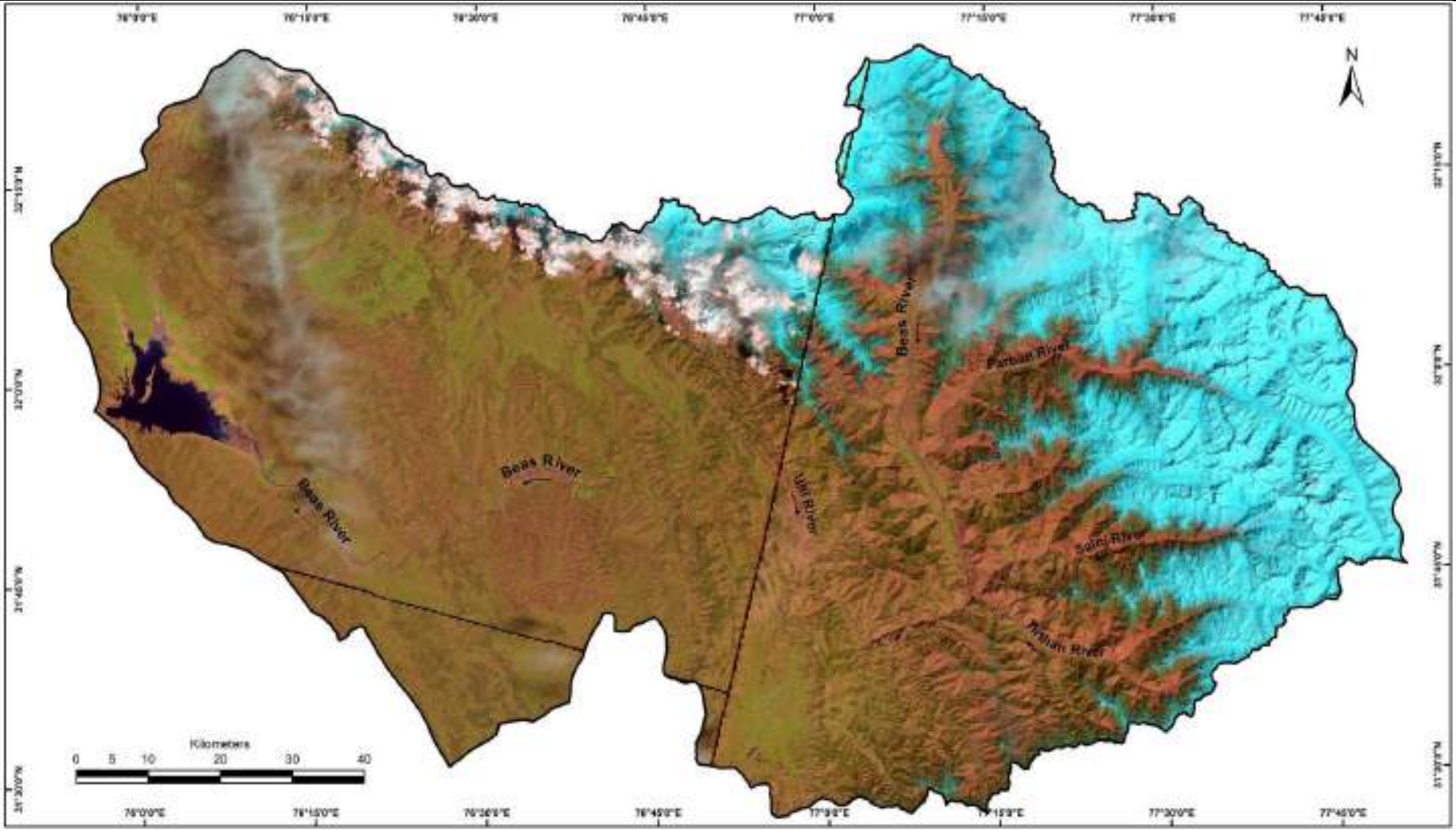


Figure 3.3: FCC generated from Sentinel-2 April 2017 data

also procured from FSI in order to understand the forest cover/ land use change since 2005. The digital data procured from FSI was downloaded and further processed in GIS domain to generate mosaic of Beas basin.

In order to understand the extent of forest cover the classification scheme suggested by Forest Survey of India, Dehradun was adopted for the preparation of land use/land cover map of the basin. The forests with >70% canopy cover has been demarcated as Very Dense Forest, between 40% and 70% canopy cover was delineated as Moderately Dense Forest and between 10% and 40% crown density as Open Forest. Furthermore, degraded forests, grass covered slopes with canopy density <10% were delineated as Scrubs. The area not included in any of the above classes is delineated as Non-forest land cover.

3.6 FOREST TYPES

Administratively the forests in the Beas basin fall under jurisdiction of Kullu, Parvati, Seraj, Mandi, Nachan, Joginder Nagar, Dharamshala, Nurpur, Palampur, Dehra and Suket Forest Divisions which are under administrative control of four Circles namely Kullu, Hamirpur, Dharamshala and Mandi of Himachal Pradesh State Forest Department. Forest types in study area have been described as per the Revised Survey of India by Champion and Seth (1968).

3.7 COMMUNITY STRUCTURE

The objectives of the present floristic study are as follows:

- To prepare an inventory of various groups of plants (Angiosperms, Gymnosperms, Pteridophytes and Bryophytes) in the basin
- To assess the community structure in the study area
- To determine Importance Value Index and
- Shannon Wiener Diversity Index for trees, shrubs and herbs

3.7.1 Sampling Locations and Methodology

The size and number of quadrats needed were determined using the species- area curve (Misra, 1968). The data on vegetation were quantitatively analyzed for density, frequency as per the methodology given in Curtis & McIntosh (1950), Dhar *et al.* (1997), Greig-Smith, (1957), Misra, (1968), Samant *et al.* (2002) and Joshi and Samant (2004). The Importance Value Index (IVI) for trees was determined as the sum of relative density, relative frequency and relative dominance (Curtis, 1959).

Sampling Site Selection

The sampling locations were selected on the basis of the area located in the vicinity of operational, under construction as well as proposed projects and their components. Entire Beas basin has been covered with required number of sampling locations as per TOR i.e. 60 locations. No sampling site was located in Tirthan catchment which has been declared as no-go area by the state government. Sampling locations were identified to capture the baseline status and depending upon the anticipated changes in the topography, vegetation, forest types, etc. so as to capture the representative baseline of the area. Reach/ coverage of each project was considered from tip of the Full Reservoir Level (FRL) to the tail water outfall point. Therefore, for projects in cascade some sampling locations were considered representative of more than one project. Coverage area for terrestrial ecology sampling sites was invariably spread over an area of 4 - 5 sq km in general in which 10-15 number of 10m x 10m quadrats were laid to capture the vegetation structure.

As per the requirement of ToR, surveys for terrestrial ecology were conducted during three seasons i.e. Pre-monsoon/Summer (May-June, 2016), Monsoon (August-September, 2016) and Post-monsoon/winter (November-December, 2016).

The number of quadrats studied varied from minimum of 10 quadrats to 15 quadrats at a particular sampling site/ area depending upon the heterogeneity/ homogeneity of the vegetation encountered at a particular site/ area (**see Table 3.2**). At each site the quadrats were laid along the altitudinal gradient beginning from the vegetation along the river bank/riverine vegetation and further up along the slope ensuring maximum possible representative coverage of the vegetation of a particular sampling location. Each sampling location/ area was divided into grids vertically as well as horizontally along the slopes thereby capturing the maximum diversity of vegetation. In case of trees total basal area/cover per unit area was calculated by measuring the '*cbh*' (circumference at breast height) of each individual tree belonging to different species, which was then converted into basal area using the formula as follows.

Based on the quadrat data, frequency, density and cover (basal area) of each species were calculated. The data on density and basal cover are presented on per ha basis.
The **Importance Value Index (IVI)** for different tree species was determined by adding up the Relative Density, Relative Frequency and Relative Dominance/ Cover values. The Relative Density and Relative Frequency values were used to calculate the IVI of shrubs and herbs.

For the calculation of dominance, the basal area was determined by using following formula.
Basal area = πr^2

The index of diversity was computed by using Shannon Wiener Diversity Index (Shannon Wiener, 1963) as:
H = - Σ (ni/n) x ln (ni/n)
Where, ni is individual density of a species and n is total density of all the species

The Evenness Index (E) is calculated by using Shannon's Evenness formula (Magurran, 2004).
Evenness Index (E) = H / ln(*S*)
Where, H is Shannon Wiener Diversity index; *S* is number of species

The forest communities were then identified on the basis of IVI values of trees. The single tree species representing > 50% of the total IVI were designated as a single species dominated community, whereas two or more species contributing 50 or > 50% of the total IVI to be named as a mixed community. Species richness has also been determined using Shannon Weiner Diversity Index.

In order to understand the composition of the vegetation, most of the plant species were identified in the field itself whereas the species that could not be identified the photographs were taken of different plant parts for identification later with the help of available published literature and floras of the region (Aswal and Mehrotra, 1994; Chowdhery and Wadhwa, 1984; Dhaliwal and Sharma, 1999; Polunin and Stainton, 1984; Murti, 2001). The nomenclature for all plant species is based upon the latest nomenclature given in www.theplantlist.org. Efforts were made to include synonyms also in addition to new names wherever required. The inventory of plant species was prepared using extensive literature citations and field surveys. Following literature was used for the preparation of up-to-date list of plant species reported from Beas basin. The following literature was consulted for the preparation of inventory of plant species reported from Beas basin in Himachal Pradesh: Samant *et al.*, (2002), Joshi and Samant (2004), Aswal and Mehrotra (1994) Chowdhery and Wadhwa (1984), Dhaliwal and Sharma (1999), Polunin and Stainton (1984) and Murti (2001).

Detailed list of sampling locations and number of quadrats sampled is given at **Tables 3.1 & 3.2** and their location on the map of Beas basin has been marked and is shown in **Figure 3.4**.

Table 3.1: Sampling sites and their locations for vegetation sampling in Beas basin

Sampling Site	Name of Project	Name of Site
V1	Beas Kund HEP	Near Power House site: Beas river
V2	Palchan Bhang HEP	Project area of Proposed Palchan Bhang HEP: Beas river
V3	Bhang HEP	Project area of Proposed Bhang HEP: Beas river
V4	Jobrie HEP	Project area of Proposed Jobrie HEP: Allain Nala
V5	Allain Duhangan HEP	Power House site: Allain Nala
V6		Downstream of diversion site: Duhangan Nala
V7	Malana III HEP	Proposed project area: Malana Nala
V8	Malana II HEP	Upstream of Dam site
V9		Upstream of Power House site
V10	Malana I HEP	Downstream of Barrage site: Malana Nala
V11		Upstream of Power house Site
V12	Tosh HEP	Downstream of Diversion site near Tosh village
V13	Nakthan HEP	Near proposed Diversion site at Tosh Nala
V14		Near proposed Power house site
V15		Near proposed Diversion site at Parbati river
V16	Parbati II HEP	Upstream of Dam site along Parbati river
V17		Upstream of Dam along Tosh Nala
V18		Downstream of Dam site
V19	Balargha HEP	Near Proposed Power House site
V20	Parbati HEP	Proposed project area of Parbati HEP
V21	Baragaon HEP	Near Power house site
V22	Sarbari II HEP	Near Power house site
V23	Fozal HEP	Near Diversion site
V24	Sharni HEP	Proposed project area of near Sarsadi Village Sharni village
V25	Sarsadi HEP	Proposed project area of near Sarsadi Village
V26	Sarsadi II HEP	Proposed project area of near Sarsadi Village
V27	Hurla HEP	Proposed project area of Hurla HEP
V28	Sainj HEP	Upstream of Dam site
V29		Near Power House site
V30	Parbati III HEP	Upstream of Resrvoir area
V31		Downstream of Diversion site
V32		Near Power house site
V33	Lambadug HEP	Downstream Diversion site
V34	Uhl I HEP	Upstream of Barrage site

Sampling Site	Name of Project	Name of Site
V35	Uhl HEP	Proposed diversion site
V36	Lower Uhl HEP	Downstream of proposed diversion site
V37	Uhl Khad HEP	Proposed Power house site: right bank of Beas river
V38	Uhl II HEP	Near Bassi Power House
V39	Uhl III HEP	Along the power channel
V40		Near Balancing reservoir near Rana Khad
V41	Beas Satluj Link (Pandoh Dam HEP)	Right Bank of reservoir area
V42		Near Dam Site
V43		Downstream of Dam site
V44	Larji I HEP	Along the reservoir area
V45		Downstream of Dam site
V46	Patikari HEP	Upstream of Power house site
V47	Khauli Khad	Near diversion weir
V48	Gaj Khad HEP	Near Power house site
V49	Neogal HEP	Upstream of Power house site
V50	Binwa HEP	Near Powerhouse site
V51	Baner I HEP	Upstream of Power house site
V52	Baner HEP	Downstream of Diversion weir
V53	Kilhi Bahl HEP	Proposed project area of Kilhi Bahl HEP
V54	Pong Dam HEP	Right bank of reservoir
V55		Left Bank of reservoir
V56	Thana Plaun HEP	Proposed Dam site
V57		Downstream of Dam site
V58	Triveni Mahadev HEP	Upstream of Proposed dam site
V59	Dhaulasidh HEP	Upstream of Proposed dam site
V60		Near Proposed Dam site

Table 3.2: No. of quadrats studied for each vegetation component

Sampling Site	Trees (10x10) m^2	Shrubs (5x5) m^2	Herbs (1x1) m^2		
			Pre-Monsoon	Monsoon	Post monsoon/Winter
1	10	10	12	15	12
2	10	10	12	15	12
3	10	10	12	15	12
4	10	10	12	15	12
5	10	10	12	15	12
6	10	10	12	15	12
7	10	10	15	15	12
8	10	10	15	15	12
9	10	10	15	15	12
10	10	10	15	15	12
11	10	10	15	15	12
12	10	10	12	12	12
13	10	10	12	12	12
14	10	10	12	12	12
15	10	10	12	12	12
16	10	10	12	12	12
17	10	10	12	12	12
18	10	10	20	12	12
19	10	10	20	12	12
20	10	10	20	12	12
21	10	10	12	15	12

Sampling Site	Trees (10x10) m^2	Shrubs (5x5) m^2	Herbs (1x1) m^2		
			Pre-Monsoon	Monsoon	Post monsoon/Winter
22	10	10	12	15	12
23	10	10	12	15	12
24	10	10	12	15	12
25	10	10	12	15	12
26	10	10	12	15	12
27	10	10	12	12	12
28	10	10	12	12	12
29	10	10	12	12	12
30	10	10	12	12	12
31	10	10	12	12	12
32	10	10	12	12	12
33	10	10	12	12	12
34	10	10	12	12	12
35	10	10	12	12	12
36	10	10	12	12	12
37	10	10	12	12	12
38	10	10	12	12	12
39	10	10	12	12	12
40	10	10	12	12	12
41	10	10	12	12	12
42	10	10	12	12	12
43	10	10	12	12	12
44	10	10	12	12	12
45	10	10	12	12	12
46	10	10	12	12	12
47	10	10	12	12	12
48	10	10	12	12	12
49	10	10	12	12	12
50	10	10	12	12	12
51	10	10	12	12	12
52	10	10	12	12	12
52	10	10	12	12	12
53	10	10	12	12	12
54	10	10	12	12	12
55	10	10	12	12	12
56	10	10	12	12	12
57	10	10	12	12	12
58	10	10	12	12	12
59	10	10	12	12	12
60	10	10	12	12	12

3.8 FAUNAL ELEMENTS

The data on faunal elements of the basin has been compiled with the help of transacts walked during field surveys, secondary sources supplemented with information provided by local people during field surveys conducted in different areas of the basin as discussed in previous section.

The study area was divided into different strata based on vegetation and topography. Sampling for habitat and animals was done in each strata. Same systematic transects were used for mammals as well as birds. Transect walks along the forest trail in the study area were undertaken. To study the wild mammalian fauna of the study area, 2 - 5 km long transects and trails were walked during early morning and evening hours. Direct sighting of animals as well as indirect signs like scat, pellets, pugmarks, scraps, vocalizations, horns etc. were also recorded during the survey trails. On each transect, the locations were marked with the help of a hand held GPS. Animals and birds observed along the route were recorded, together with information on their habitat. This method of continuous recording (Martin & Batson, 1993, Chalise, 2003) was adopted for the collection of general information on species presence and absence. It also reveals diversity and population by direct observation. This method is also known as Visual Encountered Sampling to reflect wildlife population and diversity (Mukherjee, 2007). Four to five separate walks were done along both the banks of Beas and their tributaries to collect information on riverine tract. For birds a prismatic field binocular (10 × 50) was used for bird watching during surveys.

Secondary data as well as information elicited from the locals were also noted for the presence or absence of wild animals in the area. These indirect evidences and information have to be analyzed and ascertained with the help of literature available. In addition to the field sampling the data/ information was also collected as follows.

- Direct sighting and indirect evidences such as calls, signs, pugmarks of mammals were recorded along the survey routes taking aid from Prater (1980).
- Interviews of local villagers and interaction with forest personnel for the presence and relative abundance of various animal species within each locality.

The checklist of mammalian fauna of the basin has been compiled with the help of data provided by Zoological Survey of India (ZSI) supplemented with information collected during field surveys.

For the compilation of checklist of birds, butterflies and herpetofauna found in the Beas basin, published literature was consulted along with Management Plans and Forest Working Plans of different Forest Divisions falling within the basin. In addition published research papers were also consulted.

The nomenclature of bird species is based upon http://avibase.bsc-eoc.org and of reptiles is based upon http://www.reptile-database.org.

3.9 AQUATIC ECOLOGY

3.9.1 Sampling Locations & Schedule

The sampling was carried out at 59 locations as per ToR to study various physico-chemical and biological characteristics of Beas river and its major tributaries in the basin. Water samples were collected and analyzed for physico-chemical every month for the entire year round and for biological parameters, it was done for three seasons viz. Pre-monsoon/Summer (May-June, 2016), Monsoon (August-September, 2016) and Post-monsoon/winter (November-December, 2016).

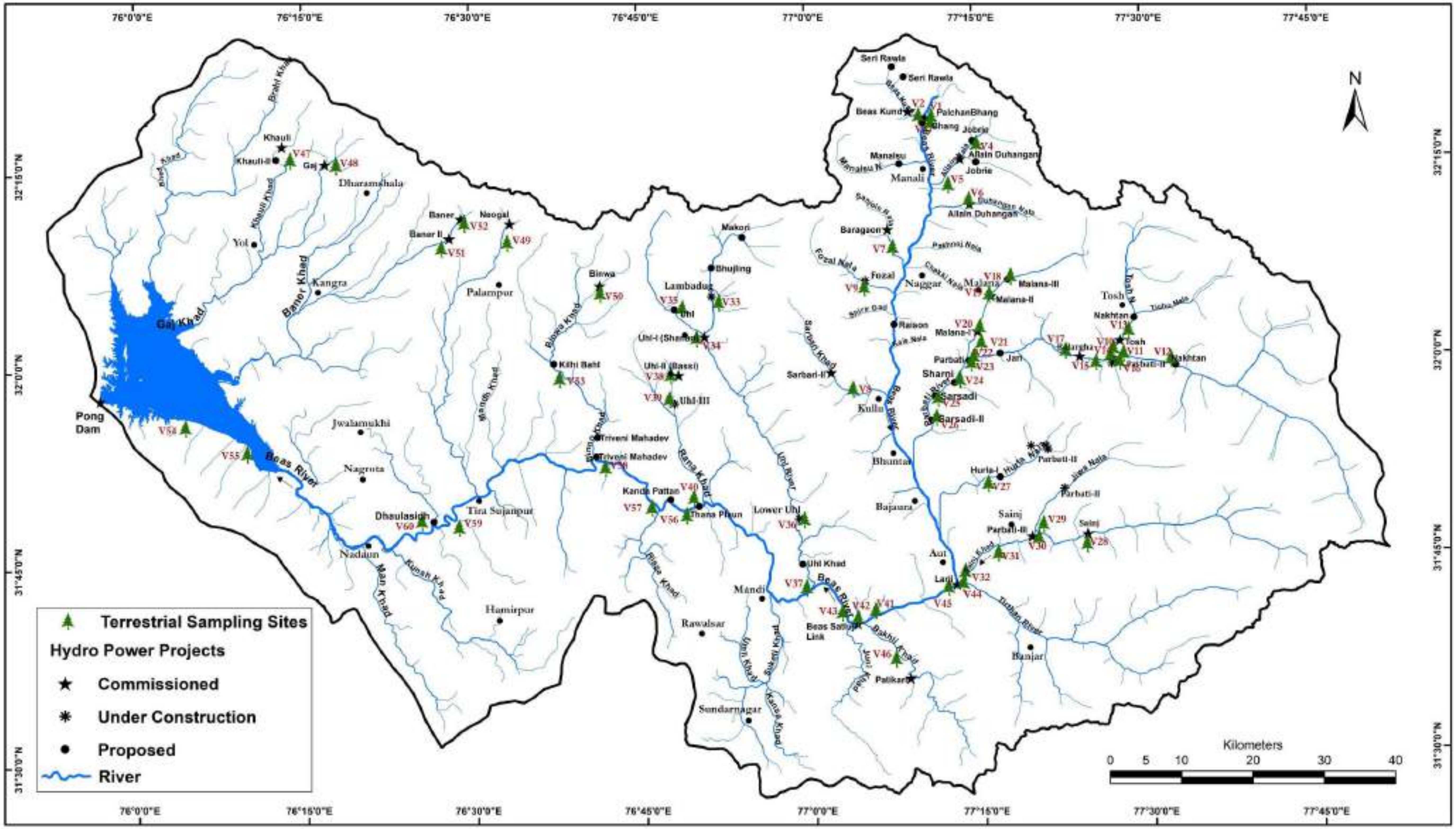


Figure 3.4: Sampling sites/locations for terrestrial ecology in Beas basin

3.9.2 Methodology

The composite water samples from the river were taken in triplicates at each site and average values were computed for the results. The details of sampling sites and their locations are given in **Table 3.3** and locations of sampling sites are marked on map is given in **Figure 3.5.**

Selection of Sampling Sites

Monthly sampling was carried out at 59 different locations as described in the **Table 3.3** to study various physico-chemical and biological characteristics. The sampling sites were located near the area where major project components are proposed like near diversion site (trench weir/ barrage/ dam site), intermediate stretch between diversion site and power house, powerhouse, near the confluence of major tributaries with the main channel and near settlements.

Sampling Methodology

The samples were taken in replicates of three at each site. The mean values were calculated for the final result. The following methods were employed for physical, chemical and biological characteristics:

3.9.2.1 Physico-chemical Parameters

The parameters like pH, temperature, electrical conductivity, total dissolved solids and dissolved oxygen were measured in the field with the help of portable instruments. The water temperature was measured with the help of graduated mercury thermometer; pH, electrical conductivity and total dissolved solids were recorded with the help of a pH, EC and TDS probes (Hanna Instruments HI 98130) in the field. Dissolved oxygen was measured with the help of Digital DO meter (Eutech ECDO 602K) in the field. For the analysis of turbidity, separate water samples were collected and brought to the laboratory for analysis. The turbidity was recorded with the help of Digital Turbidity meter.

Similarly, separate water samples were collected and after the addition of preservative were brought to the laboratory for the analysis of the parameters such as total alkalinity, total hardness, chlorides, sulphates, phosphates, and nitrates at CISMHE, University of Delhi, Delhi. Biological Oxygen Demand (BOD) and Chemical Oxygen Demand (COD) was analysed by standard analytical methods. Calcium, Magnesium, Manganese, Potassium, Sodium, Iron, and heavy metals Cd, Hg, Pb, Zn, Cr, Cu were also analysed. Total coliform was assessed via media method. To assess the primary productivity, DO analysis with dark and light bottle, applying Alkali Azide analysis technique and measuring DO with digital DO meter (diurnal curve method) was used.

3.9.2.2 Sampling of Phytoplankton, Phytobenthos and Zooplankton

For the quantification of phytoplankton and zooplankton 50 liters of water for each community was filtered at each site by using plankton net made up of fine silk cloth (mesh size 25 μm). The study was repeated three times at each site and samples were pooled. The filtrate collected for phytoplankton was preserved in 1% Lugol's Iodine solution.

For phytobenthos the sampling was performed across width of stream at a depth of 15 - 30 cm. The samples were taken from the accessible banks only. The cobbles (64 -128 mm size) usually 4 - 5 in number, were picked from the riffle and pools, in apparently different flows such as stones above and below gushing waters, swift flow and slow flow conditions so as to obtain a representative sample. Benthic diatom samples were collected by scratching the pebbles with a brush of hard bristles in order to dislodge benthos from crevices and minute cavities on the boulder surface from an area of 3 x 3 cm^2, using a sharp edged razor. The scrapings from each cobble were collected in 25μ mesh and transferred to storage vials. The samples were preserved in 1% Lugol's iodine solution.

Acid treatment according to Reimer (1962) method, adopted also by Nautiyal & Nautiyal (1999, 2002), was followed to process the samples for light microscopy. The treated samples were washed repeatedly to remove traces of acid. Samples with high organic content were treated with hydrogen peroxide (H_2O_2) to clean the diatom frustules. The permanent mounts were prepared in Naphrax for further analysis. They were examined using a BX-40 Trinocular Olympus microscope (x10 and x15 wide field eyepiece) fitted with Universal condenser and PLANAPO x100 oil immersion objective under bright field using appropriate filters to identify the species.

For preparing permanent mounts from the treated samples, the slide was first smeared with Mayer's albumen. The sample was then agitated to render it homogeneous. Quickly a drop of known volume (0.04 ml) of processed material was placed on the slide and heated gently till it dried. It was dehydrated using 95% and 100% alcohol, consecutively. The dehydrated material was transferred to Xylol twice before finally mounting in Euparol.

Table 3.3: Details of sampling locations for the collection of data on aquatic ecology

S. No.	Sub-basin	Name of the Project	Project Status	Sampling Sites	No. of sampling points
1	Beas I	Beas Kund	Operational	W1	1
2		Palchan Bhang	Proposed	W2	1
3		Bhang	Proposed	W3	1
4		Jobrie	Proposed	W4	1
5		Allain Duhangan	Operational	W & W6	2
6	Beas II	Baragaon	Operational	W7	1
7		Fozal	Operational	W8	1
8		Sarbari II	Under Construction	W9	1
9	Parbati Upper	Nakthan	Proposed	W10, W11 & W12	3
10		Tosh	Operational	W13	1
11		Parbati II	Under Construction	W14, W15 & W16	3
12		Balargha	Under Construction	W17	1
13	Malana	Malana III	Proposed	W18	1
14		Malana II	Operational	W19 & W20	2
15		Malana I	Operational	W21 & W22	2
16	Parbati Lower	Parbati	Operational	W23	2
17		Sharni	Proposed	W24	3
18		Sarsadi	Proposed	W25	3
19		Sarsadi II	Proposed	W26	1

S. No.	Sub-basin	Name of the Project	Project Status	Sampling Sites	No. of sampling points
20	Sainj	Hurla I	Proposed	W27	1
21		Sainj	Under Construction	W28, W29	2
22		Parbati III	Operational	W30, W31 & W32	3
23	Beas III	Patikari	Operational	W33	1
24		Larji	Operational	W34 & W35	2
25		BSL (Pandoh)	Operational	W36, W37 & W38	3
26	Uhl	Lambadug	Under Construction	W39	1
27		Uhl	Proposed	W40	1
28		Uhl I	Operational	W41	1
29		Uhl II	Operational	W42	1
30		Uhl III	Under Construction	W43, W44	2
31		Lower Uhl	Under Construction	W45	1
32		Uhl Khad	Proposed	W46	1
33	Beas IV	Binwa	Operational	W47	1
34		Kilhi Bahl	Proposed	W48	1
35		Neogal	Operational	W49	1
36		Baner	Operational	W50	1
37		Baner II	Operational	W51	1
38		Gaj	Operational	W52	1
39		Khauli	Operational	W53	1
40	Beas V	Thana Plaun	Proposed	W54, W55	1
41		Triveni Mahadev	Proposed	W56	1
42		Dhaulasidh	Proposed	W57	1
43		Pong Dam	Operational	W58 & W59	2
			Total		59

3.9.2.3 Identification of Diatoms & Zooplankton

The permanent mounts were then subjected to analysis under a phase contrast binocular microscope using an oil immersion lens of x100 magnification. For identifying the various diatom species, varieties and forms, the morphological characteristics used included length, width (µm), number of striae, raphe, axial area, central area, terminal and central nodules. Identifications were made according to standard literature viz. Schmidt, 1914 -1954; Hustedt, 1943; Hustedt, 1985; Krammer & Lange – Bertalot, 1986, 1991, 1999, 2000 a & b; Lange - Bertalot, H. Krammer, K. 2002; Metzeltin & Lange - Bertalot 2002; Krammer 2000, 2003; Lange Bertalot *et al.*, 2003; Werum & Lange – Bertalot, 2004 and Metzeltin *et al.*, 2005. In addition Sarode & Kamat (1984), Prasad (1992) and Gandhi (1998) were also consulted for the oriental species.

The identification of zooplankton was made with the help of Ward and Whipple (1959) and Battish (1992).

Density and Diversity of different species was calculated as follows:

a) **Density of phytoplankton (cells/lit)** and **zooplankton (indiv./lit)**
b) **Density of phytobenthos (cells/cm^2)**

Total count of cells × cover glass size/length of visual field of microscope × counted rows × total sample volume (ml)/observed sample / sampled area

c) **Species Diversity Index** (Shannon & Wiener 1963): The Shannon diversity indices were determined on the basis of counts (500 - 600 valves).

Shannon-Wiener Diversity Index H = - Σ (ni/n) x ln (ni/n)

where, pi is the proportion of total number of species made up of the i^{th} species

d) **Evenness Index** (Shannon & Wiener 1963)

Evenness Index (E) = H / ln(S)

where, H is Shannon Index of general diversity and S is Number of species

3.9.2.4 Sampling & Identification of Macro-invertebrates (Zoobenthos)

For Macro-invertebrate samples were collected from 1 sq ft area by lifting of stones and sieving of substratum from the wadeable portion of the river. The material was sieved through 125 μm sieve and preserved in 70% ethyl alcohol. Samples were collected in three replicates and pooled for further analysis. The organisms obtained were then counted after identifying them up to family level. Standard keys were used for the identification of macro invertebrate samples (Pennek, 1953; Edmondson, 1959; Macan, 1979; Edington and Hildrew, 1995).

Crude density (Indiv/m^2) = total numbers of individuals in each quadrat/ total quadrats × 11

3.9.3 Physico-Chemical Water Quality Index

The water quality objectives for freshwaters focus on a core indicator set that reflects their importance along a river stretch in a valley/basin. The core indicators pH, turbidity, electrical conductivity (salinity) and dissolved oxygen are addressed in this report.

In order to assess the water quality of Beas river and its tributary streams a Water Quality Index was used which has been developed at Washington State Department of Ecology, Environmental assessment Programme. The Water Quality Index (WQI) used in the report is a unitless number ranging from 1 to 100. A higher number is indicative of better water quality. For temperature, pH, faecal coliform bacteria and dissolved oxygen, the index expresses results relative to levels required to maintain beneficial uses (based on criteria in Washington’s Water Quality Standards, WAC 173-201A).

Water quality index is a 100 point scale that summarizes results from a total of nine different measurements viz.

- pH — Dissolved Oxygen
- Turbidity — Faecal Coliform
- Biochemical Oxygen Demand — Total Phosphates
- Nitrates — Total Suspended Solids
- Temperature

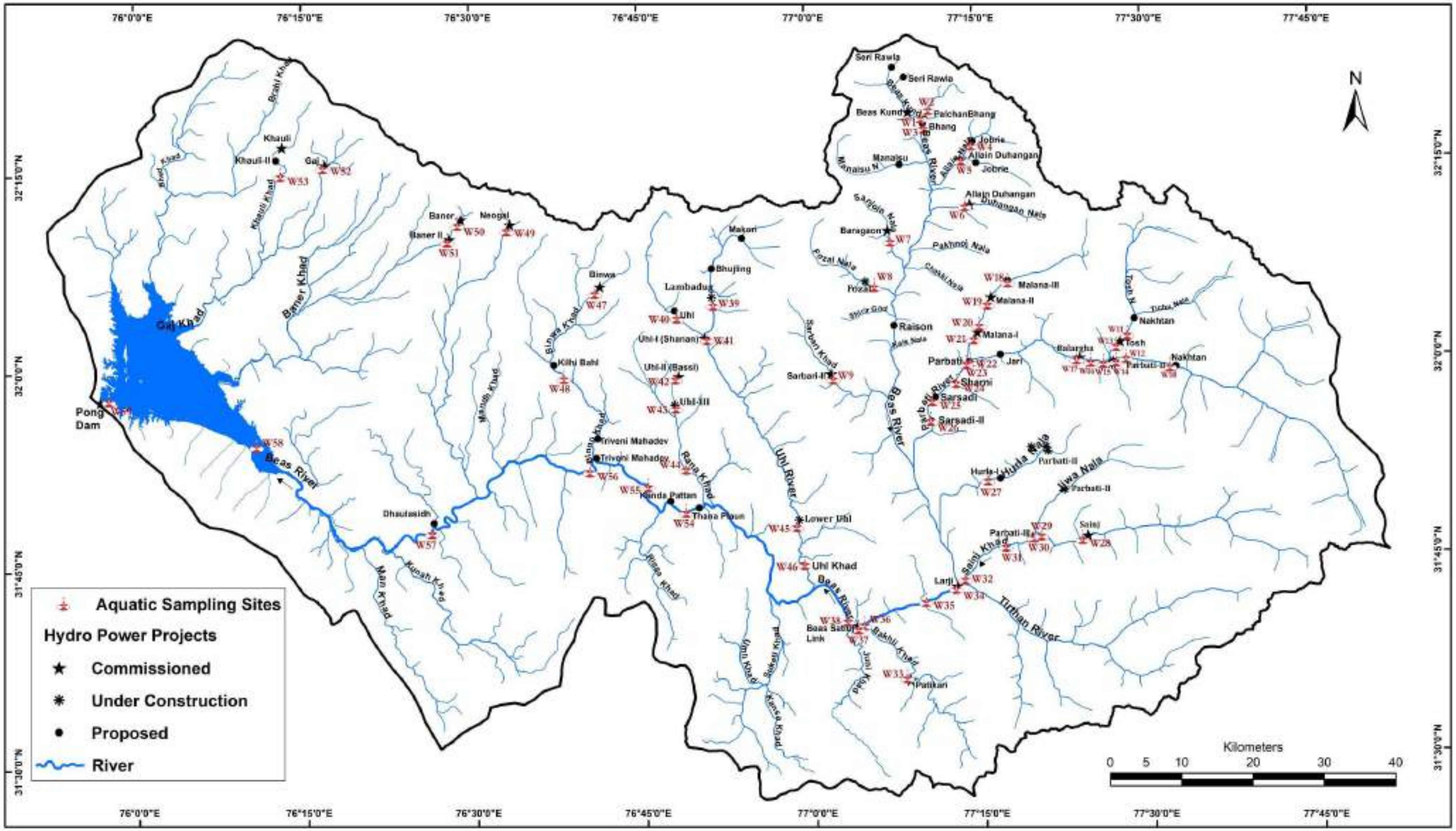


Figure 3.5: Location of Sampling sites for Aquatic Ecology in Beas basin

During the Water Quality analysis number of other parameters were also analysed from the water samples collected from different locations during the field surveys. These are as follows:

Electrical conductivity (EC)	Potassium
Total Dissolved Solids (TDS)	Iron
Chlorides	Manganese
Total Alkalinity	Zinc
Total Hardness	Cadmium
Chemical Oxygen Demand (COD)	Lead
Sulphates	Copper
Sodium	Mercury
Calcium	Total Chromium
Magnesium	

The analysis of above mentioned parameters revealed that parameters like hazardous elements and heavy metals are of least importance in hilly and mountainous streams with sparse population and good forest landscape. In general, the concentration of most of the heavy metals is Not Detectable or Below Detectable limits in such areas. The values for all or most of the parameters have been averaged for each sampling /field surveys and from different sampling locations to arrive at a meaningful conclusion and interpretation otherwise the data collected for each and every month for each parameter becomes too voluminous to arrive at any meaningful outcome.

The analysis of water quality therefore has been based upon 9 parameters as defined for WQI above.

Water Quality Index	
Range	Quality
90-100	Excellent
70-90	Good
50-70	Medium
25-50	Bad
0-25	Very bad

3.9.4 Biological Water Quality Index

For the assessment and analysis of Biological Water Quality an index named **Biological Monitoring Working Party (BMWP)** procedure was employed using species of macro-invertebrates as biological indicators (http://www.nethan-valley.co.uk/insectgroups.doc). The method is based on the principle that different aquatic invertebrates have different tolerances to pollutants. The presence of mayflies or stoneflies for instance indicates the cleanest water. The BMWP score equals the sum of the tolerance scores of all macro-invertebrate families in the sample. Therefore, a higher BMWP score is considered to reflect a better water quality. The number of different macro-invertebrates is also an important factor, because a better water quality is assumed to result in a higher diversity. Alternatively, also the **Average Score Per Taxon (ASPT)** score is calculated. The ASPT equals the average of the tolerance scores of all macro-invertebrate families found, and ranges from 0 to 10. The main difference between both indices is that ASPT does not depend on the family richness.

For the presently analysis of biological water quality above indices have been calculated for each location in Beas basin.

3.10 FISH AND FISHERIES

For collection of data on occurrence and distribution of fish species in the Beas river and its tributaries, experimental fishing was done with the help of local fishermen at various sites in the basin. Interviews were conducted with locals regarding the probable presence of fishes in the river were also conducted.

The data on fish species in Beas basin was collected from Fisheries Department of State Government and through published literature. An inventory of the fish species was prepared after consulting main sources like Indu Sharma *et al*. (2013), Mehta and Uniyal (2005 & 2008), Menon (1999), Talwar and Jhingaran (1991). and Sharma and Tandon (1990). Correct scientific names were checked and updated by following http://www.fishbase.org.

CHAPTER-4

BASIN CHARACTERISTICS

4.1 INTRODUCTION

More than 90% of the drainage system of Himachal Pradesh is a part of Indus river system with Jhelum, Chenab, Ravi, Beas and Sutlej its tributaries. Beas basin in comprised of Beas river drainage catchment in Himachal Pradesh. Beas happens to be a principal tributary of Sutlej river in India. Beas basin is flanked in the north by drainage catchment of Ravi and Chenab rivers and in the south by Sutlej river (**see Figure 4.1**). Beas river originates from Beas Kund at Rohtang Pass at an elevation of 13,050 feet (3,978 m) and flows for a length of about 470 km before joining the Sutlej River at Harike Pattan south of Amritsar in Punjab. After the confluence of two source streams viz. Beas Kund and Beas Rishi at Palchan village, the river is known as Beas. The river after passing through Manali town traverses dense evergreen forested slopes and enters the town of Kullu. At Bhuntar Beas river is joined by Parbati river on its left bank which is a major tributary. After this river flows through different terrain types cutting through the hills. The river flows in north-south direction up to Larji and then turns west up to Pandoh diversion dam. It is fed by number of streams in this stretch up to Pandoh. In addition to Parbati river major tributaries of Beas River upstream of Pandoh are Sainj, Tirthan river and Bakhli Khad joining from the east; Sanjoin, Manalsu, Fozal and Sarbari from the west. After Pandoh, Beas river flows in northerly direction and is joined by Uhl river on its right bank along its course. After this it again turns westward up to Mandi where it takes northerly turn again to be joined by Rana Khad on its right bank. It then enters Kangra valley near Sandhol. In Kangra valley Binwa, Neugal, Banganga, Gaj and Dehar are the major streams joining from the north and Kunah, Maseh, Son, Khairan Man from south. The northern and eastern tributaries of the Beas receive water from the melting snow and are perennial whereas the southern tributaries are seasonal. After leaving Himachal Pradesh the river enters plains of Punjab at Talwara and joins Sutlej at Harike Pattan.

4.2 BEAS RIVER BASIN – STUDY AREA

The Study Area covered as a part of the Beas Basin is comprised of part of Beas river catchment falling within Himachal Pradesh i.e. Beas river catchment from its origin at Rothang Pass up to Pong Dam at the inter-state boundary with Punjab. The total catchment area of Beas river in Himachal Pradesh is about 12591 sq km and its length in the study area is about 274 km.

Beas basin in Himachal Pradesh administratively falls under 5 districts viz. Kullu, Mandi, Kangra, Hamirpur and Chamba. Most part of Kullu forms the upper reaches of Beas basin while Kangra and Hamirpur form the lower part of the basin. Kullu is the largest district accounting for 38.49% of basin area followed by Kangra district with 31.44%, Mandi with 21.71% and Hamirpur with 6.73% area. Very area of Chamba district falls in the Beas basin which is about 1.63% only. Major towns located in the basin are Manali, Naggar, Kullu, Bhuntar, Bajaura, Aut, Banjar, Mandi, Ner Chowk, Sunder Nagar, Barot, Joginder Nagar, Sujanpur Tira, Nadaun, Kangra, Palampur, Yol and Dharamshala.

Figure 4.1: Map showing location of Beas basin in Himachal Pradesh

4.2.1 Beas River Drainage System

Drainage map of the study area i.e. Beas river basin in Himachal Pradesh was prepared from Survey of India Toposheets at 1:50000 scale as base map along with satellite data. The drainage map of the basin thus prepared is given at **Figure 4.2**. The major tributaries joining Beas river at either bank are described in the following paragraphs.

4.2.1.1 Major Tributaries of Beas River

a) Beas Kund Nala

It originates at an altitude of 3978 m near Rohtang Pass. After its confluence with Beas Rishi at Palchan village 10 km north of Manali river is known as Beas. The total catchment area of Beas Kund nala is about 122 sq km.

b) Allain Nala

Allain Nala, also known as Hamtah Nala in its higher reaches meets Beas river at its left bank downstream of Manali town. It descends from an altitude of 4208 m near Hamtahjot Pass. The total length of the nala is about 18.7 km with a catchment area of about 139.62 sq km.

c) ***Duhangan Nala***

Duhangan nala meets Beas river at its left bank further 3.8 km downstream of Allain nala. It originates from an unnamed glacier at an elevation of about 4200 m. The total length of the nala is about 18.6 km with a catchment area of about 88.41 sq km.

d) ***Sanjoin Nala***

It is right bank tributary of Beas river. It traverses a distance of about 14.6 km to meet Beas river near Baragaon village. Total catchment area of the nala is about 75.22 sq km.

e) ***Fozal Nala***

It is another right bank tributary of Beas river. It traverses a distance of about 14 km with a catchment area of about 122.63 sq km.

f) ***Sarbari Khad***

Sarbari khad is a right bank tributary of Beas river. The total length of the khad up to its confluence with Beas river at Dhalpur, Kullu is about 26.7 km. The total catchment area of this stream is 183 sq km.

g) ***Parbati River***

Parbati river is the largest tributary of Beas river. It meets Beas river on its left bank near Bhuntar. The river originates from Pin Parbati Pass at an elevation of around 5400m. The total length of the river from its origin to its confluence with Beas is about 82 km. The total catchment area of the river is about 1729.5 sq km. The major tributaries joining Parbati river at its right bank are Dibi ka Nal, Gohru Khol, Tosh Nala, Galigad Nala, Rashkar Gad, Brahamganga Nala, Gohar Nala, Rasol Nala, Reoni Nala, Malana Nala, Baladhi Nal while the left bank tributaries are Bakar Bihar Khol, Dauns Par Khol, Tundabhuj Khol, Bakar Kiara Khol, Shat Nal, Chharor Nal, Jari.

h) ***Malana Nala***

It originates from an unnamed glacier and travels a distance of about 25 km to join Parbati river at its right bank. It is the largest tributary of Parbati river. The Catchment area of Malana Nala is about 192 sq km.

i) ***Hurla Nala***

Hurla Nala meets Beas river on it left bank near Hurla village at 1020m. The total length of the nala is about 33.3 km with a catchment area of about 188.5 sq km.

j) ***Sainj River***

Further about 13 km downstream of Hurla Nala, Beas is fed by Sainj River which traverses a distance of about 59.5 km to join Beas River on its left bank. The catchment area of the river is 747 sq km. It originates from an unnamed glacier at an elevation of about 4200 m. The major tributaries joining Sainj river on its right bank are Rakti Nal, Chyos Nal, Jiun Nal, Riasa Nal, Jiwa Nal, Phagla Gad, Baga Gad while the left bank tributaries are Gahru Nal, Kuli Gad, Dhaugi Gad, Kanon Gad, Tirthan River.

k) ***Tirthan River***

It originates from an unnamed glacier at an elevation of 4378m and travels a distance of about 50.7 km to join Sainj river on its left bank. It is the biggest tributary of Sainj with a catchment area of Tirthan Nala is about 679 sq km.

l) ***Bakhli Khad***

Bakhli khad meets Beas river on its left bank downstream of Bakhli village. The total length of the nala is about 46 km with a catchment area of about 271.5 sq km.

m) ***Juni Khad***

Thereafter nearly 2.3 km downstream Beas river is fed by Juni Khad on its left bank near Pandoh village. The total length of the nala is about 38 km.

n) ***Uhl River***

After flowing north for another 10 km till Uhl River Beas river flows westward direction. Uhl river traverses a distance of about 73 km with a catchment area of about 755.6 sq km.

o) ***Rana Khad***

Rana Khad is a right bank tributary and meets Beas river near Tudal village. The length of the river is 27.3 km and catchment area of the river is 224.5 sq km.

p) ***Binwa Khad***

After travelling about 24 km in westward direction Beas river meets Binwa khad on its right bank at elevation of 636m. Binwa khad, also known as Banu Khad in its higher reaches. The length of the river is 42 km and catchment area of the river is 375.35 sq km.

q) ***Neugal Khad***

Neugal khad meets Beas river on its right bank near Alampur village. The length of the river is 55 km and catchment area of the river is 386 sq km.

r) ***Man Khad***

Thereafter nearly 30 km downstream Beas river is fed by Man Khad on its left bank near Nadaun village. The total length of the nala is about 31 km and catchment area of the river is 194 sq km.

s) ***Baner Khad***

Baner Khad meets Beas river on its right bank near Mahora village. The length of the river is 63 km and catchment area of the river is 749 sq km.

t) ***Gaj Khad***

Gaj Khad originates from an altitude of 4400m and travels 64 km to join the Beas river on right bank a little upstream of Pong dam lake. The catchment area of the river is 1246 sq km.

Figure 4.2: Map of Beas basin showing districts and drainage

4.3 GLACIERS & LAKES IN BEAS BASIN

Beas river is fed by number glaciers and glacial lakes. There have been number studies done in the past on the inventory of glaciers and glacial lakes in Beas basin by various workers. These reports differ in the total number of glaciers in the basin. One such prominent study was published by Space Applications Centre, Ahmedabad in May 2011 sponsored by Ministry of Environment Forests & Climate Change and Department of Space, GOI, the total number of glaciers in Beas basin has been given as 335 with an area of 698 sq km. According to report on the inventory of moraine dammed glacial lakes in Sutlej, Beas, Chenab and Ravi basins in Himachal Pradesh published in April 2014 prepared by HP Stare Centre on Climate Change study the Beas basin contains 67 lakes covering an area of about 110.15 ha.

4.4 TOPOGRAPHY & RELIEF

Beas basin is characterized by rugged topography with high ridges and peaks, with higher reaches covered with glaciers, and massive ice and snowfields.

The elevation in the basin varies from high of 6619m to a low of 325m. In order to understand the relief profile of the basin it has been divided into 600m elevation zones. Area falling under different elevation zones is given in **Table 4.1** and **Figure 4.3.** In order to understand the terrain morphology Digital Elevation Model (DEM) of the basin was prepared from SRTM 30m data and the same has been given at **Figure 4.4**.

The relief map thus prepared is given at **Figure 4.4**.

Table 4.1: Area falling under different Elevation zones in the Beas Basin

Elevation Band (m)	Area (sq km)	Area (%)
Up to 600	1336.40	10.61
601-1200	3571.44	28.37
1201-1800	1523.80	12.10
1801-2400	1358.50	10.79
2401-3000	1367.28	10.86
3001-3600	928.54	7.37
3601-4200	813.57	6.46
4201-4800	908.44	7.22
4801-5400	655.89	5.21
5401-6000	119.96	0.95
Above 6000	6.96	0.06
Total	**12590.79**	

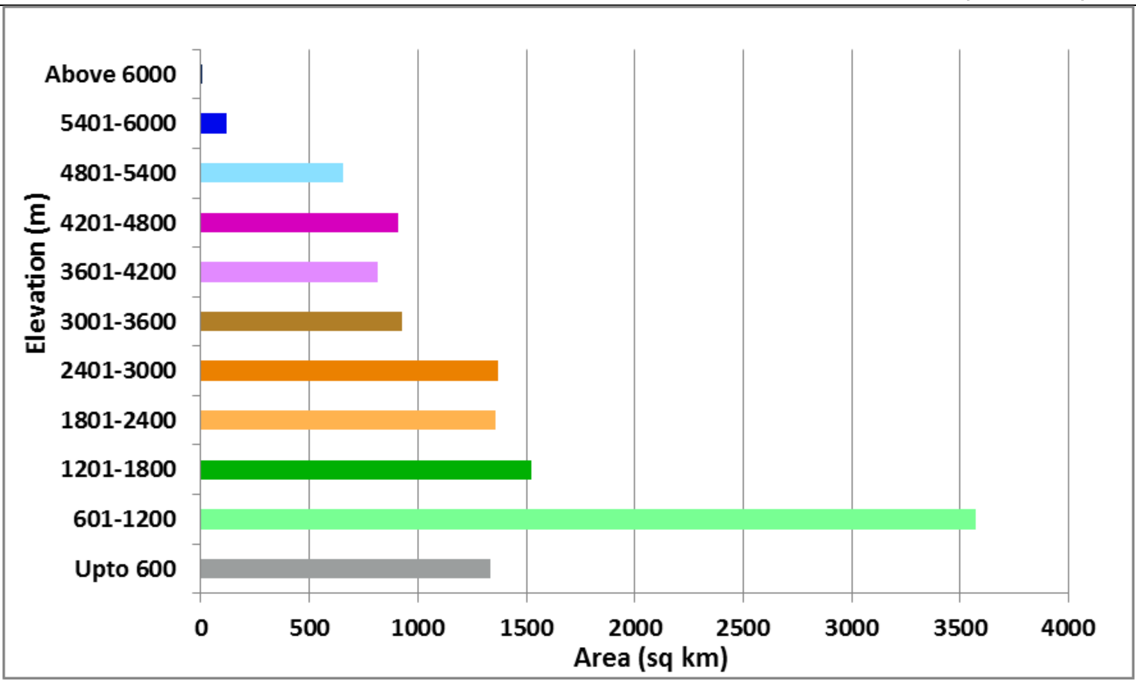


Figure 4.3: Area under different elevation zones in Beas basin

As seen from the map, table and graph more than 70% of the catchment area lies below elevation of 3000 m and about 21% of the area lies between 3000 and 4800m elevation zone.

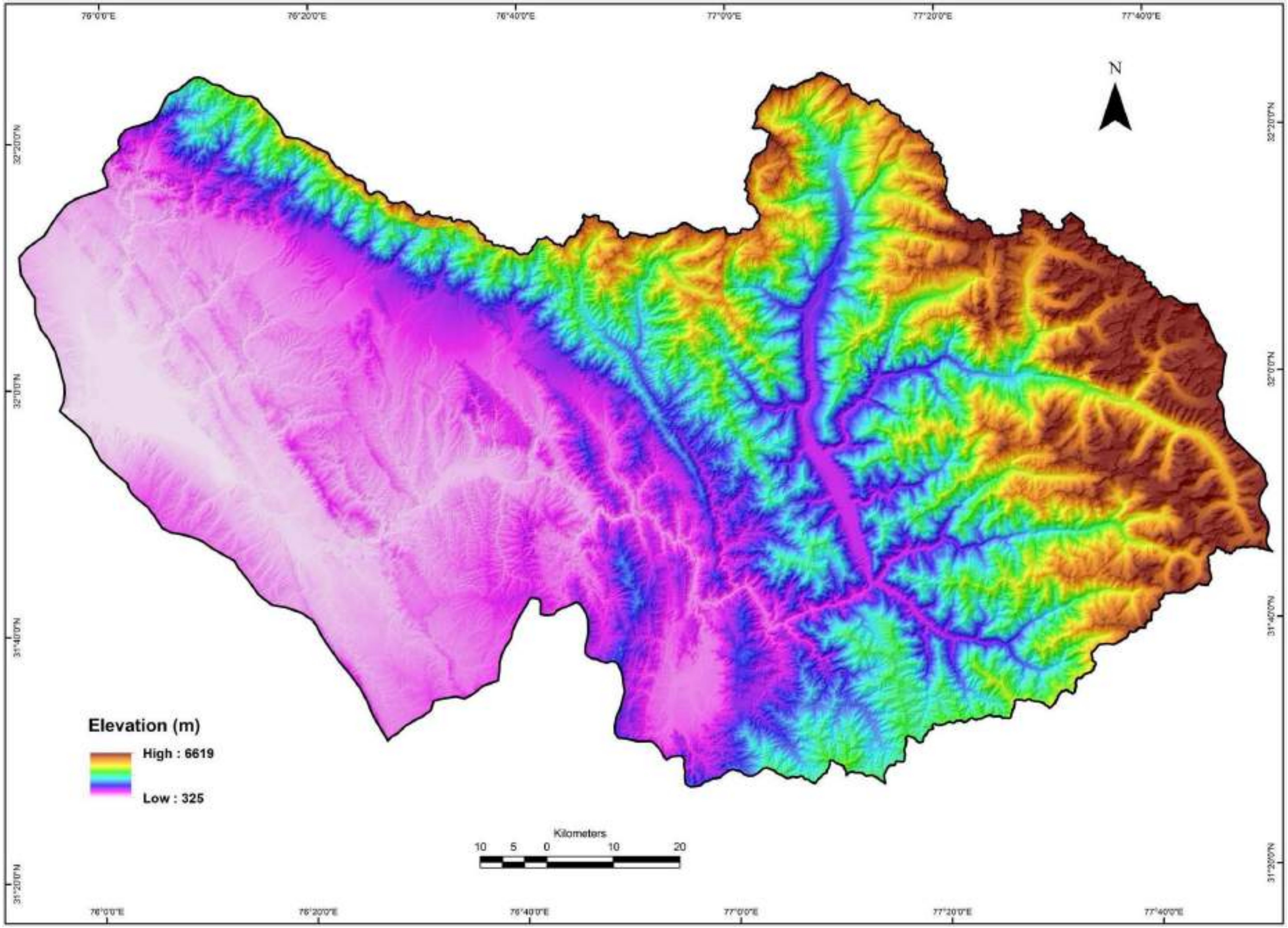


Figure 4.4: Digital Elevation Map (DEM) of Beas river basin in Himachal Pradesh

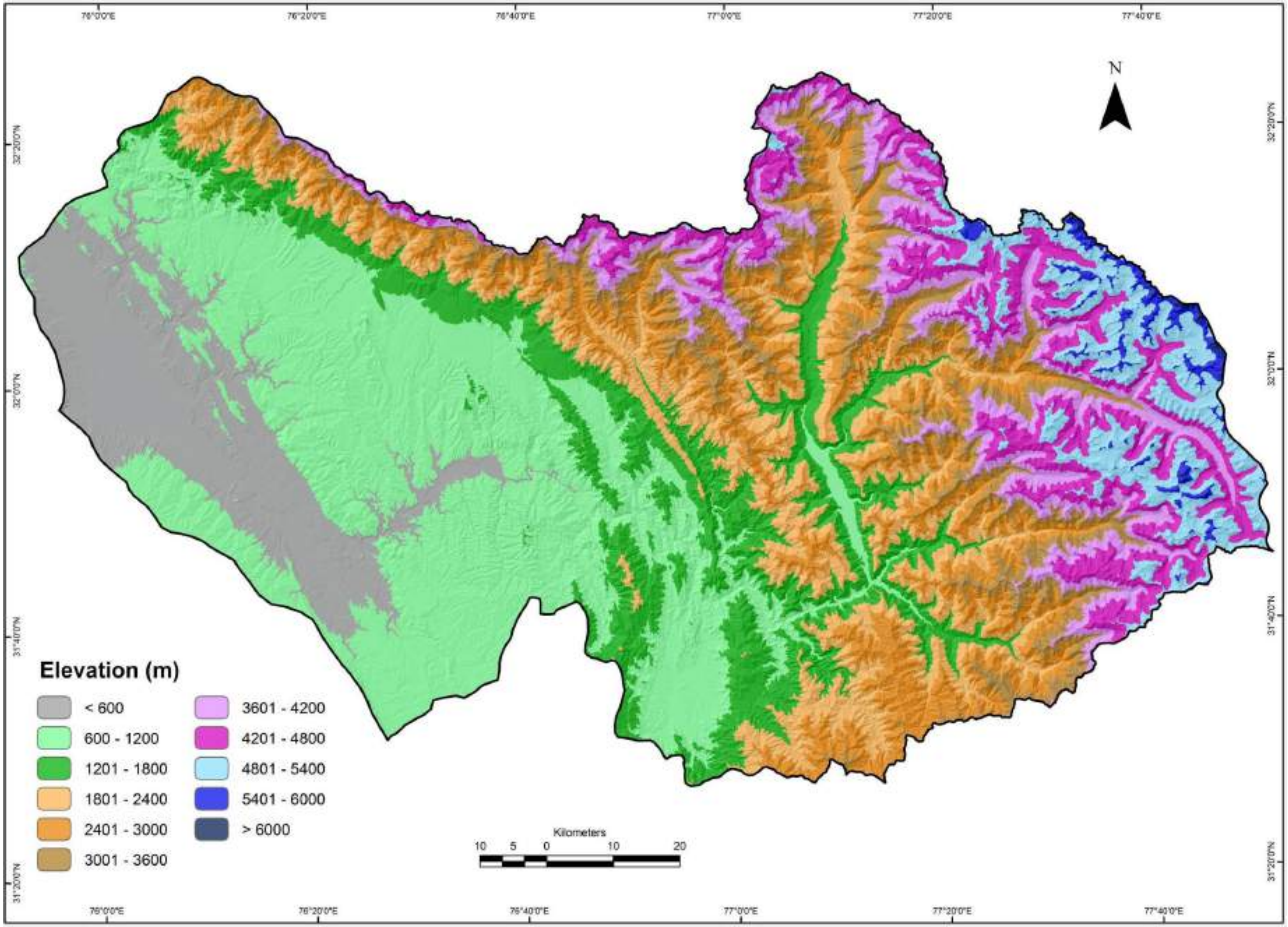


Figure 4.5: Relief map of Beas basin

4.5 SLOPE

For the preparation of slope map of the basin, SRTM 30m data was used to first generate Digital Elevation Model (DEM) of the entire basin area. First of all a Digital Terrain Model (DTM) of the area was prepared, which was then used to generate a slope map. The following slope classes and ranges were used for the study. Area falling under different slope categories is given in **Table 4.2.**

Slope in Degrees	Description
0 - 2	Gently sloping
2 - 8	Moderately sloping
8 - 15	Strongly sloping
15 - 30	Moderately steep
30 - 45	Steep
45- 60	Very steep
60 - 70	Extremely Steep
Above 70	Escarpments

Table 4.2: Area falling under different Slope Categories in the Beas Catchment in Himachal Pradesh

Slope Class	Area (sq km)	Area (%)
Gently sloping	678.21	5.39
Moderately sloping	1801.41	14.31
Strongly sloping	1825.43	14.50
Moderately steep	4153.48	32.99
Steep	3249.13	25.81
Very steep	811.92	6.45
Extremely Steep	60.70	0.48
Escarpments	10.51	0.08
	12590.79	-

The slope prepared as above has been given at **Figure 4.6** and area under different slope categories is given in **Figure 4.7**.

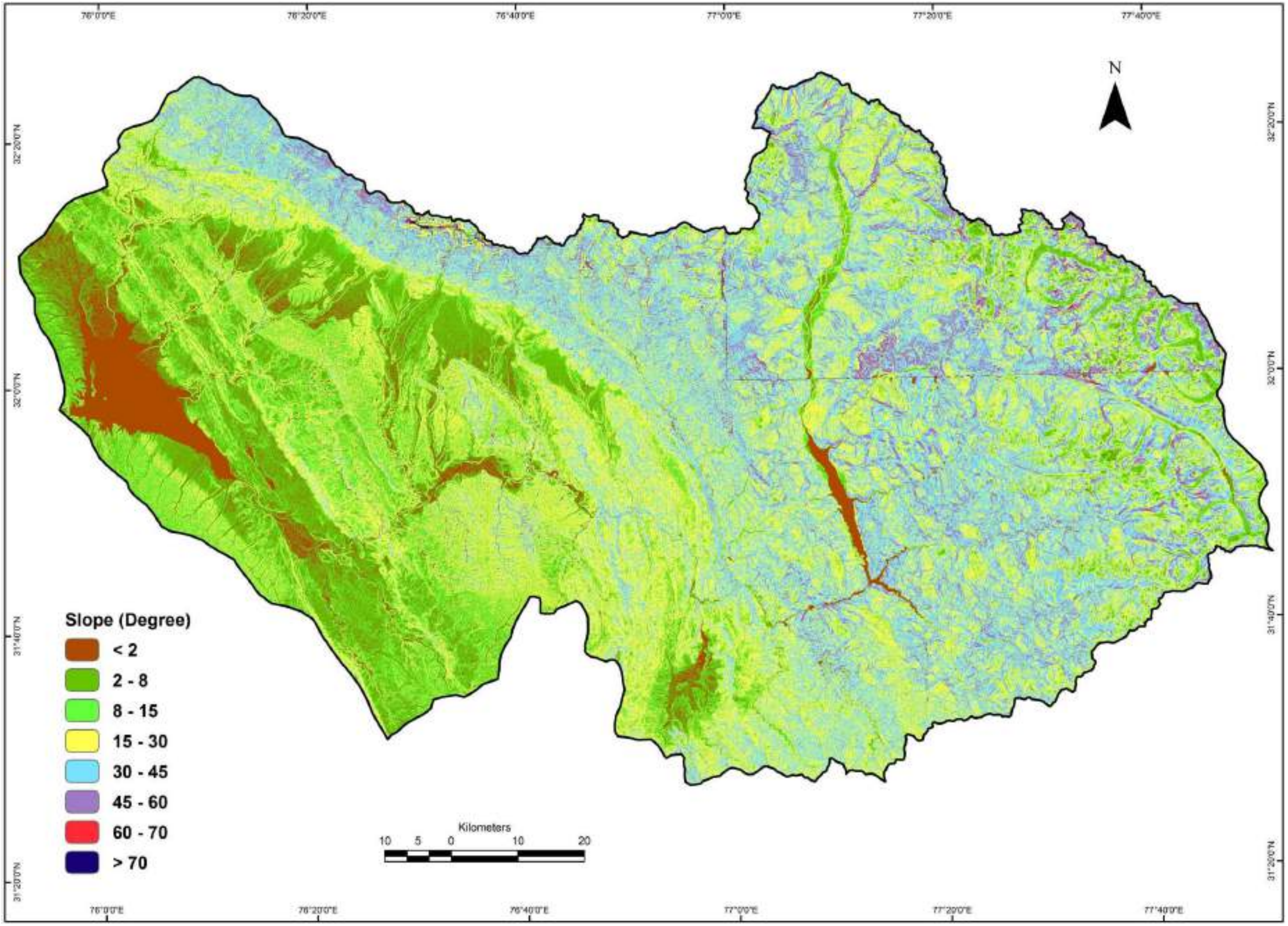


Figure 4.6: Slope map of Beas river basin in Himachal Pradesh

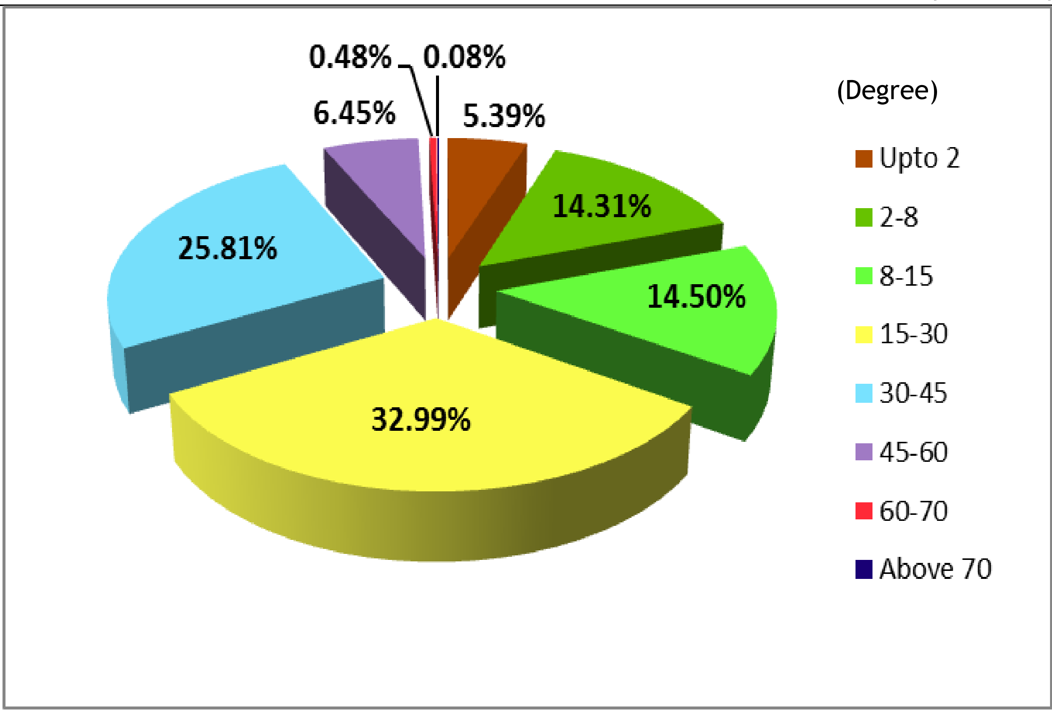


Figure 4.7: Area (percent) under different slope categories in Beas river basin in Himachal Pradesh

As seen from the table, map and graph, more than 32% of Beas river basin area in Himachal Pradesh is characterized by steep slopes while around 33% area is having moderately steep slopes.

4.6 SOILS

Soil map of the study area has been produced using soil maps collected from National Bureau of Soil Survey & Land use Planning (NBSS & LUP), Nagpur. The soil map thus prepared has been shown as **Figure 4.8**. Area distribution of various soil units has been shown in **Table 4.3**. Predominant soil type is Typic Udorthents (24.24%) which is found at middle slopes characterized by rock outcrops, deep well drained, mesic, loamy skeletal soils on very steep slopes with severe erosion. Typic Cryorthents second predominant soil type found near the ridge slopes and is characterized by rock outcrops, with shallow depth, excessively drained, loamy skeletal soils on very steep slopes prone to severe erosion. Valley floor is comprised of Dystric Eutrochrepts which are deep, well drained, mesic, coarse-loamy soils on gentle slopes with loamy surface and moderate erosion.

Table 4.3: Description and Area under different Soil Units in Beas Basin

Soil	Type	Area (sq km)	Area (%)
1	**Lithic Cryorthents** Rock Outcrops covered glaciers; *associated with*: Shallow, excessively drained, sandy-skeletal soils with sandy surface, severe erosion and strong stoniness	96.73	0.77
2	**Lithic Cryorthents** Shallow, excessively drained, sandy-skeletal soils on very steep slopes with sandy surface, severe erosion and	179.80	1.43

Soil	Type	Area (sq km)	Area (%)
	moderate stoniness; *associated with*: Rock Outcrops		
5	**Typic Cryorthents** Mountain and valley glaciers and rock outcrops; *associated with*: Medium deep, excessively drained, sandy-skeletal soils on very steep slopes with sandy surface, severe erosion and moderate stoniness	326.17	2.59
6	**Typic Cryorthents** Rock Outcrops *associated with*: Medium deep, excessively drained, loamy-skeletal calcareous soils on very steep slopes with loamy surface, severe erosion and moderate stoniness	177.31	1.41
7	**Typic Cryorthents** Rock Outcrops *associated with*: Shallow, excessively drained, loamy skeletal soils on very steep slopes with loamy surface, severe erosion and moderate stoniness	192.18	1.53
8	**Typic Cryorthents** Rock Outcrops; *associated with*: Medium deep, excessively, loamy skeletal soils on very steep slopes with loamy surface, severe erosion and strong stoniness	348.01	2.76
9	**Typic Udorthents** Rock Outcrops *associated with*: Deep, well drained, mesic, loamy skeletal soils on very steep slopes with loamy surface, severe erosion and strong stoniness	231.98	1.84
12	**Typic Udorthents** Deep, excessively drained, mesic, loamy-skeletal soils on steep slopes with loamy surface, severe erosion and moderate stoniness; *associated with*: Deep excessively drained, coarse-loamy soils with loamy surface, severe erosion and moderate stoniness	55.10	0.44
13	**Typic Udorthents** Medium deep, excessively drained, mesic, sandy-skeletal over fragmental soils on very steep slopes with loamy surface, severe erosion and moderate stoniness; *associated with*: Rock Outcrops	206.53	1.64
16	**Typic Udorthents** Rock Outcrops *associated with*: Deep, excessively drained, sandy-skeletal soils with loamy surface, very severe erosion and moderate stoniness	23.03	0.18
17	**Typic Udorthents** Medium deep, excessively drained, mesic, fragmental soils on very steep slopes with sandy surface, severe erosion and strong stoniness; *associated with*: Rock Outcrops	34.55	0.27
20	**Typic Cryorthents** Rock Outcrops *associated with*: Medium deep, somewhat excessively drained, loamy-skeletal soils on moderately steep slopes with loamy surface, severe erosion and moderate stoniness	7.62	0.06
21	**Typic Cryorthents** Deep, excessively drained, fine-loamy, calcareous soils on gentle slopes with loamy surface, severe erosion and moderate stoniness; *associated with*: Shallow, somewhat excessively drained, loamy-skeletal, calcareous soils with loamy surface, severe erosion and moderate stoniness	3.12	0.02
22	**Typic Cryorthents** Medium deep, excessively drained, sandy-skeletal soils on	148.08	1.18

Soil	Type	Area (sq km)	Area (%)
	moderately steep slopes with sandy surface, severe erosion and strong stoniness; *associated with*: Deep, excessively drained, loamy-skeletal soils with loamy surface, severe erosion and moderate stoniness.		
27	**Typic Udorthents** Shallow, somewhat excessively drained, mesic, coarse-loamy soils on moderate slopes with loamy surface and severe erosion; *associated with*: **Dystric Eutrochrepts** Medium deep, somewhat excessively drained, fine-loamy soils with loamy surface and severe erosion	120.46	0.96
29	**Typic Udorthents** Rock Outcrops *associated with*: Medium deep, excessively drained, mesic, loamy-skeletal soils on very steep slopes with loamy surface, severe erosion and moderate stoniness	206.20	1.64
30	**Lithic Udorthents** Shallow, well drained, mesic, loamy soils on steep slopes with loamy surface, very severe erosion and severe stoniness; *associated with*: **Typic Udorthents** Medium deep, well drained, coarse-loamy soils with loamy surface and very severe erosion	26.42	0.21
31	**Typic Udorthents** Deep, excessively drained, mesic, loamy-skeletal soils on very steep slopes with loamy surface, severe erosion and moderate stoniness; *associated with*: Rock Outcrops	138.78	1.10
33	**Typic Udorthents** Deep, well drained, mesic, loamy skeletal soils on moderately steep slopes with sandy surface, severe erosion and slight stoniness; *associated with*: Deep, moderately well drained, fine-loamy soils with loamy surface, severe erosion and moderate stoniness	465.07	3.69
34	**Dystric Eutrochrepts** Medium deep, somewhat excessively drained, mesic, coarse-loamy soils on moderate slopes with loamy surface, severe erosion and slight stoniness; *associated with*: **Typic Udorthents** Shallow,, somewhat excessively drained, coarse-loamy soils with loamy surface, severe erosion and slight stoniness	3.62	0.03
36	**Typic Udorthents** Shallow, excessively drained, thermic, sandy-skeletal soils on steep slopes with loamy surface, very severe erosion and strong stoniness; *associated with*: Rock Outcrops	1692.82	13.44
37	**Typic Udorthents** Shallow, somewhat excessively drained, thermic, loamy-skeletal soils on steep slopes with loamy surface, severe erosion and strong stoniness; *associated with*: Rock Outcrops	737.36	5.86
41	**Dystric Eutrochrepts** Deep, somewhat excessively drained, thermic, fine-loamy soils on moderately steep slopes with loamy surface and severe erosion *associated with*: Deep, well drained, coarse loamy soils with loamy surface and severe erosion	311.59	2.47
45	**Typic Udorthents**	25.92	0.21

Soil	Type	Area (sq km)	Area (%)
	Medium deep, well drained, thermic, coarse-loamy soils on steep slopes with loamy surface and severe erosion; *associated with*: **Dystric Eutrochrepts** Medium deep to deep, well drained, fine-loamy soils with loamy surface and moderate erosion		
48	**Typic Eutrochrepts** Medium deep, well drained, thermic, fine-loamy calcareous soils on moderately steep slopes with loamy surface and severe erosion; *associated with*: **Typic Udorthents** Medium deep, well drained, fine-loamy soils with loamy surface and moderate erosion	105.72	0.84
49	**Dystric Eutrochrepts** Medium deep, well drained, thermic, fine loamy soils on moderately steep slopes with loamy surface, severe erosion and slight stoniness; *associated with*: **Typic Udorthents** Shallow, well drained, fine-loamy soils with loamy surface and moderate erosion	225.60	1.79
51	**Dystric Eutrochrepts** Deep, well drained, thermic, fine-loamy soils on very steep slopes with loamy surface and severe erosion; *associated with*: **Typic Udorthents** Medium deep, well drained, fine-loamy soils with loamy surface and severe erosion	63.15	0.50
53	**Lithic Udorthents** Shallow, well drained, thermic, loamy soils on very steep slopes with loamy surface and very severe erosion; *associated with*: **Typic Udorthents** Medium deep, well drained, coarse-loamy soils with loamy surface and severe erosion	140.10	1.11
55	**Dystric Eutrochrepts** Deep, well drained, thermic, fine-loamy soils on moderate slopes with loamy surface and moderate erosion; *associated with*: **Typic Udorthents** Medium deep, well drained, loamy-skeletal soils with loamy surface and severe erosion	11.13	0.09
56	**Lithic Udorthents** Shallow, excessive drained, thermic, loamy soils on very steep slopes with loamy surface and severe erosion; *associated with*: **Dystric Eutrochrepts** Medium deep to deep, well drained, fine loamy soils with loamy surface and moderate erosion	346.32	2.75
57	**Dystric Eutrochrepts** Medium deep, well drained, thermic, fine-loamy soils on moderate slopes with loamy surface, severe erosion and slight stoniness; *associated with*: **Typic Udorthents** Medium deep, somewhat excessively drained, coarse-loamy	14.46	0.11

Soil	Type	Area (sq km)	Area (%)
	soils with loamy surface and severe erosion		
58	**Lithic Udorthents** Shallow, excessively drained, thermic, loamy soils on steep slopes with loamy surface and severe erosion; *associated with*: **Dystric Eutrochrepts** Medium deep, well drained, fine-loamy soils with loamy surface and moderate erosion	18.04	0.14
59	**Typic Eutrochrepts** Deep, well drained, thermic, fine-loamy calcareous soils on moderately steep slopes with loamy surface and severe erosion; *associated with*: **Dystric Eutrochrepts** Deep, well drained, coarse-loamy soils with loamy surface and severe erosion	66.71	0.53
64	**Typic Udorthents** Medium deep, well drained, thermic, coarse-loamy soils on moderate slopes with loamy surface and moderate erosion; *associated with*: **Typic Udifluvents** Shallow, excessively drained, coarse-loamy, calcareous soils with loamy surface and moderate erosion	893.73	7.10
68	**Typic Udorthents** Deep, excessively drained, thermic, coarse-loamy soils on steep slopes with loamy surface, moderate erosion and moderate stoniness; *associated with*: **Typic Udorthents** Deep, well drained, fine-loamy soils with loamy surface and moderate erosion	11.62	0.09
69	**Typic Dystrochrepts** Deep, well drained, thermic, fine-loamy soils on gentle slopes with loamy surface and severe erosion; *associated with*: **Typic Udifluvents** Medium deep, well drained, coarse-loamy soils with loamy surface and moderate erosion	148.10	1.18
70	**Dystric Eutrochrepts** Deep, well drained, thermic, fine-loamy soils on steep slopes with loamy surface and severe erosion; *associated with*: **Typic Udifluvents** Medium deep, well drained, coarse loamy soils with loamy surface and moderate erosion	32.64	0.26
71	**Typic Udorthents** Medium deep to deep, well drained, thermic, coarse-loamy soils on steep slopes with loamy surface and severe erosion; *associated with*: **Typic Eutrochrepts** Medium deep, well drained, calcareous, fine loamy soils with loamy surface and moderate erosion	308.37	2.45
72	**Typic Udorthents** Medium deep to deep, well drained, thermic, loamy-skeletal soils on steep slopes with loamy surface and severe erosion; *associated with*:	489.32	3.89

Soil	Type	Area (sq km)	Area (%)
	Typic Eutrochrepts Medium deep,, well drained, calcareous, fine-loamy soils with loamy surface and moderate erosion		
75	**Typic Udorthents** Medium deep, well drained, thermic, loamy-skeletal soils on very gentle slopes with loamy surface, moderate erosion and moderate stoniness; *associated with*: **Dystric Eutrochrepts** Deep, well drained, fine-loamy soils with loamy surface and slight erosion	701.30	5.57
77	**Typic Udorthents** Deep, somewhat excessively drained, thermic, coarse-loamy soils on gentle slopes with loamy surface and moderate erosion; *associated with*: **Dystric Eutrochrepts** Deep, well drained, fine-loamy soils with loamy surface and moderate erosion	585.26	4.65
78	**Typic Udorthents** Medium deep, well drained, thermic, coarse-loamy soils on gentle slopes with loamy surface and severe erosion; *associated with*: **Dystric Eutrochrepts** Medium deep, moderately well drained, fine-loamy soils with loamy surface and severe erosion	368.07	2.92
79	**Typic Udorthents** Medium deep, well drained, thermic, loamy-skeletal soils on moderately steep slopes with loamy surface and moderate erosion; *associated with*: **Typic Udorthents** Medium deep, well drained, fine-loamy soils with loamy surface and severe erosion	383.45	3.05
80	**Typic Udorthents** Medium deep, well drained, thermic, loamy-skeletal soils on moderately steep slopes with loamy surface and severe erosion; *associated with*: **Typic Udorthents** Medium deep, well drained, fine-loamy soils with loamy surface and severe erosion	539.29	4.28
81	**Typic Udorthents** Medium deep, somewhat excessively drained, thermic, coarse-loamy soils on gentle slopes with loamy surface and moderate erosion; *associated with*: **Typic Hapludalfs** Deep, well drained, fine-loamy soils with loamy surface and slight erosion	157.48	1.25
82	**Dystric Eutrochrepts** Deep, moderately well drained, thermic, fine-loamy soils on moderate slopes with loamy surface and moderate erosion; *associated with*: **Typic Udorthents** Medium deep, well drained, coarse-loamy soils with loamy surface and moderate erosion	818.32	6.50
83	**Dystric Eutrochrepts** Medium deep, well drained, thermic, fine-loamy soils on	82.01	0.65

Soil	Type	Area (sq km)	Area (%)
	moderate slopes with loamy surface and moderate erosion; *associated with*: **Typic Udorthents** Medium deep, well drained, fine-loamy soils with loamy surface and moderate erosion		
87	**Udic Ustorthents** Medium deep, well drained, hyperthermic, fine-loamy, calcareous soils on moderate slopes with loamy surface and moderate erosion; *associated with*: **Typic Ustorthents** Medium deep, well drained, loamy-skeletal soils with loamy surface and severe erosion	33.38	0.27
88	**Typic Ustifluvents** Shallow, well drained, hyperthermic, sandy soils on very gentle slopes with sandy surface and moderate erosion; *associated with*: **Typic Ustifluvents** Shallow, well drained, coarse-loamy soils with loamy surface and moderate erosion	50.38	0.40
92	**Typic Eutrochrepts** Medium deep, well drained, thermic, fine-loamy, calcareous soils on very gentle slopes with loamy surface and slight erosion; *associated with*: **Dystric Eutrochrepts** Deep, well drained, loamy-skeletal soils with loamy surface and slight erosion	7.96	0.06
95	**Typic Ustipsamments** Deep, excessively drained, hyperthermic, calcareous, sandy soils on very gentle slopes with loamy surface, slight erosion and moderate flooding; *associated with*: **Typic Ustifluvents** Deep, well drained, calcareous fine-loamy over sandy soils with loamy surface and moderate flooding	230.41	1.83
	Total	**12590.79**	**100.00**

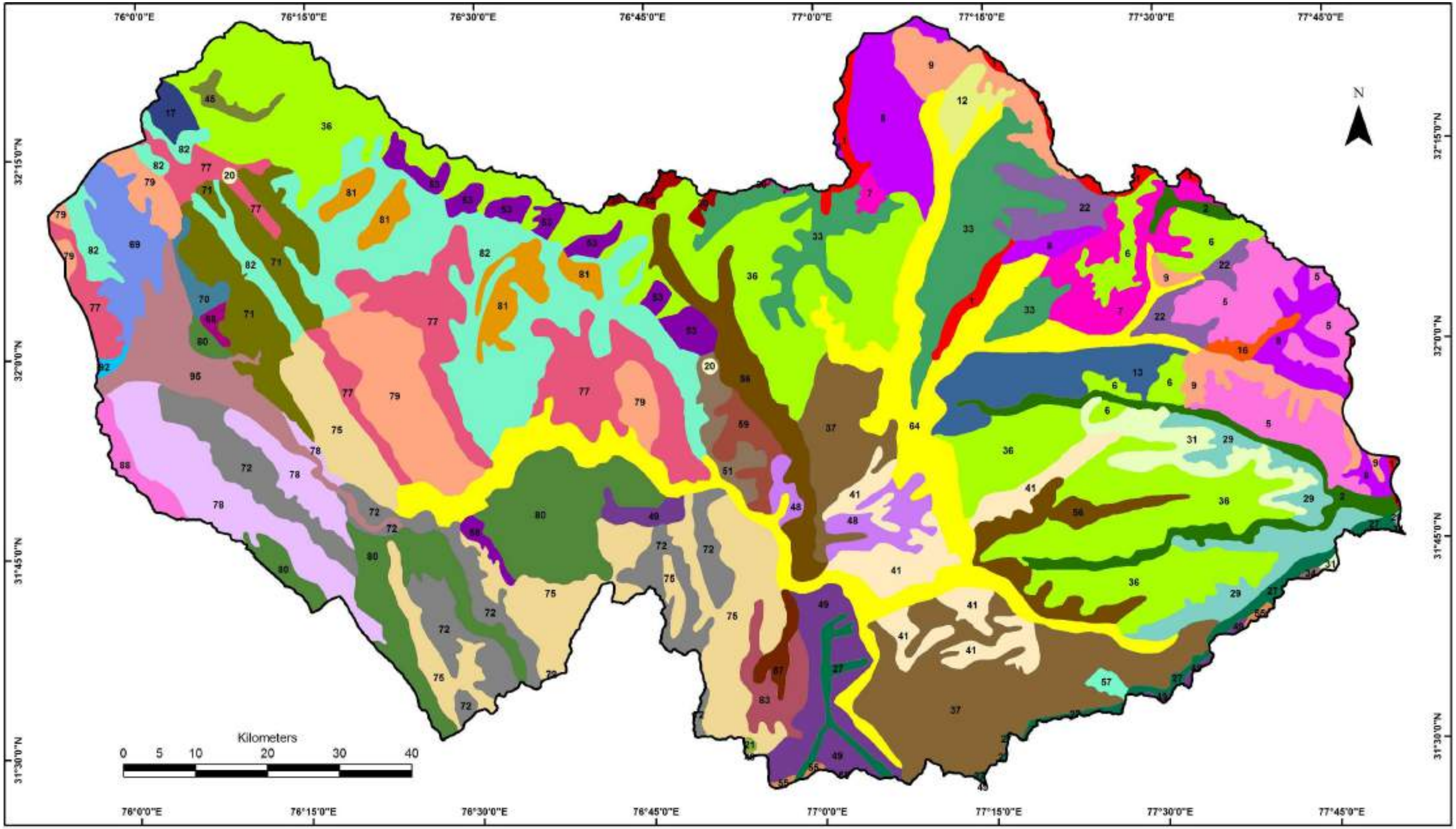


Figure 4.8: Soil Map of Beas Basin as per data from NBSS & LUP (For Soil Description refer Table 4.3)

4.7 BEAS SUB-BASINS

For the convenience of study and analysis of various physical and biological parameters and their interpretation, entire Beas basin in India has been delineated into 11 sub-basins comprised of major tributaries and covering varied domains as well as hydroelectric projects (**see Figure 4.9**). The characteristics of each sub-basin have been listed in **Table 4.4**.

Table 4.4: Characteristics of Sub-basins of Beas river basin

S. No.	Sub-basin	Altitudinal Range (m)	Projects	Status	River/Stream	Area (sq km)
1	Beas I Sub-basin	1671-6002	Beas Kund	Commissioned	Beas Kund Nala	**618.35**
			Palchan Bhang	Proposed	Kothi Nala	
			Bhang	Proposed	Beas River	
			Jobrie	Proposed	Jobrie & Allain Nala	
			Allain Duhangan	Commissioned	Allain & Duhangan Nala	
2	Beas II Sub-basin	1168-4927	Baragaon	Commissioned	Sanjoin & Bijara Nala	**798.21**
			Fozal	Under Construction	Fozal Nala	
			Raison	Proposed	Beas	
			Sarbari II	Commissioned	Sarbari Khad	
3	Malana Sub-basin	1427-5756	Malana I	Commissioned	Malana Nala	**158.04**
			Malana II	Commissioned	Malana Nala	
			Malana III	Proposed	Malana Nala	
4	Parbati Upper Sub-basin	1427-6619	Nakhtan	Proposed	Tosh Nala & Parbati River	**1437.11**
			Toss	Commissioned	Tosh Nala	
			Jari	Proposed	Parbati River	
			Balargha	Commissioned	Parbati River	
			Parbati II	Under Construction	Parbati River	
			Parbati	Proposed	Parbati River	
5	Parbati Lower Sub-basin	1168-3721	Sharni	Proposed	Parbati River	**137.02**
			Sarsadi	Proposed	Parbati River	
			Sarsadi II	Proposed	Parbati River	
6	Sainj Sub-basin	1168-5673	Sainj	Under Construction	Sainj River	**1108.37**
			Parbati III	Commissioned	Sainj River	
			Hurla I	Proposed	Hurla Nala	
7	Tirthan Sub-basin	1168-5201	-	-	-	**685.25**

S.	Sub-basin	Altitudinal	Projects	Status	River/Stream	Area
8	Beas III Sub-basin	798-3346	Patikari	Commissioned	Bakhli Khad	**703.44**
			Pandoh	Commissioned	Beas River	
			Larji	Commissioned	Beas River	
9	Uhl Sub-basin	657-5171	Lambadug	Under Construction	Lambadug Khad	**1711.71**
			Uhl	Proposed	Uhl River	
			Uhl I (Shanan)	Commissioned	Uhl River	
			Uhl II (Bassi)	Commissioned	Rana & Neri Khad	
			Uhl III	Under Construction	Rana & Neri Khad	
			Lower Uhl	Under Construction	Uhl River	
			Uhl Khad	Proposed	Uhl River	
10	Beas IV Sub-basin	414-4907	Gaj	Commissioned	Gaj Khad	**3644.10**
			Khauli	Commissioned	Khauli Khad	
			Baner	Commissioned	Baner Khad	
			Neogal	Commissioned	Neogal Nala	
			Baner II	Commissioned	Baner Khad	
			Binwa	Commissioned	Binwa Khad	
			Kilhi Bahl	Proposed	Binwa & Awa Nala	
			Pong Dam	Commissioned	Beas River	
11	Beas V Sub-basin	325-2039	Triveni Mahadev	Proposed	Beas River	**1589.19**
			Dhaulasidh	Proposed	Beas River	
			Thana Plaun	Proposed	Beas River	

Figure 4.9: Map of Beas basin showing sub-basins

4.7.1 Beas I Sub-basin

Beas I Sub-basin is the Northern-most sub-basin and is drained by Beas river. The sub-basin is comprised of the catchment of Beas river up to its confluence with Duhangan near Jagatsukh village (**Figure 4.10**). Total catchment area of the sub-basin is about 618.35 sq km. The major right bank tributaries are Sarai Nala, Halindi Nala and Manalsu Nala while the major left bank tributaries are Raoli Khol, Shikari Khol, Khanora Nal, Chhor Nala, Allain Nala and Duhangan Nala. Most of the habitations like Kothi, Ruara, Bahang, Bashist, Koshla, Aleo, Parini, Hamtah and Jagatsukh are found on the left bank of river. Habitations like Marhi, Solang, Buruwah, Goshal, Kalong, Chhyal, Slumsa, Rarsha, Salin are on the right bank of Beas river.

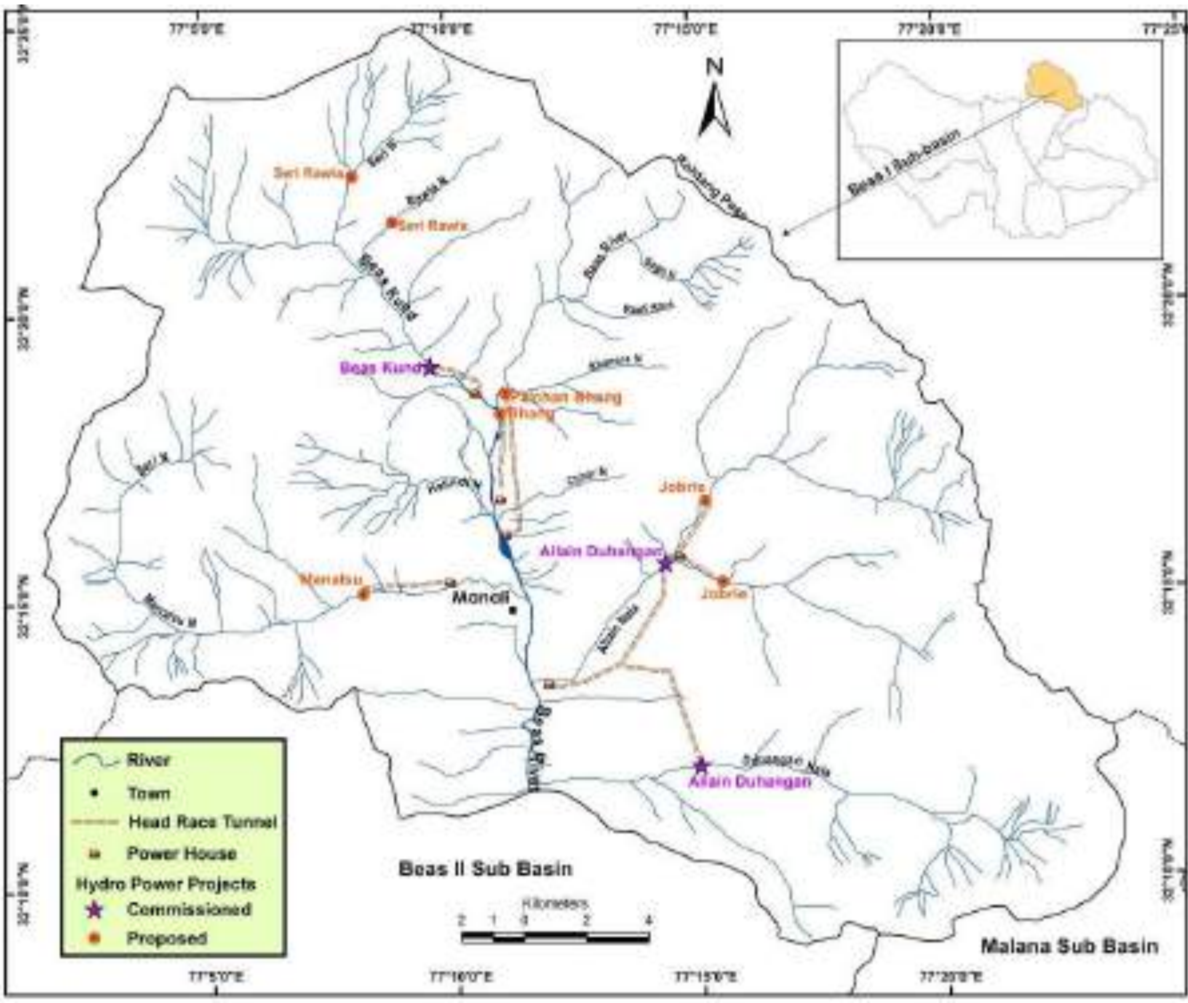


Figure 4.10: Drainage map of Beas I sub-basin

The elevation varies from 1671 m to about 6002 m (**Figure 4.11**). Majority of the sub-basin area i.e. around 54% lies in the 3600 to 4800 m elevation range, followed by 3000 to 3600 m and 2400 to 3000 m elevation range which covers nearly 20% and 13% of the sub-basin area, respectively. Elevation range from 1670 to 2400 m covers around 7% and the balance 6% of the sub-basin area is between 4800 and 6000 m elevation range.

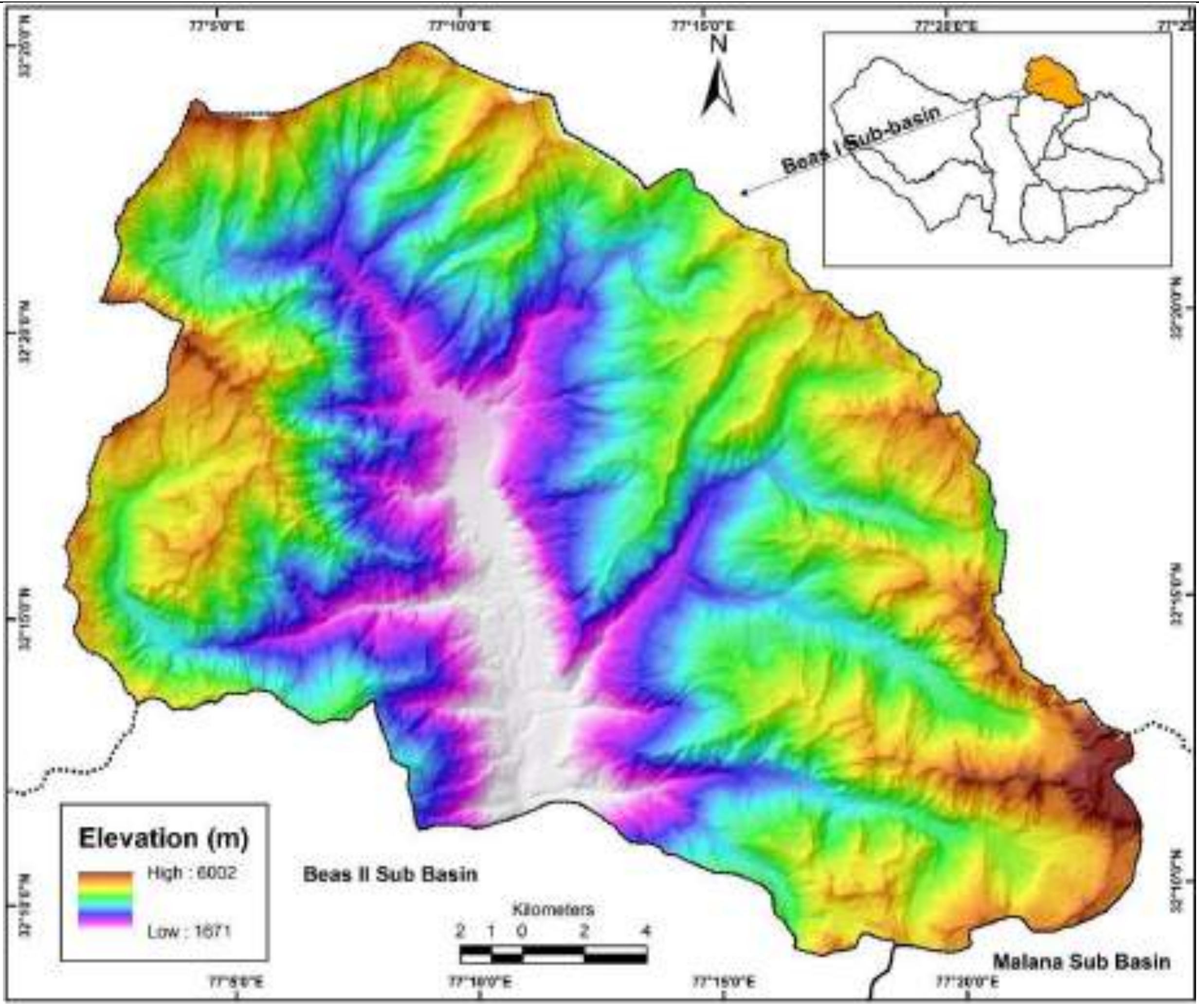


Figure 4.11: DEM of Beas I Sub-basin

Field observations in Beas I sub basin:

Allain Nala:

Allain nala is the left bank tributary of Beas River. Allain Duhangan HEP is an operational project diverting water from Allain Nala. The site is accessible by a metallic road which connects to the State Highway up to Naggar. Project area of Allain Duhangan HEP consists of temperate vegetation mainly represented by coniferous forests. Power house of Allain Duhangan HEP is located at the upstream of Beas and Allain Nala confluence on the left bank of Allain nala near Naggar village. It was observed during field survey in the area that to control the erosion of river banks, check walls have been constructed by project proponents (Bhilwara Group). The topography of the area is moderately steep.

Tail race water of Allain Duhangan HEP has been utilized by small hydro project for generation of 4 MW. One more project is under construction on Allain nala near the confluence of Allain - Beas river. Jobrie SHEP (12MW) is another in the upper most reaches of Allain Nala which is in proposal stage.

A view of Allain nala

Check walls near river bank of Allain nala

Sampling for terrestrial ecology in study area

Landscape view of Allain nala

Aquatic Sampling in Allain nala

Beas Kund:

Beas river originates from Beas Kund near Rohtang Pass at an elevation of 3978 m. The area is devoid of vegetation due to high altitude except for few species of grasses. Marhi SHEP (5 MW) is the first upper most operational project in the Beas catchment. Diversion site and power house of Marhi SHEP are located along the Manali - Keylong road. Bhang SHEP (9 MW) is also upstream of Marhi SHEP on Beas river which is in proposal stage. Palchan Bhang SHEP (9MW) project is another project near Bhang SHEP on Kothi Nala which is in proposal stage.

There is a motorable road, so accessibility in this area is easy. Main economic source in the area is tourism.


Beas Kund temple near Rohtang Pass

Water sample collection at Beas Kund

Diversion site of Marhi SHEP

Board showing location of Marhi SHEP

Sheep herds seen on the road near Marhi SHEP

4.7.2 Beas II Sub-basin

Beas Sub-basin-II is comprised of catchment area of Beas river between the confluence point of Duhangan nala with river Beas near Jagatsukh village and confluence point of Parbati river with river Beas near Bhuntar in Kullu district (**Figure 4.12**). Total catchment area of the sub-basin is about 798.21 sq km. Some of the major right bank tributaries in the sub-basin are Sanjoin nala, Phojal nala, Shirir Gad, Mandrol nala, Babeli nala, Sarbari Khad and Mahul Khad, while the major left bank tributaries are Kanoi nala, Pakhnoj nala, Chhak nala, Nashala nala, Machin ala, Raogi nala, Kais nala and Balindhi nala. Some of the major habitations on the left bank of the river in the sub-basin are Khaknal, Karjan, Haripur, Chakki, Nagar, Laran, Archhandi, Jana, Barogi, Seo Bagh, Kukri Ser, Jagot, Kinja, Talogi while major villages on the right bank are Rampur, Baragran, Patli Kuhl, Dobhi, Phojal, Kothi, Raisan, Jola, Banogi, Sarwari, Akhara, Kullu, Dhalpur, Dughilog, Shanghan, Mahul, Shamshi.

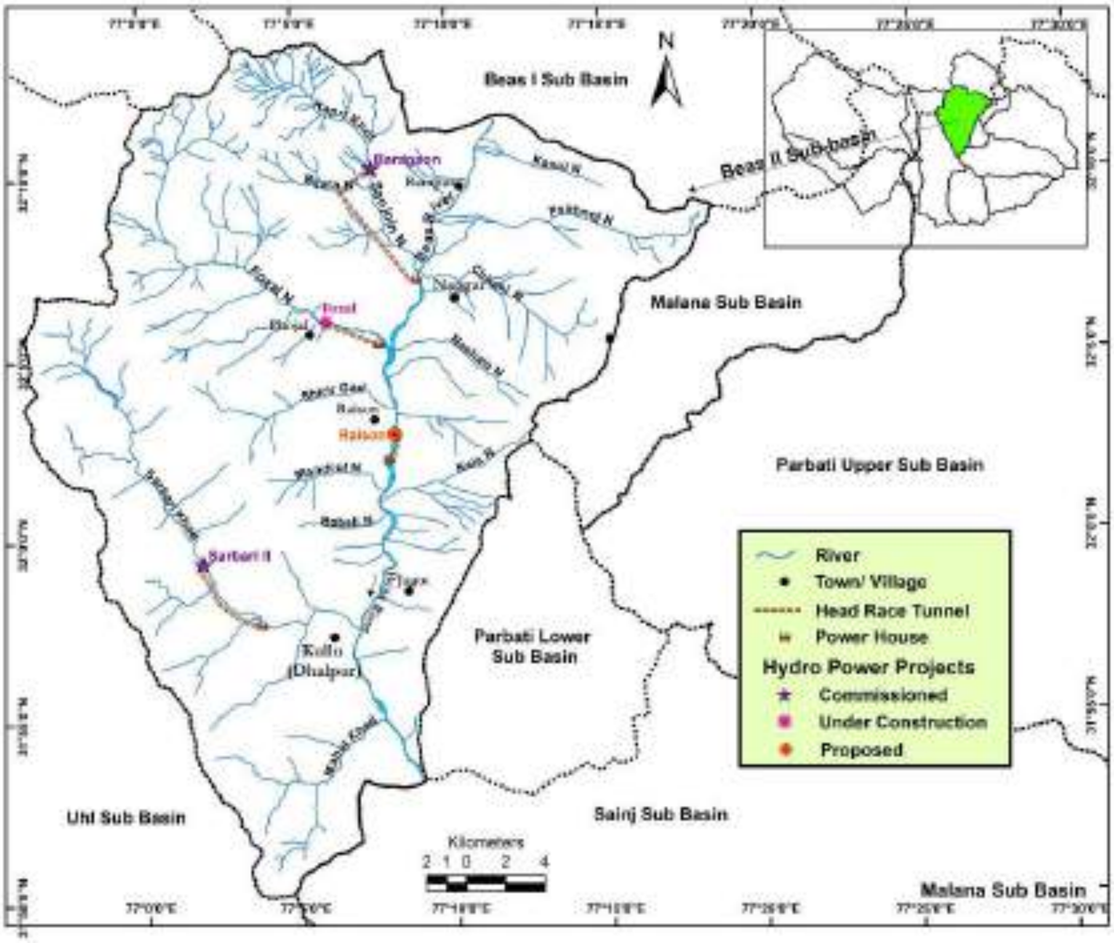


Figure 4.12: Drainage map of Beas II Sub-basin

The elevation varies from 1160 m to about 4900m (**Figure 4.13**). Elevation range of up to 1800 m covers only 17% of the sub-basin area. Around 68% of the area almost falls under elevation range of 1801 to 2400 m, 2401 to 3000 m and 3001 to 3600 m i.e. 26%, 24% and 18%, respectively. About 10% of the area falls under 3601 to 4200 m elevation range and the rest 5% of the sub-basin area is between 4201 and 4900 m elevation range.

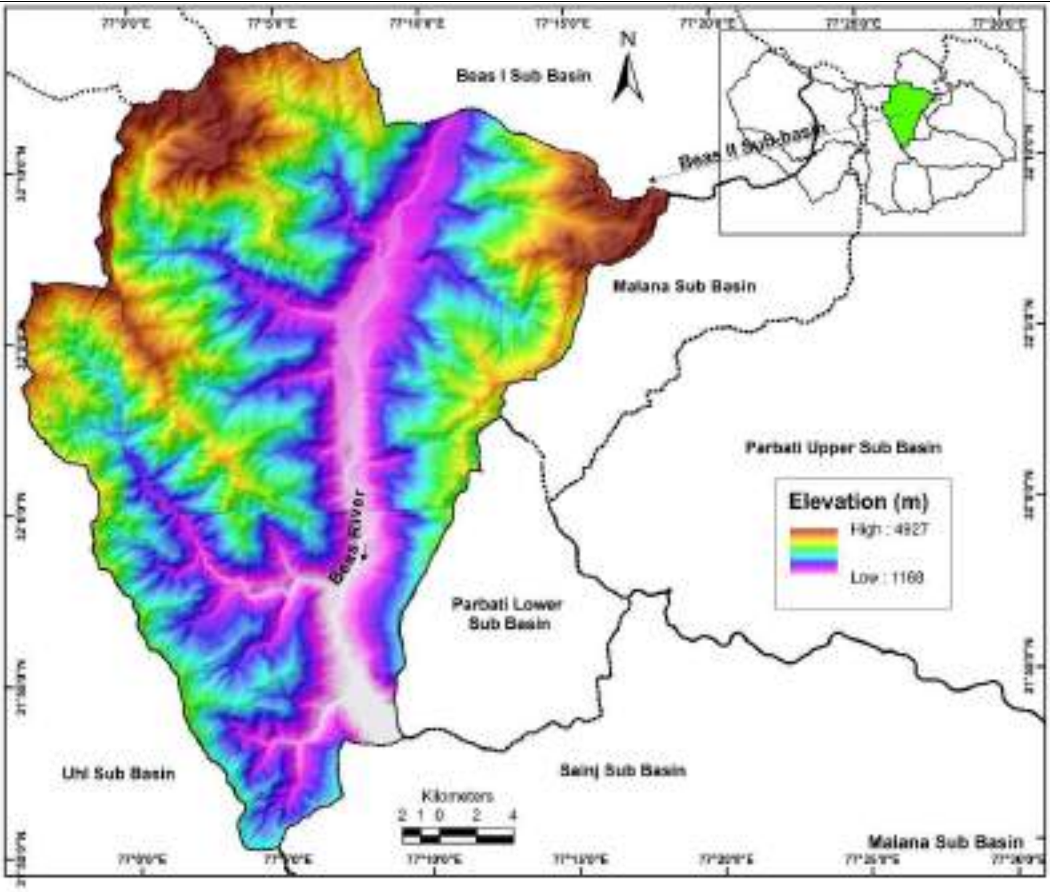


Figure 4.13: DEM of Beas II Sub-basin

Field observations in Beas II sub basin:

Sanjoin Nala: Sanjoin nala is the right bank tributary of Beas river, upstream of Fozal Nala. One operational project Baragaon SHEP (24 MW) is there at this nala.

Fojal Nala: Fojal Nala is a right bank tributary of Beas river which meets at Dobhi on Kullu Manali Highway. The area is well connected through metallic road via Kullu- Manali highway. One project is under construction at this nala named as Fozal SHEP (9MW). The area is rich in apple orchards, which are the main economy of this area. Apple is a cash crop in the area; in addition, some other crops are also cultivated by the local people for their livelihood.

Sarbari Khad: Sarbari khad is the right bank tributary of Beas river. There is an operational project on this khad; Sarbari II SHEP (5.4 MW).

Fozal Nala

Apple Tree in Fozal Nala catchment

4.7.3 Malana Sub-basin

Malana Sub-basin comprises of the catchment area of Malana nala, a right bank tributary of river Parbati. Malana nala is the largest tributary of Parbati river which originates from an unnamed glacier and travels about 25.52 km before joining river Parbati. Total catchment area of the sub-basin is about 158 sq km (**Figure 4.14**). Important streams joining Malana nala at its right bank are Bare nala, Bukora nala, Khirui nala, Nihani nala, Kabadang nala, Rangcha nala and Lahri nala while the important left bank stream is Thuchaning nala. Almost entire area on the left bank of nala is uninhabited except Thuchaning and Bhutoling villages. Villages on the right bank of the nala are Weohun, Atudang, Ragrang chin, Majigh, Malana, Bhelang Sharn, Bashona, Pohal.

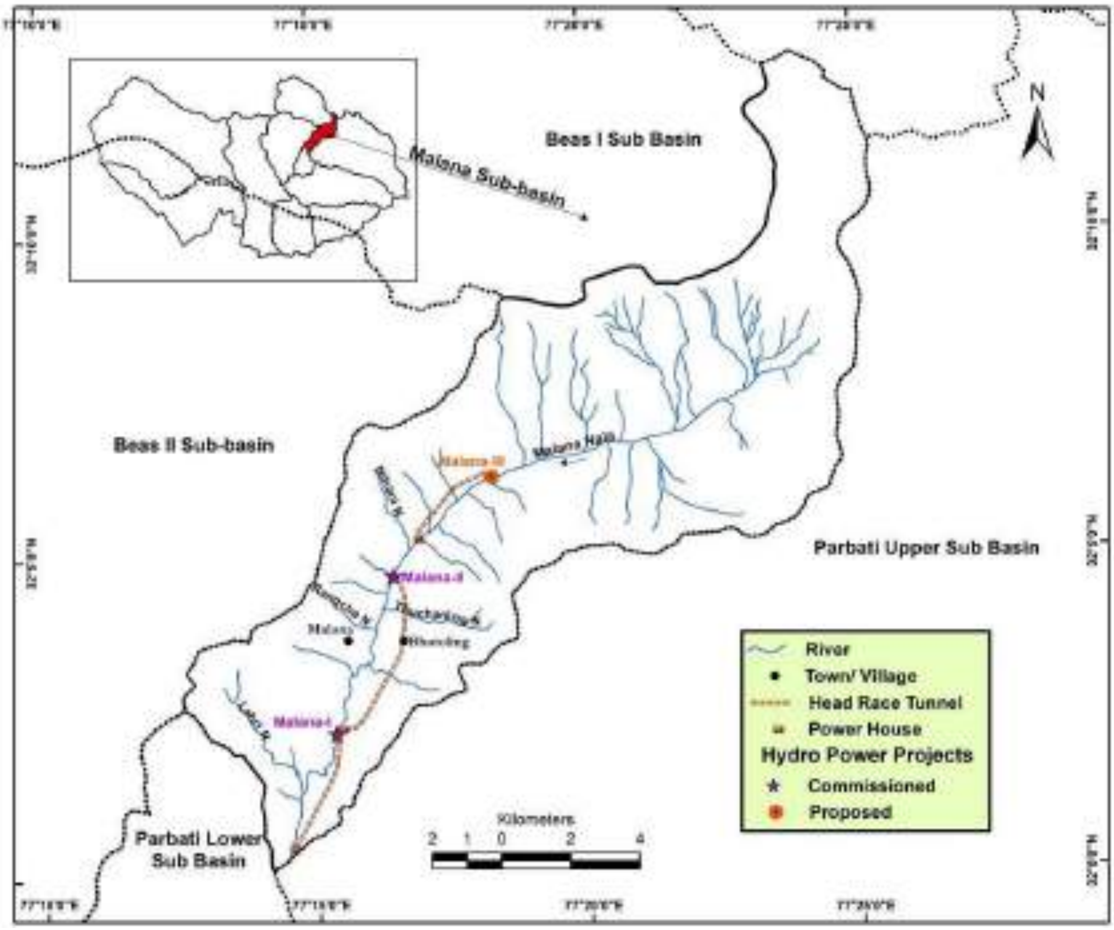


Figure 4.14: Drainage map of Malana Sub-basin

The elevation varies from 1400 m to about 5700 m (**Figure 4.15**). The area upto 2400 m elevation band covers nearly 6% of the sub-basin area. Elevation band between 2401 to 3000 m covers around 13% of the area. Around 70% of the area almost falls under elevation range of 3001 to 3600 m, 3601 to 4200 m and 4201 to 4800 m i.e. 24%, 26% and 19%, respectively. Rest 12% of the sub-basin area lies between 4801 to 5700 m elevation range.

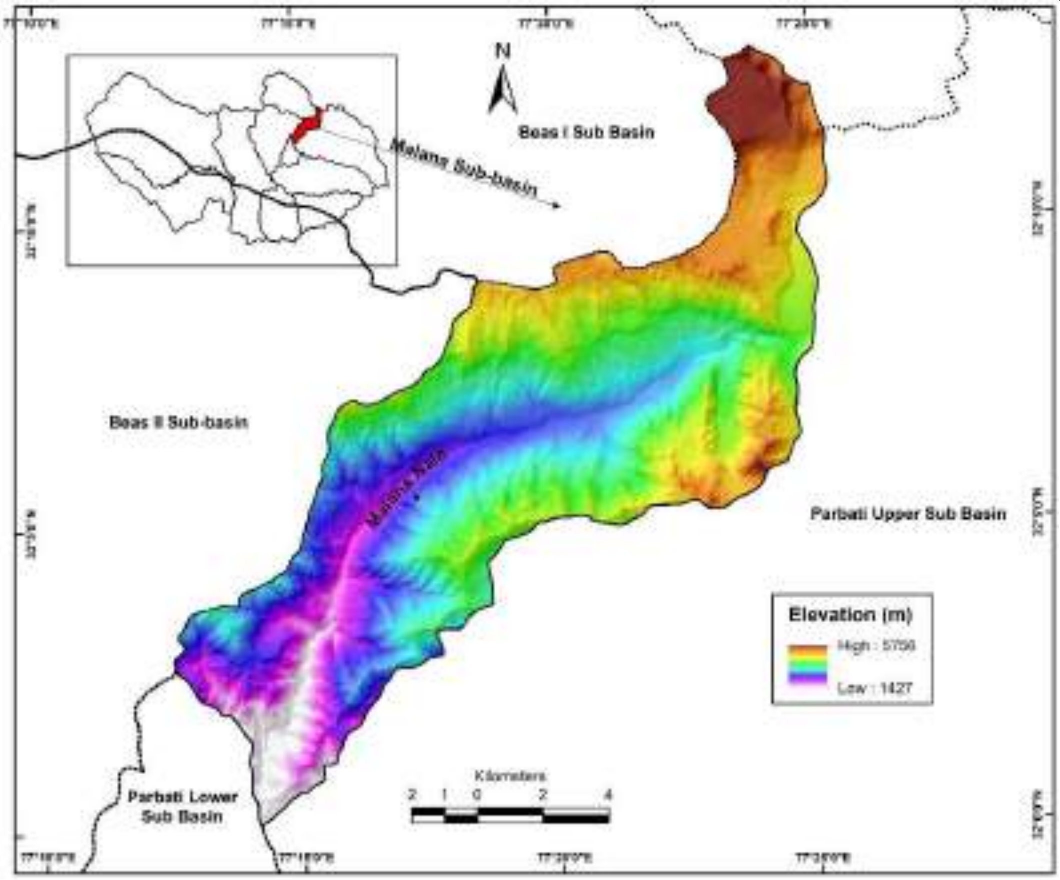


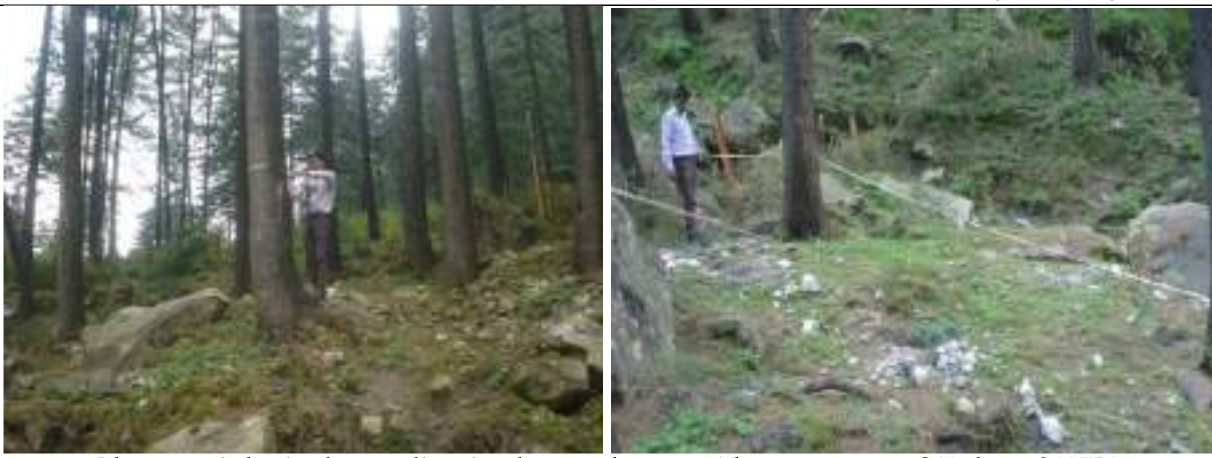
Figure 4.15: DEM of Malana Sub-basin

Field observations in Malana sub basin:

Malana Nala:

Malana Nala is the right bank tributary of Parbati river and meets near village Jari. There are two commissioned hydro-electric projects on Malana River i.e. Malana I (86 MW), and Malana II (100MW). Malana I HEP is the downstream project utilizes tail race water of Malana II. During field surveys even in monsoon season, it was observed that intermediate stretch between diversion site of Malana I till tailrace outlet is devoid of flows which can also be seen on enclosed photographs taken during field surveys shown below. One more project is upstream of existing Malana II which is in proposal stage and is called Malana III.


Dry stretch of between diversion and power house site of Malana I HEP



Phytosociological sampling in the study area (downstream of Malana I HEP)

Diversion site of Malana II HEP

Reservoir of Malana II HEP

Aquatic sampling downstream of barrage in Malana river

Bird watching and terrestrial sampling in Malana catchment downstream of barrage

Site of *Cannabis sativa* cultivation in Malana Village

Area upstream of Malana II HEP

River bank stabilization in Malana Nala

4.7.4 Parbati Upper Sub-basin

Parbati Upper sub-basin comprises of the catchment area of Parbati river from its origin at Pin Parbati Pass up to its confluence with Malana Nala (**Figure 4.16**). Parbati river is the largest tributary of Beas river. It meets Beas river at its left bank near Shamshi village. The river originates from Pin Parbati Pass at an elevation of around 5400m. Total catchment area of the sub-basin is about 1437.11 sq km. The major tributaries joining Parbati river at its right bank are Dibi ka Nal, Gohru Khol, Tosh nala, Galigad nala, Rashkar Gad, Brahamganga Nala, Gohar nala, Rasol nala, Reoni nala, while the left bank tributaries are Bakar Bihar Khol, Dauns Par Khol, Tundabhuj Khol, Bakar Kiara Khol, Jari nala, Khanora nala. Sub-basin area from the origin of Patbati river up to its confluence with Tosh nala near Pulga village is almost uninhabited. Most of the settlements are found near the river bank and is evenly distributed among both the banks. Major villages in the sub-basin are Tosh, Barsheni, Tulga, Pulga, Nakthan, Shila, Lapas, Balargha, Manikaran, Kasol, Chhalal, Jari.

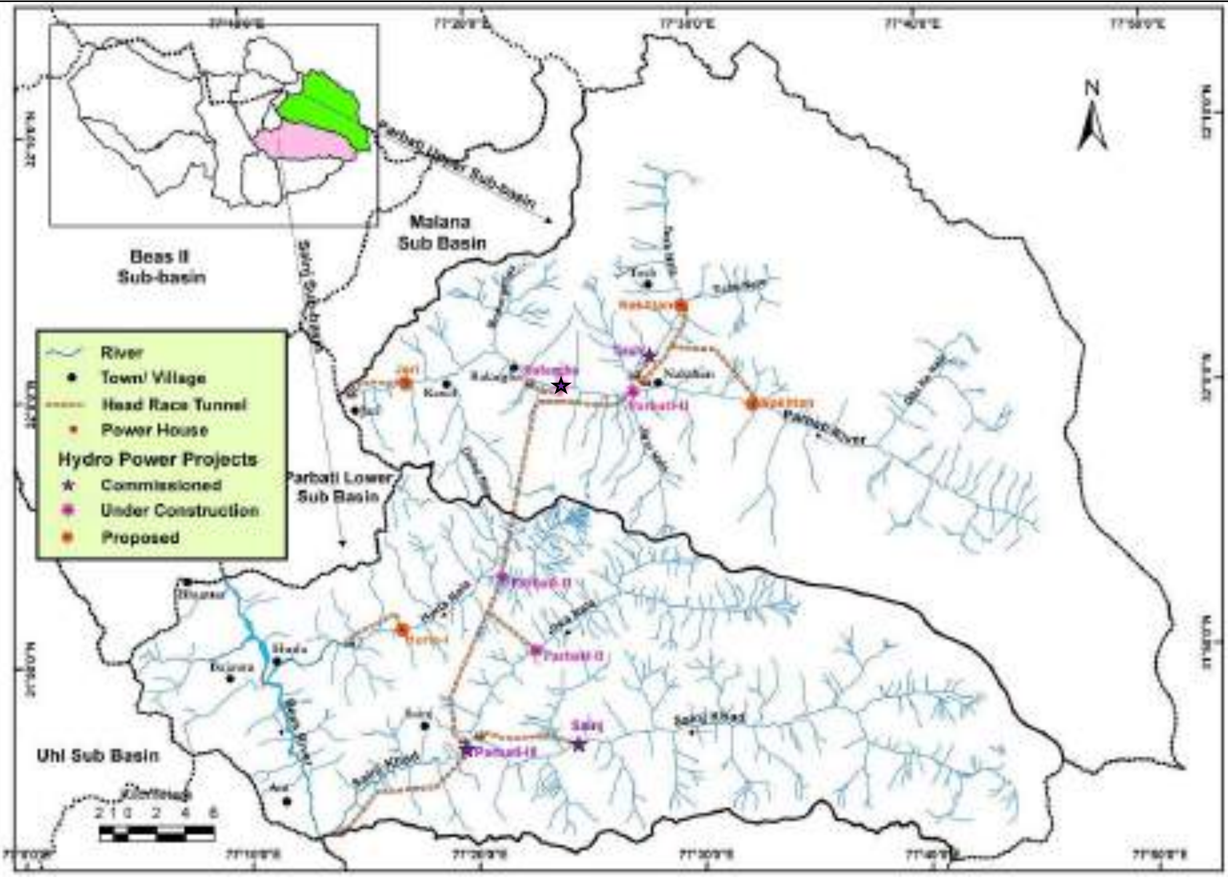


Figure 4.16: Drainage map of Parbati Upper and Sainj sub-basins

The elevation varies from 1400 m to about 6600 m (**Figure 4.17**). Elevation range of up to 1800 m covers only 5% of the sub-basin area. Elevation band between 2401 to 3600 m covers around 15% of the area. Elevation bands between 3601m to 4200 m, 4201m to 4800 and 4801m to 5400 m cover almost 73% of sub-basin area i.e. 12%, 25% and 36%, respectively. The balance 8% of the area lies in the higher elevation band of 5401 to 6600 m.

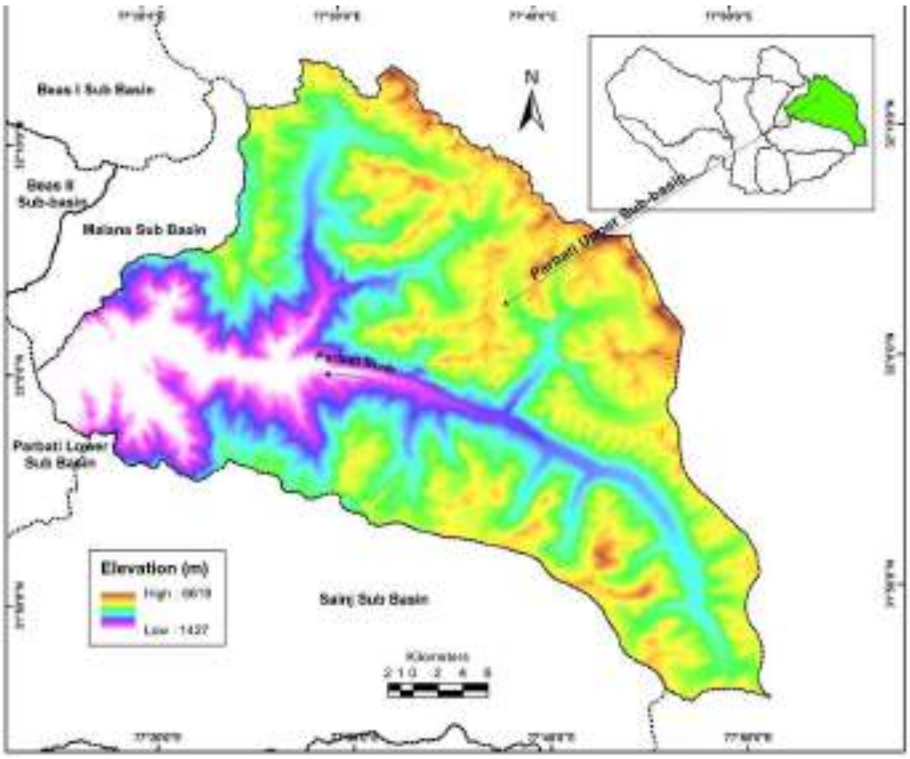


Figure 4.17: DEM of Parbati Upper sub-basin

Field observations in Parbati Upper sub-basin:

Bhuntar (Beas- Parbati Confluence):

Bhuntar is the main town of Kullu district well connected by national highway and also has an airport. Bhuntar town is at confluence of Beas and Parbati rivers. The area is surrounded by hills having good vegetation cover.

A view of confluence of Beas and Parbati rivers Settlements along river bank of Beas

Parbati River:

Parbati river is left bank tributary of Beas river which is joined first with Tosh river near Tosh Village and then confluences with Beas river near Bhuntar. Upstream of the confluence, Khirganga hot water spring is main tourist attraction in the area. This area is well connected with road network, nearest airport is Bhuntar. There is an operational project on Tosh river named Tosh SHEP (10 MW). Diversion site of Parbati II HEP is located just downstream of the confluence of Tosh and Parbati river which diverts water of Parbati river to Sainj Khad. Power house of Parbati II HEP is located in the right bank on Sainj Khad near Siund village. Nakthan HEP (520MW) project which is in proposal stage, has two diversion structures one each on Tosh nala and Parbati river with power house at confluence of Tosh Nala with Parbati river.

Balaragha HEP has recently became operational and is located on Parbati river. Balaragha HEP is located downstream of Parbati II HEP. Power house is located in the right bank of Parbati river along the Bhuntar-Pulga road opposite to the Adit-1 of Parbati II HEP.

Downstream of Balaragha HEP, there are five HEPs have been proposed which are Jari, Parbati, Sharni, Sarsadi and Sarsadi-II.

Diversion structure of Balaragha HEP

PH site of Balaragha HEP

Balaragha HEP and its surroundings

Tosh Nala and Parbati River Confluence

Under construction dam of Parbati II HEP

4.7.5 Sainj Sub-basin

Sainj sub-basin comprises of the catchment area of Sainj Khad from its confluence with Parbati river and a part of Beas river catchment from Bhuntar town up to its confluence with Sainj Khad near dam site of Larji HEP (see **Figure 4.16**). This sub-basin includes the catchment of two major tributaries of Beas river i.e. Hurla nala and Sainj Khad. Hurla nala meets Bear river on its left bank near Hurla village at 1020m. The total length of the nala is about 33.3 km with a catchment area of about 188.5 sq km. Further about 13 km downstream of Hurla Nala, Beas is fed by Sainj Khad which traverses a distance of about 59.5 km from its origin to join Beas River on left bank. The catchment area of the river is 747 sq km. It originates from unnamed glacier at an elevation of about 4200 m. The major tributaries joining Sainj Khad on its right bank are Rakti Nal, Chyos Nal, Jiun Nal, Riasa Nal, Jiwa Nal, Phagla Gad, Baga Gad while the left bank tributaries are Gahru Nal, Kuli Gad, Dhaugi Gad, Kanon Gad, Tirthan River. The other major tributaries joining Beas river at its right bank are Bajaura khad, which also happens to be the district boundary of Kullu and Mandi districts and Shiri gad. The sub-basin is densely populated with settlements on banks of Beas river, Hurla nala and Sainj Khad. Major villages on the banks of river Beas are Bhuntar, Bajaura, Nagwain, Panarsa and Aut. Major villages in the catchment of Hurla nala are Hurla, Narogi, Tharas, Sharan, Hawai, Kayund, Manihar, Garsha etc. Major villages in the catchment of Sainj khad are Sainj, Dushahar, Deori Dhar, Shansher, Bhallan, Raila, Gadaparli, Kanon, Madana, Khain, Bahli, Parkachi, etc.

The elevation varies from 1100 m to about 5700 m (**Figure 4.20**). Only 16% of the sub-basin area lies in the 1101 to 1800m elevation band. Around 60% of the area almost falls under elevation range of 1801 to 2400 m, 2401 to 3000 m, 3001 to 3600 and 3601 to 4200 m i.e. 17%, 15%, 14% and 14%, respectively. Elevation band between 4201 to 4800 m covers around 16% of the area. Rest 8% of the sub-basin area lies between 4801 to 5700 m elevation range.

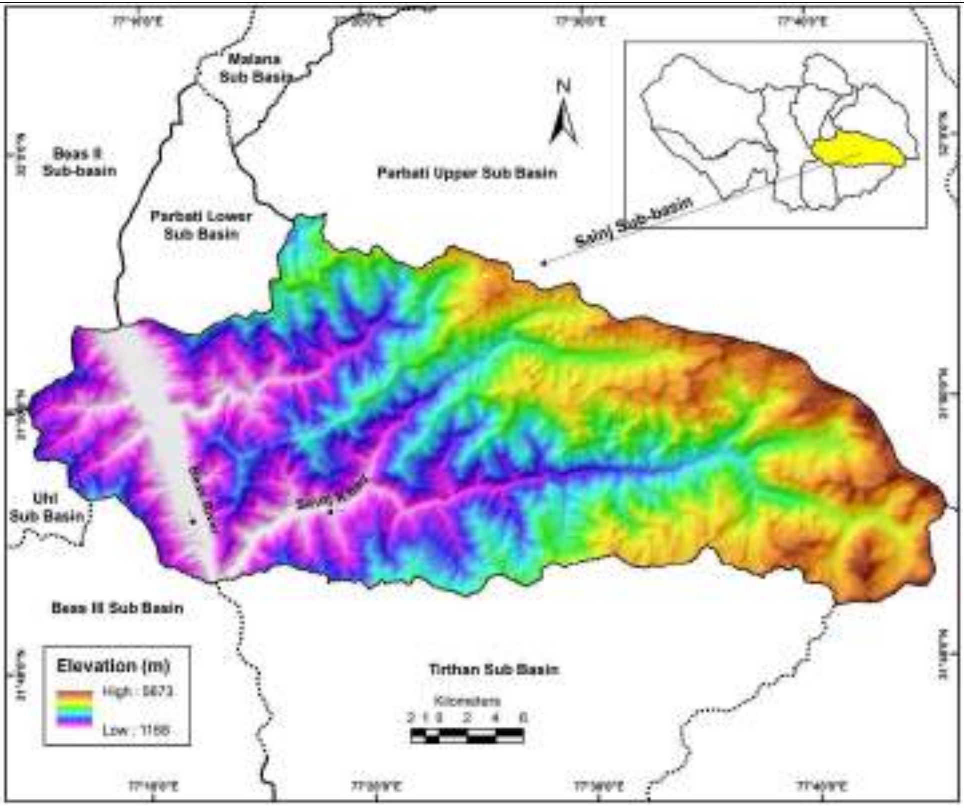


Figure 4.18: DEM of Sainj Sub-basin

<u>Field observations in Sainj sub basin:</u>

<u>Hurla Nala:</u> Hurla nala is the left bank tributary of Beas river. Hurla-I SHEP is proposed on this nala.

<u>Sainj Khad:</u>

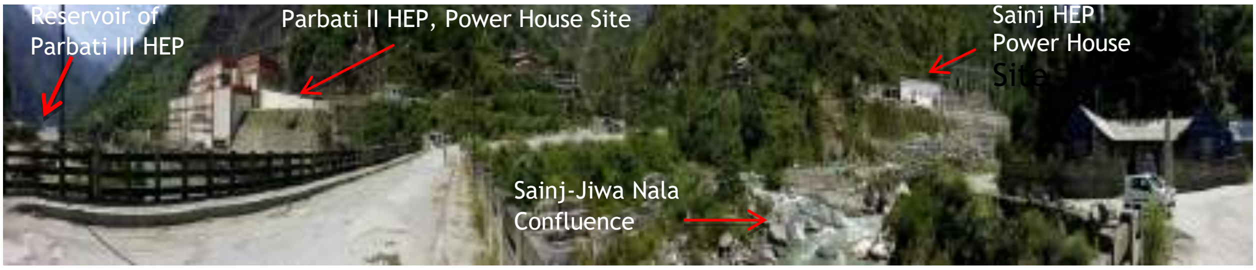
Sainj Khad is the left bank tributary of Beas river. Sainj HEP (100MW) is an under construction project developed by HPPCL on Sainj Khad. Dam site is located approximately 8 km from Neuli and approximately 16 km from Sainj HEP Power house site. Powerhouse site is located on right bank of Sainj Khad near Jiwa Nala and Sainj Khad confluence. Parbati II HEP Power house is also located adjacent to confluence of Jiwa nala and Sainj Khad. Parbati stage II is inter-basin project as it utilizes the water of Parbati river (Dam site of Parbati stage II located near Tosh- Parbati confluence at Pulga) and diverts water of Parbati river to Sainj Khad catchment. Tailrace of Parbati II HEP outfalls in the reservoir of Parbati III HEP i.e. upstream of diversion site of Parbati III HEP. It was observed that fish ladder has been provided in the dam structure of Sainj project. (Shown below)

Dam Site of Sainj HEP

Intake structure of Sainj HEP

Fish Ladder in Dam structure of Sainj HEP

Confluence of Sainj Khad and Jiwa Nala and Power House site of Sainj HEP



Panoramic view of Parbati II HEP (Power House site) and Sainj HEP (Power House Site)

4.7.6 Parbati Lower sub-basin

Parbati Lower sub-basin comprises of the catchment area of Parbati river from its confluence with Malana nala till it meets river Beas near Shamshi village (**Figure 4.18**). The river flows for only about 18 km in the sub-basin. Total catchment area of the sub-basin is about 137.02 sq km. The major tributary joining Parbati river at its right bank is Baladhi nala, while the left bank tributaries are Charror nala and Shat nala. The sub-basin is thickly populated with settlements on both the banks of river. Major villages in the sub-basin are Baladhi, Ghajyari, Banasha, Chhashni, Danogi, Bharain, Bhuin, Narogi, Barogi, Sarsari, Jalagran, Shat.

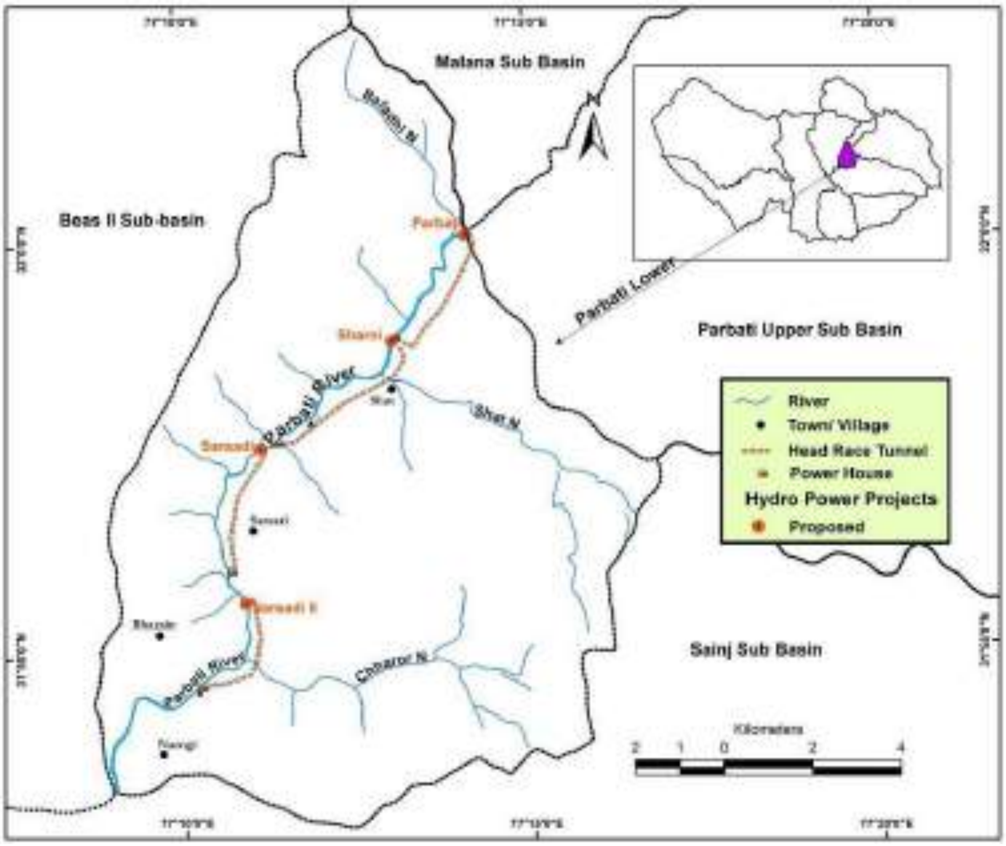


Figure 4.19: Drainage Map of Parbati Lower sub-basin

The river bed level varies from 1100 m to about 3700 m (**Figure 4.19**). About 33% of the sub-basin area lies in the 1101 to 1800 m elevation band. Around 35% of the area is covered by 1801 to 2400 m elevation band. Elevation band between 2401 to 3000 m covers around 25% of the area. The higher elevation band between 3001 and 4200 m covers the balance 7% of the sub-basin area.

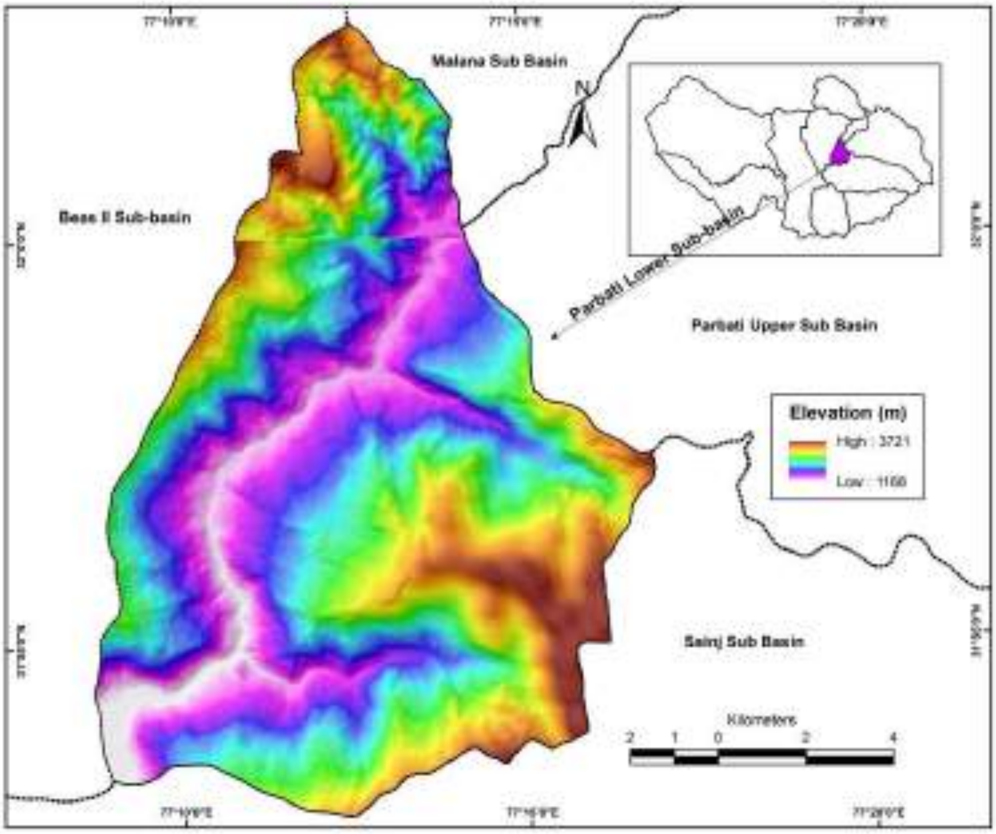


Figure 4.20: DEM of Parbati Lower sub-basin

4.7.7 Tirthan Sub-basin

Tirthan sub-basin comprises of the catchment area of Tirthan river from its origin and upto its confluence with Sainj Khad near Larji village (**Figure 4.21**). It originates from unnamed glacier at an elevation of 4378m and travels a distance of about 50.7 km to join Sainj Khad at its left bank. It is the biggest tributary of Sainj Khad. The Catchment area of Tirthan sub-basin is about 685 sq km. The important tributaries joining Tirthan river at its right bank are Rakhundi nala, Kalwari nala, Ghori gad, Kamand gad, while the important left bank tributaries are Mani nala, Koki gad, Jibhi gad, Maahlra nala and Palachan gad. No project has been proposed in this sub-basin as it has been declared as no go area for hydropower projects by the state government.

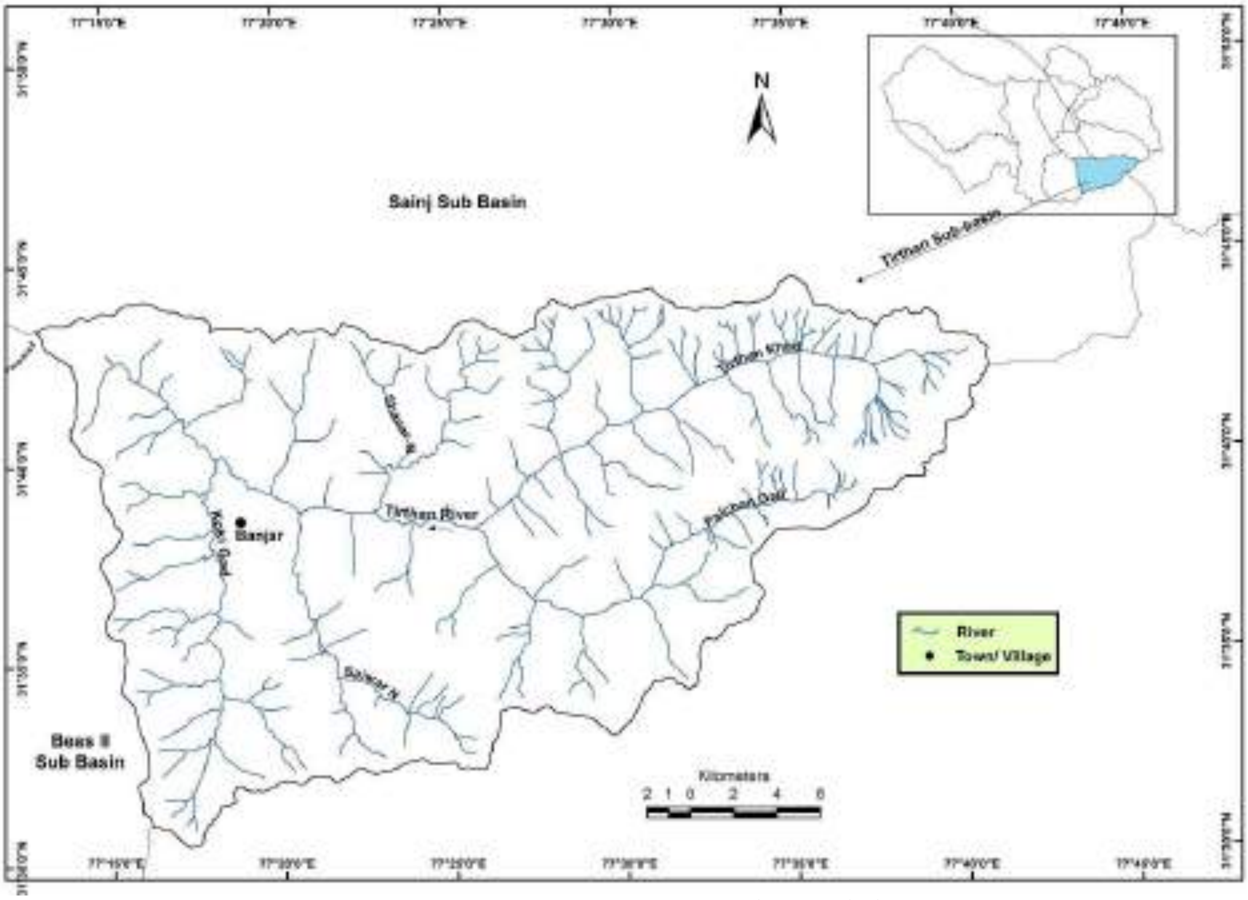


Figure 4.21: Drainage map of Tirthan Sub-basin

The elevation varies from 1100 m to about 5200 m (**Figure 4.22**). Only 11% of the sub-basin area lies in the 1101 to 1800m elevation band. Elevation band between 1801 to 2400 m covers around 20% of the area. Around 52% of the area almost falls under elevation range of 2401 to 3000 m and 3001 to 3600 i.e. 33% and 19%, respectively. Elevation range from 3601 to 4800 m covers around 16% and the balance 1% area lies in the higher elevation band of 4801 to 5400 m.

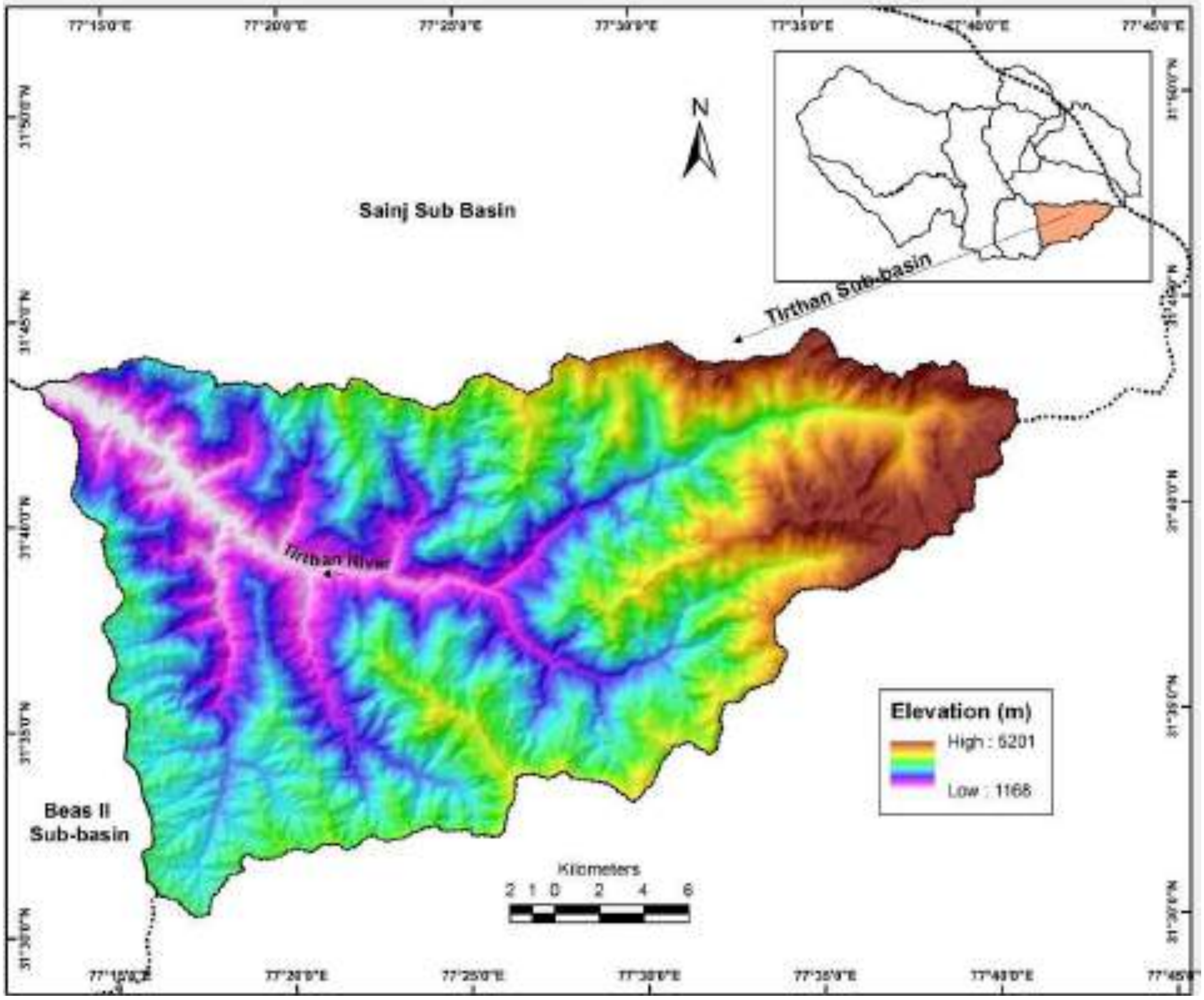


Figure 4.22: DEM of Tirthan Sub-basin

4.7.8 Beas III Sub-basin

Beas Sub-basin-III is comprised of catchment area of Beas river between the confluence point of Tirthan River with river Beas and upstream of Uhl River near Ghamun village (**Figure 4.23**). Total catchment area of the sub-basin is about 703.44 sq km. Some of the major right bank tributaries in the sub-basin are Chul Nala, Sariwar Khad while the major left bank tributaries are Gurahan Gad, Bakhli Khad and Juni Khad. The sub-basin is thickly populated with settlements on both the banks of river. Some of the major habitations on the right bank of the river in the sub-basin are Khini, Thalat, Jadaorr, Khandli, Kabriana, Shanor, Ranogi, Patajis,Kanda, Norena, Ghamir, Nahogi, Bhabas, Rataun, Nuser, Bota, Thata, Sumar, Banot, Kun, Niyal and Ghamun while major villages on the left bank are Bachhar, Panjal, Dobha, Basahan, Mathej, Thahri, Bhatwara, Jhuli, Thachi, Shiwadhar, Tharan, Thanuta, Ghidha, Marwa, Nulagi, Shiwadhar, Bhakhalwar, Buksaid, Thach, Sianj, Kut, Pandoh, Taryambla, etc.

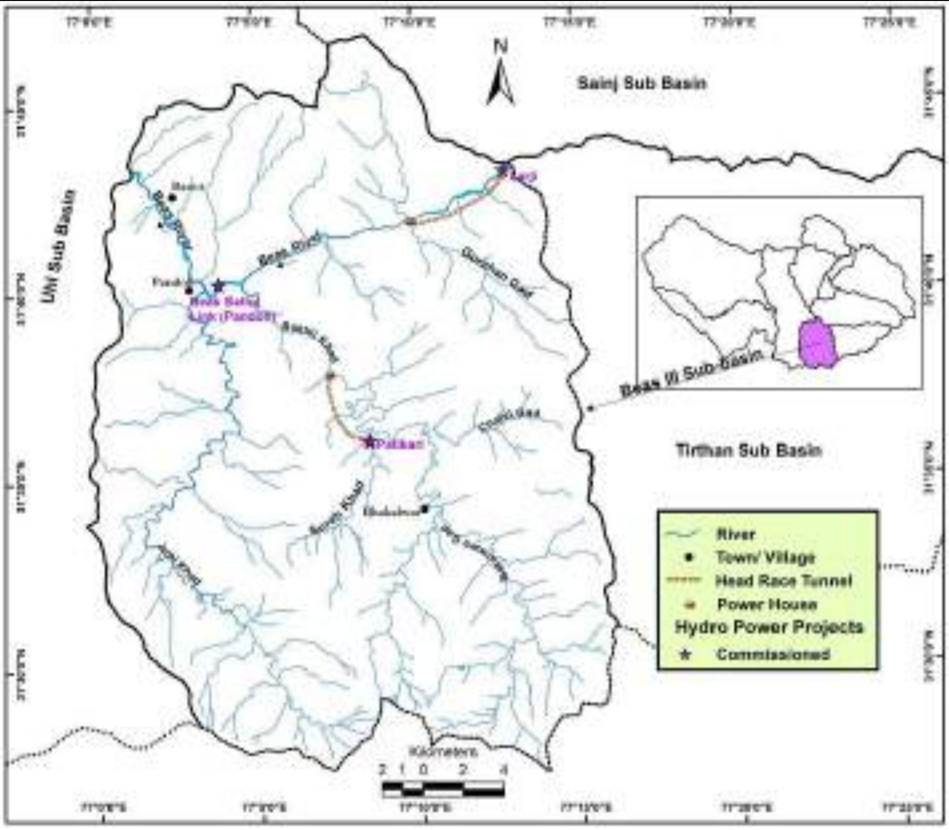


Figure 4.23: Drainage map of Beas III Sub-basin

The elevation varies from 800 m to about 3400 m (**Figure 4.24**). Only 10% of the sub-basin area lies in the 801 to 1200m elevation band. Elevation band between 1201 to 1800 m and 1801 to 2400m covers almost equal area i.e. 32% each. Around 25% of the area falls under elevation range of 2401 to 3000 m and the rest 1% area lies in the elevation band of 3001 to 3400 m.

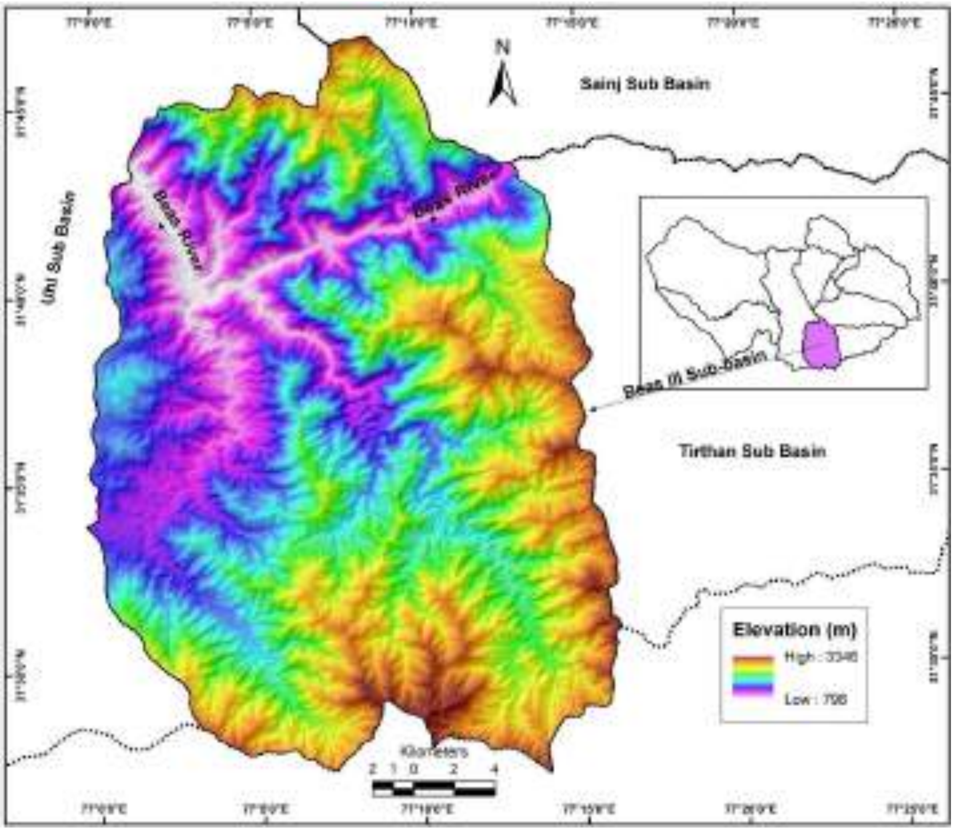


Figure 4.24: DEM of Beas III Sub-basin

Field observations in Beas III sub basin:

Larji HEP reservoir and Dam site:

Larji HEP (126 MW) utilizes water of Sainj Khad, Tirthan river and Beas river. There is a head race tunnel of 3 km (starts near Larji Dam and ends at Aut) along Kullu- Mandi highway. Hills are covered with vegetation. Accessibility in this area is very good. Pandoh HEP is another operational project located downstream Larji HEP on Beas river.

A view of reservoir of Larji HEP

Dam structure of Larji HEP

Outlet of Power House of Larji HEP

Bakhli Khad: Bakhli Khad is the left bank tributary of Beas river which meets near Pandoh HEP. There is an operational project Patikari SHEP (16MW) on this Khad.

4.7.9 Uhl Sub-basin

Uhl sub-basin comprises of the catchment area of Uhl river including catchment area of Beas river from downstream of Pandoh Dam to the confluence of Rana and Arnodi Khads with river Beas in Mandi district (**Figure 4.25**). Major tributaries joining river Beas at its right bank in the sub-basin are Uhl river, Kushak nala, Dev ki Khad, Luni Khad and Rana Khad, while the major tributaries joining river Beas at its left bank in the sub-basin are Suketi Khad, Kasani Khad and Arnodi Khad. Uhl river traverses about 73 km with a catchment area of about 755.6 sq km. Rana Khad meets Beas river near Tudal village. The length of the river is 27.3 km and catchment area of the river is 224.5 sq km. The sub-basin is densely populated, and a large area is under agricultural fields. Major settlements on the banks of river Beas are Mandi, Mangwai, Tamlu, Sari, Kot, Charori.

Major villages in the catchment of Uhl river are Bingahr, Bahladhar, Chumasagran, Tikkar, Ganwag, Chhudhal, Kalangehr, Kortong, Draggar, Chelang, Kaljhar, Garaman, Gahang, Madharwan, etc. Major villages in the catchment of Rana Khad are Banogi, Nauhli, Dagsali, Kaduna, Nagar, etc. Major villages in the catchment of Suketi Khad are Chhachol, Banna, pipli, Gagal, Kehr, Bhangrotu, Maltehr, Sianji, Sundarnagar, Ner Chowk, Tholag, Lohakar, Nanawan, Batwar, etc.

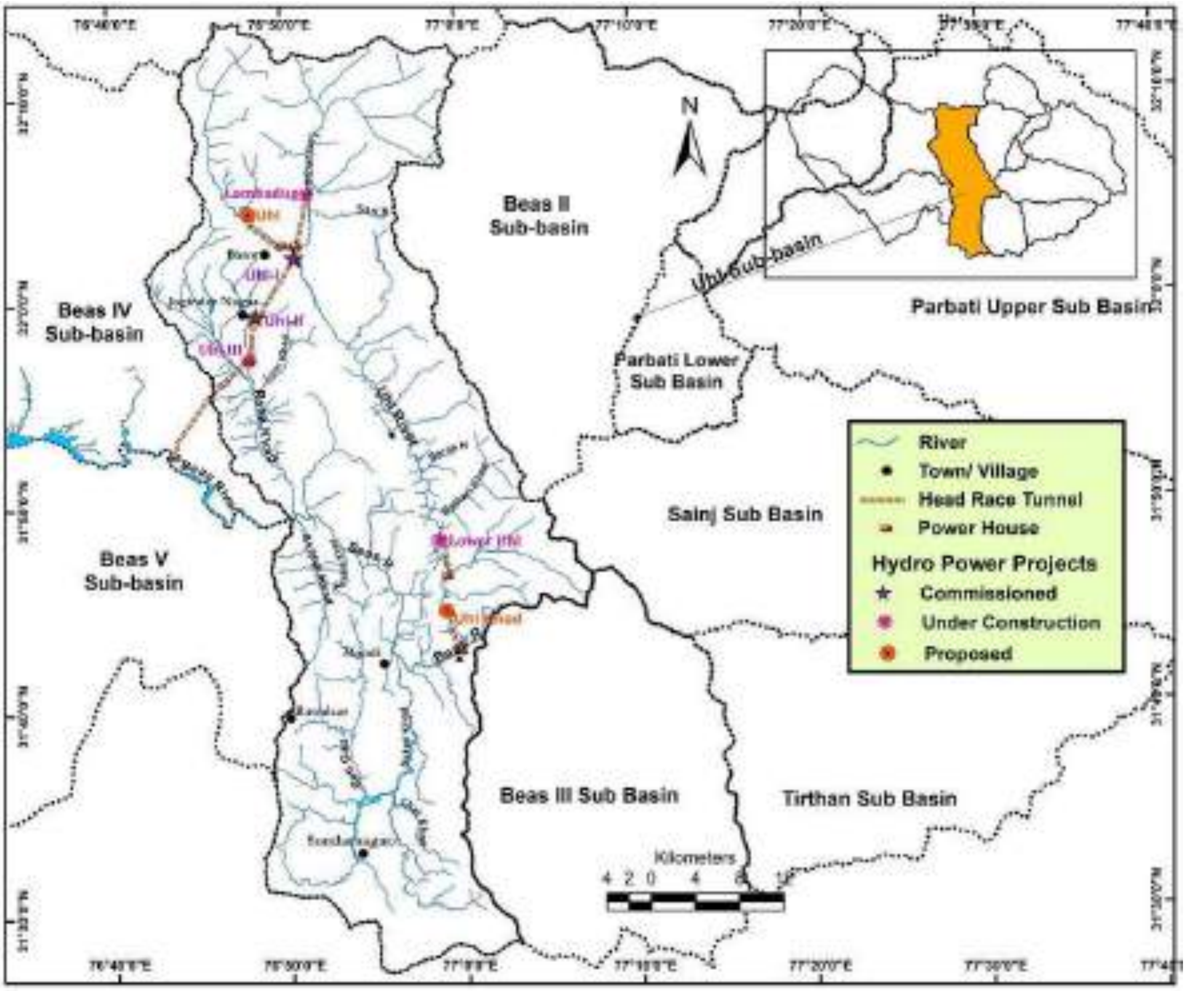


Figure 4.25: Drainage map of Uhl Sub-basin

The elevation varies from 650 m to about 5200 m (**Figure 4.26**). Majority of the sub-basin area i.e. around 32% lies in the 650 to 1200 m elevation range, followed by 1201 to 1800 m and 1801 to 2400 m elevation range which covers nearly 29% and 13% of the sub-basin area respectively. Elevation range from 2401 to 3000 m, 3001 to 3600 and 3601 to 4200m covers around 22% i.e. 9%, 6% and 6% respectively. Rest 4% area lies in the higher elevation band of 4201 to 5400 m.

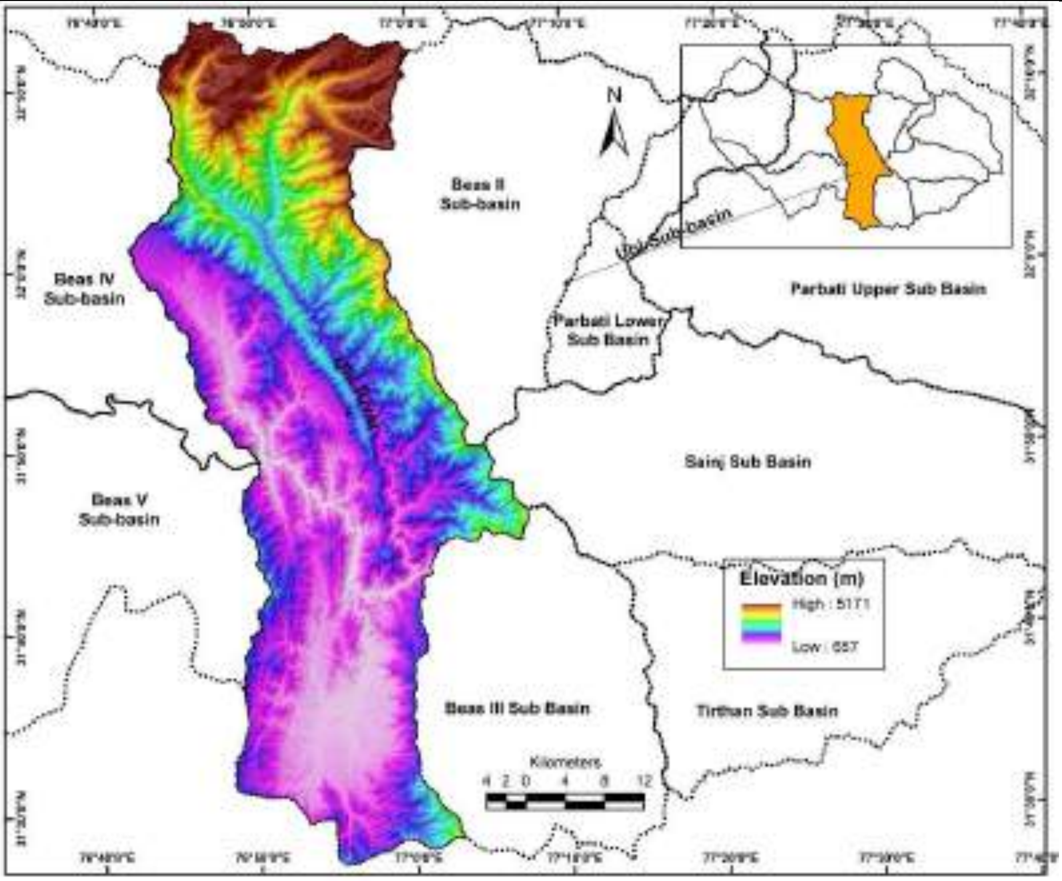


Figure 4.26: DEM of Uhl Sub-basin

__Field observations in Uhl sub basin:__

__Uhl river:__

Uhl river is the right bank tributary of Beas river which meets near Mandi town. During field surveys it was observed that fishing is common practice in Uhl river. Area is covered with good vegetation cover. Lambadug HEP (under construction) is the upper most HEP in the catchment of Uhl river. Diversion site of Uhl-I HEP is located at the downstream of Lambadug power house site. Uhl I HEP (Shanan) is an operational project diverting water from Uhl river to Shannan Khad. Power house of Uhl-I HEP is located along Shanan Khad near Joginder Nagar (Mandi). Uhl II HEP (Bassi Hydro Project) is a tail race development of Uhl-I HEP. Tailrace waters of Uhl II HEP are utilized by Uhl III HEP. Power house of Uhl II HEP is located near Neri Khad near Joginder Nagar town. Power house of Uhl III HEP is at the downstream of Rana Khad-Beas river confluence discharging tailrace water in the reservoir of proposed Triveni Mahadev HEP on Beas river.

Lower Uhl HEP and Uhl SHEP are two under construction hydroelectric projects on Uhl river. Uhl SHEP (14MW) is located near Baltikar village being developed by USP hydro Energy Pvt. Ltd. Lower Uhl (13 MW) is a downstream project of Uhl SHEP located near IIT Mandi. Uhl Khad HEP is the most downstream project on Uhl river. Power house of Uhl Khad is on right bank of Beas river near Uhl-Beas confluence.

Fishing in Uhl River

Landside in Uhl river

Uhl river

Aquatic sampling in Uhl river

Diversion site of Uhl I HEP

Outlet of Uhl I used by Bassi PH

Outlet of Uhl I HEP with open trench

4.7.10 Beas IV Sub-basin

Beas IV sub-basin comprises of the right bank catchment area of Beas river from the confluence of Rana and Arnodi Khads with river Beas up to Pong Dam (**Figure 4.27**). The major tributaries joining river Beas at its right bank in the sub-basin are Binno (Binwa) Khad, Chahan Khad, Ganunu Khad, Harori Khad, Mandh Khad, Neugal Khad, Lohar Khad, Tall Khad, Nakehr Khad, Baner Khad, Minnu Khad, Gaj Khad and Khauli Khad. Binno (Binwa) Khad meets river Beas on its right bank at elevation of 636m. Binwa Khad is also known as Binno Khad in higher reaches. The length of the river is 42 km and catchment area of the river is 375.35 sq km. Neugal Khad meets Beas river on its right bank near Alampur village. The length of the river is 55 km and catchment area of the river is 386 sq km. Baner Khad meets Beas river on its right bank near Mahora village. The length of the river is 63 km and catchment area of the river is 749 sq km. Gaj Khad originates from an altitude of 4400m and travels 64 km to join the Beas river on right bank a little upstream of Pong dam lake. The catchment area of the river is 1246 sq km. The sub-basin is densely populated and a large area is covered by agricultural fileds. Major settlements on the bank of river Beas are Tulah, Molago, Chamar, Tikri, Alampur, Sialkar, Kulehra, Jajwal, Kurhu, Borwari, Kother, Janota, etc. The major towns in the sub-basin are Joginder Nagar, Baijnath, Kangra, Gaggal, Palampur, Dharamshala, etc.

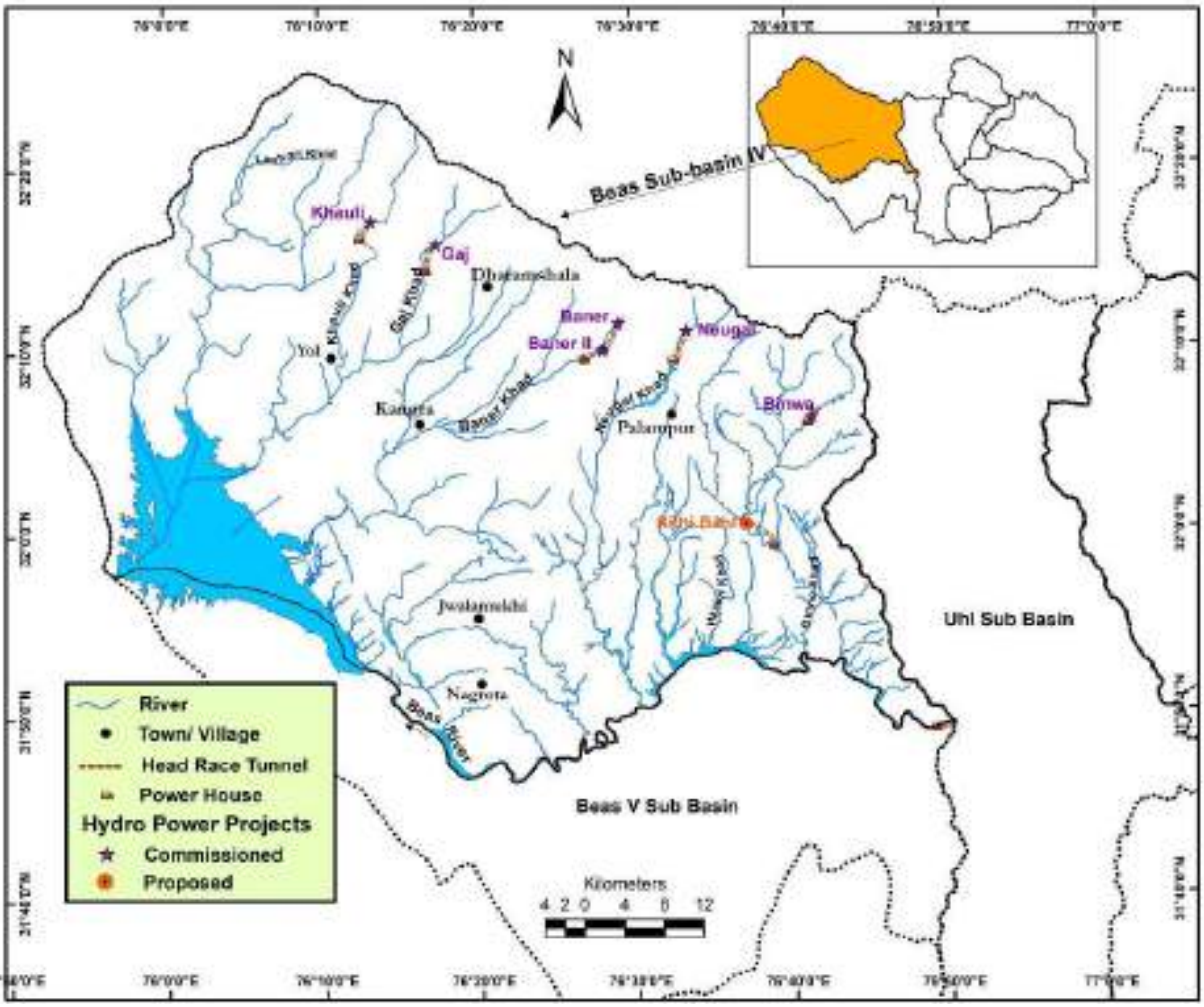


Figure 4.27: Drainage map of Beas IV Sub-basin

The elevation varies from 400 m to about 4900 m (**Figure 4.28**). Elevation range from 401 to 600 m covers around 26% of sub-basin area. Majority of area i.e. 49% lies in 601 to 1200m elevation band. Only 10% of the sub-basin area lies in the 1101 to 1800m elevation range. Elevation band between 1801 to 2400 m and 2401 to 3000 covers around 12% of the area i.e. 6% each. The balance 4% area lies in the elevation band of 3001 to 4800 m.

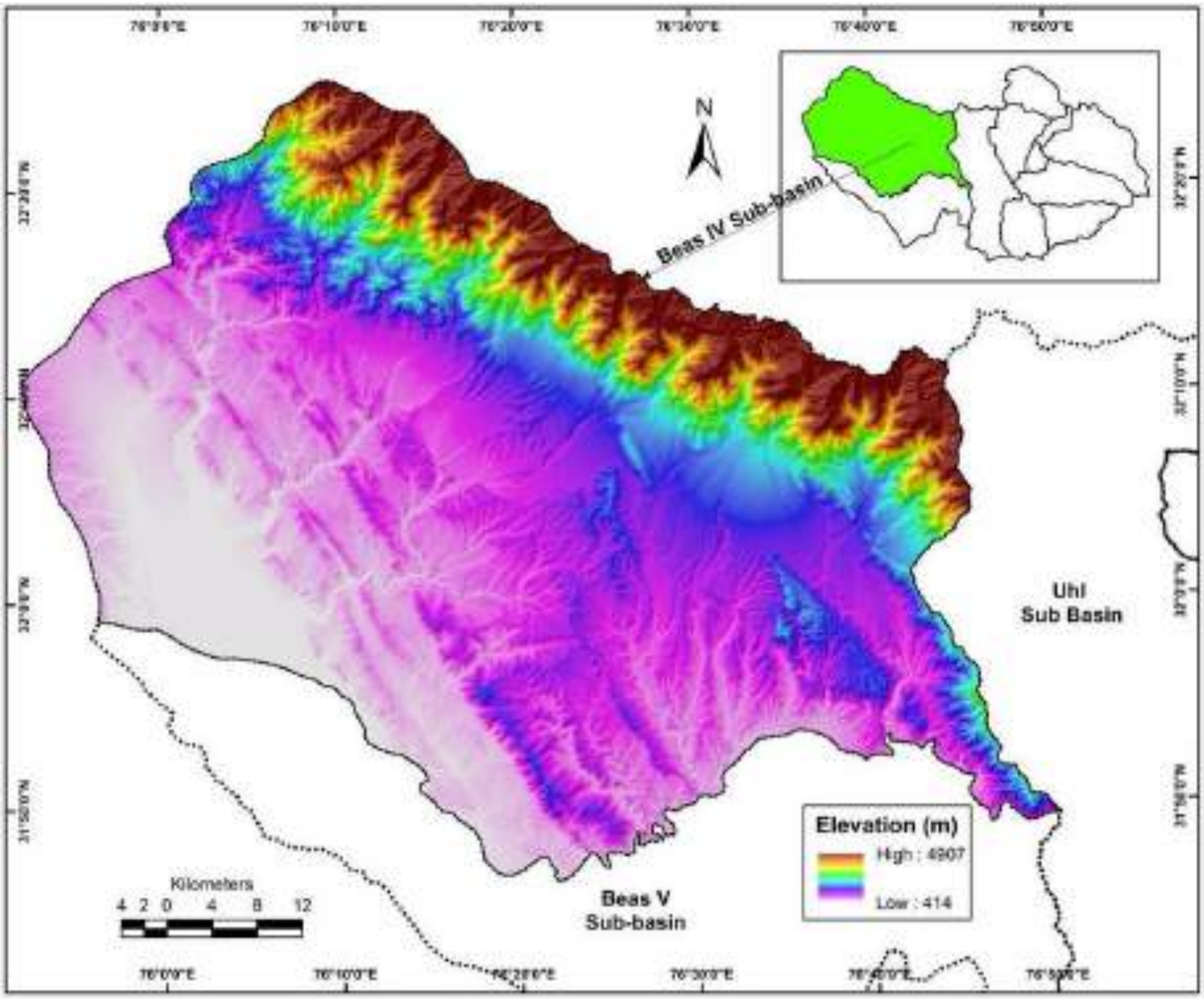


Figure 4.28: DEM of Beas IV Sub-basin

Field observations in Beas IV sub basin:

Binwa Khad:

Binwa Khad is the right bank tributary of Beas river. Binwa SHEP (6MW) is an operational project on this khad. Another project is at the downstream of the Binwa SHEP at Binwa Khad named Kilhi Bahl which is in proposal stage. Binwa Khad passes through Paprola town which is famous for Baijnath temple. This is an archeological site and a famous religious and tourist place. Palampur is another tourist destination which is famous for tea gardens is approximately 16 km from Paprola. A metallic canal was made in Binwa khad near Paprola by the Irrigation Department for irrigation purposes.

Baijnath Temple

Metalled canal in Binwa Khad

Aquatic sampling in Binwa Khad

Terrestrial sampling in the study area

Khauli Khad, Gaj Khad, Baner Khad and Neugal Khad:

Khauli Khad, Gaj Khad, Baner Khad and Neugal Khad are the right bank tributaries of Beas river. On Gaj Khad and Khauli Khad; there are one operational projects i.e. Gaj SHEP (10.5 MW) and Khauli SHEP (12MW) and on Baner Khad, there are two operational projects named Baner SHEP and Baner II SHEP, and in Neugal Khad also there is an operational project called Neugal SHEP (15MW). The area is accessible by road from Dharamsala which is a tourist destination.

Gaj Khad

Khauli Khad

A view of Baner Khad

Outlet of power house at Baner Khad

Reservoir in Baner Khad

Power house site at Baner khad

4.7.11 Beas V Sub-basin

Beas V sub-basin comprises of the left bank catchment area of Beas river from the confluence of Rana and Arnodi Khads with river Beas up to Pong Dam (**Figure 4.29**). Total area of sub-basin is around 1589 sq km. The major tributaries joining river Beas at its left bank in the sub-basin are Jogi khala, Sun Khad, Sakrain Khad, Thuthuri Khad, Chanehd Khad, Jhangi Khad, Masaut Khad, Naled Khad, Bakar Khad, Sukahd Khad, Jangled Khad, Jamiri Khad, Riani Khad, Pung Khad, Salasi Khad, Kunah Khad, Masinh Khad, Sahri Khad, Nalsoha Khad, Karoa Khad, Barwara Khad, Thor Khad, Chanaur Khad, Bargolan di Khad, Dada Khad, Gurhala Khad. The sub-basin is densely populated and a large area is under agricultural fileds. Major settlements on the bank of river Beas are Bajrana, Dhandor, Khanaur, Haldwara, Baghera, Sujanpur, Majhot, Janglu, Nadaun, Nagrota, Kuhna, Kohala, Nangal, Thor, Chaplah, Kulher etc. The major towns in the sub-basin are Dharampur, Sandhol, Hamirpur, Bangana, Garli, Mairi, Bharwain, Dhaliara etc.

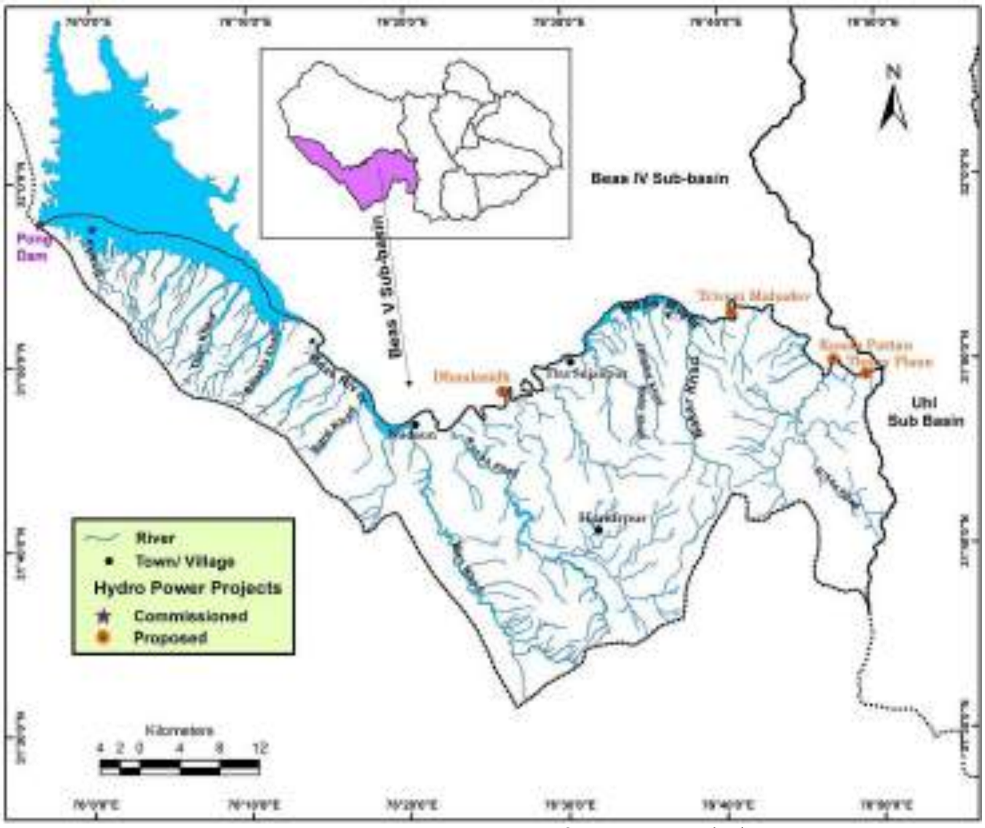


Figure 4.29: Drainage map of Beas V Sub-basin

The elevation varies from 380 m to about 2040 m (**Figure 4.30**). 25% of the sub-basin area lies in the 380 to 600m elevation band. Majority of area i.e. 70% lies in 601 to 1200m elevation band. Around 5% of the area falls under elevation range of 1201 to 2400 m.

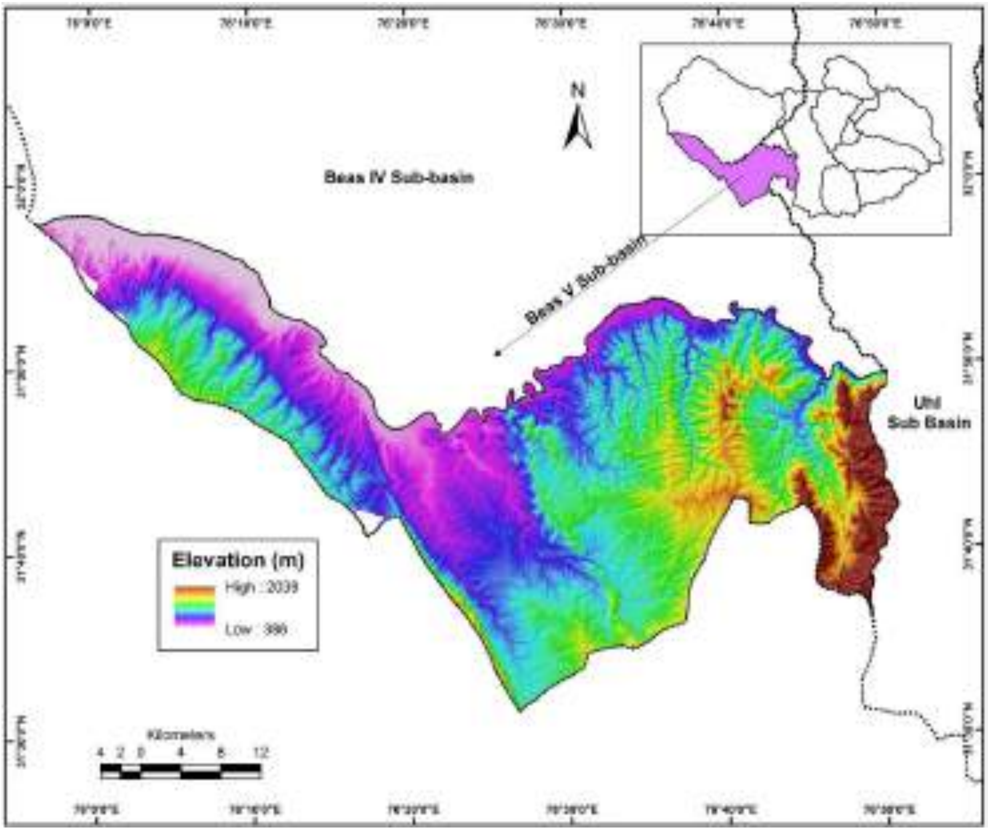


Figure 4.30: DEM of Beas V Sub-basin

Field observations in Beas V sub basin:

Beas River: On Beas river from the downstream of the Pandoh HEP and up to the Pong dam, there are three projects are which are under investigation stage namely Thana Plaun HEP (141MW), Triveni Mahadev HEP (78MW) and Dhaulasidh HEP (66MW). Pong HEP (396MW) is a project on the Beas river which is the border of Himachal Pradesh and Punjab.

Pong Dam Reservoir:

Pong dam reservoir was constructed on Beas river by Bhakra Beas Management Board (BBMB), Himachal Pradesh whose office is in located Talwara town lsituated near the Pong reservoir. The area is well connected by road and rail network. Mukeriyan is the nearest railway station which is approximately 30 km from Talwara town (near Pong reservoir). Topography of the area is almost flat.

Pong Dam Reservoir

Pong Dam Reservoir

Pong Dam downstream view

CHAPTER-5

HYDRO-METEOROLOGY

5.1 INTRODUCTION

The entire Beas Basin within Himachal Pradesh is spread over five districts namely Kullu, Mandi, Kangra, Hamirpur and Chamba. Mainly entire Beas basin is spread over Kullu, Mandi, Kangra and Hamirpur districts and a very small portion falls in Chamba district. In order to understand the climatology of basin data pertaining to climate and rainfall has been given for each of the four main districts covering study area viz Kullu, Mandi, Kangra and Hamirpur districts. The data has been sourced from Indian Meteorological Department, Government of India as well as from the Environmental Impact Assessment (EIA) Reports of different Hydro Electric Power (HEP) Projects in the basin.

In addition, data on worldweatheronline portal has been sourced. World Weather Online's weather API (application programming interface) allows to access current, past and future weather data for use.

The following stations are falling within our study area:

In Kullu District - Kullu and Manali
In Mandi District – Jogindernagar, Mandi and Sundernagar
In Kangra District – Jwalamukhi, Kangra and Yol
In Hamirpur District – Hamirpur and Tira Sujanpur

Data pertaining to Maximum, Minimum and Average Temperature (^{0}C), Average Rainfall (mm), Average Humidity (%) and Average and Maximum Wind Speed (Kmph) for a period 2014-2016 has been sourced and shown in pictorial form under respective districts.

5.1.1 Kullu District

The climate of the district is cool and dry. There are three broad seasons viz. cold season from October to February, hot season from March to June and rainy season from July to September. Snowfall generally occurs in December and January at higher hills and most of the regions are cut off from the district headquarters since the mountain passes are closed. The district receives moderate rainfall and bulk of it is received during the months of July, August, December and January. August is the wettest month throughout the district. From climatic point of view the most enjoyable altitude is between 1,500 to 1,800 m as this range is neither too hot nor too cold.

A comparative data of average annual rainfall for five years of district is given in **Table 5.1**. Highest average annual rainfall in the district i.e. 1291.70 mm was recorded during the year 2013 where lowest average annual rainfall i.e. 1017.10 mm was recorded in the year 2016. In addition to this, average annual rainfall data for various years at various locations as sourced from the EIA Reports of different HEPs is given in **Table 5.2**.

Maximum and minimum temperature recorded at Bhunter during the year 2010 is given in **Table 5.3,** which reflects the month of May as the hottest one, seconded closely by the months of April and June. In addition, monthly maximum and minimum temperature and relative humidity at Bhunter for different period and at Manali from the year 1968-80 is given in **Table 5.3**.

Table 5.1: Average Monthly Rainfall (mm) of Kullu District

Month	Year wise Average Monthly Rainfall (mm)					Average
	2012	2013	2014	2015	2016	
January	140.30	110.90	83.10	110.80	37.90	96.60
February	184.00	274.60	150.70	212.20	74.10	179.12
March	85.20	117.10	204.90	195.00	186.60	157.76
April	98.00	40.90	88.30	113.30	92.50	86.60
May	24.80	41.10	114.60	47.10	57.50	57.02
June	44.50	155.90	50.00	91.60	58.60	80.12
July	180.20	214.40	181.00	235.80	185.90	199.46
August	265.40	205.80	114.20	108.90	282.60	195.38
September	166.60	63.80	70.80	62.20	36.40	79.96
October	4.30	10.10	21.30	15.30	4.90	11.18
November	13.50	21.90	5.10	26.50	0.00	13.40
December	77.50	35.20	72.60	34.90	0.10	44.06
Total	**1284.30**	**1291.70**	**1156.60**	**1253.60**	**1017.10**	**1200.66**

Source: Meteorological Deptt., Govt. of India

Table 5.2: Average Monthly Rainfall (mm) at different locations in Kullu District

Month	Banjar 1955-88	Kullu 1955-80	Najan 1968-77	Larji May 1967-89	Pulga-Gwachha 1965-1977 & Apr 1987-Dec 1990	Kasol 1965-84	Dhara 1965-84	Sainj 1971-1983 & Aug 1985-Feb 1990	Naggar 1968-79	Manali 1969-80 & 1987-88	Niharni June 1985-Dec 1990	Swankanda Dhar Dec 1986-Feb1990	Manali 1968-80
January	75.13	95.32	49.67	78.04	17.40	94.27	57.72	86.44	159.91	58.76	59.00	0.17	145.00
February	95.61	107.20	36.70	67.77	50.12	120.09	78.46	89.18	102.13	150.76	150.38		145.60
March	93.59	111.47	49.20	84.70	51.85	119.63	90.70	134.90	147.83	153.15	144.25	14.83	187.30
April	67.77	57.08	66.04	57.80	64.00	99.52	78.50	71.89	83.86	146.42	24.75	62.67	111.30
May	71.53	46.38	52.48	64.40	54.52	93.11	64.85	90.49	67.16	147.31	68.00	266.67	69.10
June	101.40	58.17	65.62	102.29	74.99	82.03	55.27	94.60	73.69	83.34	123.50	135.75	94.50
July	297.00	151.30	185.47	191.57	181.70	225.66	153.50	218.89	190.88	220.44	256.25	458.25	235.00
August	161.79	130.31	210.50	155.08	170.71	211.91	149.48	191.17	183.17	264.89	249.38	386.25	243.60
September	91.37	85.30	36.33	67.22	77.14	113.74	61.12	86.08	80.65	146.09	101.75	527.50	108.40
October	37.04	37.74	22.94	27.93	31.13	43.79	34.08	28.27	24.17	37.67	35.13	6.00	33.10
November	16.32	16.66	11.33	19.42	5.86	28.64	12.56	22.96	32.49	33.70	0.50		39.80
December	34.58	38.20	12.20	34.36	32.45	46.25	21.07	39.85	30.67	48.15	25.88	0.67	46.50
Total	**1143.13**	**935.13**	**798.48**	**950.58**	**811.87**	**1278.64**	**857.31**	**1154.72**	**1176.61**	**1490.68**	**1238.77**	**1858.76**	**1459.20**

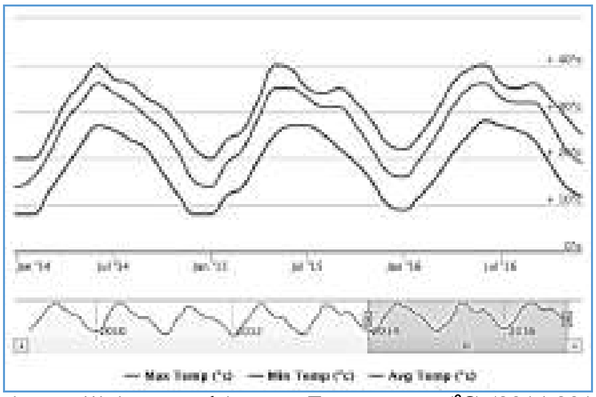
Source: EIA Reports of Nakhtan, Balargha, Jari, Allain Duhangan, Sainj and Malana-II HEPs

Table 5.3: Maximum and Minimum Temperature (^{0}C) at different locations in Kullu District

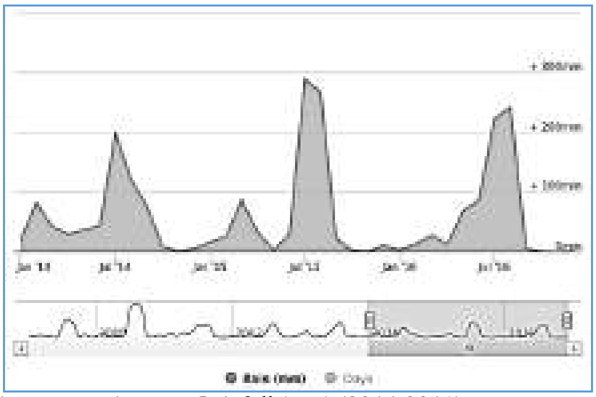
Month	Temperature (^{0}C) at Bhunter for different period		Relative Humidity (%) at Bhunter for different period		Temperature (^{0}C) at Manali for 1968-80		Relative Humidity (%) at Manali for 1968-80		Temperature (^{0}C) at Bhunter 2010	
	Maximum	Minimum	Morning	Evening	Maximum	Minimum	Morning	Evening	Maximum	Minimum
January	20.3	-1.6	89	54	10.1	-1.8	76	68	19	1.5
February	22.9	-0.2	87	50	11.1	-1.0	72	65	18.9	4.4
March	27.8	2.6	80	47	15.9	2.8	60	55	26.8	8.5
April	32.6	5.8	71	40	21.6	6.1	56	48	30.9	11.0
May	36.0	8.6	63	37	24.9	8.6	57	50	32.0	14.8
June	36.8	12.2	65	42	26.6	12.4	71	58	31.3	15.5
July	34.9	15.6	81	60	25.5	14.8	86	75	29.9	19.4
August	33.6	16.1	86	64	25.0	14.6	91	81	30.6	20.2
September	32.9	11.5	80	56	24.7	10.4	86	73	29.4	17.3
October	30.8	5.8	78	46	22.5	5.4	73	65	28.3	10.5
November	26.3	1.1	83	44	18.4	1.3	62	58	24.3	5.7
December	21.6	-1.4	88	53	14.0	-0.3	60	54	18.5	0.5
Average	**29.7**	**6.3**	**79.3**	**49.4**	**20.0**	**6.1**	**70.8**	**62.5**	**26.7**	**10.8**
Source:	EIA Reports of Nakhtan, Balargha and Jari HEPs				EIA Reports of Allain Duhangan, Sainj and Malana-II HEPs				Meteorological Deptt., Govt. of India	

Data pertaining to Maximum, Minimum and Average Temperature (^{0}C), Average Rainfall (mm), Average Humidity (%) and Average and Maximum Wind Speed (Kmph) for a period 2014-2016 for two stations Kullu & Manali falling within Kullu district, sourced from worldweatheronline portal has been shown in pictorial form as below:

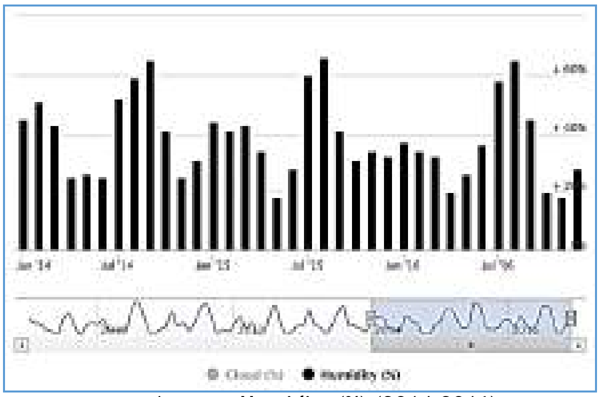
Kullu, Himachal Pradesh



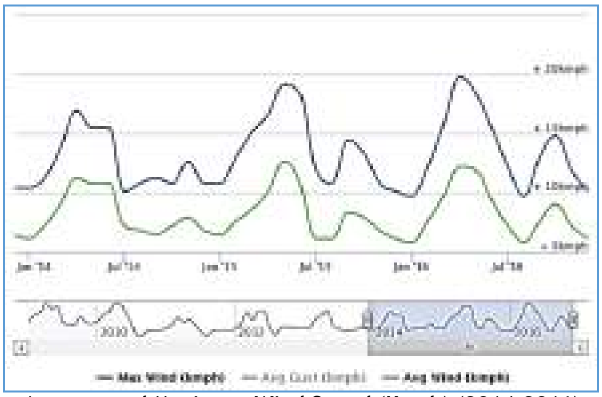
Maximum, Minimum and Average Temperature (^{0}C) (2014-2016)



Average Rainfall (mm) (2014-2016)

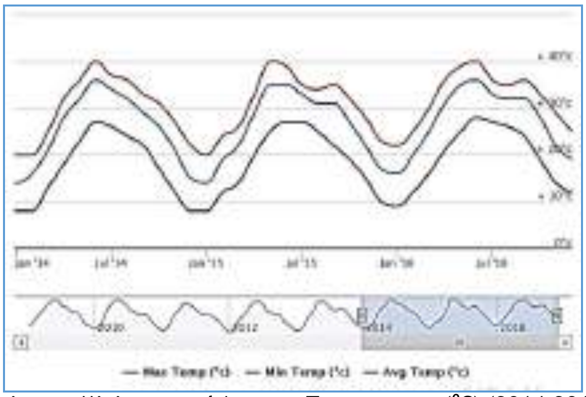


Average Humidity (%) (2014-2016)

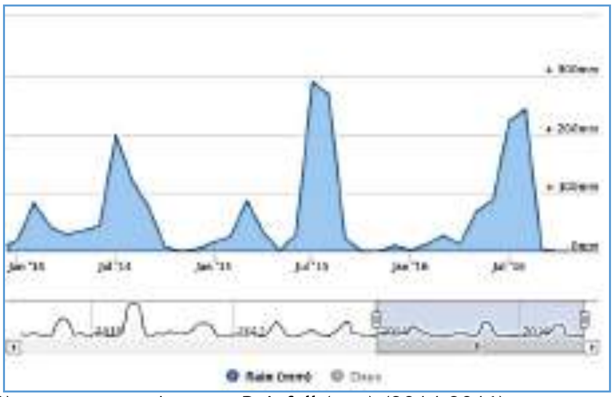


Average and Maximum Wind Speed (Kmph) (2014-2016)

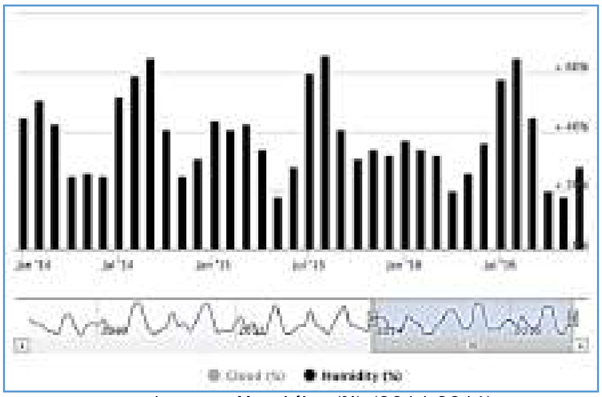
Manali, Himachal Pradesh

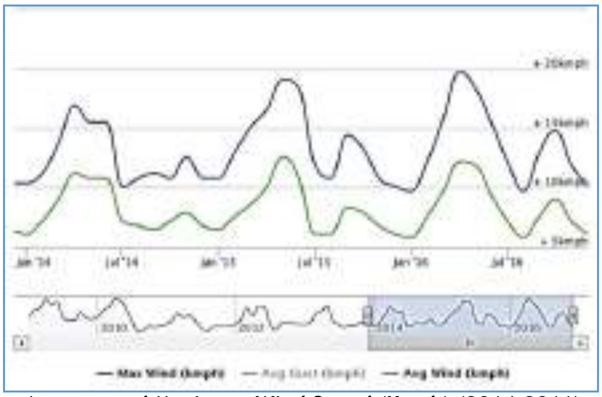


Maximum, Minimum and Average Temperature (^{0}C) (2014-2016)



Average Rainfall (mm) (2014-2016)


Average Humidity (%) (2014-2016)


Average and Maximum Wind Speed (Kmph) (2014-2016)

5.1.2 Mandi District

The District being mostly hilly, the climate varies according to the altitude of the place. The district being mountainous, the climate is temperate. In upper areas, the climate remains cold throughout the year. The areas of Padhar, Chohar, Seraj and Sonar usually experience sufficient snowfall during winter which often comes down to 1,300 metres altitudes. In summer, other low areas and Balh valley are quite hot. The winter starts from the middle of November and continues till the middle of March. Thereafter, the mercury continues rising till the onset of monsoons which starts from the last week of June or first week of July and continues till the middle of September. During October and November, the nights are pleasant and days are a bit hot. The sub-temperate climatic conditions prevail in Dhauladhar micro sub-region, as it is a mountainous track. Higher reaches of the region receive sufficient snowfall every year during winter and remain cut off from the other parts of the district. The lower areas are comparatively hot. The climatic conditions of the higher reaches of Beas basin are temperate. In winter these areas receive snowfall almost every year where the weather remains cool throughout the year. Lower areas are comparatively hot during the summer. Month of July and August receive heaviest rainfall in this region. Rainfall is mostly received during the monsoon months. In Mandi Lesser Himalaya, the climate is mild during winter in upper areas whereas lower altitudes are hot in summer. The district receives an ample and uniformly distributed rainfall.

A comparative data of average annual rainfall for five years of district is given in **Table 5.4**. Highest average annual rainfall in the district i.e. 1620.70 mm was recorded during the year 2014 where lowest average annual rainfall i.e. 1396.60 mm was recorded in the year 2016. In addition to this, average annual rainfall data from the year 1954 to 1980 at Mandi town as sourced from the EIA Report of Dhaulasidh HEP and from the year 1982 to 1993 at Pandoh Dam as sourced from the working plan of Mandi Forest Division is given in **Table 5.4**.

Maximum and minimum temperature from the month of January to December in Mandi district as recorded for the year 2010 at Meteorological Centre, Sundernagar is given in **Table 5.5**, which reflects the month of May as the hottest one, seconded closely by the months of April and June. In addition, monthly maximum and minimum temperature and relative humidity at Mandi from the year 1954-80 is given in **Table 5.5**.

Table 5.4: Average Monthly Rainfall (mm) of Mandi District

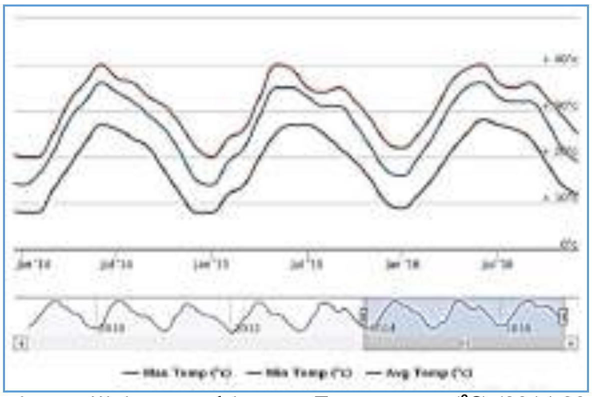
Month	Year wise Average Monthly Rainfall at Mandi (mm)					Mandi 1954-80	Pandoh Dam Site 1982-93
	2012	2013	2014	2015	2016		
January	114.50	62.40	64.10	87.50	13.50	74.30	58.03
February	39.30	142.50	113.20	130.20	42.80	60.20	71.63
March	27.30	71.50	105.90	154.40	93.10	81.80	69.43
April	94.60	29.00	62.10	100.10	24.70	47.60	50.37
May	6.30	18.70	102.90	38.80	165.10	51.10	79.72
June	36.70	381.90	124.70	113.40	208.20	130.00	203.16
July	426.90	393.50	396.90	407.50	314.60	500.00	327.04
August	480.60	321.40	374.60	340.90	415.10	427.60	309.84
September	186.90	97.80	152.10	73.00	108.60	186.80	125.91
October	2.90	14.10	27.50	29.60	10.90	45.80	48.30
November	5.00	17.60	2.30	9.70	0.00	13.80	15.97
December	22.20	23.20	94.40	39.40	0.00	23.20	45.59
Total	**1443.20**	**1573.60**	**1620.70**	**1524.50**	**1396.60**	**1642.20**	**1404.99**
Source:	Meteorological Deptt., Govt. of India					EIA Report of Dhaulasidh HEP	Working Plan of Mandi Forest Division

Table 5.5: Maximum and Minimum Temperature (^{0}C) at different locations in Mandi District

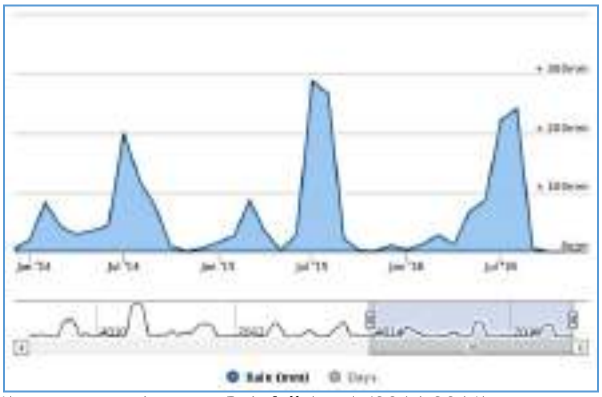
Month	Temperature (^{0}C) at Mandi 1954-80		Relative Humidity (%) at Mandi 1954-80	Temperature (^{0}C) at Sundernagar 2010	
	Maximum	Minimum		Maximum	Minimum
January	18.5	2.8	73	21.2	2.2
February	21.1	4.2	69	22	5.5
March	25.8	9.0	61	31.3	11.0
April	30.8	13.5	55	34.9	14.6
May	34.7	17.3	48	36.0	17.9
June	36.0	20.1	55	33.7	18.4
July	31.8	21.1	75	30.3	21.5
August	31.0	20.5	81	30.5	22.2
September	30.7	18.4	75	29.8	19.1
October	28.8	12.3	71	29.4	12.6
November	24.9	6.8	74	25.6	6.9
December	20.6	3.1	75	20.1	1.2
Average	**27.89**	**12.43**	**67.67**	**28.7**	**12.8**
Source:	EIA Report of Dhaulasidh HEP			Meteorological Deptt., Govt. of India	

Data pertaining to Maximum, Minimum and Average Temperature (^{0}C), Average Rainfall (mm), Average Humidity (%) and Average and Maximum Wind Speed (Kmph) for a period 2014-2016 for three stations Jogindernagar, Mandi & Sundernagar falling within Mandi district, sourced from worldweatheronline portal has been shown in pictorial form as below:

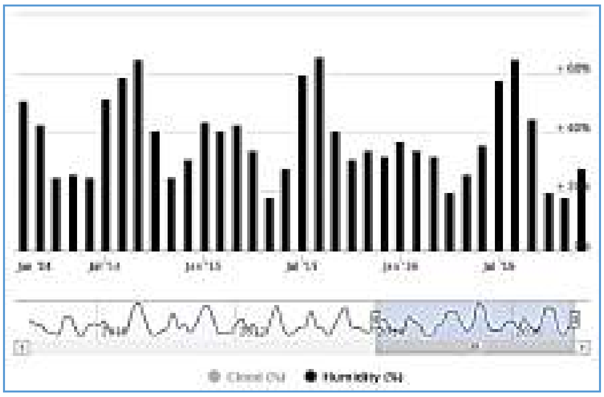
Jogindarnagar, Himachal Pradesh



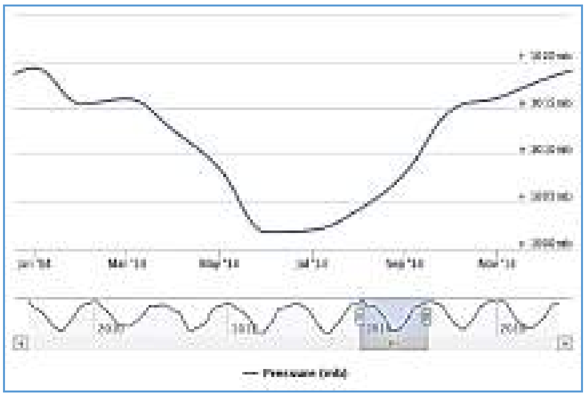
Maximum, Minimum and Average Temperature (^{0}C) (2014-2016)



Average Rainfall (mm) (2014-2016)

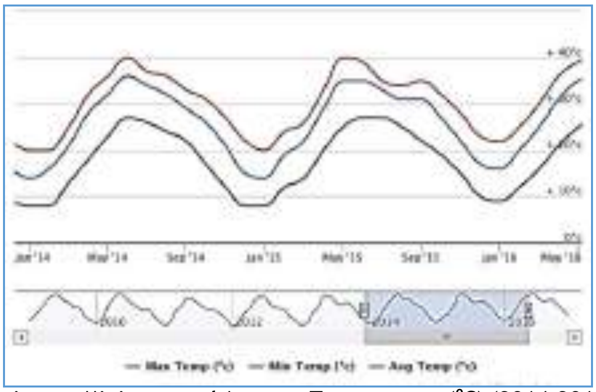


Average Humidity (%)(2014-2016)

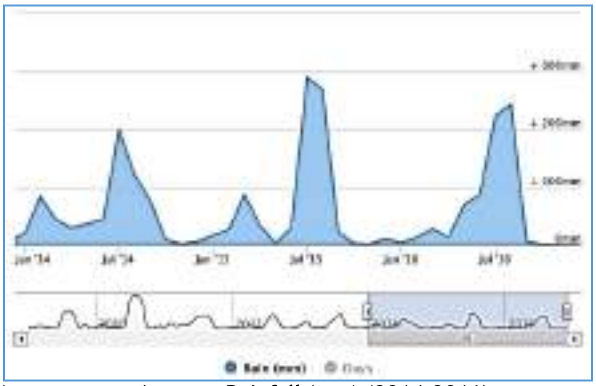


Average and Maximum Wind Speed (Kmph) (2014-2016)

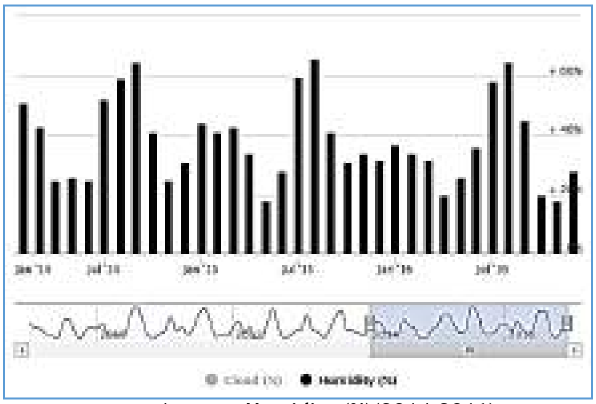
Mandi, Himachal Pradesh



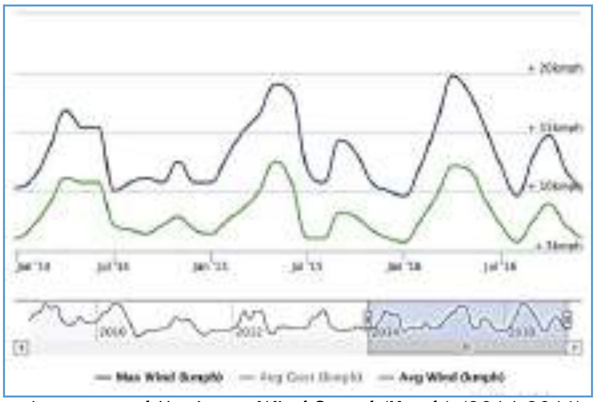
Maximum, Minimum and Average Temperature (^{0}C) (2014-2016)



Average Rainfall (mm) (2014-2016)

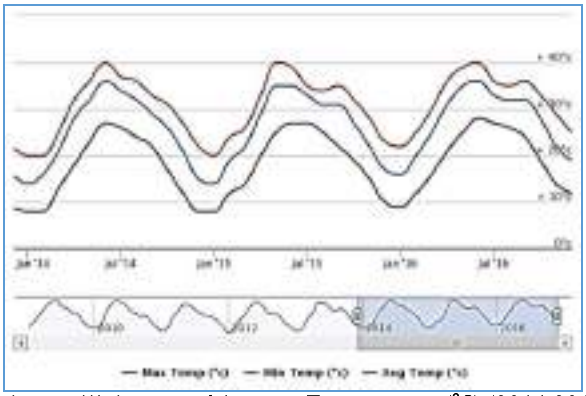


Average Humidity (%)(2014-2016)

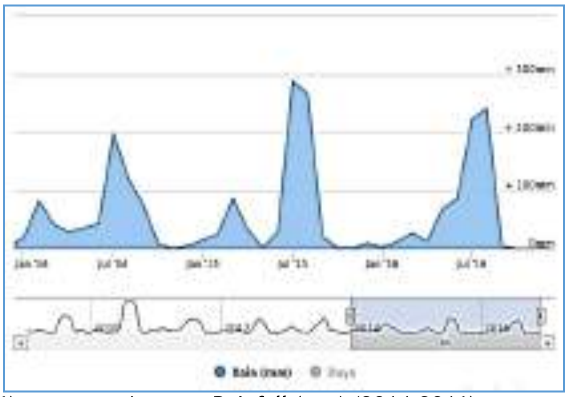


Average and Maximum Wind Speed (Kmph) (2014-2016)

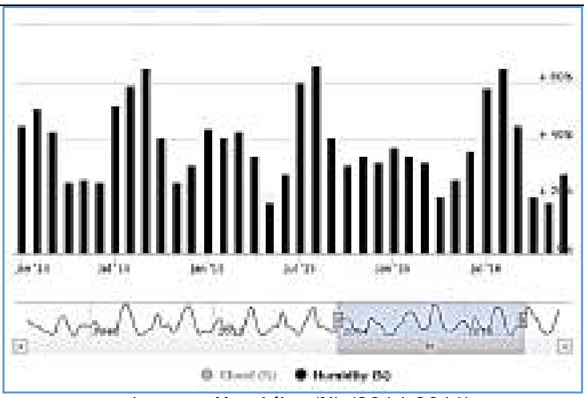
Sundarnagar, Himachal Pradesh

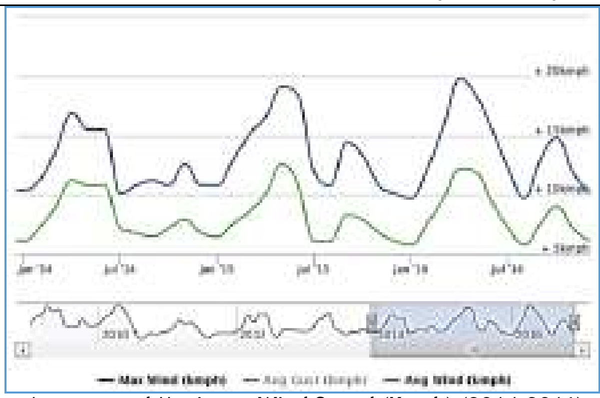


Maximum, Minimum and Average Temperature (^{0}C) (2014-2016)



Average Rainfall (mm) (2014-2016)


Average Humidity (%) (2014-2016)


Average and Maximum Wind Speed (Kmph) (2014-2016)

5.1.3 Kangra District

The climate in the district unfolds four broad seasons. The winter generally spreads over from December to February. The period from March to June is summer. Hot and rainy season generally extends from July to September. October and November exhibit autumn. While during the winter months, the places at high altitudes remain covered under snow. The temperature during the winter months even in the lower areas is too cold because of the lashing cold breeze of the mountain ranges of Dhauladhar and Hathi Dhar. The places lying at higher altitudes are too wet in the rainy season. Dharmshala, the headquarters of the district receives plentiful rains during the summer months. In the valleys and southern parts of the district, the days are extremely hot. During the monsoon period the land becomes fresh and green and the small water channels in the hills begin to swell. The climatic conditions prevailing in Kangra district are most useful for growing food crops, forestry, tea plantation, floriculture and other natural herbals.

A comparative data of average annual rainfall for five years of district is given in **Table 5.6**. Highest average annual rainfall in the district i.e. 2403.50 mm was recorded during the year 2013 where lowest average annual rainfall i.e. 1519.10 mm was recorded in the year 2014. In addition to this, average annual rainfall data for various years at various locations as sourced from the EIA Reports of different HEPs is given in **Table 5.6**.

Maximum and minimum temperature from the month of January to December in Kangra district as recorded for the year 2010 at Meteorological Centre, Dharamshala is given in **Table 5.7**, which reflects the month of May as the hottest one, seconded closely by the months of April and June. In addition, monthly maximum and minimum temperature and relative humidity at Dharamshala from the year 1954-80 is given in **Table 5.7**.

Table 5.6: Average Monthly Rainfall (mm) of Kangra District

Month	Year wise Average Monthly Rainfall (mm)					Lambadug 1988-93	Dharamshala 1954-80
	2012	2013	2014	2015	2016		
January	170.60	52.20	62.00	65.90	7.60	124.00	114.50
February	45.90	121.30	123.80	115.30	36.80	119.00	100.70
March	37.30	72.50	98.00	180.60	98.80	255.80	98.80
April	53.30	28.90	52.70	66.30	13.20	111.40	48.60
May	9.90	26.50	45.20	32.20	89.80	117.60	59.10
June	35.90	370.40	100.20	160.60	132.60	125.00	202.70
July	603.90	666.00	449.20	624.70	529.60	283.22	959.70
August	940.20	739.60	386.30	576.90	585.40	236.40	909.20
September	308.90	169.40	119.10	109.60	111.50	171.60	404.80

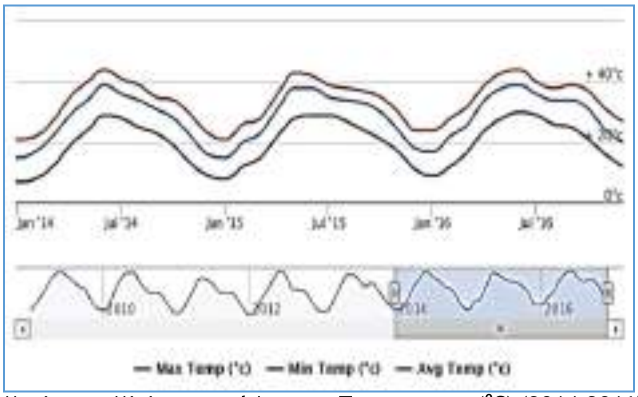
Month	Year wise Average Monthly Rainfall (mm)					Lambadug 1988-93	Dharamshala 1954-80
	2012	2013	2014	2015	2016		
October	9.10	89.40	38.00	28.30	3.90	12.25	66.30
November	4.00	19.80	0.70	8.60	0.00	35.12	16.70
December	31.60	47.50	43.80	27.40	3.40	52.10	54.00
Total	**2250.60**	**2403.50**	**1519.00**	**1996.40**	**1612.60**	**1643.49**	**3035.10**
Source:	Meteorological Deptt., Govt. of India					EIA Report of Lambadug HEP	EIA Report of Dhaulasidh HEP

Table 5.7: Maximum and Minimum Temperature (^{0}C) at Dharamshala

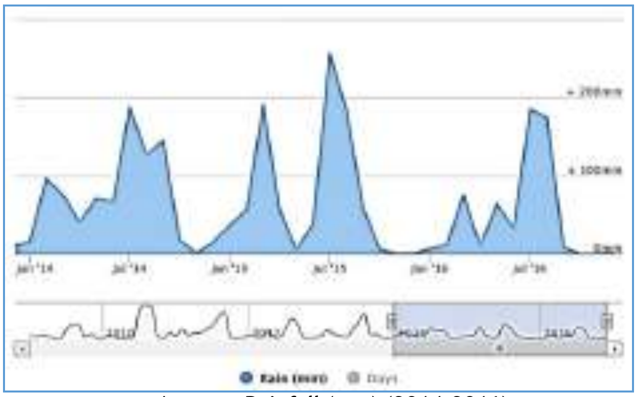
Month	Temperature (^{0}C) at Dharamshala 1954-80		Relative Humidity (%) at Dharamshala 1954-80	Temperature (^{0}C) at Dharamshala 2010	
	Maximum	Minimum		Maximum	Minimum
January	14.5	5.9	59	19.5	7
February	16.6	7.7	55	18.8	5.3
March	21.1	11.8	48	26.8	11.1
April	26.2	16.3	39	32.3	16.1
May	30.5	20.1	35	34.0	17.8
June	31.4	21.8	52	33.1	17.5
July	27.2	20.7	80	27.6	16.9
August	26.3	20.2	84	25.4	17.4
September	26.3	18.7	75	26.3	16.2
October	24.8	15.3	56	25.8	13
November	20.7	10.7	52	24.6	9.4
December	16.7	7.4	57	19.1	4.9
Average	**23.53**	**14.72**	**57.67**	**26.1**	**12.7**
Source:	EIA Report of Dhaulasidh HEP			Meteorological Deptt., Govt. of India	

Data pertaining to Maximum, Minimum and Average Temperature (^{0}C), Average Rainfall (mm), Average Humidity (%) and Average and Maximum Wind Speed (Kmph) for a period 2014-2016 for three stations Jwalamukhi, Kangra & Yol falling within Kangra district, sourced from worldweatheronline portal has been shown in pictorial form as below:

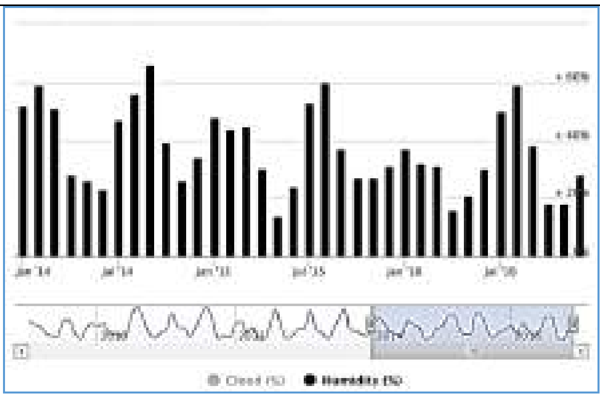
Jawala Mukhi, Himachal Pradesh



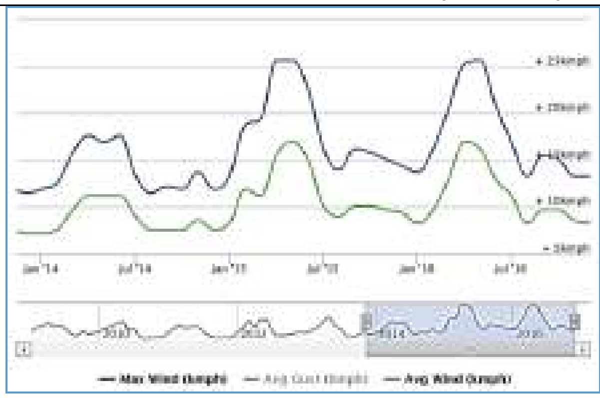
Maximum, Minimum and Average Temperature (^{0}C) (2014-2016)



Average Rainfall (mm) (2014-2016)

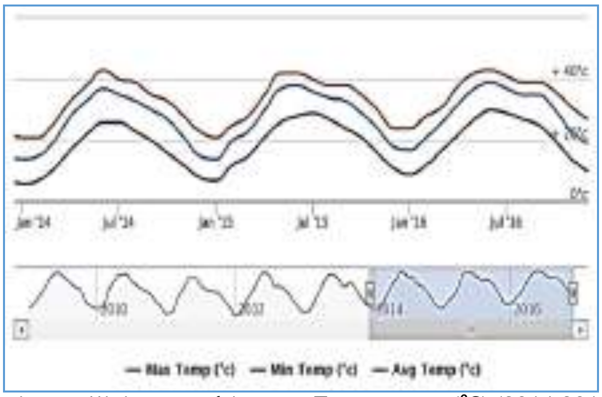


Average Humidity (%) (2014-2016)

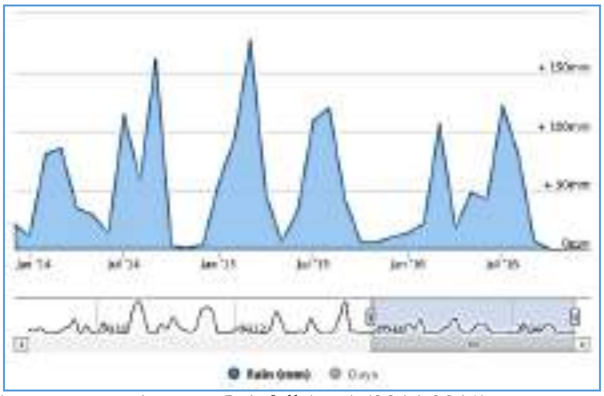


Average and Maximum Wind Speed (Kmph) (2014-2016)

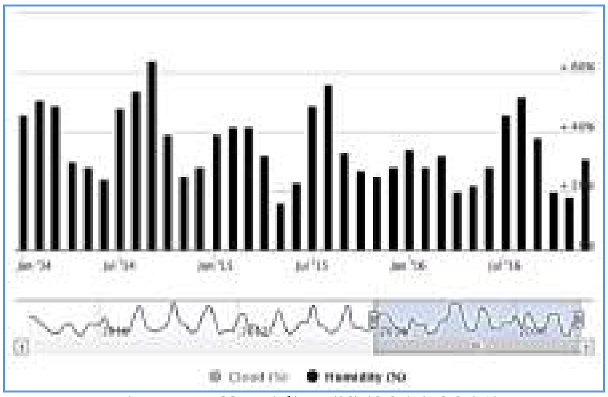
Kangra, Himachal Pradesh



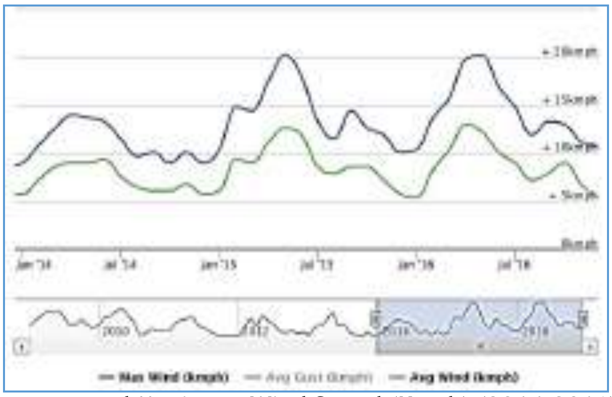
Maximum, Minimum and Average Temperature (^{0}C) (2014-2016)



Average Rainfall (mm) (2014-2016)

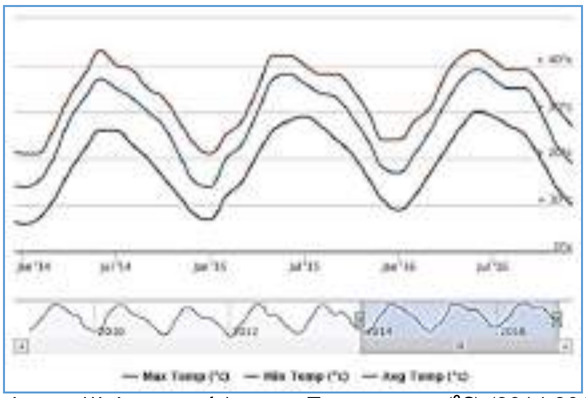


Average Humidity (%)(2014-2016)

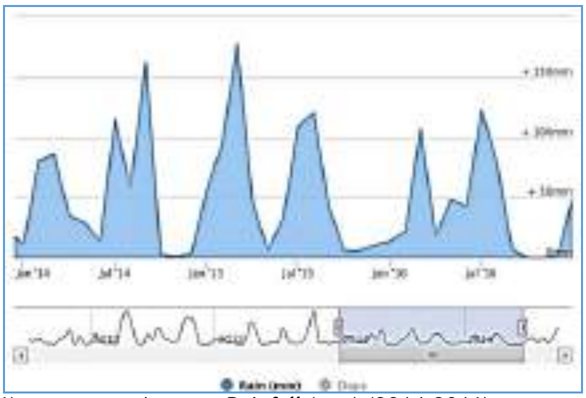


Average and Maximum Wind Speed (Kmph) (2014-2016)

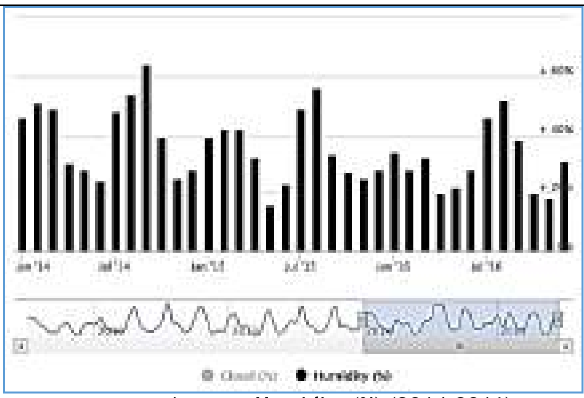
Yol, Himachal Pradesh



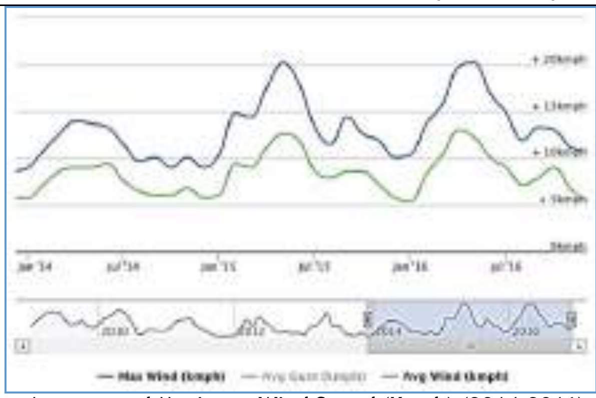
Maximum, Minimum and Average Temperature (^{0}C) (2014-2016)



Average Rainfall (mm) (2014-2016)



Average Humidity (%) (2014-2016)



Average and Maximum Wind Speed (Kmph) (2014-2016)

5.1.4 Hamirpur District

The district falls in the humid sub-tropical zone. The climate of the district has four broad seasons. The winter generally spread over from December to February. The period from March to June is summer. Hot and rainy season generally extends from July to September. October and November exhibit autumn. The temperature during the winter months is too cold. The district receives the plentiful rains during the monsoon period. During summer the days are extremely hot. Climate plays a vital role in the field of life style and economic growth of the state, especially the performance of agriculture, horticulture and tourism sector is closely related to the performance of rain and snowfall during the season.

A comparative data of average annual rainfall for five years of district is given in **Table 5.8.** Highest average annual rainfall in the district i.e. 1482.40 mm was recorded during the year 2015 where lowest average annual rainfall i.e. 1198.80 mm was recorded in the year 2016.

Maximum and minimum temperature recorded during the year 2010 is given at **Table 5.9**. The maximum and minimum temperature is recorded at Una, which is nearest center for this purpose. In Hamirpur the maximum temperature is recorded in the month of May whereas minimum temperature is recorded in January month.

Table 5.8: Average Monthly Rainfall (mm) of Hamirpur District

Month	Year wise Average Monthly Rainfall (mm)					Average
	2012	2013	2014	2015	2016	
January	132.00	45.10	42.10	79.00	11.20	**61.88**
February	32.10	121.40	91.70	106.90	25.70	**75.56**
March	25.50	80.30	107.40	153.40	67.60	**86.84**
April	44.90	9.70	37.30	72.50	7.20	**34.32**
May	1.30	13.90	55.50	28.40	87.90	**37.40**
June	14.80	295.00	71.40	143.00	165.00	**137.84**
July	374.60	441.40	349.00	368.10	275.80	**361.78**
August	557.30	280.80	374.40	396.00	469.10	**415.52**
September	235.70	73.40	95.10	83.20	86.60	**114.80**
October	5.00	24.40	24.00	15.50	0.20	**13.82**
November	4.00	12.80	0.10	8.40	0.00	**5.06**
December	28.10	29.80	55.50	28.00	2.50	**28.78**
Total	**1455.30**	**1428.00**	**1303.50**	**1482.40**	**1198.80**	**1373.60**

Source: Meteorological Deptt., Govt. of India

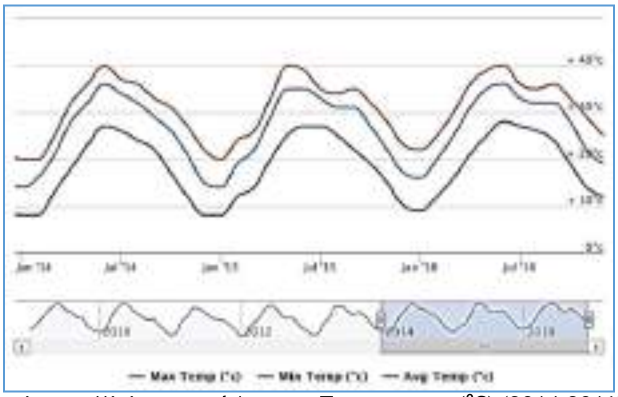
Table 5.9: Maximum and Minimum Temperature (^{0}C) at Hamirpur, 2010

Month	Maximum	Minimum
January	20.0	7.0
February	22.0	9.0
March	31.0	16.0
April	37.0	21.0
May	40.0	24.0
June	38.0	24.0
July	34.0	23.0
August	31.0	22.0
September	29.0	19.0
October	29.0	15.0
November	25.0	11.0
December	21.0	6.0
Average	**30.0**	**16.0**

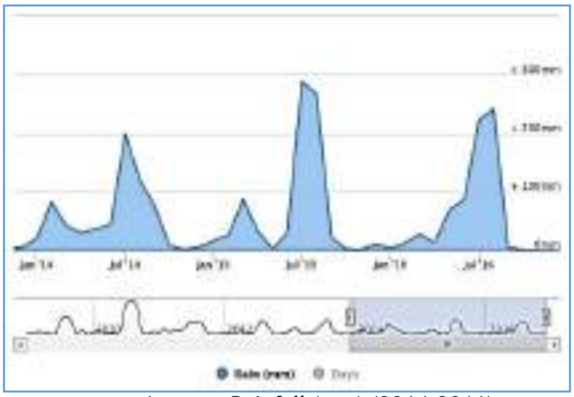
Source: worldweatheronline.com

Data pertaining to Maximum, Minimum and Average Temperature (^{0}C), Average Rainfall (mm), Average Humidity (%) and Average and Maximum Wind Speed (Kmph) for a period 2014-2016 for two stations Hamirpur & Tira Sujanpur falling within Hamirpur district, sourced from worldweatheronline portal has been shown in pictorial form as below:

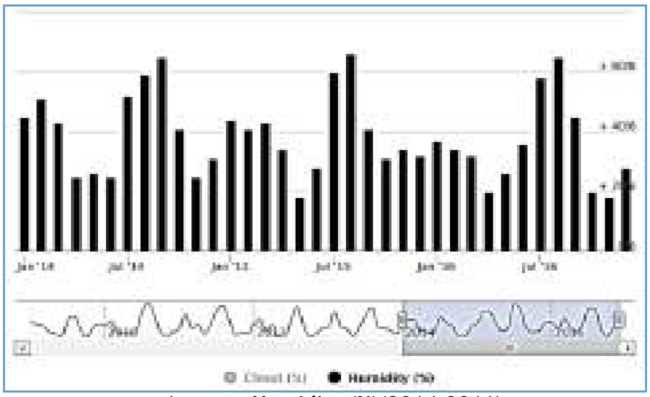
Hamirpur, Himachal Pradesh



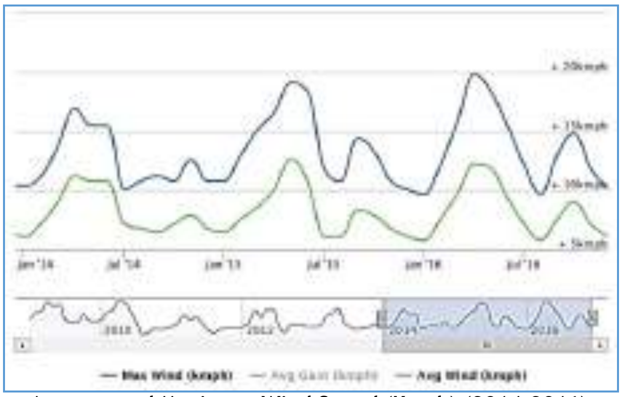
Maximum, Minimum and Average Temperature (^{0}C) (2014-2016)



Average Rainfall (mm) (2014-2016)

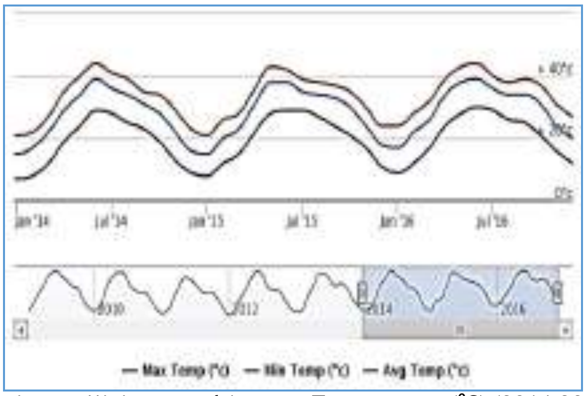


Average Humidity (%)(2014-2016)

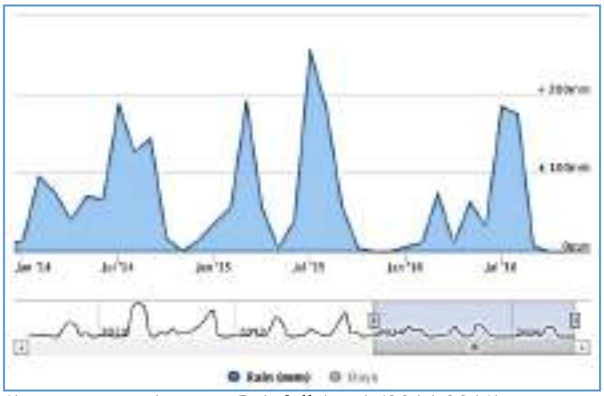


Average and Maximum Wind Speed (Kmph) (2014-2016)

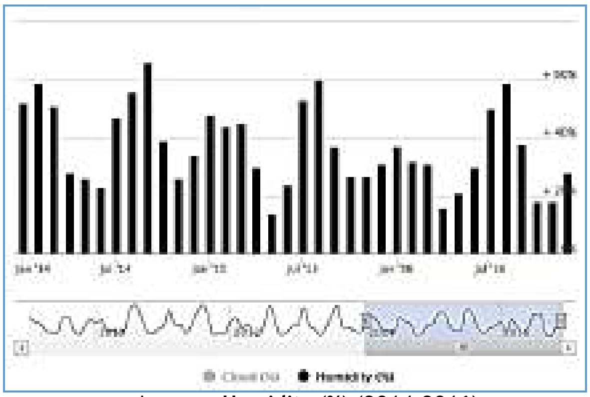
Tira Sujanpur, Himachal Pradesh



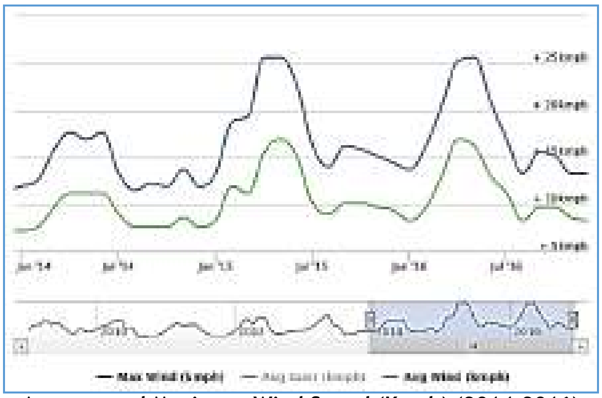
Maximum, Minimum and Average Temperature (^{0}C) (2014-2016)



Average Rainfall (mm) (2014-2016)



Average Humidity (%) (2014-2016)



Average and Maximum Wind Speed (Kmph) (2014-2016)

5.1.5 Rainfall Scenario of Beas Basin using TRMM Data

In addition, the rainfall scenario of Beas basin has been studied and analyzed using TRMM data which is shown in **Figure 5.1**. The Tropical Rainfall Measuring Mission (TRMM) is a joint mission between NASA and the Japan Aerospace Exploration Agency (JAXA) designed to measure rainfall for weather and climate research. TRMM is designed to measure tropical precipitation and its variation from a low-inclination orbit combining a suite of sensors to overcome many of the limitations of remote sensors previously used for such measurements from space. TRMM is a comprehensive and systematic program designed to increase the extent and accuracy of tropical rainfall measurement. The TRMM science program consists of a broad research effort which includes development of cloud models, rain retrieval algorithms for the space sensors, use of TRMM measurements with other satellite data to improve sampling, a surface-based verification system, and a TRMM science data and information system (TSDIS).

The average annual rainfall for the period 1998-2009 is available for the tropic region in Geotiff format which gives a fairly good assessment of hypsometric variation in rainfall in Himalayan region and same has been presented as **Figure 5.1**, which shows that in Beas basin area, rainfall varies from < 500 mm per year in most upstream catchment in Kullu district at places such as origin of Beas Kund Nala, Tosh Nala and Parbati River to > 4000 mm per year in the upstream reaches of Kangra district. This rainfall data has been assessed for comparative estimation of yields during environment flow assessment.

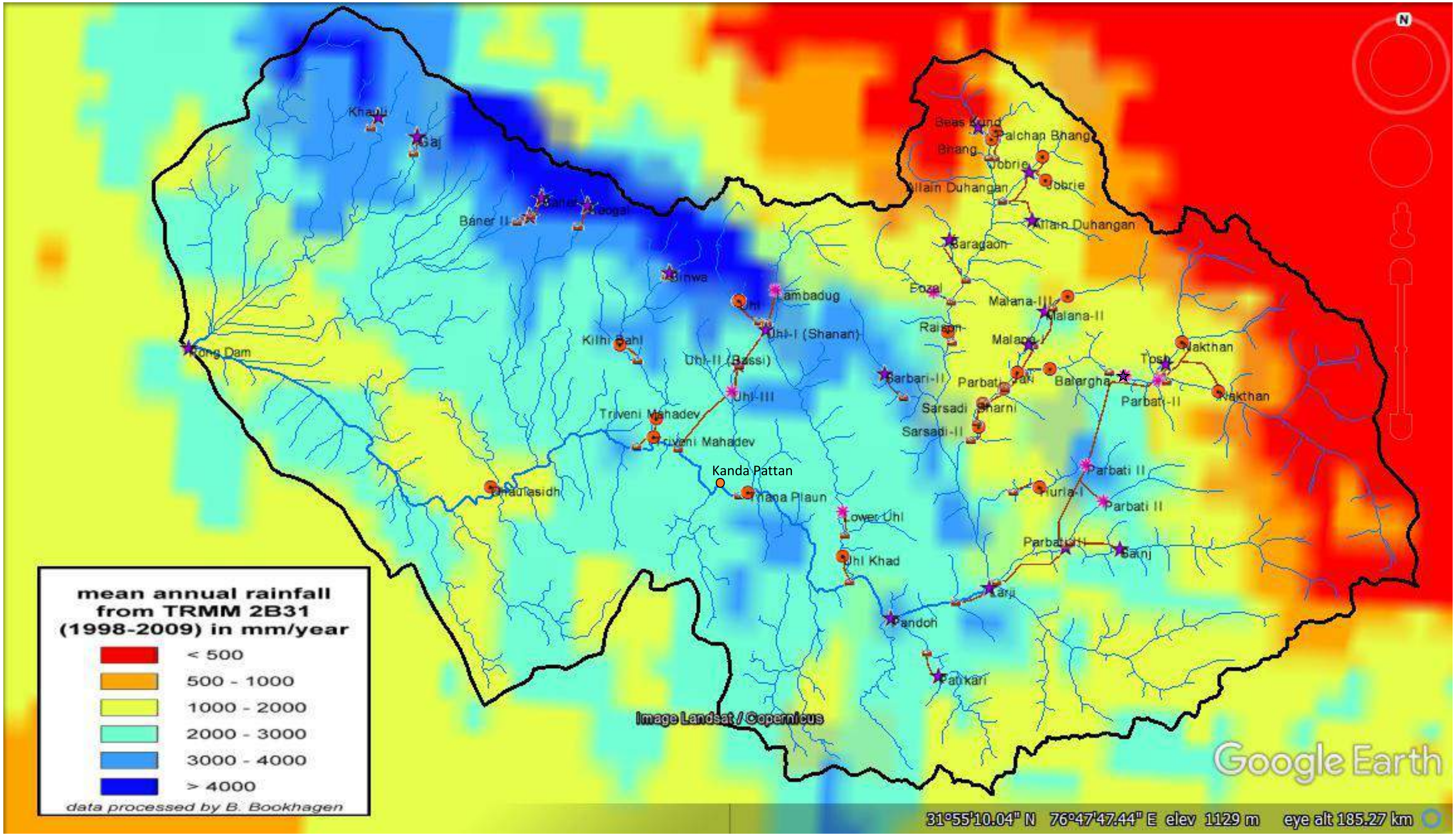


Figure 5.1: Rainfall Scenario of Beas Basin

5.2 WATER DISCHARGE AND AVAILABILITY

Efforts have been made to procure 10 daily discharge series for various projects from various sources. There are 50 hydro projects in the Beas river basin, out of which 18 projects are with installed capacity of 25 MW or more i.e. projects which are covered under EIA notification and can be studied for environment flow assessment by habitat simulation and hydraulic modelling. Smaller projects (less than 25 MW installed capacity) do not give good results when subjected to modelling and therefore for all such projects environment flow is recommended based on present norms of EAC/MoEF&CC.

Out of 18 projects, considered for modelling study for the purpose of environment flow assessment, 10 are commissioned projects, 3 are under construction and 5 are under different stages of survey & investigations. Downstream of Pong dam is outside the study area and therefore it was not considered for environment flow assessment. Similarly, Uhl II (Bassi) is tailrace development of Uhl I without any additional diversion and therefore, the water release from Uhl I will remain in Uhl river and no additional release is considered from Uhl II. For Uhl III, in the absence of discharge data, assessment could not be carried out.

Data was sought for all above projects from project developers through the Office of Director, Ministry of Environment, Forests & Climate Change. Data for following 10 projects have been made available by the respective project developers.

- Nakhtan
- Parbati II
- Sainj
- Parbati III
- Malana I
- Malana II
- Than Plaun
- Triveni Mahadev
- Dhaulasidh
- Allain Duhangan

Discharge series for following five projects have been derived based on catchment area proportions and taking into account relevant interception catchment proportions:

- Malana III
- Lambadug
- Uhl I (Shanan)
- Larji
- Beas Satluj Link (Pandoh)

Hydro dynamic modelling has been carried out for above 15 projects. Input data used for present modeling study has been described below:

		Nakhtan HEP		Parbati-II HEP		Sainj HEP			Parbati-III HEP
		CA: 687.44 (Parbati River) + 332.67 (Tosh Nala) sq km		CA: 1155 (Parbati River) + 44 (Jigrai Nala) sq km		CA: 434.33 sq km			CA: 650 sq km
		2006-07		1994-95		1998-99			1994-95
		Flow in cumec		Flow in cumec		Flow in cumec			Flow in cumec
		Parbati river	Tosh Nala	Pulga Dam	Jigrai Nala	Sainj khad			Sainj khad
Jun	I	22.87	14.89	42.25	1.73	17.69	Jan	I	8.152
	II	19.7	13.12	62.65	2.34	26.99		II	8.016
	III	24.5	16.84	82.18	2.89	36.89		III	7.796
Jul	I	56.08	37.56	117.42	3.8	37.42	Feb	I	5.928
	II	49.17	32.6	141.8	4.4	40.31		II	4.662
	III	66.66	45.74	152.74	4.66	39.45		III	6.833
Aug	I	60.08	40.84	169.64	5.05	15.62	Mar	I	6.39
	II	49.6	32.49	159.34	4.81	17.5		II	9.296
	III	44.88	29.96	148.54	4.56	12.96		III	10.586
Sep	I	28.53	18.47	92.49	3.16	9.09	Apr	I	13.633
	II	26.9	17.48	55.89	2.14	7.5		II	15.857
	III	21.31	13.98	37.62	1.58	6.12		III	18.27
Oct	I	18.52	12.08	24.86	1.48	5.17	May	I	27.285
	II	16.4	10.69	22.87	1.38	4.15		II	35.774
	III	15.5	10.31	23.75	1.42	3.73		III	33.923
Nov	I	14.56	9.39	21.71	1.32	3.39	Jun	I	35.385
	II	11.71	7.29	21.27	1.3	3.09		II	48.316
	III	9.1	5.93	19.57	1.21	3.13		III	53.668
Dec	I	8.04	5.34	18.77	0.76	2.99	Jul	I	50.936
	II	7.15	4.98	17.98	0.74	2.78		II	59.088
	III	6.92	4.66	16.79	0.72	2.56		III	47.935
Jan	I	6.44	4.04	14.59	0.67	2.49	Aug	I	106.587
	II	5.26	3.41	13.41	0.64	2.45		II	79.016
	III	4.96	3.01	12.52	0.62	2.39		III	80.729
Feb	I	4.81	2.96	12.77	0.63	5.59	Sep	I	55.27
	II	4.41	2.9	11.97	0.61	5.75		II	34.646
	III	4.68	3.13	11.83	0.6	5.87		III	25.438
Mar	I	4.98	3.22	12.45	0.62	6.33	Oct	I	21.63
	II	4.89	3.15	13.66	0.65	6.22		II	15.884
	III	5.81	3.99	14.92	0.68	6.86		III	14.003
Apr	I	5.39	5.76	16.43	0.98	7.19	Nov	I	11.662
	II	11.69	8.01	17.17	1.02	7.46		II	9.925
	III	12.88	8.78	18.56	1.1	12.39		III	8.779
May	I	16.58	11.28	22.41	1.31	20.42	Dec	I	7.876
	II	21.7	14.85	24.84	1.45	19.2		II	7.419
	III	22.42	15.04	53.24	2.99	29.59		III	7.548

		Malana-I HEP			Malana-II HEP	Malana-III HEP
		Malana river			Malana river	Malana river
		CA: 178.50 sq km			CA: 158.00 sq km	CA: 124.75 sq km
		1994-95			1990-91	1998-99
		Flow in cumec			Flow in cumec	Flow in cumec
Apr-15	I	4.95	Jun	I	15.82	12.52
	II	7.96		II	11.7	9.26
	III	13.11		III	17.17	13.58
May-15	I	15.15	Jul	I	20.45	16.18

		Malana-I HEP			Malana-II HEP	Malana-III HEP
		Malana river			Malana river	Malana river
		CA: 178.50 sq km			CA: 158.00 sq km	CA: 124.75 sq km
		1994-95			1990-91	1998-99
		Flow in cumec			Flow in cumec	Flow in cumec
	II	16.07		II	17.99	14.23
	III	14.31		III	16.79	13.28
Jun-15	I	11.59	Aug	I	18.11	14.33
	II	15.20		II	19.16	15.16
	III	21.02		III	17.56	13.89
Jul-15	I	25.75	Sep	I	18.17	14.38
	II	35.72		II	17.57	13.90
	III	38.66		III	14.31	11.32
Aug-15	I	29.67	Oct	I	8.67	6.86
	II	29.36		II	7.69	6.08
	III	20.27		III	6.95	5.50
Sep-15	I	15.60	Nov	I	5.85	4.63
	II	13.72		II	5.73	4.53
	III	9.38		III	3.59	2.84
Oct-15	I	6.79	Dec	I	2.95	2.33
	II	5.93		II	2.53	2.00
	III	4.21		III	2.3	1.82
Nov-15	I	3.89	Jan	I	2.18	1.72
	II	3.79		II	2.09	1.65
	III	3.46		III	2.2	1.74
Dec-15	I	3.08	Feb	I	2.18	1.72
	II	2.93		II	2.41	1.91
	III	2.45		III	2.56	2.03
Jan-16	I	2.24	Mar	I	2.71	2.14
	II	2.26		II	2.86	2.26
	III	2.07		III	4.37	3.46
Feb-16	I	2.12	Apr	I	6.77	5.36
	II	2.10		II	6.78	5.36
	III	2.13		III	8.42	6.66
Mar-16	I	2.42	May	I	11.08	8.77
	II	2.93		II	12.31	9.74
	III	2.61		III	11.77	9.31

		Larji HEP	Beas Satluj Link (Pandoh) HEP			Thana Plaun HEP	Triveni Mahadev HEP		Dhaulasidh HEP
		Beas river	Beas river			Beas river	Beas river		Bear River
		CA: 4921.00 sq km	CA: 5280.00 sq km			CA: 7378.00 sq km	CA: 8155 (7740+415) sq km		CA: 9580 sq km
		1994-95	1990-91			2002-03	2002-03	2007-08	2003-04
		Flow in cumec	Flow in cumec			Flow in cumec	Flow in cumec		Flow in cumec
		Beas river	Beas river			Beas river	Beas river	Binwa khad	Beas River
Jan	I	61.72	98.43	June	I	214.55	264.96	17.12	136.71
	II	60.69	102.73		II	245.69	299.93	28.38	111.91
	III	59.02	116.43		III	335.50	399.79	32.00	158.56
Feb	I	44.88	122.00	July	I	450.68	530.8	50.06	157.69
	II	35.29	97.01		II	360.67	429.74	29.44	325.76

		Larji HEP	Beas Satluj Link (Pandoh) HEP			Thana Plaun HEP	Triveni Mahadev HEP		Dhaulasidh HEP
		Beas river	**Beas river**			**Beas river**	**Beas river**		**Bear River**
		CA: 4921.00 sq km	**CA: 5280.00 sq km**			**CA: 7378.00 sq km**	**CA: 8155 (7740+415) sq km**		**CA: 9580 sq km**
		1994-95	**1990-91**			**2002-03**	**2002-03**	**2007-08**	**2003-04**
		Flow in cumec	**Flow in cumec**			**Flow in cumec**	**Flow in cumec**		**Flow in cumec**
		Beas river	**Beas river**			**Beas river**	**Beas river**	**Binwa khad**	**Beas River**
	III	51.73	95.48		**III**	255.68	311.87	38.31	495.15
March	**I**	48.38	98.03	Aug	**I**	290.16	350.59	38.65	763.14
	II	70.38	167.01		**II**	564.71	635.28	47.20	364.01
	III	80.14	141.19		**III**	356.74	425.4	35.12	381.6
April	**I**	103.21	144.19	Sept	**I**	239.49	293.69	23.99	360.89
	II	120.05	181.91		**II**	361.52	306.84	16.13	221.7
	III	138.32	147.61		**III**	54.32	75.12	11.81	154.45
May	**I**	206.57	217.94	Oct	**I**	66.43	82.34	11.57	59.78
	II	270.84	278.03		**II**	42.04	52.73	9.25	39.2
	III	256.82	264.40		**III**	44.25	53.8	6.35	40.66
June	**I**	267.89	277.04	Nov	**I**	53.45	60.05	7.94	28.59
	II	365.79	370.76		**II**	29.03	34.13	8.03	21.98
	III	406.31	409.77		**III**	20.26	23.2	4.43	21.77
July	**I**	385.62	389.12	Dec	**I**	20.40	23.42	5.76	23.61
	II	447.34	450.87		**II**	20.60	23.72	4.25	21.66
	III	362.90	368.11		**III**	30.43	34.92	9.42	19.69
Aug	**I**	806.95	809.93	Jan	**I**	17.46	18.93	5.14	16.46
	II	598.21	601.11		**II**	16.93	18.12	3.89	35.09
	III	611.18	613.94		**III**	16.14	16.92	1.65	50.28
Sept	**I**	418.44	422.46	Feb	**I**	23.50	24.89	0.91	54.48
	II	262.30	268.98		**II**	39.08	42.13	1.85	44.4
	III	192.59	195.32		**III**	15.97	16.66	2.33	44.4
Oct	**I**	163.76	169.23	March	**I**	31.99	41.09	5.50	45.92
	II	120.25	127.25		**II**	40.91	48.86	5.79	41.37
	III	106.01	122.29		**III**	95.14	108.98	8.31	29.34
Nov	**I**	88.29	103.30	April	**I**	87.69	101.15	9.23	13.54
	II	75.14	93.04		**II**	104.60	129.52	9.55	24.37
	III	66.46	79.83		**III**	78.11	101.04	10.08	24.37
Dec	**I**	59.63	75.77	May	**I**	94.36	118.38	12.01	49.68
	II	56.17	76.42		**II**	118.37	156.97	14.30	25.77
	III	57.14	78.99		**III**	127.65	164.65	18.44	27.81

		Allain Duhangan HEP		Lambadug HEP	Uhl-I (Shanan) HEP
		CA: 128.90 (Allain Nala) + 66.2 (Duhangan Nala) sq km		**CA: 197.00 sq km**	**CA: 365.00 sq km**
		2002-03	**2007-08**	**1990-91**	**1998-99**
		Flow in cumec		**Flow in cumec**	**Flow in cumec**
		Allain Nala	**Duhangan Nala**	**Lambadug khad**	**Uhl River**
Jan	**I**	2.19	0.86	1.00	1.86
	II	2.06	0.82	1.00	1.85
	III	1.87	0.77	0.89	1.65
Feb	**I**	1.79	0.74	0.95	1.76

		Allain Duhangan HEP		Lambadug HEP	Uhl-I (Shanan) HEP
		CA: 128.90 (Allain Nala) + 66.2 (Duhangan Nala) sq km		CA: 197.00 sq km	CA: 365.00 sq km
		2002-03	2007-08	1990-91	1998-99
		Flow in cumec		Flow in cumec	Flow in cumec
		Allain Nala	Duhangan Nala	Lambadug khad	Uhl River
	II	1.82	0.70	1.19	2.21
	III	1.94	0.77	1.41	2.62
Mar	I	1.91	0.80	1.83	3.39
	II	1.92	0.75	2.15	3.98
	III	2.53	0.98	2.93	5.43
Apr	I	3.50	1.27	3.93	7.28
	II	4.34	1.48	4.60	8.53
	III	4.71	1.54	4.65	8.61
May	I	9.04	3.23	5.62	10.42
	II	11.65	4.63	5.79	10.73
	III	10.89	4.36	9.15	16.96
Jun	I	12.80	5.00	5.67	10.50
	II	15.42	6.24	6.79	12.59
	III	15.66	6.84	6.21	11.50
Jul	I	15.14	6.87	8.42	15.59
	II	17.25	7.26	12.71	23.54
	III	16.00	6.65	14.86	27.53
Aug	I	27.94	10.65	14.33	26.55
	II	21.44	8.33	13.59	25.18
	III	20.11	7.27	7.68	14.24
Sep	I	15.14	5.94	5.48	10.15
	II	9.64	3.58	3.62	6.71
	III	7.60	2.37	2.89	5.35
Oct	I	6.04	1.99	2.77	5.14
	II	4.52	1.37	2.37	4.38
	III	4.01	1.31	1.94	3.60
Nov	I	3.48	1.02	1.53	2.84
	II	3.15	0.85	1.45	2.69
	III	2.76	0.79	1.31	2.42
Dec	I	2.68	0.74	1.16	2.15
	II	2.39	0.66	1.10	2.05
	III	2.20	0.61	1.10	2.04

CHAPTER-6

ECOLOGICAL ASPECTS- TERRESTRIAL

6.1 LAND USE/ LAND COVER

Himachal Pradesh is one of the Himalayan biodiversity hot spots and is endowed with rich diversity of terrestrial and aquatic species. The diversity of topographical and climatic condition has favoured the growth of luxuriant forests, which are home to myriad plant and animal species.

As per legal status, the Recorded Forest Area in the state is 37033 sq km, which is 66.52% of its geographic area. Reserved Forests, Protected Forests and Unclassed Forests constitute 5.12%, 89.23% and 2.63% of the total Recorded Forest area, respectively. The Protected Areas constitute 11.68% of the geographic area of the state.

Land use/ Land cover map derived for entire state as per data of 2015 procured from FSI, Dehradun under different classes is given in **Table 6.1.** As seen from the **Table 6.1** non-forest constitutes main land use in the state and accounts for more than 73.06 % of the entire state. Very Dense forest constitutes 5.79% while Moderately Dense forest covers 11.46 % of the total area.

Table 6.1: Area under different Forest cover categories in Himachal Pradesh

S. No.	Land use/ land cover	Area (sq km)	Area (%)
1	Very Dense Forest	3224	5.79
2	Moderately Dense Forest	6381	11.46
3	Open Forest	5091	9.14
4	Scrub	301	0.54
5	Non-Forest	40676	73.06
	Total	**55673**	**100.00**

(Source: Indian State of Forest Report, 2015, Forest Survey of India)

Major part of Beas river basin is comprised of the Beas river system traversing the districts of Kullu, Mandi, Hamirpur and Kangra of Himachal Pradesh.

6.1.1 Forest Cover in Beas Basin

Total forest cover as per Forest Survey of India (2015) of four districts viz. Kullu, Mandi, Hamirpur and Kangra, comprised Beas basin was summarized in **Table 6.2**. Among the four districts Kullu has the maximum area under Very Dense (586 sq km), while Kangra district has maximum area under Moderately Dense forest (1221 sq km) (see **Table 6.2**).

Forest cover map prepared for the entire basin delineated as described above from the data of 2015 procured from FSI, Dehradun is given at **Figure 6.1** and area under different density classes is given in **Table 6.3.** As seen from the **Table 6.3** non-forest constitutes main land use in the basin and accounts for more than 60.60 % of the entire basin area. Very Dense forest constitutes 9.31% while Moderately Dense forest covers 17.79% of the total area.

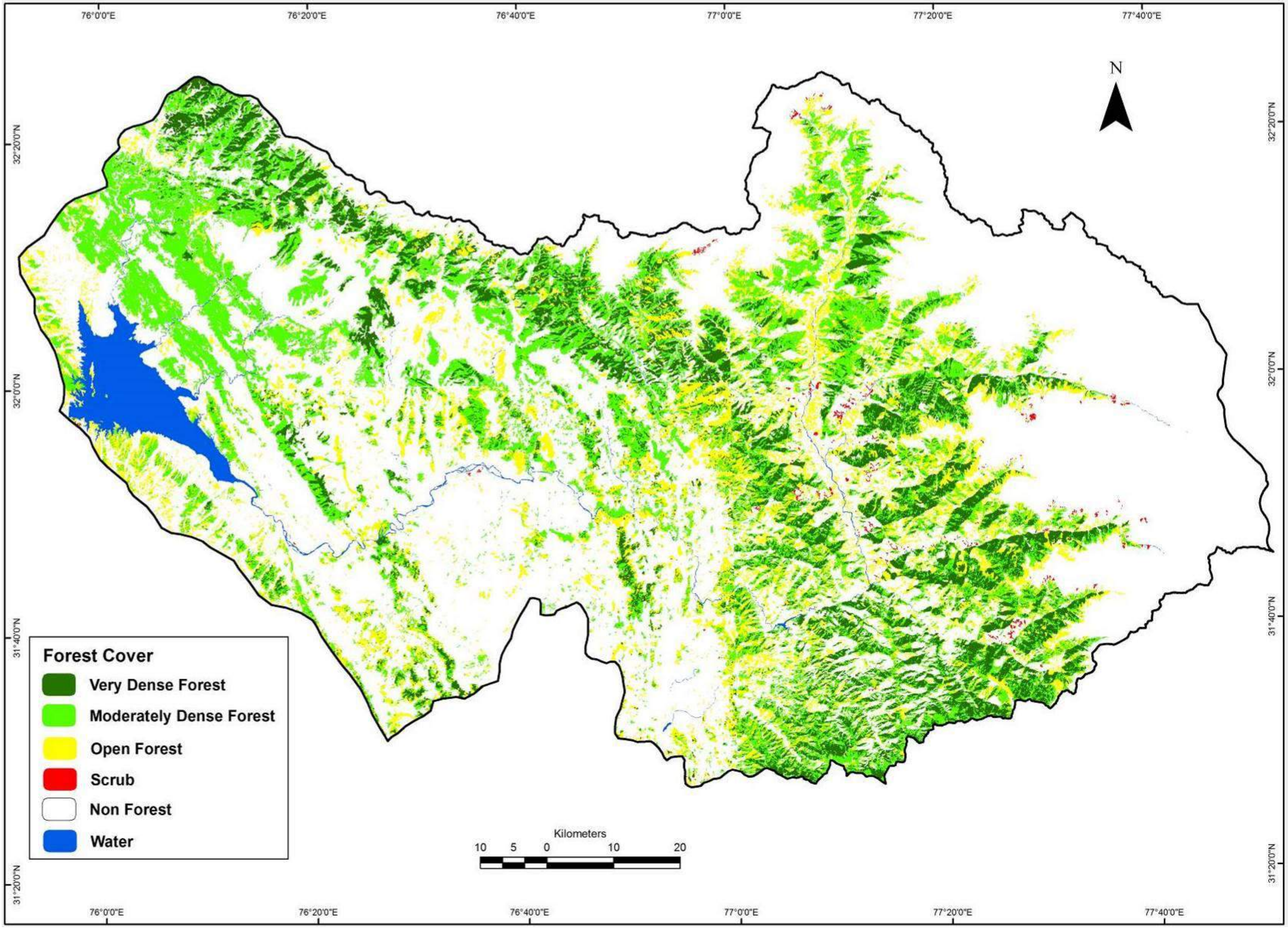


Figure 6.1: Forest cover map of Beas Basin based upon FSI data (2015)

Table 6.2: Area under different forest cover classes in four districts covering Beas basin

District	Forest Cover (Sq km)					Total Geographic area (Sq km)	Scrub (sq km)	Non-forest (sq km)
	Very Dense	Moderately Dense	Open	Total (Sq km)	% of Geographic Area			
STATE	3224	6381	5091	14696	26.40	55673	301	40676
Kullu	586	785	588	1959	35.60	5503	23	3521
Mandi	373	735	568	1676	42.43	3950	29	2245
Hamirpur	39	91	115	245	21.91	1118	0	873
Kangra	310	1221	537	2068	36.03	5739	4	3667

(*Source:* Indian State of Forest Report, 2015, Forest Survey of India)

Table 6.3: Area under different forest cover classes in Beas basin (2015 Data)

S. No.	Land use/ land cover	Area (sq km)	Area (%)
1	Very Dense Forest	1171.97	9.31
2	Moderately Dense Forest	2240.09	17.79
3	Open Forest	1260.01	10.01
4	Scrub	21.47	0.17
5	Non-Forest	7630.50	60.60
6	Waterbody	266.76	2.12
	Total	**12590.79**	**100.00**

6.2 FOREST TYPES

The forests in the Beas basin, the study area are covered under four administratice Circles viz. Kullu, Hamirpur, Dharamshala and Mandi. Entire study area falls under 11 Forest Divisions with Kullu and Parbati Forest Divisions under Kullu Circle; Suket, Mandi, Nachan and Joginder Nagar under Mandi Circle, Dharamshala, Nurpur and Palampur under Dharamshala Circle and Dehra under Hamirpur Circle.

In addition a forest type/ vegetation map of the basin was also prepared based upon the digital data downloaded from Biodiversity Information System portal of Indian Institute of Remote Sensing (IIRS), Dehradun - http://bis.iirs.gov.in/.

Forest type map of the entire beas basin is given at **Figure 6.2**. It can be seen from the data compiled in **Table 6.4** that more tha 28% of study area is under Semi-Evergreen forests confined mainly in the lower elevations of the basin. Agriculture is the main land use in the basin accounting for nearly 20% of the basin area. Snow and barren land is next dominant land cover in the basin with 12.44% of basin area. Mosit alpine scrun scrub constitutes one of the dominant forest type in the basin followed by Temperate coniferous forest and Grassland scrub. Degraded forest comprised of scrub formations also constitute about 9% of the basin area.
Montane wet temperate forests constitute nearly 4% of the basin area.

Major forest types in represented in the Beas basin as per the 'Revised Survey of the Forest Types of India' by Champion and Seth (1968) have been listed in **Table 6.5**. Forests are represented by 7 major Groups in the basin. Species composition of major Groups and Sub-groups is given in the following paragraphs.

Table 6.4: Area under different forest types in Beas basin

Forest/ Vegetation Type	Area (sq km)	(%)
Agriculture	2514.77	19.97
Barren land	11.59	0.09
Grassland scrub	657.19	5.22
Mixed moist deciduous	15.50	0.12
Moist alpine scrub	1392.28	11.06
Montane Wet Temperate	486.00	3.86
Plantation	0.08	0.00
Scrub	1130.99	8.98
Semi-evergreen	3585.28	28.48
Settlements	70.11	0.56
Snow	1555.33	12.35
Temperate coniferous	763.34	6.06
Water bodies	408.33	3.24
Total	**12590.79**	

Table 6.5: Forest Types found in the Beas Basin

Major Group	Type Group	Sub Group	Forest Type
DRY TROPICAL	5-Tropical Dry Deciduous Forest	**5-B:**Northern Dry Mixed deciduous forests	**5B/C2** Northern Dry Mixed Deciduous forest
MONTANE SUB-TROPICAL	9-Sub Tropical Pine Forest		**9C1a:** Himalayan sub-tropical pine forest **9/C1b:** Upper or Himalayan Chir Pine Forest **9/ C1/DS1:** Himalayan sub tropical scrub **9/C1/DS2:** Sub tropical *Euphorbia* scrub
SUB TROPICAL DRY EVERGREEN FOREST	10-Sub Tropical Dry Evergreen Forest		**10/C1a** *Olea cuspidata* Scrub forest
MONTANE TEMPERATE FORESTS	12-Himalayan Moist Temperate Forest	**12-C1:** Lower Western Himalayan Temperate forests **C2:** Upper West Himalayan Temperate forest	**12/C1a**: Ban Oak Forests (*Quercus incana*) **12/C1b**: Moru Oak Forest (*Q. dilatata*) **12/C1b**: (a, b) DS1/Oak scrub **12/C1c**: Moist Deodar Forests **12/C1d**: Western Mix Coniferous Forest **12/C1e**: Moist Temperate deciduous forests **12/C1f**: Low-level blue pine forest (*Pinus wallichiana*) **12/C2a**: Kharsu Oak forest (*Quercus semecarpifolia*) **12/C2b**: Himalayan upper oak-fir forest **12/DS1**: Montane Bamboo brakes **12/DS3**: Himalayan Temperate pastures **12/C1/DS2**: Himalayan temperate secondary scrub
SUB ALPINE FOREST	14-Sub Alpine Forest	**14-C:**West Himalayan Sub Alpine birch/fir Forest (*Betula/Abies*)	**14/C1a**: West Himalayan Sub Alpine fir forest **14C1b**: West Himalayan Sub Alpine Birch/fir forests
ALPINE SCRUB	15-Moist Alpine Scrub		**15C1**: Birch-Rhododendron scrub forest **15/C3**: Alpine Pastures
DRY ALPINE SCRUB	16-Dry Alpine Scrub		**16C1**: Dry alpine scrub

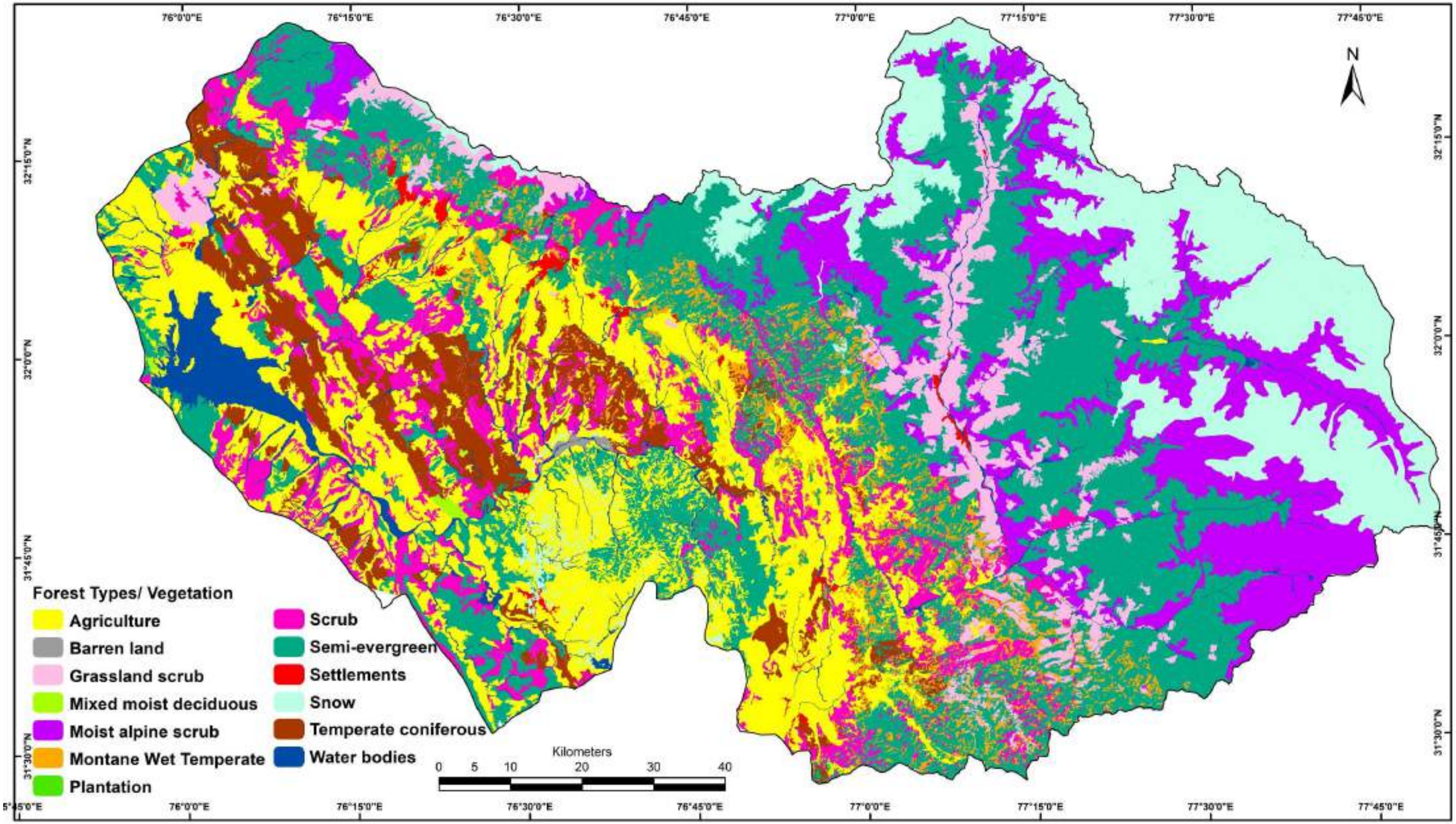


Figure 6.2: Forest /Vegetation type map of Beas basin based upon IIRS data

6.2.1 Group 5 Tropical Dry Deciduous Forest

Sub-Group 5B Northern Tropical Dry Deciduous Forest

This is a dry deciduous forest in which the upper canopy is light but probably fairly even and continuous in the climax form. The canopy is formed of mainly deciduous trees. The undergrowth is thin represented mainly by shrubs including some xerophytic evergreen species.

a) 5B/C2 Northern dry mixed deciduous forest

This is an open, dry deciduous forest in which the top canopy is thin but probably complete. Most trees have low spreading crowns and leafless during the hot weather. The main tree species occurring in the top storey are *Acacia catechu, Aegle marmelos, Anogeissus latifolia, Ehretia acuminata, Flacourtia indica, Holarrhena pubescens, Mitragyna parvifolia,* and *Ougeinia oojeinensis*. Second storey consists of trees like *Butea monosperma, Cassia fistula, Diospyros cordifolia, Mallotus philippensis, Nyctanthes arbor-tristis, Phyllanthus emblica*, etc. The common shrubs are *Justicia adhatoda, Bauhinia vahlii, Carissa opaca, Dendrocalamus strictus, Murraya koenigii* and *Woodfordia fruticosa*. This type of forest observed throughout the dry areas in Joginder Nagar, Dharamshala, Mandi and Sainj area (Beas sub-basins III, IV and V). The common grasses which colonise the riverine soil include *Heteropogon contortus, Imperata cylindrica, Neyraudia arundinacea, Saccharum* spp., etc.

6.2.2 Group 9 Sub-tropical Pine Forest

This is a forest dominated by chir pine in the top canopy. Broad-leaved, especially evergreen oaks increase with increasing altitude and leaving the pine on the warmer and drier ridges. Towards the lower limit of this forest there is an increase in the trees of the dry deciduous type. Climbers and bamboos are usually absent. The important forest types that form a part of this forest are described below.

a) 9/ C1a Himalayan sub-tropical pine forest

This is a more or less pure forest of chir pine forest with a scattered lower canopy of deciduous trees and a low scrub growth of xerophytic shrubs. The top canopy of the forest is dominated by *Pinus roxburghii* either singly or with a scattered group of deciduous tree storey. The main tree associates of the second storey include *Acacia catechu, Dalbergia sissoo, Mallotus philippensis, Phyllanthus emblica, Pyrus pashia* and *Syzygium cumini*. The common shrubs are *Berberis aristata, Carissa spinosa, Colebrookea oppositifolia, Dodonaea viscosa, Murraya koenigii, Myrsine affricana, Rubus ellipticus* and *Woodfordia fruticosa*. This type of forest observed throughout the low hill areas in Joginder Nagar, Mandi and Kangara area (Beas sub-basins III, IV and V). Herbaceous vegetation is represented by dry habitat loving grasses like *Chrysopogon fulvus, Cymbopogon* spp., *Dichanthium annulatum* and *Themeda anathera*.

b) 9C1/b Upper or Himalayan Chir pine forest

This is a high forest in which the top storey is dominated by chir pine (*Pinus roxburghii*) and scattered deciduous species restricted to the middle storey. This forest type is found in the lower Himalaya between 1200 and 1800 m which towards upper limits give way to temperate forests. The main broad-leaved tree species found in the middle storey are *Engelhardtia* *spicata, Lyonia ovalifolia, Myrica esculenta, Pyrus pashia, Quercus leucotrichophora, Sapindus mukorosii* and *Rhododendron arboreum*. The common Shrubs in the forest are *Berberis lycium, Colebrookea oppositifolia, Indigofera heterantha, Leptodermis lanceolata, Prinsepia utilis, Rubus ellipticus*, etc. This type of forest observed in the sub-basins like Sainj, Parvati, Malana, Uhl, Beas III, IV and V.

c) 9/C1/DS1 Himalayan Sub-tropical scrub

This type of low scrub are found over considerable areas in the siwalik chir zone, extending up into the Himalayan chir forest and passes down into the lower mixed deciduous forests. The dominant species vary place to place and often one or two of them predominating. Both edaphic and biotic factors are involved in determining the species. *Carissa opaca, Dodonaea viscosa, Rubus ellipticus* and *Woodfordia fruticosa* are the important shrubs found in these forests. This type of forest is observed in Uhl and Beas IV and V sub-basin areas.

d) 9/C1/DS2 Sub-tropical Euphorbia scrub

This type of forest occurs below the height of chir forests especially on rocky southern aspects. *Euphorbia royleana* is found abundantly throughout the dry rocky ridges either pure form or mixed with other shrubs like *Justicia adhatoda, Dodonaea viscosa, Maytenus senegalensis, Woodfordia fruticosa,* etc. Their distribution is mainly related to edaphic factors especially dry rocky ridges. But due to some biotic pressure like lopping, their population is becoming denser and purer in the entire lower catchment. This type Scrub forest is observed in Tirthan and Sainj sub-basins.

6.2.3 Group 12 Himalayan Moist Temperate Forest

These are rich and diverse forests comprised of coniferous and broad-leaved species found in the moist temperate regions of the Himalaya from Kashmir to Arunachal Pradesh. The top canopy is comprised of coniferous or broad-leaved species or their mixture. These forests extend along the whole length of the Himalaya above the sub-tropical forests and towards higher elevations they give way to sub-alpine forests. The altitudinal range is from 1500 to 3300 m depending on the latitude, aspect and configuration of the ground. These forests may be the following types:

a) 12/ C1a Ban oak forest (Quercus leucotricophora)

Dominated by ban oak (*Quercus leucotrichophora*), this forest is found on relatively moister sites. The trees form a close canopy when they are not affected by biotic pressure. These forests are found in the lower part of the temperate belt of the western Himalaya, between 1800 m and 2300 m, but it often reaches as low elevation as 1200 m where it occupies the moister ravines and other favourable sites. The main associates are *Carpinus viminea, Ilex dipyrena, Litsea umbrosa, Lyonia ovalifolia, Myrica esculenta, Persea odoratissima, Pyrus pashia, Symplocos paniculata, Rhododendron arboreum,* etc. Climbers are few such as *Clematis montana, Hedera nepalensis, Parthenocisus semicordata*, *Smilax aspera*, etc. Shrubs are *Benthamida capitata, Berberis lycium, Indigofera heterantha, Leptodermis suaveolans, Rosa brunonii*, *Rubus ellipticus* and *Viburnum cotinifolium*. This type of forest is observed in Sainj, Uhl and Beas III, IV and Beas V sub-basins areas.

b) 12/CI b Moru oak forest

This forest is dominated by Moru oak (*Quercus dilatata*) and occur in a narrow belt above the ban oak forests between 2000 and 2500 m elevations. The height of trees is between 20 to 30m, though taller trees having long boles may also be found in the first storey. There is relatively greater admixture of secondary species in the top canopy and well marked evergreen second storey. The main species found in the first storey are *Abies pindrow, Acer caesium, Quercus dialata* and *Q. leucotrichophora*. Second storey represented by *Buxus wallichiana, Ilex dipyrena, Litsea umbrosa, Lyonia ovalifolia* and *Rhododedndron arboreum*. The undergrowth constitutes *Berberis aristata, Deutzia corymbosa, Rosa macrophyla, Rubus* spp., *Sinarundinaria* spp. and *Viburnum cotinifolium*. The herbaceous growth consists of *Anemone obtusiloba, Geranium wallichianum, Paeonia emodi, Valeriana hardwickii*, etc. This type of forest is observed in the upper reaches of Parbati I, II, Malana, Beas II, and Uhl sub-basin.

c) 12/C1c Moist deodar forest

This is more or less pure forest of deodar with a little proportion of other species. These forests are found in the temperate areas of western Himalaya from Garhwal, Himachal Pradesh to Kashmir, between 1700 to 2500 m elevation. The canopy is fairly complete though not very dense. The main tree species found in the first storey are *Cedrus deodara* and *Pinus wallichiana*. Second storey consists of *Acer caesium, Aesculus indica, Quercus leucotricophora* and *Rhododendron arboreum*. Climbers and epiphytes are few. The prominent climbers are *Clematis montana, Hedera nepalensis, Jasmium officinale, Parthenocissus semicordata,* and *Rubia cordifolia*. Understorey consists of few shrubs like *Berberis lycium, Deutzia staminea, Indigofera heterantha, Lonicera angstifolia* and *Rosa macrophylla*. This type of forest is observed in Beas I, Beas II, Malana, Parbati Upper and II, Sainj, Trithan and Uhl sub-basins.

d) 12/C1d Western mixed coniferous forest

This is a mixed coniferous forest of the temperate areas comprised of fir, spruce, deodar and blue pine. These forests are found above the deodar forests in western Himalaya from Kashmir to Kumaon between 2400 and 3000 m elevations. Varying admixture of evergreen and deciduous broad-leaved trees may occur mixed in this forest. The main species in the first storey include *Abies pindrow, Cedrus deodara, Picea smithiana* and *Pinus wallichiana*. Second storey consists of *Acer acuminatum, A. caesium, Corylus jacquemonti, Euonymus pendulus, Juglans regia, Rhododendron arboreum* and *Taxus baccata*. Shrubs are dominated by small bamboo thickets with others tall spreading shrubs. *Berberis* spp., *Cotoneaster microphyllus, Deutzia corymbosa, Ribes* spp., *Sorbaria tomentosa, Thamnocalamus falcata, T. spathiflora, Viburnum nervosum,* etc. are common shrubs in the understorey. This type of forest is observed in Parbati Upper and II, Great Himalayan National Park (Sainj) and Trithan sub-basins.

e) 12/C1e Moist temperate deciduous forest

This is a deciduous forest in which individual trees may attain 20-30 m height. The tree have large girths. This type of forest is found between elevations 1800 and 2700 m. The main tree species in the first storey are *Abies pindrow, Acer caesium, Aesculus indica, Carpinus viminea, Fraxinus micrantha, Juglans regia, Prunus cornuta*, etc. Second storey include *Cornus macrophylla, Corylus jaquemontii, Lyonia ovalifolia, Rhus succadanea, Rhododendron* *arboreum* and *Taxus baccata*. Shrubs are *Berberis* spp., *Cotoneaster microphyllus, Deutzia corymbosa, Jasminum humile, Ribes* spp., *Sarcococca saligna, Sorbaria tomentosa, Thamnocalamus falcata* and *Viburnum cotinifolium*. This type of forest is observed in Malana, Parbati Upper and II, Great Himalayan National Park (Sainj) and Trithan sub-basins. Herbaceous growth belonging to species of *Aconitum, Impatiens, Lilium, Paeonia, Polygonatum, Spiraea*, etc.

f) 12/C1f Low level blue pine forest (Pinus wallichiana)

This forest is dominated by blue pine (*Pinus wallichiana*) but there are other species found mixed with it. Blue pine is a primary colonizer though other species may come up after sometime in vacant areas. This type of forest is found in the temperate areas of western Himalaya especially in reverain soil though it is not as widely distributed as the moist deodar forest. The other tree species found in the forest are *Acer caesium, Cedrus deodara* and *Rhododendron arboreum*. Undergrowth is represented by species of *Berberis, Cotoneaster, Rabdosia* and *Sarcococca*. This type of forest is observed in Sainj, Trithan, Beas II, Parvati II, Malana and Uhl sub-basins.

g) 12/CI/DS2 Himalayan temperate secondary scrub

An irregular or dense scrub cover with a few predominating and scattered residual trees of the Oak-deodar forest occur on excessively grazed and lopped areas of the temperate forest. *Berberis lycium, Indigofera gerardiana, Prinsepia utilis* and *Pyrus pashia* are the important secondary nature of scrub communities which occur especially on southern aspect. This type of scrub forest is observed in Sainj, Trithan and Uhl sub-basins.

h) 12/C2a Kharsu oak (Quercus semecarpifolia)

This forest is dominated by Kharsu oak (*Quercus semecarpifolia*) and forms a dense crop. The main tree species found in the first storey are *Abies pindrow, Acer caesium, Picea smithiana, Pius wallichiana* and *Quercus semecarpifolia*. Second storey consists of *Betula utilis, Ilex dipyrena, Prunus cornuta, Rhododendron arboreum*, and *Sorbus foliolosa*. Understorey consists of few tall spreading shrubs like *Cotoneaster bacillaris, Ribes glaciale, Rosa macrophylla, Rhododendron campanulatum, Viburnum cotinifolium*, etc. This type of forest is observed in Beas II, Parbati Upper and II, Sainj, Trithan and Beas IV sub-basins.

i) 12/C2b West Himalayan Upper oak-fir forests

This type of forest occurs above the mixed coniferous forest along the higher ranges of the Western and Central Himalaya, between 2600 and 3400 m elevations. The main tree species found in the first storey are *Abies pindrow*, *Picea smithiana* and *Pius wallichiana* Second storey consists of *Acer caesium, Aesculus indica, Corylus jacquemontii* and *Quercus semecarpifolia*. Undergrowth constitutes spreading shrubs like *Rosa macrophylla, R. sericea, Rubus niveus, Thamnocalamus spathiflora* and *Viburnum foetens*. Herbs belonging to species of *Ainsliaea, Fragaria, Galium, Valeriana*, etc. This type of forest is observed in Malana and Parbati Upper and II sub-basins.

j) 12/DS1 Montane bamboo brakes

Dense bamboo brakes occur throughout the moist temperate forest of Himalaya from western Himachal Pradesh to eastern part of Arunachal Pradesh. Small bamboos species like

Sinarundinaria falcata and *Thamnocalamus spathiflora* form dense and impenetrable brakes as an undergrowth in higher oak, rhododedndron and coniferous forest. This type of bamboo brakes is observed as an underwood in Sainj and Parbati Lower sub-basins.

k) 12/ DS3 Himalayan temperate pastures

These Himalayan grasslands occur on ridges and slopes especially where moist or wet conditions are present. The common grasses in the mixed coniferous forest zone of western Himalaya are *Agrostis* spp., *Calamagrostis* spp., *Dactylis glomerata*, *Danthonia* spp., *Festuca* spp. and *Poa* spp.

l) 12/1SI Alder forest

These forests occur along the banks of the large streams and sometimes extending up to ravines and moist unstable hill slopes along the whole Himalaya range, except from Kashmir. The altitudinal range is wide from 1500 to 3000m. The top storey is dominated by *Alnus nitida, Celtis tetradra, Populus ciliata* and *Ulmus villosa*. The undergrowth is thin and vary place to place depend on site and conditions. This type of subsidiary Alder forest is observed in Beas II sub-basin, Malana (Kulu valley) sub-basin and Sainj sub-basin.

6.2.4 Group14 Sub-alpine Forest

These forests are a typically dense growth of small crooked trees or large shrubs with patches of coniferous overwood. These forests are the topmost tree forests of the Himalaya forming the tree line at elevations of more than 2900 m and extending to over 3500 m. The forest of this group are comprised of the following types.

a) 14/CI West Himalayan sub-alpine birch-fir forests

This is an irregular forest consisting mainly of fir, birch and rhododendron. This type of forest is found above 3000 m in the western Himalaya. The underwood is fairly dense. They may further be of the following sub-types:

b) ***14/C1a West Himalayan sub-alpine high level fir forest***

The main species found in the first storey are *Abies spectabilis, Picea smithiana* and *Pinus wallichiana*. Second storey is comprised of *Betula utilis, Prunus cornuta, Rhododendron campanulatum* and *Taxus baccata*. Undergrowth is composed of *Berberis* spp., *Cotoneaster acuminatus, Deutzia corymbosa, Ribes* spp., and *Viburnum foetens*. Among herbs are *Anemone obtusiloba, Geranium* spp., *Osmunda claytoniana, Trillidium govanianum*, etc. This type of forest is observed in Beas II and Parbati Upper and II sub-basins.

c) 14/C1b West Hiamalayan birtch/fir forest

The main species found in this forest are *Betula utilis, Abies spectabilis* and *Pinus wallichiana*. Second storey is composed of *Betula utilis, Quercus semecarpifolia, Rhododendron campanulatum, Sorbus foliolosa* and *Taxus baccata*. Understorey is composed of *Cotoneaster acuminatus, Lonicera* spp., *Ribes glaciale, Rosa sericea, Rubus niveus* and *Smilax* sp.

6.2.5 Group 15 Moist Alpine Scrub

This consists of the alpine zone vegetation found just below the snowline and usually above the tree line in the moister tracts of Himalaya. Arctic climatic conditions are experienced in this tract of vegetation. The vegetation of this group consists of the following forest types:

a) 15/C1 Birch-Rhododendron scrub forest

This is low evergreen forest dominated by Rhododendron and also including other deciduous species. The trunks of trees are short and may be bent at the base. This type of forest is found in the alpine areas along the whole length of the Himalaya. The main species in the first storey are *Betula utilis, Rhododendron campanulatum* and *Sorbus foliolosa*. Undergrowth constitutes *Berberis* spp., *Gaultheria trichophylla, Lonicera* spp. and *Rhododendron lepidotum*. This is an alpine xerophytic formation in which dwarf shrubs predominate. This type is found at high elevations near Tibet. The characteristic plants are *Artemisia maritima*, *Caragana* spp., *Kobresia duthei, Lonicera* spp. and *Potentilla* spp.

b) 15/C3 Alpine meadows

These are meadows lying below the snowline all along the higher Himalaya. They are composed of perennial mesophytic herbs, sedges and few grasses. The important herbs are species of *Aconitum, Anemone, Fritillaria, Gentiana, Festuca, Iris, Kobresia, Primula* and *Ranunculus*.

6.2.6 Group16 Dry Alpine Scrub

This is the alpine vegetation of the cold and dry tracts of the trans-Himalaya and the inner dry valleys of the main Himalayan ranges.

a) 16/CI Dry alpine scrub

This is an alpine xerophytic formation in which dwarf shrubs predominate. This type of forest is found at high elevations in the cold deserts. The main species are *Caragana* spp., *Juniperus communis*, *Kobresia duthei, Lonicera* spp. and *Potentilla* spp. This type of vegetation is observed in Beas I sub-basin, Parbati Upper and Parbati Lower sub-basin and Uhl sub-basin areas.

6.3 FLORISTICS

Bio-geographically, the study area i.e. Beas basin is situated in the Biogeographic zone- 2A of North West Himalaya (Rodgers *et al*., 1988). The entire area is comprsed of complex hill system with elevation ranging from 325 m to about 6620 m, traversed throughout by a number of rivers and rivulets.

The flora of the study area covers the vast canvas of Himalayan ecosystem along an altitudinal gradient, a meeting ground of cold deserts of trans Himalayan region to the temperate and alpine Himalayan flora. At lower altitudes, there are forests of pine and at higher altitudes the presence of oak-rhododendron forests with horse chestnuts and maples. The temperate zone has coniferous forest of cedar, fir and spruce. The alpine areas harbor herbaceous flora like species of *Aconitum, Corydalis, Delphinium, Gentiana, Meconopsis, Pedicularis, Primula, Saxifraga*, etc. At higher elevations, the flora is of the cold desert type with prominence of species of *Astragalus, Caragana, Ephedra, Juniperus* and stunted *Hippophae* and rhododendrons.

The floristic studies covered the following parameters:

- Taxonomic Diversity and preparation of inventory of plant species
- Preparation of checklist of higher plants including groups like Angiosperms (trees, shrubs and herbs), Gymnosperms and Pteridophytes and lower plants groups like bryophytes, lichens and macro-fungi.

6.3.1 Taxonomic Diversity

Botanically the Beas basin and adjacent areas is part of north western Himalaya and has been a centre of floristic studies from the last two centuries. Willium Moorcroft was the first botanist who collected plants from Kangra, Kullu, Lahul and Spiti in 1821. Other workers explored plant species from different regions of Himachal Pradesh were Colonel Munro, Lt. Co. Edward Madden, J. E. Winterbottom, Richard Strachey. J. S. Gamble, Brandis (1881), J.F. Duthie (1892 and 1893).

During the 2nd half of 20th century Scientists from Botanical Survey of India Northern Circle (BSD), Dehra Dun, like M. A. Rau, T. A. Rao, N. C. Nair, P. K. Hajra, H. J. Chowdhery made frequent and periodical visits to various parts of Himachal Pradesh. Chowdhery and Wadhwa (1984) have published a comprehensive list of flowering plants of Himachal Pradesh. Apart from the above a number of contributions have also been made on vegetation, medicinal, ethnobotanical and ecology by various workers (Samant and Dhar, 1997; Samant *et al.*, 1998; Dhaliwal and Sharma, 1999; Singh and Rawat, 2000; Kaur and Lal, 2011; Kumar *et al.*, 2013; Kumar and Kumar, 2014 Kumar, 2014).

For the documentation of floristics of Beas basin data was collected from secondary sources made available by Botanical Survey of India (BSI) through MoEF&CC and also collected from other secondary sources like published reports, research articles and literature. An inventory of different plant groups was prepared based upon the data collected as above. According to this 1727 species of plants have been documented so far from the study area**.** A brief overview of number of plant species in various taxonomic groups is given in **Table 6.6** and discussed in following paragraphs.

Table 6.6: Summary of number plants species in Beas basin

GROUP	Families	Genera	Species	Total no. of species
Angiosperms				
Dicots	133	600	1263	
Monocots	29	165	318	
Total	**162**	**765**	**1581**	**1727**
Gymnosperms	3	7	14	
Pteridophytes	18	36	113	
Bryophytes	11	12	19	

The detailed inventory of angiosperm plant species reportedly found in the basin prepared from secondary data/literature is given at **Annexure-I** of **Volume II** of the report. The plant species nomenclature is based upon http://www.theplantlist.org.

6.3.1.1 Angiosperms

In all total 1581 species of angiosperms could be documented compiled from primary as well as secondary sources. These angiosperm species belong to 699 genera and 161 families. Most dominant family in the basin is Poaceae with 153 species followed by Asteraceae with 122 species, Fabaceae with 119 species, Lamiaceae 79 species, Rosaceae with 69 species and Ranunculaceae with 49 species (**see Table 6.7**).

Table 6.7: List of dominant angiospem families along with number of species

Family	Number of Species	Family	Number of species
Poaceae	153	Acanthaceae	27
Asteraceae	122	Rubiaceae	26
Fabaceae	119	Plantaginaceae	25
Lamiaceae	79	Boraginaceae	24
Rosaceae	61	Boraginaceae	24
Ranunculaceae	49	Caryophyllaceae	23
Brassicaceae	44	Euphorbiaceae	23
Polygonaceae	44	Gentianaceae	23
Cyperaceae	40	Orchidaceae	22

6.3.1.2 Gymnosperms

The gymnosperms are represented by 8 geners 14 species belonging to three families with Pinaceae as most dominant family represented by 7 species. A detailed list of the same is given in **Table 6.8**. *Juniperus* is most common genus represented by 6 species followed by *Pinus* with 3 species.

Table 6.8: List of Gymnosperms reportedly found in Beas basin

S.No.	Family	Scientific Name
1	Cupressaceae	*Juniperus communis*
2	Cupressaceae	*Juniperus indica*
3	Cupressaceae	*Juniperus pseudosabina*
4	Cupressaceae	*Juniperus recurva*
5	Cupressaceae	*Juniperus indica*
6	Cupressaceae	*Juniperus communis*
7	Ephedraceae	*Ephedra gerardiana*
8	Pinaceae	*Abies pindrow*
9	Pinaceae	*Abies spectabilis*
10	Pinaceae	*Cedrus deodara*
11	Pinaceae	*Picea smithiana*
12	Pinaceae	*Pinus roxburghii*
13	Pinaceae	*Pinus wallichiana*
14	Pinaceae	*Taxus wallichiana*

6.3.1.3 Pteridophytes

This group is represented by 113 species belonging to 18 families with Pteridaceae, Dryopteridaceae, Polypodiaceae and Woodsiaceae being the largest families. A detailed list of the same is given in **Table 6.9**. Pteridaceae with 28 species is the largest family followed by Dropteridaceae with 23 species. The genus *Polystichum* is most common species found represented by 11 species followed by *Dryopteris* and *Thelypteris* with 9 species each.

Table 6.9: List of Pteridophytes reportedly found in Beas basin

S.No.	Family	Scientific Name
1	Aspleniaceae	*Asplenium dalhousiae*
2	Aspleniaceae	*Asplenium laciniatum*
3	Aspleniaceae	*Asplenium trichomanes*
4	Athyriaceae	*Athyrium foliolosum*
5	Athyriaceae	*Athyrium schimperi*
6	Athyriaceae	*Diplazium esculentum*
7	Blechnaceae	*Woodwardia unigemmata*
8	Davalliaceae	*Araiostegia beddomei*
9	Davalliaceae	*Araiostegia delavayi*
10	Davalliaceae	*Araiostegia pulchra*
11	Dennstaedtiaceae	*Dennstaedtia scabra*
12	Dennstaedtiaceae	*Hypolepis polypodioides*
13	Dennstaedtiaceae	*Pteridium aquilinum*
14	Dryopteridaceae	*Cyrtomium anomophyllum*
15	Dryopteridaceae	*Cyrtomium caryotideum*
16	Dryopteridaceae	*Dryopteris carolihopei*
17	Dryopteridaceae	*Dryopteris cochleata*
18	Dryopteridaceae	*Dryopteris juxtaposita*
19	Dryopteridaceae	*Dryopteris nigropaleacea*
20	Dryopteridaceae	*Dryopteris ramosa*
21	Dryopteridaceae	*Dryopteris redactopinnata*
22	Dryopteridaceae	*Dryopteris wallichiana*
23	Dryopteridaceae	*Dryopteris xanthomelas*
24	Dryopteridaceae	*Dryopteris zayuensis*
25	Dryopteridaceae	*Polystichum discretum*
26	Dryopteridaceae	*Polystichum lentum*
27	Dryopteridaceae	*Polystichum mehrae*
28	Dryopteridaceae	*Polystichum nepalense*
29	Dryopteridaceae	*Polystichum obliquum*
30	Dryopteridaceae	*Polystichum piceopaleaceum*
31	Dryopteridaceae	*Polystichum setiferum*
32	Dryopteridaceae	*Polystichum squarrosum*
33	Dryopteridaceae	*Polystichum squarrosum*
34	Dryopteridaceae	*Polystichum thomsonii*
35	Dryopteridaceae	*Polystichum yunnanense*
36	Equisetaceae	*Equisetum diffusum*
37	Equisetaceae	*Equisetum ramosissimum*
38	Lygodiaceae	*Lygodium flexuosum*
39	Lygodiaceae	*Lygodium japonicum*
40	Oleandraceae	*Oleandra wallichii*
41	Ophioglossaceae	*Botrychium schaffneri*
42	Osmundaceae	*Osmunda claytoniana*
43	Osmundaceae	*Osmunda claytoniana* subsp. *vestita*
44	Osmundaceae	*Osmunda japonica*
45	Polypodiaceae	*Drynaria mollis*
46	Polypodiaceae	*Lepisorus mehrae*
47	Polypodiaceae	*Lepisorus nudus*

S.No.	Family	Scientific Name
48	Polypodiaceae	*Lepisorus pseudonudus*
49	Polypodiaceae	*Lepisorus sesquipedalis*
50	Polypodiaceae	*Lepisorus tenuipes*
51	Polypodiaceae	*Microsorum membranaceum*
52	Polypodiaceae	*Phymatopteris melacodon*
53	Polypodiaceae	*Phymatopteris oxyloba*
54	Polypodiaceae	*Polypodiodes amoena*
55	Polypodiaceae	*Polypodiodes lachnopus*
56	Polypodiaceae	*Polypodiodes microrhizoma*
57	Polypodiaceae	*Pyrrosia flocculosa*
58	Polypodiaceae	*Pyrrosia porosa*
59	Pteridaceae	*Adiantum capillus-veneris*
60	Pteridaceae	*Adiantum edgeworthii*
61	Pteridaceae	*Adiantum incisum*
62	Pteridaceae	*Adiantum philippense*
63	Pteridaceae	*Adiantum venustum*
64	Pteridaceae	*Adiantum venustum* subsp. *tibeticum*
65	Pteridaceae	*Aleuritopteris albomarginata*
66	Pteridaceae	*Aleuritopteris anceps*
67	Pteridaceae	*Aleuritopteris bicolor*
68	Pteridaceae	*Aleuritopteris farinose* var. *grisea*
69	Pteridaceae	*Aleuritopteris formosa*
70	Pteridaceae	*Aleuritopteris rufa*
71	Pteridaceae	*Coniogramme intermedia*
72	Pteridaceae	*Coniogramme pubescens*
73	Pteridaceae	*Coniogramme serrulata*
74	Pteridaceae	*Didymochlaena truncatula* (Syn. *Adiantum lunulatum*)
75	Pteridaceae	*Gymnopteris vestita*
76	Pteridaceae	*Onychium cryptogrammoides*
77	Pteridaceae	*Onychium japonicum*
78	Pteridaceae	*Onychium siliculosum*
79	Pteridaceae	*Paraceterach vestita* (Syn. *Gymnopteris vestita*)
80	Pteridaceae	*Pellaea nitidula*
81	Pteridaceae	*Pteris aspericaulis*
82	Pteridaceae	*Pteris cretica*
83	Pteridaceae	*Pteris quadriaurita*
84	Pteridaceae	*Pteris terminalis*
85	Pteridaceae	*Pteris vittata*
86	Selaginellaceae	*Selaginella chrysocaulos*
87	Selaginellaceae	*Selaginella chrysorhizos*
88	Selaginellaceae	*Selaginella subdiaphana*
89	Thelypteridaceae	*Thelypteris arida*
90	Thelypteridaceae	*Thelypteris auriculata*
91	Thelypteridaceae	*Thelypteris dentata*
92	Thelypteridaceae	*Thelypteris erubescens*
93	Thelypteridaceae	*Thelypteris nudata*
94	Thelypteridaceae	*Thelypteris papilio*
95	Thelypteridaceae	*Thelypteris prolifera*
96	Thelypteridaceae	*Thelypteris pyrrhorhachis*
97	Thelypteridaceae	*Thelypteris tylodes*
98	Woodsiaceae	*Athyrium anisopterum*
99	Woodsiaceae	*Athyrium atkinsonii*
100	Woodsiaceae	*Athyrium fimbriatum*
101	Woodsiaceae	*Athyrium micropterum*
102	Woodsiaceae	*Athyrium pectinatum*
103	Woodsiaceae	*Athyrium rupicola*
104	Woodsiaceae	*Athyrium setiferum*

S.No.	Family	Scientific Name
105	Woodsiaceae	*Athyrium strigillosum*
106	Woodsiaceae	*Deparia allantodioides*
107	Woodsiaceae	*Deparia boryana*
108	Woodsiaceae	*Deparia peterseni*
109	Woodsiaceae	*Diplazium maximum*
110	Woodsiaceae	*Hypodematium crenatum*
111	Woodsiaceae	*Woodsia elongata*
112	Pteridaceae	*Onychium contiguum*
113	Oleandraceae	*Oleandra wallichii*

6.3.1.4 Bryophytes

A list of 19 species of bryophytes belonging to 11 families reported from Beas basin was prepared from the published data and the same is given at **Table 6.10**. Marchantiaceae, Bryaceae and Anthocerotaceae are most dominant families with 3 species each.

Table 6.10: List of Bryophytes reportedly found in Beas basin

S. No.	Family	Scientific Name
1	Anthocerotaceae	*Anthoceros himalayensis*
2	Anthocerotaceae	*Anthoceros erectus*
3	Anthocerotaceae	*Anthoceros chambensis*
4	Aytoniaceae	*Fimbraria dilatata*
5	Bryaceae	*Bryum argenteum*
6	Bryaceae	*Bryum cellulare*
7	Bryaceae	*Bryum dichotomum*
8	Funariaceae	*Funaria hygrometrica*
9	Marchantiaceae	*Marchantia palmata*
10	Marchantiaceae	*Marchantia nepalensis*
11	Marchantiaceae	*Marchantia polymorpha*
12	Meteoriaceae	*Aerobryidium filamentosum*
13	Polytrichaceae	*Polytrichum densifolium*
14	Polytrichaceae	*Pogonatum microstomum*
15	Porellaceae	*Madotheca porella*
16	Pottiaceae	*Barbula convoluta*
17	Ricciaceae	*Riccia fluitans*
18	Ricciaceae	*Riccia discolor*
19	Sphagnaceae	*Sphagnum palustre*

6.3.2 Rare, Endangered and Threatened (RET) Plant Species

As the basin is characterized by wide elevational range and it harbours rich diversity of plant species. Some of the species endemic to Western Himalaya and the state are found in the basin. Also due to specific habitats, it is home to number of rare, endangered and threatened plant species. An exercise was undertaken to document all such species listed in IUCN Redlist (2017-2), BSI Red Data Book of Indian Plants (Vol. 1-3), by Nayar & Sastry (1987-88) and Conservation Assessment and Management Prioritisation (CAMP) Reports for the Threatened Wild Medicinal Plants of Himachal Pradesh (1998; 2003 & 2012) in addition to other published literature and articles.

Nayar and Sastry (1987-1990) have reported 22 species of rare and endangered plant species from Himachal Pradesh. In Beas basin, there are 14 plant species that are under different threat categories as per Red Data Book of Plants published by Botanical Survey of India (see **Tables 6.11 & 6.12**). According to Red-list Status of candidate species as per Shimla

Conservation Assessment Management Prioritisation (CAMP) December, 2010 by Foundation for Revitalisation of Local Health Traditions (FRLHT), there are 41 species found in Beas basin (**Table 6.13**). However according to IUCN (2017-2) only 107 species have been assessed for their conservation status globally and most of them are listed in 'Least Concern' category and only 8 are in VU category, 2 in Near Threatened, 4 each in Critically Endangered and Endangered category. Four species are listed as Data Deficient category and one species is reported extinct in wild (see **Table 6.14**).

Table 6.11: RET species reported from Beas basin and their conservation status based upon BSI Red Data Book

S.No.	Family	Scientific Name	Conservation Status
1	Aceraceae	*Acer caesium*	VU
2	Asteraceae	*Saussurea costus*	EN
3	Amaryllidaceae	*Allium stracheyi*	VU
4	Cyperaceae	*Carex munroi*	I
5	Liliaceae	*Eremurus himalaicus*	R
6	Orchidaceae	*Cypripedium cordigerum*	R
7	Ranunculaceae	*Aconitum ferox*	VU
8	Valerianaceae	*Nardostachys grandiflora*	VU
9	Plantaginaceae	*Picrorhiza kurroa*	VU
10	Dioscoreaceae	*Dioscorea deltoidea*	VU
11	Brassicaceae	*Erysimum thomsonii*	Rare
12	Fabaceae	*Hedysarum astragaloides*	Rare
13	Fabaceae	*Hedysarum microcalyx*	VU
14	Campanulaceae	*Campanula wattiana*	Rare

EN=Endangered; VU=Vulnerable; R=Rare; I= Indeterminate

Table 6.12: RET species occurring in Beas basin according to H.J. Chowdhery (1999). In: Mudgal, V. & Hajra, P.K.

S.No.	Family	Scientific Name
1	Amaryllidaceae	*Allium stracheyi* Baker
2	Apiaceae	*Angelica glauca* Edgew.
3	Asteraceae	*Jurinea dolomiaea* Boiss.
4	Asteraceae	*Saussurea obvallata* (DC.) Sch.-Bip.
5	Betulaceae	*Betula utilis* D. Don
6	Boraginaceae	*Arnebia euchroma* I.M. Johnst.
7	Caprifoliaceae	*Nardostachys jatamansi* DC.
8	Cupressaceae	*Juniperus communis* Thunb.
9	Dioscoreaceae	*Dioscorea deltoidea* Wall.
10	Ephedraceae	*Ephedra gerardiana* Wall. ex Florin
11	Polygonaceae	*Rheum spiciforme* Royle
12	Polygonaceae	*Rheum webbiana* Royle
13	Scrophulariaceae	*Picrorhiza kurrooa* Royle

Table 6.13: RET species occurring in Beas basin according to CAMP' Workshop by FRLHT 2010 held at Shimla

S.No.	Family	Scientific Name	Conservation Status
1	Amaryllidaceae	*Allium stracheyi*	VU
2	Apiaceae	*Angelica glauca*	EN

S.No.	Family	Scientific Name	Conservation Status
1	Apiaceae	*Selinum connifolium* (=*S. tenuifolium*)	VU
2	Apiaceae	*Selinum vaginatum*	VU
5	Asparagaceae	*Polygonatum cirrhifolium*	EN
6	Asparagaceae	*Polygonatum multiflorum*	EN
7	Asparagaceae	*Polygonatum verticillatum*	EN
8	Asteraceae	*Jurinea dolomiaea* (=*J. macrocephala*)	CR
9	Asteraceae	*Saussurea obvallata*	EN
10	Berberidaceae	*Berberis aristata*	EN
11	Berberidaceae	*Sinopodophyllum hexandrum*	EN
12	Betulaceae	*Betula utilis*	EN
13	Bignoniaceae	*Oroxylum indicum*	NE
14	Boraginaceae	*Arnebia benthamii*	EN
15	Cupressaceae	*Juniperus communis*	VU
16	Dioscoreaceae	*Dioscorea deltoidea*	EN
17	Fabaceae	*Desmodium gangeticum*	NE
18	Gentianaceae	*Gentiana kurroo*	CR
19	Gentianaceae	*Swertia chirayita*	CR
20	Hypericaceae	*Hypericum peforatum*	VU
21	Lauraceae	*Cinnamomum tamala*	VU
22	Lauraceae	*Litsea glutinosa*	VU
23	Liliaceae	*Lilium polyphyllum*	CR
24	Liliaceae	*Fritillaria roylei*	EN
25	Orchidaceae	*Malaxis muscifera*	CR
26	Orchidaceae	*Dactylorhiza hatagirea*	CR
27	Pinaceae	*Taxus wallichiana* (= *T. baccata*)	EN
28	Plantaginaceae	*Picrorhiza kurroa*	CR
29	Polygonaceae	*Rheum moorcroftianum*	EN
30	Polygonaceae	*Rheum speciforme*	NT
31	Polygonaceae	*Rheum webbianum*	VU
32	Ranunculaceae	*Aconitum laeve*	NE
33	Ranunculaceae	*Aconitum violaceum*	VU
34	Rutaceae	*Skimmia laureola*	VU
35	Rutaceae	*Zanthoxylum armatum*	EN
36	Solanaceae	*Atropa acuminata*	CR
37	Solanaceae	*Hyoscyamus niger*	NT
38	Symplocaceae	*Symplocos paniculata*	VU
39	Valerianaceae	*Nardostachys grandiflora*	EN
40	Zingiberaceae	*Roscoea alpina*	VU

CR=Critically Endangered; EN=Endangered; VU=Vulnerable; NT=Near Threatened

Table 6.14: Plant species found in Beas basin listed in Red List of Plants by IUCN (2017-2)

S.No.	Family	Scientific Name	Conservation Status
1	Asteraceae	*Saussurea costus*	CR
2	Apiaceae	*Angelica glauca*	EN
3	Bignoniaceae	*Jacaranda mimosifolia*	VU
4	Boraginaceae	*Myosotis alpestris*	NT
5	Caprifoliaceae	*Nardostachys jatamansi* (Syn. *Nardostachys grandiflora*)	CR
6	Fabaceae	*Indigofera heterantha* (Syn. *Indigofera gerardiana*)	VU
7	Fabaceae	*Tephrosia angustissima* (Syn. *Tephrosia purpurea*)	EN
8	Fabaceae	*Saraca asoca*	VU

S.No.	Family	Scientific Name	Conservation Status
9	Gentianaceae	*Gentiana kurroo*	CR
10	Juglandaceae	*Juglans regia*	NT
11	Liliaceae	*Lilium polyphyllum*	CR
12	Orchidaceae	*Cypripedium cordigerum*	VU
13	Orchidaceae	*Cypripedium himalaicum*	EN
14	Orchidaceae	*Malaxis muscifera*	VU
15	Plantaginaceae	*Plantago lanceolata*	VU
16	Ranunculaceae	*Aconitum heterophyllum*	EN
17	Ranunculaceae	*Aconitum violaceum*	VU
18	Solanaceae	*Brugmansia suaveolens*	EX in Wild
19	Ulmaceae	*Ulmus wallichiana*	VU

CR= Critically Endangered; EN= Endangered; VU= Vulnerable; NT= Near Thraetened

6.3.3 Endemic Plant Species

In order to understand the floristic importance of Beas basin an exercise was undertaken to enumerate plant species which are endemic to Himalaya and occur in the basin. Here a list of plant species endemic to Himalaya was which included species occuring the Himalayan Mountain Range (i.e. the Himalaya) above about 1000 m. Of 333 endemic and near endemic vascular plants so far recorded from Himalaya (Behera *et al*., 2002; Grierson & Long, 1983; Hara, 1972; Jain & Rao, 1983; Kanai, 1963; Malik *et. al.,* 2007; Nayar, 1996; Rau, 1974) 182 species are found in Western Himalaya. Of 84 plant species endemic to North West Himalaya (Included here are the Himalaya above about 1000 m in the area westward of the Kali Gandaki River Gorge in Central Nepal – Jain & Rao, 1983; Kanai, 1963; Rau, 1974) and Himachal Pradesh (Chaudhery, 1999) 64 species are reported from Beas basin. Detailed list is given at **Table 6.15**.

Table 6.15: List of plant species endemic to Western Himalaya and Himachal Pradesh and found in Beas basin

S. No.	Family	Name of the Species
1	Amaryllidaceae	*Allium stracheyi*
2	Apiaceae	*Bupleurum falcatum*
3	Apiaceae	*Cortia depressa*
4	Apiaceae	*Heracleum wallichii*
5	Apiaceae	*Pleurospermum brunonis*
6	Apiaceae	*Selinum vaginatum*
7	Asteraceae	*Aconitum ferox*
8	Asteraceae	*Anaphalis royleana*
9	Asteraceae	*Aster falconeri*
10	Asteraceae	*Erigeron bellidioides*
11	Asteraceae	*Saussurea costus*
12	Berberidaceae	*Berberis aristata*
13	Berberidaceae	*Berberis jaeschkeana*
14	Berberidaceae	*Berberis lycium*
15	Betulaceae	*Alnus nitida*
16	Betulaceae	*Corylus jacquemontii*
17	Buxaxeae	*Sarcococca pruniformis*
18	Campanulaceae	*Codonopsis clematidea*
19	Cannabaceae	*Celtis australis*

S. No.	Family	Name of the Species
20	Caryophyllaceae	*Stellaria media*
21	Crassulaceae	*Rhodiola heterodonta*
22	Elaeagnaceae	*Hippophae salicifolia*
23	Fabaceae	*Desmodium elegans*
24	Fabaceae	*Hedysarum astragaloides*
25	Fabaceae	*Hedysarum microcalyx*
26	Fabaceae	*Oxytropis mollis*
27	Fagaceae	*Quercus floribunda*
28	Juglandaceae	*Juglans regia*
29	Lamiaceae	*Phlomis bracteosa*
30	Moraceae	*Morus serrata*
31	Oleaceae	*Fraxinus micrantha*
32	Oleaceae	*Fraxinus xanthoxyloides*
33	Oleaceae	*Syringa emodi*
34	Onagraceae	*Epilobium latifolium*
35	Orchidaceae	*Dactylorhiza hatagirea*
36	Orobanchaceae	*Pedicularis bicornuta*
37	Orobanchaceae	*Pedicularis pectinata*
38	Papaveraceae	*Corydalis crassifolia*
39	Papaveraceae	*Corydalis govaniana*
40	Papaveraceae	*Meconopsis aculeata*
41	Plantaginaceae	*Veronica biloba*
42	Poaceae	*Agrostis munroana*
43	Poaceae	*Agrostis pilosula*
44	Polygonaceae	*Rheum spiciforme*
45	Polygonaceae	*Rheum webbianum*
46	Ranunculaceae	*Aconitum heterophyllum*
47	Ranunculaceae	*Caltha palustris*
48	Ranunculaceae	*Delphinium brunonianum*
49	Ranunculaceae	*Ranunculus arvensis*
50	Rosaceae	*Rosa macrophylla*
51	Rosaceae	*Rosa webbiana*
52	Rosaceae	*Rubus niveus*
53	Rosaceae	*Sorbus lanata*
54	Rosaceae	*Spiraea canescens*
55	Rubiaceae	*Galium asperuloides*
56	Rubiaceae	*Rubia cordifolia*
57	Salicaceae	*Salix denticulata*
58	Sapindaceae	*Acer acuminatum*
59	Sapindaceae	*Acer caesium*
60	Sapindaceae	*Aesculus indica*
61	Saxifragaceae	*Bergenia stracheyi*
62	Scrophulariaceae	*Picrorhiza kurroa*
63	Ulmaceae	*Ulmus wallichiana*
64	Xanthorrhoeaceae	*Eremurus himalaicus*

6.3.4 Medicinal & Economically Important Plants

This region harbours a wide range of medicinal plants used in Ayurvedic, Homoeopathic and Unani medicines or used by the local people. An inventory of medicinal plant species used by local tribal people was prepared from data collected through literature survey. These plants are used internally for treating stomachic diarrhoea, dysentery, cough, cold, fever and asthma and externally for rheumatism, skin diseases, cuts, boils and injuries. Detailed list of the medicinally important plants species is given in **Annexure II** of **Volume II** of the report.

In addition to plants being used for medicinal purposes, these are used for many other purposes like as timber, fuelwood, etc. List of important plants species used for miscellaneous purposes is given at **Table 6.16**.

Table 6.16: List of important plant species used for medicinal purposes

S.No.	Family	Name of Species	Common Name	Habit	Parts used
1	Acanthaceae	*Barleria cristata*	-	Herb	Root
2	Acanthaceae	*Justicia adhatoda*	Vasinga	Shrub	Roots
3	Aceraceae	*Acer caesium*	Kinchula	Tree	Bark
4	Acoraceae	*Acrous calamus*	Vacha	Herb	Roots/ Rhizome
5	Amaranthaceae	*Achyranthes aspera*	Chirchita	Herb	Whole plant
6	Anacardiaceae	*Pistacia integerrima*	Kakra singi	Tree	Galls
7	Apiaceae	*Carum carvi*	Kalajiri	Herb	Seeds
8	Apiaceae	*Chaerophyllum reflexum*	-	Herb	Roots
9	Apiaceae	*Ferula jaeschkeana*	-	Herb	Roots
10	Apocynaceae	*Holarrhena pubescens*	Hartaki	Tree	Frut-pods
11	Araceae	*Arisaema tortuosum*	-	Herb	Tubers
12	Araliaceae	*Hedera nepalensis*	-	Climber	Stems,twigs
13	Asclepiadaceae	*Cryptolepis buchananii*	-	Climber	Stems,twigs
14	Asparagaceae	*Asparagus adscendens*	Satavar	Shrub	Root/Tubers
15	Asteraceae	*Achillea millefolium*	-	Herb	Roots, Leaves
16	Asteraceae	*Ageratum conyzoides*	Phulya	Herb	Leaves
17	Asteraceae	*Artemisia indica*	Kunja	Herb	Leaves, young twigs
18	Asteraceae	*Bidens pilosa*	Kuri	Herb	Flowers
19	Asteraceae	*Echinops cornigerus*	Kandaru	Herb	Roots, Seeds
20	Asteraceae	*Eclipta prostrate*	BHANGRA	Herb	Whole plant
21	Asteraceae	*Emilia sonchifolia*	-	Herb	Root
22	Asteraceae	*Jurinea macrocephala*	Dolu	Herb	Roots
23	Asteraceae	*Saussurea costus*	Kuth	herb	Roots
24	Asteraceae	*Saussurea obvallata*	Brhamkamal	herb	Flowers
25	Asteraceae	*Sonchus asper*	Kaduyeh	Herb	Leaves
26	Asteraceae	*Tanacetum dolichophillum*	Dhup	Herb	Roots
27	Asteraceae	*Tridex procumbens*	Pathar chatta	Herb	Roots, Leaves
28	Asteraceae	*Vernonia anthelmintica*	Kala jeera	Herb	Seeds
29	Berberidaceae	*Berberis aristata*	Rasut	Shrub	Root, bark
30	Berberidaceae	*Berberis lycium*	-	Shrub	Roots, barks
31	Bignoniaceae	*Oroxylum indicum*	-	Tree	Bark
32	Bombacaceae	*Bombax ceiba*	Semal	Tree	Barks, Fruits
33	Boraginaceae	*Arnebia benthami*	Balchhad	Herb	Roots
34	Brassicaceae	*Cardamine impatiens*	-	Herb	Leaves
35	Brassicaceae	*Megacarpea polyandra*	Barmula	Herb	Roots
36	Caesalpiniaceae	*Bauhinia variegata*	Kachnar	Tree	Floral buds

S.No.	Family	Name of Species	Common Name	Habit	Parts used
37	Caesalpiniaceae	*Cassia tora*	-	Shrub	Roots
38	Capparidaceae	*Capparis spinosa*	-	Climber	Leaves
39	Capparidaceae	*Cleome viscosa*	Jakhya	Herb	Seed
40	Caryophyllaceae	*Arenaraia neelgherrensis*	Musakarni	Herb	Leaves
41	Celastraceae	*Celastrus paniculata*	Malkoni	Climber	Whole plant
42	Combretaceae	*Anogeissus latifolia*	Dhaura	Tree	Bark
43	Combretaceae	*Terminalia bellirica*	Bahera	Tree	Fruits
44	Combretaceae	*Terminalia chebula*	Harar	Tree	Fruit
45	Convolvulaceae	*Evolvulus alsinoides*	Sankhpushpi	Herb	Whole plant
46	Cordiaceae	*Ehretia acuminata*	-	Tree	Roots
47	Coriariaceae	*Coriaria nepalensis*	-	Shrub	Leaves
48	Crassulaceae	*Sedum ewersii*	Pathar chatta	Herb	Succulent Leaves
49	Cucurbitaceae	*Trichosanthes dioica*	Ilaru	Climber	Fruit
50	Cupressaceae	*Juniperus communis*	Dhupi	Shrub	Leaves
51	Cupressaceae	*Juniperus indica*	Dhupi	Shrub	Leaves
52	Cuscutaceae	*Cuscuta reflexa*	Akaas Bel	Climber	Whole plant
53	Dioscoreaceae	*Dioscorea deltoidea*	-	Herb	Tubers
54	Dipsacaceae	*Morina longifolia*	Kandaru	Herb	Roots
55	Elaeagnaceae	*Hippophae salicifolia*	Pangadee	Shrub	Whole plant
56	Ephedraceae	*Ephedra gerardiana*	Somlata	Shrub	Whole plant
57	Ericaceae	*Lyonia ovalifolia*	Ayanar	Tree	Leaves
58	Ericaceae	*Rhododendron arboreum*	Buraans	Tree	Flowers
59	Euphorbiaceae	*Andrachne cordifolia*	Bishpata	Shrub	Leaves
60	Euphorbiaceae	*Euphorbia hirta*	Dudhi	Herb	Whole plant
61	Euphorbiaceae	*Phyllanthus emblica*	Aonla	Tree	Fruits
62	Fagaceae	*Quercus leucotrichophora*	Baanj-Liqwal	Tree	Acorn
63	Flacourtiaceae	*Flacourtia indica*	-	Tree	Fruit
64	Fumariaceae	*Fumaria indica*	Katphapar	Herb	Whole plant
65	Gentianaceae	*Gentiana kurroo*	-	Herb	Roots
66	Geraniaceae	*Geranium wallichianum*	Ratanjot	Herb	Roots
67	Juglandaceae	*Juglans regia*	Okhar	Tree	Bark, leaves
68	Lamiaceae	*Ajuga bracteosa*	Neelkanthi	Herb	Roots
69	Lamiaceae	*Colebrookea oppositifolia*	Vanda	Shrub	Roots
70	Lamiaceae	*Leucus cephalotus*	Dronpushpi	Herb	Roots
71	Lamiaceae	*Micromeria biflora*	-	Herb	Whole plant
72	Lamiaceae	*Origanum vulgare*	Van-Tulsi	Herb	Leaves
73	Lauraceae	*Cinnamomum tamala*	Tejpata	Tree	Leaves
74	Liliaceae	*Cardiocrinum giganteum*	-	Herb	Roots
75	Liliaceae	*Fritillaria roylei*	-	Herb	Roots
76	Liliaceae	*Polygonatum cirrhifolium*	Maida	Herb	Roots
77	Liliaceae	*Polygonatum verticillatum*	Mahamaida	Herb	Roots
78	Liliaceae	*Trillidium govanianum*	-	Herb	Roots
79	Linaceae	*Reinwardtia indica*	Phyunli	Herb	Roots
80	Loganiaceae	*Buddleja asiatica*	-	Shrub	Roots
81	Lythraceae	*Woodfordia fruticosa*	Dhaura	Shrub	Flowers
82	Malvaceae	*Abelmoschus manihot*	-	Herb	Roots
83	Malvaceae	*Sida cordata*	-	Herb	Roots
84	Malvaceae	*Urena lobata*	-	Shrub	Roots
85	Melastomaceae	*Osbeckia stellata*	-	Shrub	Roots
86	Menispermaceae	*Cissampelos pareira*	Pahari jad	Climber	Leaves, roots
87	Menispermaceae	*Stephania glabra*	Biskaphar	Climber	Tubers
88	Menispermaceae	*Tinospora cordifolia*	Giloyah	Climber	Stems,twigs
89	Mimosaceae	*Acacia catechu*	Khair	Tree	Bark
90	Myrtaceae	*Syzygium cumini*	Jamun	Tree	Fruit

S.No.	Family	Name of Species	Common Name	Habit	Parts used
91	Nyctaginaceae	*Boerhavia diffusa*	Punernava	Herb	Whole plant
92	Oleaceae	*Jasminum humile*	-	Shrub	Leaves
93	Orchidaceae	*Cypripedium cordigerum*	-	Herb	Roots
94	Orchidaceae	*Dactylorhiza hatagirea*	Hat-jari	Herb	Roots
95	Oxalidaceae	*Oxalis corniculata*	Khatibuti	Herb	Leaves
96	Paeoniaceae	*Paeonia emodi*	Mamekh	Herb	Roots
97	Papaveraceae	*Argemone mexicana*	-	Herb	Seeds
98	Papaveraceae	*Corydalis govaniana*	Bhutkesi	Herb	Roots
99	Papaveraceae	*Meconopsis aculeata*	-	Herb	Roots
100	Fabaceae	*Abrus precatorius*	Rati	Climber	Roots, seeds
101	Fabaceae	*Astragalus candolleanus*	Rudravanti	Herb	Roots
102	Fabaceae	*Butea monosperma*	Plaas	Tree	Flowers
103	Fabaceae	*Clitoria ternata*	Aprajita	Climber	Root
104	Fabaceae	*Desmodium triquetrum*	-	Shrub	Roots
105	Fabaceae	*Indigofera heterantha*	Sakina	Shrub	Floral buds
106	Fabaceae	*Lespedeza gerardiana*	-	Herb	Roots
107	Fabaceae	*Robinia pseudo-acacia*	-	Tree	Bark
108	Plataginaceae	*Plantago erosa*	Isabgol	Herb	Seeds
109	Plumbaginaceae	*Plumbiga zeylanica*	Chtrak	Herb	Roots
110	Poaceae	*Cynodon dactylon*	Doob	Herb	Whole plant
111	Podophyllaceae	*Sinopodophyllum hexandrum*	Van-kakri	Herb	Fruits
112	Polygonaceae	*Rheum australe*	Dolu	Herb	Roots
113	Polygonaceae	*Rumex nepalensis*	Kholya	Herb	Leaves
114	Ranunculaceae	*Aconitum chasmanthum*	Mohra	Herb	Tubers
115	Ranunculaceae	*Aconitum heterophyllum*	Patish	Herb	Tubers
116	Ranunculaceae	*Aconitum violaceum*	Meetha	Herb	Tubers
117	Ranunculaceae	*Actaea acuminata*	-	Herb	Roots
118	Ranunculaceae	*Anemone rivularis*	Jakri	Herb	Roots
119	Ranunculaceae	*Delphinium denudatum*	Nirvishi	Herb	Roots
120	Ranunculaceae	*Thalictrum foliolosum*	Mamiri	Herb	Leaves, roots
121	Rhamnaceae	*Rhamnus purpurea*	-	Shrub	Roots
122	Rosaceae	*Potentilla atrosanguinea*	-	Herb	Roots
123	Rosaceae	*Prinsepia utilis*	Bhenkal	Shrub	Seeds
124	Rosaceae	*Prunus cerasoides*	Padam	Tree	Bark
125	Rosaceae	*Rosa brunonii*	Kunja	Shrub	Flowers
126	Rosaceae	*Rubus ellipticus*	Hinsol	Shrub	Young twigs
127	Rubiaceae	*Galium aparine*	Kuri	Herb	Whole plant
128	Rubiaceae	*Randia tetrasperma*	Medanphal	Shrub	Fruits
129	Rubiaceae	*Rubia cordifolia*	Manjishta	Climber	Seeds
130	Rutaceae	*Aegle marmelos*	Bel	Tree	Fruits, Leaves
131	Sapindaceae	*Cardiospermum helicacabum*	-	Herb	Roots
132	Saururaceae	*Houttuynia cordata*	Brahmi Pata	Herb	Leaves
133	Saxifragaceae	*Bergenia ciliata*	Silphari	Herb	Roots
134	Scrophulariaceae	*Picrorhiza kurroa*	Kutaki	Herb	Roots
135	Scrophulariaceae	*Verbascum thapsus*	Akal vir	Herb	Flower buds
136	Solanaceae	*Atropa acuminata*	-	Herb	Roots
137	Solanaceae	*Hyocyamus niger*	Khurasini ajwaayan	Herb	Whole plant
138	Solanaceae	*Withania somnifera*	Aswgandha	Herb	Roots
139	Symplocaceae	*Symplocos paniculata*	Lodh	Tree	Bark
140	Taxaceae	*Taxus baccata*	Thuner	Tree	Bark, leaves
141	Tiliaceae	*Triumfeta rhomboidea*	-	Herb	Leaves
142	Urticaceae	*Boehmeria platyphylla*	Khagsa	Shrub	Leaves

S.No.	Family	Name of Species	Common Name	Habit	Parts used
143	Urticaceae	*Urtica dioica*	Kandali	Herb	Leaves
144	Valerianaceae	*Nardostachys grandiflora*	Jata-mansi	Herb	Roots
145	Valerianaceae	*Valeriana hardwickii*	Tagar	Herb	Roots
146	Verbenaceae	*Callicarpa macrophylla*	Daya	Shrub	Flowers
146	Verbenaceae	*Vitex negundo*	Nirgundi	Tree	Leaves
146	Violaceae	*Viola betonicifolia*	Vanfasa	Herb	Whole plant
146	Violaceae	*Viola biflora*	-	Herb	Whole plant
146	Violaceae	*Viola odorata*	-	Herb	Whole plant
146	Zingiberaceae	*Hedychium spicatum*	Kapur kachri	Herb	Roots
146	Zygophyllaceae	*Tribulus terrestris*	-	Herb	Roots

6.3.5 Floristic Profile across the Basin

The species richness across the terrain and eco-zones i.e. in different sub-basins ranges from 94 to 171 with maximum in the Parbati Upper sub-basin and minimum in Beas I (**see Table 6.17**). Important trees of this basin are *Taxus wallichiana, Cedrus deodara, Pinus wallichiana, Picea smithiana, Abies pindrow*. It is home to latge number of medicinal plants also. Uhl sub-basin is another biodiversity rich due to diverse habitats congenial for growth of different species. Dominant trees of Uhl sub-basin are *Aegle marmelos, Bauhinia variegata, Cinnamomum tamala, Neolitsea umbrosa, Mallotus philippensis* and *Sapium insigne*. At lower to mid elevations *Pinus roxburghii* is a very common species. However, with the increasing altitude montane Himalayan species become more prominent and lowland species are rare or absent. Beas I and Beas II sub-basins located in the high altitudinal zone are mainly comprised of coniferous species like *Abies pindrow, Cedrus deodara, Picea smithiana* and *Pinus wallichiana*.

As already discussed in previous section on medicinal plants large number of medicinal plants are found in the basin owing diverse habitats and elevation range. Some of the important medicinal plants like *Aconitum chasmanthum, A. heterophyllum, Arnebia benthami, Dactylorhiza hatagirea, Dioscorea deltoidea, Ephedra gerardiana, Ferula jaeschkeana, Nardostachys grandiflora, Picrorhiza kurroa, Rheum australe*, etc. are found in higher altitude areas of Beas I, Beas II, Parbati Upper, Sainj and Tirthan sub-basins.

Table 6.17: Floristic profile of different sub-basins

Sub-Basin	Total no. of species	RET-FRLHT	RET-IUCN Redlist (2017-2)	RET-BSI Red Data Book	Endemic to Western Himalaya
Beas I	129	10	4	2	13
Beas II	111	2	1	-	7
Malana	94	2	1	1	6
Parbati Upper	171	9	3	3	16
Parbati Lower	125	30	3	1	12
Sainj	101	1	1	-	4
Tirthan	108	33	10	1	7
Beas III	133	1	1	-	4
Uhl	143	3	1	-	10
Beas IV	154	2	2	0	8
Beas V	101	1	1	0	6

Sub-basin wise assessment of ecological values has been dealt with in a separate chapter i.e. Chapter 7 - Assessment of Ecological Values.

6.3.6 Community Structure

The phytosociological studies were carried out for the analysis of community structure coverings all three season (pre-monsoon, monsoon and winter). The sampling for the same was conducted at the 60 locations mentioned in **Table 6.18.**

Table 6.18: Sampling locations for phytosociological studies

Sub-basin	Sampling Site	Name of Project	Name of Site
Beas I	V1	Beas Kund HEP	Near Power House site: Beas river
	V2	Palchan Bhang HEP	Project area of Proposed Palchan Bhang HEP: Beas river
	V3	Bhang HEP	Project area of Proposed Bhang HEP: Beas river
	V4	Jobrie HEP	Project area of Proposed Jobrie HEP: Allian Nala
	V5	Allain Duhangan HEP	Power House site: Allain Nala
	V6		Downstream of diversion site: Duhangan Nala
Malana	V7	Malana III HEP	Proposed project area: Malana Nala
	V8	Malana II HEP	Upstream of Dam site
	V9		Upstream of Power House site
	V10	Malana I HEP	Downstream of Barrage site: Malana Nala
	V11		Upstream of Power house Site
Parbati Upper	V12	Tosh HEP	Downstream of Diversion site near Tosh village
	V13	Nakthan HEP	Near proposed Diversion site at Tosh Nala
	V14		Near proposed Power house site
	V15		Near proposed Diversion site at Parbati river
	V16	Parbati II HEP	Upstream of Dam site along Parbati river
	V17		Upstream of Dam along Tosh Nala
	V18		Downstream of Dam site
	V19	Balargha HEP	Near Proposed Power House site
	V20	Parbati HEP	Proposed project area of Parbati HEP
Beas II	V21	Baragaon HEP	Near Power house site
	V22	Sarbari II HEP	Near Power house site
	V23	Fozal HEP	Near Diversion site
Parbati Lower	V24	Sharni HEP	Proposed project area of near Sarsadi Village Sharni village
	V25	Sarsadi HEP	Proposed project area of near Sarsadi Village
	V26	Sarsadi II HEP	Proposed project area of near Sarsadi Village
Sainj	V27	Hurla HEP	Proposed project area of Hurla HEP
	V28	Sainj HEP	Upstream of Dam site
	V29		Near Power House site
	V30	Parbati III HEP	Upstream of Reservoir area
	V31		Downstream of Diversion site
	V32		Near Power house site
Uhl	V33	Lambadug HEP	Downstream Diversion site
	V34	Uhl I HEP	Upstream of Barrage site
	V35	Uhl HEP	Proposed diversion site
	V36	Lower Uhl HEP	Downstream of proposed diversion site
	V37	Uhl Khad HEP	Proposed Power house site: right bank of

Sub-basin	Sampling Site	Name of Project	Name of Site
			Beas river
	V38	Uhl II HEP	Near Bassi Power House
	V39	Uhl III HEP	Along the power channel
	V40		Near Balancing reservoir near Rana Khad
Beas III	V41	Beas Satluj Link (Pandoh Dam)	Right Bank of reservoir area
	V42		Near Dam Site
	V43		Downstream of Dam site
	V44	Larji HEP	Along the reservoir area
	V45		Downstream of Dam site
	V46	Patikari HEP	Upstream of Power house site
Beas IV	V47	Khauli Khad	Near diversion weir
	V48	Gaj Khad HEP	Near Power house site
	V49	Neogal HEP	Upstream of Power house site
	V50	Binwa HEP	Near Powerhouse site
	V51	Baner I HEP	Upstream of Power house site
	V52	Baner HEP	Downstream of Diversion weir
	V53	Kilhi Bahl HEP	Proposed project area of Kilhi Bahl HEP
Beas V	V54	Pong Dam HEP	Right bank of reservoir
	V55		Left Bank of reservoir
	V56	Thana Plaun HEP	Proposed Dam site
	V57		Downstream of Dam site
	V58	Triveni Mahadev HEP	Upstream of Proposed dam site
	V59	Dhaulasidh HEP	Upstream of Proposed dam site
	V60		Near Proposed Dam site

Details of site wise phyto-sociological data for all seasons has been given at **Annexure-III** of **Volume II** of the report of the report. The description of the results of the same is given in the following paragraphs.

6.3.6.1 Density of Trees

Upper catchment of Beas basin (Manali- Kullu) is comprised of temperate forest. *Pinus wallichiana, Cedrus deodara, Picea smithiana* and *Corylus colurna* were dominant tree species in these forests and are found in association with *Aesculus indica, Acer caesium, Alnus nepalensis, Celtis australis, Ulmus villosa, Fraxinus floribundus, Populus ciliata, Juglans regia, Quercus semecarpifolia, Salix fragilis, Salix tetrasperma, Ilex dipyrena* and *Betula utilis.*

In the middle stretch covering area between Kullu to Mandi forest is comprised of temperate to sub-tropical forest type. *Pinus wallichiana, Cedrus deodara Quercus semecarpifolia, Salix fragilis* and *Betula alnoides* are dominant at higher elevations in temperate areas, while at lower elevations *Adina cordifolia, Bauhinia variegata, Bombax ceiba, Celtis australis, Dalbergia sissoo, Mallotus philippensis, Rhus succedanea, Ficus palmata, Grewia optiva, Morus alba, Toona hexandra, Albizia* sp., *Boehmeria rugulosa, Phoebe lanceolata, Populus ciliata,* etc. are common.

The area downstream of Mandi up to Pong Dam forest is generally classified under tropical forest type. Tree component is mainly comprised mainly of *Syzygium cumini, Albizia lebbeck, Albizia chinensis, Boehmeria rugulosa, Delonix regia, Dalbergia sissoo, Sapium insigne, Bombax ceiba, Adina cordifolia, Eucalyptus citriodora, Mallotus philippensis, Lannea grandis, Bombax ceiba, Azadirachta indica,* etc.

The density of trees varied from site to site. The overall tree density throughout the study area ranged from minimum of 120 number of trees/ha to maximum of 530 trees/ha (**Table 6.19**). Highest tree density was recorded at sampling site located near diversion site of Fozal HEP (left bank of Fozal Nala) and Sampling site located near the Diversion weir of Khauli Khad HEP, where *Pinus roxburghii, Quercus* spp. and *Bauhinia variegata* are the dominant species followed by sampling site located upstream of Uhl-I HEP barrage site (Right Bank of Ulh river) and lowest density of tree species were recorded at sampling site located in proposed project area of Jobrie HEP (right bank of Allain Nala).

Table 6.19: Density of trees (no./ha) recorded at different sampling sites

Sampling Sites	Density (no./ha)	Sampling Sites	Density (no./ha)
Site V1	330	Site V32	270
Site V2	320	Site V33	490
Site V3	360	Site V34	510
Site V4	120	Site V35	340
Site V5	370	Site V36	410
Site V6	270	Site V37	295
Site V7	219	Site V38	470
Site V8	280	Site V39	410
Site V9	420	Site V40	260
Site V10	160	Site V41	250
Site V11	390	Site V42	260
Site V12	250	Site V43	250
Site V13	200	Site V44	430
Site V14	380	Site V45	230
Site V15	310	Site V46	290
Site V16	260	Site V47	530
Site V17	340	Site V48	280
Site V18	360	Site V49	310
Site V19	330	Site V50	360
Site V20	220	Site V51	390
Site V21	460	Site V52	360
Site V22	400	Site V53	360
Site V23	530	Site V54	190
Site V24	440	Site V55	170
Site V25	450	Site V56	350
Site V26	490	Site V57	310
Site V27	423	Site V58	440
Site V28	500	Site V59	340
Site V29	270	Site V60	330
Site V30	490		
Site V31	370		

6.3.6.2 Dominance

Among the trees *Pinus wallichiana, Cedrus deodara, Picea smithiana* and *Fraxinus floribunda* are the most frequent occurring species. *Cedrus deodara* was the most dominant species in temperate zone covering area of Upper catchment of Beas river up to Kulu, Malana Nala, Parbati river, Upper catchment of Uhl river areas. Pure stands of *Cedrus deodara* were recorded with high IVI values at most of the sites. *Pinus wallichiana* were the other dominant trees of the forests in this region. However, *Juglans regia* and *Picea smithiana* were also found dominant at some places. While at lower elevation comprising of temperate and sub-tropical region *Pinus wallichiana* was more commonly found at higher elevation ridges while species of *Quercus*, *Pinus* *roxburghii*, *Alnus nepalensis*, *Celtis australis* are dominant in tropical forests. In the tropical region of Beas basin *Dalbergia sissoo, Populus ciliata, Adina cordifolia, Bombax ceiba, Albizia species, Eucalyptus citriodora, Mallotus philippensis, Lannea grandis* show frequent distribution with high IVI value. In all 91 species of trees were recorded from different sites.

Figure 6.3 to **Figure 6.10** shows the Importance Value Index of dominant tree species at various sampling sites however, detailed data of the same are given at **Annexure-III** of **Volume II** of the report.

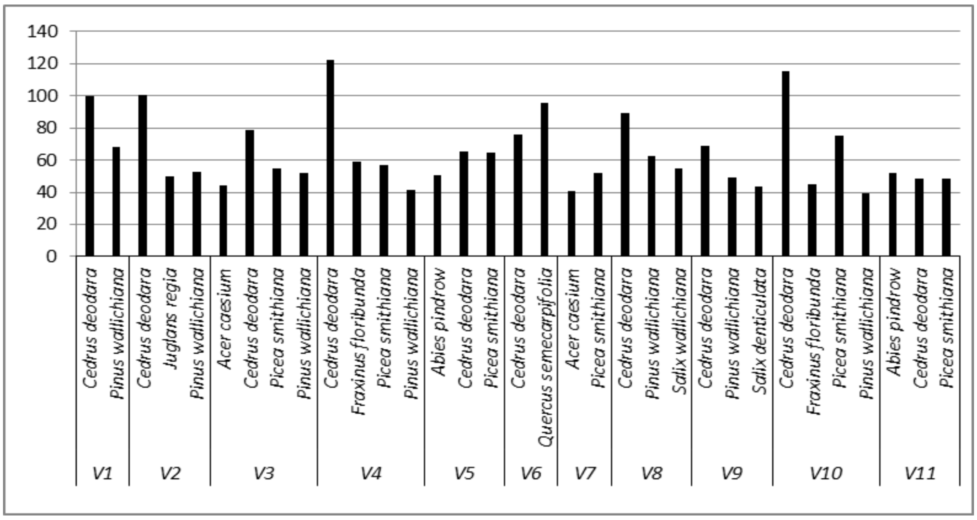


Figure 6.3: Importance Value Index of dominant tree species at sampling sites V1 – V11

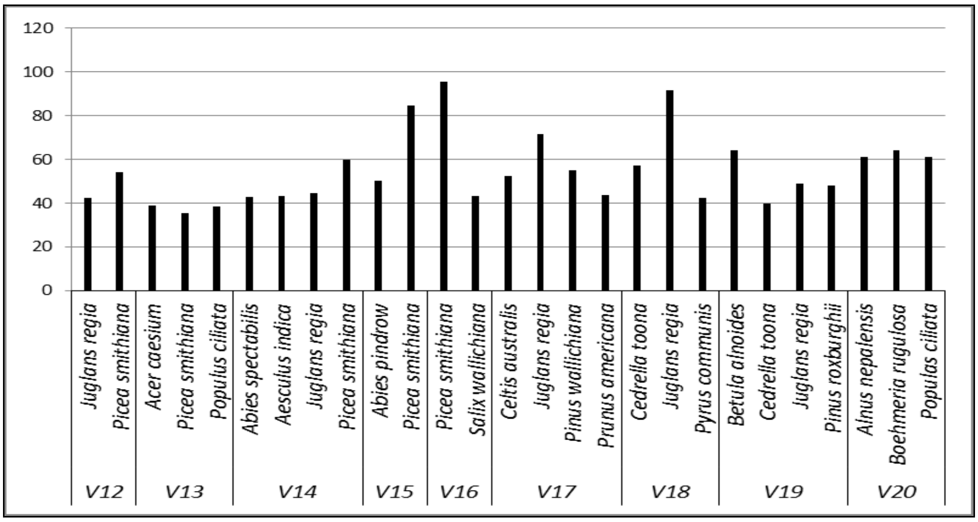


Figure 6.4: Importance Value Index of dominant tree species at sampling sites V12 – V20

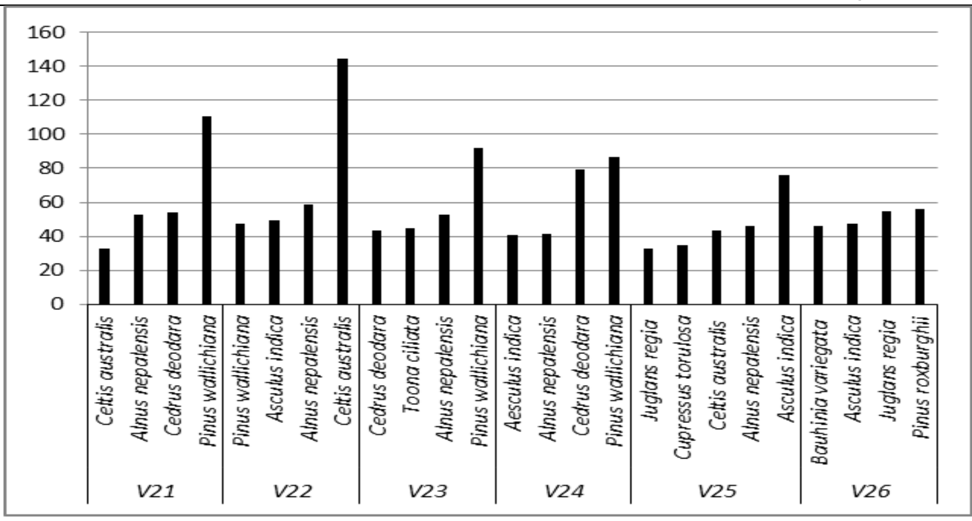


Figure 6.5: Importance Value Index of dominant tree species at sampling sites V21 – V26

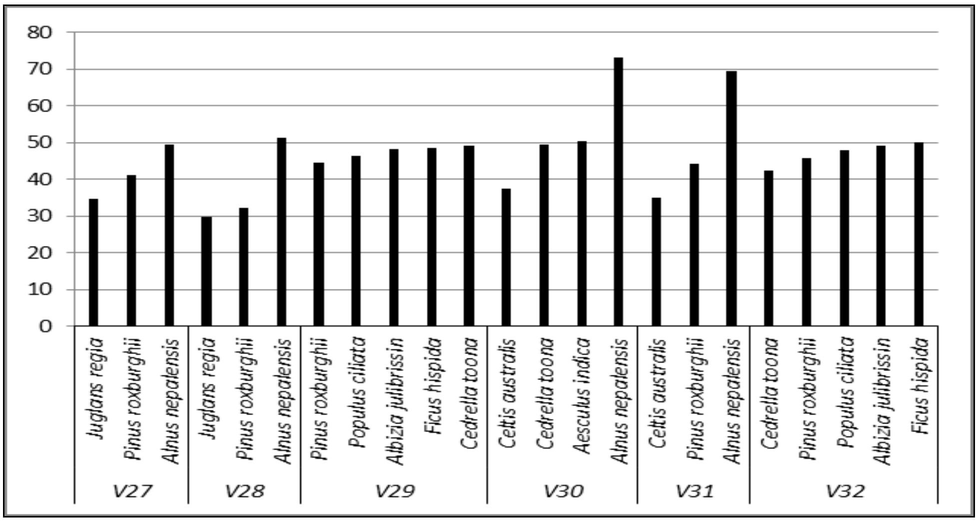


Figure 6.6: Importance Value Index of dominant tree species at sampling sites V27 – V32

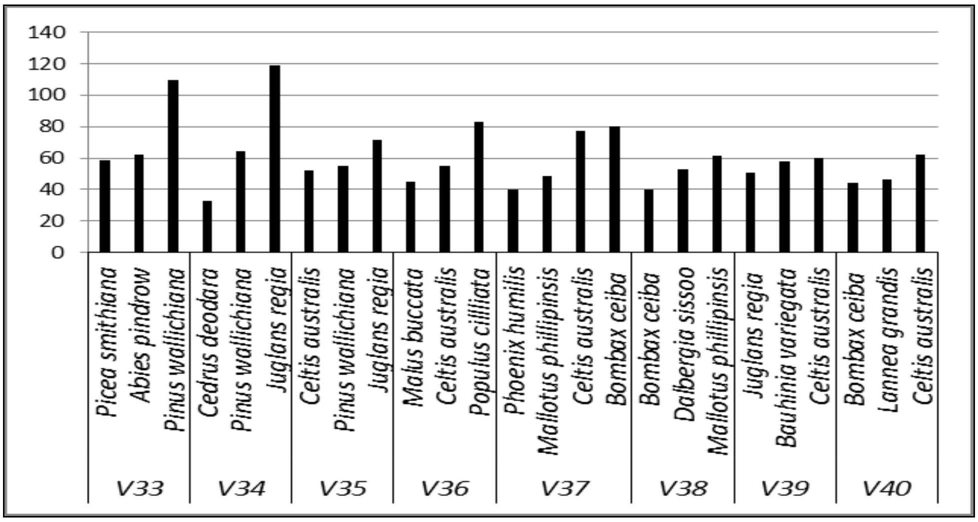


Figure 6.7: Importance Value Index of dominant tree species at sampling sites V33 – V40

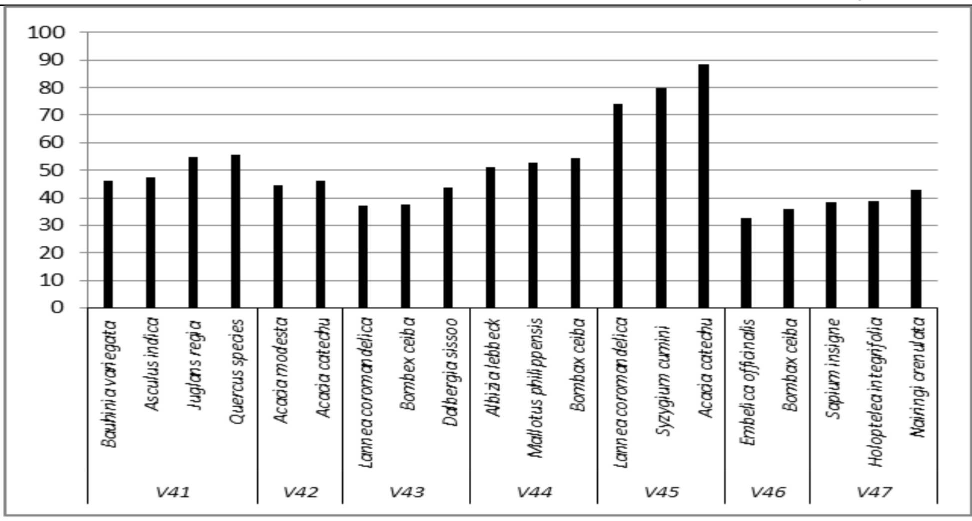


Figure 6.8: Importance Value Index of dominant tree species at sampling sites V41 – V47

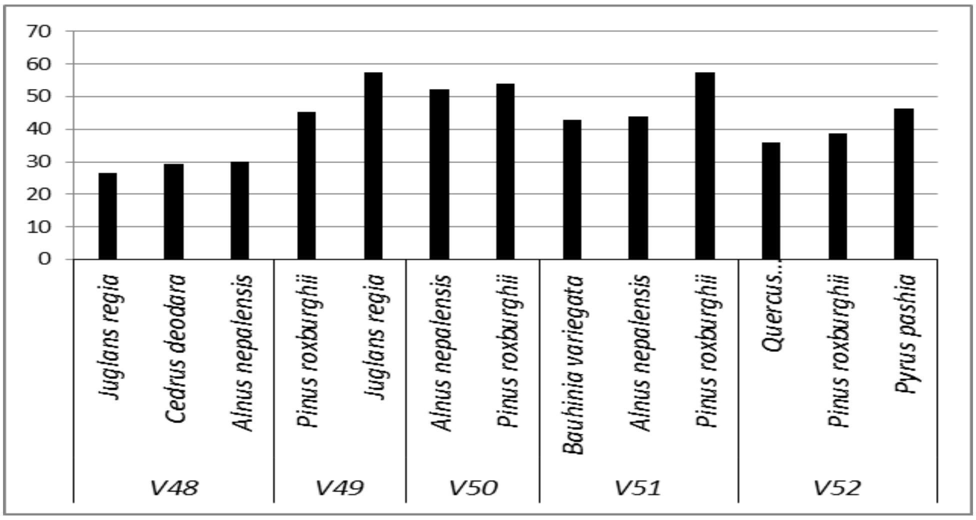


Figure 6.9: Importance Value Index of dominant tree species at sampling sites V48 – V52

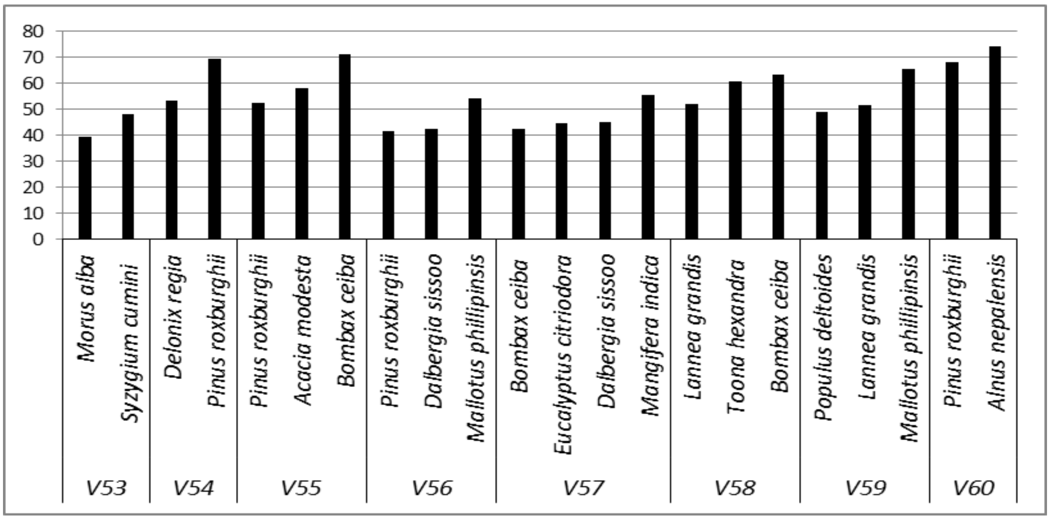


Figure 6.10: Importance Value Index of dominant tree species at sampling sites V53 – V60

During the field surveys 128 species of shrubs were recorded, species like *Rhododendron anthopogon*, *Rosa webbiana*, and *Juniperus communis* with other species like *Ephedra vulgaris*, *Cotoneaster bacillaris*, *Sorbaria tomentosa*, *Berberis jaeschkeana*, *Berberis lycium*, *Artemisia nilagirica* and *Berberis aristata*, were the most dominant shrub species in temperate region of Beas basin. *Sorbaria tomentosa, Artemisia nilagirica* and *Berberis aristata* were dominant at sites located at lower elevations in all seasons whereas *Rosa webbiana, Berberis lycium* and *Rhododendron campanulatum* were dominant at sites located at higher elevations.

In the middle stretch of Beas basin where vegetation is of temperate and sub-tropical forest type *Berberis aristata, Debregeasia longifolia, Boehmeria platyphylla, Leucosceptrum canum, Maesa chisia, Melocalamus compactiflorus, Oxyspora paniculata, Sarcococca saligna, Colebrookea oppositifolia Indigofera gerardiana Debregeasia longifolia* are the dominant shrub species with IVI values more than 50. At the lower elevations comprised of sub-tropical and tropical forest type *Lantana camara, Murraya koenigii* and *Justicia adhatoda* are the dominant shrub species with high IVI values. Predominant shrub species recorded from the study are in the lower catchment of Beas river are *Boehmeria macrophylla, Caryopteris odorata, Debregeasia salicifolia, Urtica dioica, Desmodium elegans, Woodfordia fruticosa,* etc. (see **Table 6.20**).

In all 250 species of herbs were recorded during field surveys. *Gentiana kurroo, Iris kemaonesis, Poa alpina, Dactylis glomerata, Thymus serpyllum, Bistorta macrophylla, Axyris hybrida, Senecio chrysanthemoides, Origanum vulgare, Ageratum conyzoides, Artemisia nilagirica, Argemone mexicana, Achyranthes aspera, Anaphalis contorta, Nepeta ciliaris, Urena lobata, Datura stramonium, Fragaria vesca, Micromeria biflora, Mentha longifolia, Eragrostis pilosa, Buddleja asiatica, Curcuma aromatica, Parthenium hysterophorus, Cyperus rotundus* and *Chrysopogon fulvus* were found dominant at different sampling sites with each of them having IVI of more than 30. In general species like *Artemisia maritima, Gentiana kurroo, Ageratum conyzoides* and *Argemone mexicana* were the most dominant species at most of the sites during the surveys (see **Table 6.21**).

Table 6.20: IVI of dominant shrub species at different sampling sites

Site	Name of Species	IVI
V1	*Rosa webbiana*	43
	Berberis jaeschkeana	47
	Rhododendron anthopogon	78
V2	*Cotoneaster bacillaris*	13
	Spiraea sorbifolia	51
	Artemisia nilagirica	52
	Lonicera quinquelocularis	69
V3	*Spiraea sorbifolia*	40
	Artemisia nilagirica	40
	Lonicera quinquelocularis	54
V4	*Indigofera pulchella*	56
	Artemisia nilagirica	85
V5	*Berberis aristata*	22
	Rosa webbiana	53
	Daphne cannabina	62
V6	*Rosa webbiana*	33
	Urtica dioica	40
	Sorbaria tomentosa	46
V7	*Berberis lycium*	34
	Solanum indicum	37
V8	*Leycesteria formosa*	33
	Sinarundinaria falcata	36
	Zanthoxylum armatum	38
V9	*Cannabis sativa*	31
	Rhamnus triqueter	34
	Chenopodium album	35
V10	*Prinsepia utilis*	30
	Rubus niveus	44
V11	*Indigofera pulchella*	42
	Elsholtzia fruticosa	58
V12	*Sorbaria tomentosa*	20
	Cotoneaster bacillaris	20
	Indigofera gerardiana	41
	Viburnum nervosum	45
V13	*Berberis glaucocarpa*	32
	Desmodium elegans	34
	Rosa brunonii	44
	Indigofera gerardiana	76
V14	*Viburnum nervosum*	36
	Buddleja crispa	36
	Indigofera gerardiana	37
	Rosa macrophylla	38
	Staphylea emodi	39
V15	*Sorbaria tomentosa*	64
V16	*Solanum surattense*	43
	Chromolaena odoratum	45
	Brassiopsis mitis	46
V17	*Trevesia palmata*	41
	Strobilanthes extensa	43
	Melocalamus compactiflorus	62

Site	Name of Species	IVI
V18	*Debregeasia longifolia*	53
	Maesa chisia	54
	Oxyspora paniculata	73
V19	*Maesa chisia*	52
	Leucosceptrum canum	90
V20	*Melocalamus compactiflorus*	71
V21	*Debregeasia longifolia*	50
	Boehmeria platyphylla	56
V22	*Boehmeria platyphylla*	47
	Berberis aristata	48
	Berberis lycium	104
V23	*Colebrookea oppositifolia*	59
	Berberis aristata	97
V24	*Boehmeria platyphylla*	41
	Sarcococca saligna	85
V25	*Sarcococca saligna*	50
	Indigofera tinctoria	56
V26	*Rubus ellipticus*	44
	Desmodium elegans	48
	Sarcococca saligna	88
V27	*Sinarundinaria falcata*	30
	Viburnum mullaha	43
V28	*Sinarundinaria falcata*	39
	Viburnum mullaha	50
V29	*Desmodium gangeticum*	31
	Zanthoxylum armatum	43
V30	*Cannabis sativa*	27
	Girardinia diversifolia	27
	Desmodium gangeticum	27
	Sinarundinaria falcata	30
	Viburnum mullaha	43
V31	*Sinarundinaria falcata*	39
	Viburnum mullaha	50
V32	*Desmodium gangeticum*	31
	Zanthoxylum armatum	43
V33	*Juniperus communis*	58
	Spiraea sorbifolia	66
	Rosa webbiana	84
V34	*Gerardiana heterophylla*	52
	Lonicera quinquelocularis	82
V35	*Rosa webbiana*	86
	Sorbaria tomentosa	89
V36	*Cotoneaster affinis*	56
	Berberis lycium	57
	Rosa webbiana	70
V37	*Eupatorium adenophorum*	38
	Rhamnus virgatus	40
	Artemisia capillaris	43
V38	*Artemisia capillaris*	32
	Cannabis sativa	35
	Urtica dioica	46
V39	*Justicia adhatoda*	34
	Urtica dioica	41
	Berberis asiatica	41
V40	*Urtica dioica*	42
	Eupatorium adenophorum	44
	Justicia adhatoda	44
V41	*Desmodium elegans*	56
	Sarcococca saligna	83
V42	*Murraya koenigii*	53
	Woodfordia fruticosa	53
	Lantana camara	68
V43	*Justicia adhatoda*	45
	Lantana camara	55
V44	*Justicia adhatoda*	41
	Lantana camara	73
V45	*Murraya koenigii*	43
	Carissa spinarum	47
	Boehmeria macrophylla	53
V46	*Boehmeria macrophylla*	61
	Murraya koenigii	69
V47	*Murraya koenigii*	53
	Lantana camara	58
V48	*Indigofera tinctoria*	39
	Debregeasia salicifolia	40
	Rosa brunonii	42
V49	*Artemisia capillaris*	34
	Rubus ellipticus	35
	Indigofera tinctoria	36
	Sarcococca saligna	40
V50	*Rosa brunonii*	32
	Berberis aristata	33
	Debregeasia salicifolia	36
V51	*Inula cuspidata*	37
	Eupatorium adenophorum	38
	Debregeasia salicifolia	40
V52	*Eupatorium adenophorum*	32
	Debregeasia salicifolia	41
	Cannabis sativa	41
V53	*Colebrookea oppositifolia*	46
	Justicia adhatoda	47
	Debregeasia salicifolia	49
V54	*Eupatorium adenophorum*	41
	Rhamnus virgatus	43
	Myrsine africana	47
	Caryopteris odorata	50
V55	*Myrsine africana*	43
	Lantana camara	43
	Caryopteris odorata	62
V56	*Artemisia capillaris*	51
	Urtica dioica	52
V57	*Desmodium elegans*	52
	Artemisia capillaris	61
	Lantana camara	62
V58	*Myrsine africana*	44
	Artemisia capillaris	46
	Lantana camara	58
V59	*Ziziphus jujuba*	31
	Urtica dioica	32
	Mimosa himalayana	37
	Ziziphus jujuba	44
V60	*Trevesia palmata*	43
	Berberis asiatica	44
	Sinarundinaria falcata	48

Table 6.21: IVI of dominant shrub species at different sampling sites

Sampling Sites	Name of Species	IVI	Sampling Sites	Name of Species	IVI
V1	*Eremurus himalaicus*	40	V23	*Rumex hastatus*	31
	Gentiana kurroo	33		*Anaphalis contorta*	22
V2	*Gentiana kurroo*	41	V24	*Tagetes minuta*	38
	Iris kemaonesis	54		*Anaphalis contorta*	27
V3	*Polygonum bistorta*	38	V25	*Eriophorum comosum*	22
	Deutzia corymbosa	38		*Anaphalis contorta*	29
	Poa alpina	40	V26	*Stellaria media*	23
V4	*Poa alpina*	41		*Trifolium pratense*	20
	Gentiana kurroo	40	V27	*Fagopyrum esculentum*	33
	Dactylis glomerata	42		*Impatiens bicolor*	33
V5	*Artemisia nilagirica*	45		*Achyranthes aspera*	35
	Gentiana kurroo	39	V28	*Anaphalis contorta*	39
V6	*Arenaria serpyllifolia*	41		*Achyranthes aspera*	44
V7	*Carum copticum*	15	V29	*Oxalis corniculata*	44
	Thymus serpyllum	17		*Achyranthes aspera*	68
V8	*Pilea scripta*	17	V30	*Delphinium denudatum*	36
	Poa alpina	16		*Achyranthes aspera*	37
	Bistorta macrophylla	16	V31	*Impatiens bicolor*	32
V9	*Trifolium pratense*	18		*Achyranthes aspera*	51
	Senecio chrysanthemoides	19	V32	*Tagetes erecta*	46
V10	*Allium stracheyi*	15		*Achyranthes aspera*	55
	Anemone rivularis	17	V33	*Ranunculus arvensis*	62
	Origanum vulgare	20		*Argemone mexicana*	55
V11	*Oenothera rosea*	15		*Axyris hybrida*	63
	Trifolium pratense	15	V34	*Bromus gracillimus*	47
V12	*Artemisia vulgaris*	14		*Carex obscura*	53
	Dioscorea deltoidea	17		*Caltha palustris*	48
	Potentilla argyrophylla	14	V35	*Desmodium tiliaefolium*	59
V13	*Arthraxon lancifolius*	19		*Saxifraga diversifolia*	62
	Fagopyrum esculentum	17	V36	*Carex infuscata*	48
V14	*Cirsium wallichii*	17		*Potentilla nepalensis*	48
	Inula cappa	19	V37	*Epilobium hirsutum*	52
V15	*Cyperus cuspidatus*	15		*Bidens pilosa*	56
	Dioscorea deltoidea	20	V38	*Aster peduncularis*	40
V16	*Sida rhombifolia*	18		*Ageratum conyzoides*	48
	Urena lobata	16	V39	*Rumex hastatus*	83
V17	*Athyrium angustum*	18	V40	*Delphinium vestitum*	40
	Equisetum ramossimum	22		*Mentha longifolia*	43
	Nepeta ciliaris	22		*Ajuga parviflora*	42
V18	*Setaria palmifolia*	22	V41	*Plantago major*	26
	Solanum nigrum	16		*Fragaria vesca*	28
V19	*Athyrium angustum*	19	V42	*Arundo donax*	21
	Hedychium spicatum	18		*Solanum nigrum*	21
	Artemisia nilagirica	17		*Artemisia nilagirica*	22
V20	*Hydrocotyle nepalensis*	18	V43	*Parthenium hysterophorus*	30
	Molineria capitulata	17		*Cyperus rotundus*	34
V21	*Artemisia vulgaris*	23	V44	*Parthenium hysterophorus*	27
	Rumex hastatus	20		*Ageratum conyzoides*	29
	Chrysopogon fulvus	20		*Poa annua*	30
V22	*Rumex hastatus*	32	V45	*Ageratum conyzoides*	23
	Lindenbergia grandiflora	26		*Oxalis corniculata*	25

Sampling Sites	Name of Species	IVI
	Cuscuta reflexa	31
V46	*Ageratum conyzoides*	23
	Poa annua	24
	Curcuma aromatica	26
V47	*Cyperus rotundus*	32
	Poa annua	34
V48	*Cannabis sativa*	22
	Rhus parviflora	23
	Buddleja asiatica	28
V49	*Datura stramonium*	19
	Cannabis sativa	20
	Eragrostis pilosa	22
V50	*Fragaria vesca*	21
	Ajuga parviflora	22
	Colocasia esculenta	25
V51	*Colocasia esculenta*	19
	Geranium ocellatum	19
	Aster peduncularis	20
	Micromeria biflora	20
V52	*Fragaria indica*	23
	Polygonum plebeium	25

Sampling Sites	Name of Species	IVI
	Datura stramonium	25
V53	*Epilobium hirsutum*	25
	Xanthium indicum	30
V54	*Solanum nigrum*	28
	Artemisia nilagirica	30
V55	*Cynodon dactylon*	28
	Cannabis sativa	33
V56	*Ageratum conyzoides*	26
	Artemisia capillaries	29
	Colocasia esculenta	36
V57	*Ageratum conyzoides*	21
	Xanthium indicum	24
	Ajuga parviflora	36
V58	*Cynodon dactylon*	31
	Ageratum conyzoides	86
V59	*Bidens bipinnata*	22
	Euphorbia hirta	65
V60	*Fagopyrum esculentum*	26
	Anaphalis contorta	26
	Andropogon ischaemum	36

6.3.6.3 Species Diversity

To understand the species richness Shannon Weiner Diversity was calculated for trees, shrubs and herbs. Amongst trees the diversity Index ranged from low of 1.17 at sampling site V22 located near power house site of Sarbari II HEP to highest at sampling site V54 at sampling site located at left bank of Pong dam reservoir (2.82) (**Table 6.22**).

Among shrubs, highest diversity Index was recorded at sampling site V31 in the downstream of Dam site of Parbati III HEP (3.14) followed by sampling site V28 (3.13) in the Upstream of Sainj HEP Dam site and lowest at sampling site V4 located near proposed project area of Jobrei HEP (left bank of Alain Nala) (1.37) (**Table 6.22**).

Diversity of herb species shows seasonal variation in the study area. Maximum Diversity for herbs was recorded during monsoon season varied from lowest 2.27 at sampling site V-14 located near to the proposed Dam site of Nakthan HEP and highest value of diversity was recorded from sampling site V59 (3.17) located near to the proposed Dam site of Dhaulasidh HEP. During pre-monsoon season sampling, species diversity of herbs varied from lowest 1.75 at sampling site V14 (Near proposed power site of Nakthan HEP) and highest 2.98 at sampling site (Site V35) located near to the diversion site of proposed Uhl HEP. During winter season sampling the Diversity Index ranged from lowest of 1.91 (at Site V1) to highest of 2.83 (at Site V59) (**Table 6.22**).

Table 6.22: Shannon Weiner Diversity Index computed at different sampling sites

Site	Trees	Shrubs	Herbs		
			Pre Monsoon	Monsoon	Winter
V1	1.89	1.91	2.45	2.85	2.18
V2	1.78	1.96	2.37	2.92	2.05
V3	1.86	2.21	2.47	2.88	2.17
V4	1.52	1.37	2.23	2.72	1.91
V5	1.88	2.01	2.59	2.91	2.12
V6	1.58	2.42	2.50	2.83	2.25
V7	2.16	2.42	2.77	2.94	2.44
V8	1.74	2.41	2.84	2.89	2.43
V9	1.75	2.53	2.72	3.06	2.51
V10	1.54	2.64	2.75	2.99	2.62
V11	2.01	2.41	2.72	2.96	2.541
V12	2.40	2.68	2.98	3.17	2.83
V13	2.34	2.16	2.91	2.96	2.79
V14	2.29	2.25	2.76	3.02	2.66
V15	2.19	2.34	2.86	3.04	2.61
V16	2.03	1.61	2.91	3.01	2.67
V17	1.92	2.12	2.74	2.95	2.66
V18	1.93	1.81	2.89	3.05	2.81
V19	1.81	1.78	2.86	2.97	2.74
V20	1.81	2.11	2.90	3.00	2.80
V21	1.54	2.10	2.65	2.95	2.74
V22	1.17	1.80	2.42	2.97	2.52
V23	1.92	1.74	2.46	2.85	2.38
V24	1.71	1.69	2.59	2.8	2.45
V25	1.6	2.05	2.31	2.87	2.59
V26	1.95	2.17	2.54	2.85	2.36
V27	2.26	2.38	2.44	2.66	2.38
V28	2.5	3.13	2.24	2.50	2.27
V29	2.74	2.41	2.18	2.44	2.15
V30	2.11	2.41	2.70	2.84	2.45
V31	2.15	2.14	2.53	2.69	2.54

Site	Trees	Shrubs	Herbs		
			Pre Monsoon	Monsoon	Winter
V32	1.9	2.43	2.31	2.54	2.39
V33	1.57	1.54	1.79	2.38	2.18
V34	1.43	1.69	1.93	2.28	2.05
V35	1.92	1.50	1.75	2.27	2.18
V36	1.91	1.75	1.92	2.37	2.17
V37	1.66	2.29	1.91	2.28	2.05
V38	1.92	2.55	2.17	2.38	2.16
V39	1.89	2.36	2.37	2.53	2.21
V40	2.01	2.17	2.27	2.45	2.14
V41	2.12	2.05	2.60	2.80	2.53
V42	1.95	2.06	2.57	2.70	2.45
V43	1.68	2.03	2.52	2.68	2.45
V44	2.16	2.11	2.66	2.74	2.47
V45	1.9	1.92	2.78	2.68	2.44
V46	1.71	2.25	2.54	2.82	2.47
V47	1.92	1.74	2.37	2.69	2.46
V48	2.24	1.98	2.05	2.55	2.29
V49	2.622	2.43	2.31	2.55	2.29
V50	2.337	2.37	2.51	2.59	2.43
V51	1.86	2.51	2.33	2.54	2.33
V52	1.943	2.27	2.55	2.64	2.44
V53	2.324	2.30	2.28	2.35	2.28
V54	2.82	2.04	2.04	2.29	2.13
V55	1.45	2.86	2.27	2.39	1.94
V56	1.77	2.00	2.42	2.61	2.37
V57	1.78	2.31	2.65	2.76	2.35
V58	2.57	1.89	2.27	2.47	2.16
V59	2.14	1.80	2.42	2.62	2.54
V60	2.25	2.05	2.77	2.29	2.16

6.4 FAUNAL RESOURCES

In this section description of faunal elements comprised of mammals, avifauna, reptiles, amphibia and butterfly found in the study area is given. An inventory of different species belonging to different groups mentioned above was prepared by using secondary data. Literature consulted for the preparation of inventory are Dutta (1999), Chakraborty *et al*. (2005), Mahabal (2005), Mehta (2005), Saikia *et al*. (2007), Uniyal (2007), Bhardwaj and Uniyal (2009), ZSI (2009), Kumar and Mattu (2014), Chandel and Kumar (2014), Singh *et al*. (2015). In addition, data available in various EIA studies of hydroelectric projects planned in the basin was also used. Thereafter sub-basin wise checklist of species was prepared based on the distribution range of each species. The elevation range for each species was determined from the literature mentioned above and other sources. Using the criteria of IUCN redlist (2017-2) and Wildlife (Protection) Act, 1972, each species was assessed for its conservation status.

6.4.1 Mammals

According to data compiled from from secondary sources like published literature and Forest Working Plans and Wildlife management plan of Protected Areas and the forest and wildlife divisions, 40 mammalian species are reportedly found in the Beas basin and same is given at **Table 6.23**. Family Bovidae is the largest family represented by 6 species while Viverridae is represented by 4 species, Felidae, Muridae, Mustelidae, Cervidae and Cercoitecidae having 3 species. The conservation status of the mammals reported from the basin was assessed based upon their listing in different lists published by agencies like International Union for Conservation of Nature (IUCN) Red List of Threatened Species (2017-2) and different Schedules notified under Wildlife (Protection) Act, 1972.

6.4.1.1 Conservation Status

Conservation status of mammal species found in the study area according to IUCN Red List of Threatened Species (2017-2) and different Schedules notified under Wildlife (Protection) Act, 1972 is given at **Table 6.23**.

Nine species of mammals are included in Schedule-I according to WPA 1972, 14 species in Schedule-II and rest of the species are either under Schedule- III, IV or V species. Six species have restricted distribution inhabiting higher elevations of the basin.

According to IUCN Red List (2017-2), 11 species are listed under different threat categories of which 2 species are under Endangered category viz. *Panthera uncia* and *Moschus chrysogaster* (*Moschus moschiferus*), 4 are under Vulnerable category viz. *Panthera pardus, Capricornis sumatraensis*, *Rusa unicolor* and *Ursus thibetanus* while 5 species are listed as Near Threatened category. Rest of the 29 species of mammals reported from the basin are under Least Concern (LC) category (**refer Table 6.23**).

Among these threatened species Snow Leopard, Musk Deer, Serow, and Himalayan tahr are confined to upper reaches of the basin.

Table 6.23: List of mammals reportedly found in Beas basin and their conservation status

S. No.	Family	Common Name	Scientific Name	Distribution Range (m)	IUCN Redlist (2017-2)	IWPA Schedules
1	Cercopithetidae	Rhesus Macaque	*Macaca mulatta*	Up to 3100	LC	II
2		Hanuman Langur	*Semnopithecus entellus*	1800-3200	LC	II
3	Felidae	Common Leopard	*Panthera pardus*	up to 3000	VU	I
4		Leopard Cat	*Prionailurus bengalensis*	up to 1400	LC	I
5		Snow Leopard	*Panthera uncia*	above 3000	EN	I
6		Jungle Cat	*Felis chaus*	up to 3000	LC	II
7	Viverridae	Small Civet	*Viverricula indica*	Foothills	LC	II
8		Common Palm Civet	*Paradoxurus hermaphroditus*	Lower Reaches	LC	II
9	Herpestidae	Common Mongoose	*Herpestes edwardsii*	Foothills	LC	IV

S. No.	Family	Common Name	Scientific Name	Distribution Range (m)	IUCN Redlist (2017-2)	IWPA Schedules
10	Hyaenidae	Striped Hyaena	*Hyaena hyaena*	Foothills	NT	III
11	Canidae	Jackal	*Canis aureus*	up to 3500	LC	II
12		Indian Fox	*Vulpes bengalensis*	Foothills	LC	II
13	Ursidae	Asiatic Black Bear	*Ursus thibetanus*	1500-3500	VU	II
14		Brown Bear	*Ursus arctos*	above 3000	LC	I
15	Mustelidae	Common Otter	*Lutra lutra*	up to 3600	NT	II
16		Stone Marten	*Martes foina*	above 1500	LC	II
17		Yellow-throated Marten	*Martes flavigula*	1200-2700	LC	II
18		Himalayan Weasel	*Mustela sibirica*	1500-4800	LC	II
19	Bovidae	Blue Sheep	*Pseudois nayaur*	above 3500	LC	I
20		Siberian Ibex	*Capra sibirica*	3800-4400	LC	I
21		Himalayan Tahr	*Hemitragus jemlahicus*	2000-3800	NT	I
22		Serow	*Capricornis sumatraensis*	1800-3400	VU	I
23		Goral	*Naemorhedus goral*		NT	III
24	Cervidae	Sambar	*Cervus unicolor*	Foothills	VU	III
25		Barking Deer	*Muntiacus muntjak*	500-2500	LC	III
26		Musk Deer	*Moschus chrysogaster*	above 2400	EN	I
27		Indian Wild Boar	*Sus scrofa*	up to 1500	LC	III
28	Hystricidae	Indian Porcupine	*Hystrix indica*	1300-2700	LC	IV
29	Leporidae	Black-naped Hare	*Lepus nigricollis*	up to 1200	LC	IV
30	Pteropodidae	Flying Fox	*Pteropus giganteus*	up to 2100	LC	-
31		Fulvous Fruit Bat	*Rousettus leschenaulti*	Up to 2100	LC	V
32	Rhinopomoatidae	Common Yellow Bat	*Scotophilus hardwickii*	up to 2100	LC	V
33	Sciuridae	Kashmir Flying Squirrel	*Eoglaucomys fimbriatus*	1800-3000	LC	II
34		Red Flying Squirrel	*Petaurista Petaurista*	up to 3500	LC	II
35	Muridae	House Rat	*Rattus rattus*	all human settlement	LC	V
36		House Mouse	*Mus musculus*	all human settlement	LC	V
37		Lesser Bandicoot rat	*Bandicota bengalensis*	all human settlement	LC	-
38	Cricetidae	Royle's Vole	*Alticola roylei*	1700-2800	NT	-
39	Soricidae	Himalayan Water Shrew	*Chimarrogale himalayica*	above 3000	LC	V
40		House Shrew	*Suncus murinus*	up to 3000	LC	V

EN = Endangered; VU = Vulnerable; LC = Least Concern, NT = Near Threatened

6.4.1.2 Sub-basin wise Mammals Distribution

Species richness in different sub-basins ranges from 30 to 36 species with maximum in sub-basin Beas IV and minimum in sub-basin Beas I (**Table 6.24 & Annexure-IV** of **Volume II** of the report). There is not much variation in the species richness along the elevational gradient, however it is slightly higher at middle elevations i.e. between 1800 and 2100 m (see **Figure 6.11**). The sub-basins in lower reaches like like Beas IV, Beas V, Uhl, etc. harbour more species as compared to the sub-basins located in upper reaches like Beas I, Beas II, Malana and Parbati. The species like Rhesus Macaque (*Macaca mulatta*), Common Leopard (*Pathera pardus*), Jungle Cat (*Felis chaus*), Jackal (*Canis aureus*) and Common Otter (*Lutra lutra*) are widely distributed throughout the basin. Upper reaches of the basin harbour species with relatively restricted distribution and threatened species. The species confined to the upper reaches are Snow Leopard (*Panthera uncia*), Brown Bear (*Ursus arctos*), Blue Sheep (*Pseudois nayur*), Siberian Ibex (*Capra sibirica*), Himalayan Tahr (*Hemitragus jemlahicus*) and Musk Deer (*Moschus chrysogaster*). All species are categorised either under IUCN redlist (2017-2) or Schedule I category or under both categories.

Mammalian species confined to the foothills and lower reaches include Indian Fox (*Vulpes bengalensis*), Hyaena (*Hyaena hyaena*), Common Mongoose (*Herpestes edwardsii*), Commom Palm Civet (*Paradoxurus hermaphrodites*), and Sambar (*Cervus unicolor*).

Table 6.24: Sub-basin wise mammalian species richness

Sub-basins	Total species richness	No. of RET species	No. of Schedule I species
Beas I	30	8	6
Beas II	33	7	6
Malana	31	8	7
Parbati Upper	31	9	8
Parbati Lower	32	8	8
Sainj	33	8	8
Tirthan	33	8	8
Beas III	31	8	5
Uhl	35	8	8
Beas IV	36	8	7
Beas V	33	5	4

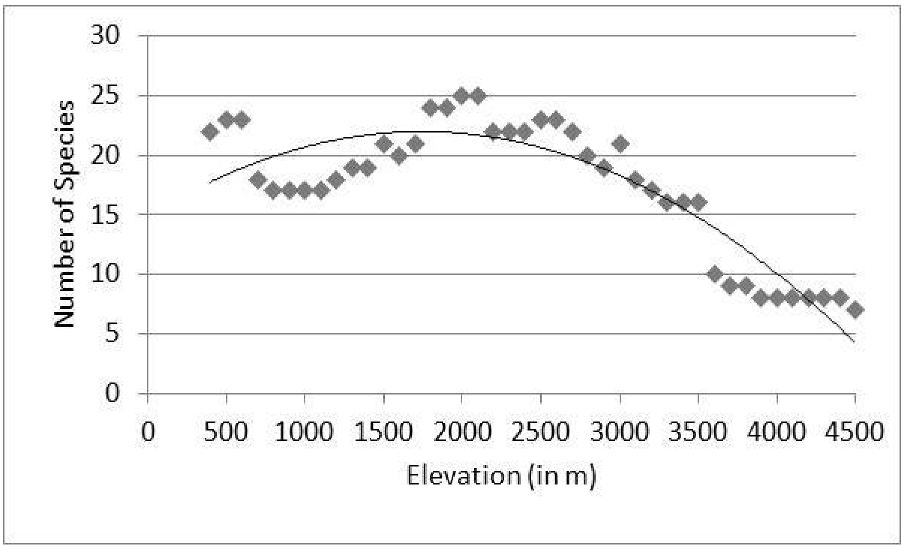


Figure 6.11: Distribution of mammals in Beas basin along the elevational gradient

6.4.2 Avi-fauna

Himachal Pradesh lies in the Western Himalaya Endemic Bird Area (EBA 128) as out of 11 endemic birds, 10 have been reported from Himachal Pradesh. Most of the protected areas in Himachal Pradesh are designated as Important Birding Areas (IBAs).

6.4.2.1 Birds in Beas Basin

For the compilation of checklist of birds found in the Beas basin the published literature and documents were consulted like Chandel *et al.* (2014), Kumar and Kumar (2012). IBA's checklist was also consulted for preparation of inventory of the birds reportedly found in entire Beas basin. According to it **625 species** of birds belonging to 23 Orders and **96 families** are reported from the area (**refer Annexure V** of **Volume II** of the report)**.**

According to this list, Muscicapidae with 53 species is the largest family in the basin followed by Accipitridae with 44 species and Anatidae with 24 species of birds. Nomenclature of scientific names of bird species and their classification is based upon the portal http://avibase.bsc-eoc.org/avibase.jsp.

Out of 625 species of birds 64 species have not been evaluated by IUCN Redlist (2017-2) while 511 have been listed in Least Concern category. Fifty species have been listed under diferent threat categories of IUCN (2017-2) and WPA Schedules (**see Table 6.25**). Five species have been listed as Critically Endangered category (White-rumped Vulture, Slender-billed Vulture, Red-headed Vulture, Sociable Lapwing and Great Indian Bustard) while 6 species (Steppe Eagle, Egyptian Vulture, Greater Adjutant, Saker Falcon, Red-necked Falcon and Lesser Florican) are listed as Endangered in IUCN Redlist.
According to WPA (1972) 22 species have been listed as Schedule-I species and 8 species are endemic to Himalaya are reported from the basin.

Pong Dam lake is the richest area in terms of bird species diversity where 415 species of burds have been reported and is home to number of wintering species.

Table 6.25: Conservation status of birds reported from Beas basin

S. No.	Family	*Scientific Name*	Common Name	IUCN Red List (2017-2)	WPA Schedule	Endemic
1	Accipitridae	*Accipiter badius*	Shikra		I	
2	Accipitridae	*Accipiter gentilis*	Northern Goshawk		I	
3	Accipitridae	*Accipiter nisus*	Eurasian Sparrowhawk		I	
4	Accipitridae	*Accipiter virgatus*	Besra		I	
5	Accipitridae	*Aegypius monachus*	Cinereous Vulture	NT		
6	Accipitridae	*Aquila chrysaetos*	Golden Eagle		I	
7	Accipitridae	*Aquila heliaca*	Eastern Imperial Eagle	VU		
8	Accipitridae	*Aquila nipalensis*	Steppe Eagle	EN	I	
9	Accipitridae	*Buteo buteo*	Eurasian Buzzard		I	
10	Accipitridae	*Circaetus gallicus*	Short-toed Eagle		I	
11	Accipitridae	*Circus cyaneus*	Hen Harrier		I	
12	Accipitridae	*Circus macrourus*	Pallid Harrier	NT	I	
13	Accipitridae	*Circus*	Pied Harrier		I	

S. No.	Family	*Scientific Name*	Common Name	IUCN Red List (2017-2)	WPA Schedule	Endemic
		melanoleucos				
14	Accipitridae	*Clanga clanga*	Greater Spotted Eagle	VU		
15	Accipitridae	*Clanga hastata*	Indian Spotted Eagle	VU		
16	Accipitridae	*Elanus caeruleus*	Black-winged Kite		I	
17	Accipitridae	*Gypaetus barbatus*	Bearded Vulture/ Lammergeier	NT		
18	Accipitridae	*Gyps bengalensis*	White-rumped Vulture	CR		
19	Accipitridae	*Gyps himalayensis*	Himalayan Griffon	NT		
20	Accipitridae	*Gyps tenuirostris*	Slender-billed Vulture	CR		
21	Accipitridae	*Haliaeetus albicilla*	White-tailed Sea Eagle		I	
22	Accipitridae	*Haliaeetus leucoryphus*	Pallas fishing eagle	VU	I	
23	Accipitridae	*Haliastur indus*	Brahminy Kite		I	
24	Accipitridae	*Icthyophaga humilis*	Lesser Fish Eagle	NT		
25	Accipitridae	*Icthyophaga ichthyaetus*	Grey-headed Fish Eagle	NT		
26	Accipitridae	*Ictinaetus malayensis*	Black Eagle		I	
27	Accipitridae	*Neophron percnopterus*	Egyptian Vulture	EN		
28	Accipitridae	*Sarcogyps calvus*	Red-headed Vulture	CR		
29	Aegithalidae	*Aegithalos niveogularis*	White Throated Tit			Endemic
30	Anatidae	*Aythya nyroca*	Ferruginous Duck	NT		
31	Anatidae	*Mareca falcata*	Falcated Duck	NT		
32	Anhingidae	*Anhinga melanogaster*	Oriental Darter	NT		
33	Burhinidae	*Esacus recurvirostris*	Great Thick-knee	NT		
34	Charadriidae	*Vanellus duvaucelii*	River Lapwing	NT		
35	Charadriidae	*Vanellus gregarius*	Sociable Lapwing	CR		
36	Charadriidae	*Vanellus vanellus*	Northern Lapwing	NT		
37	Ciconiidae	*Ciconia episcopus*	White necked strock	VU		
38	Ciconiidae	*Ephippiorhynchus asiaticus*	Black-necked Stork	NT		
39	Ciconiidae	*Leptoptilos dubius*	Greater Adjutant	EN		
40	Ciconiidae	*Leptoptilos javanicus*	Lesser Adjutant	VU		
41	Ciconiidae	*Mycteria leucocephala*	Painted Stork	NT		
42	Cisticolidae	*Prinia burnesii*	Long-tailed Grass Babbler	NT		
43	Cisticolidae	*Prinia burnesii*	Rufous-vented prinia	NT		
44	Columbidae	*Columba eversmanni*	Pale-backed Pigeon	VU		
45	Falconidae	*Falco cherrug*	Saker Falcon	EN		
46	Falconidae	*Falco chicquera*	Red-necked Falcon	EN	I	
47	Falconidae	*Falco jugger*	Laggar Falcon	NT		
48	Falconidae	*Falco peregrinus*	Peregrine Falcon		I	
49	Fringillidae	*Callacanthis burtoni*	Spectacled Finch			Endemic
50	Fringillidae	*Pyrrhula aurantiaca*	Orange Bullfinch			Endemic
51	Gruidae	*Antigone antigone*	Sarus Crane	VU		

S. No.	Family	*Scientific Name*	Common Name	IUCN Red List (2017-2)	WPA Schedule	Endemic
52	Haematopodidae	*Haematopus ostralegus*	Eurasian Oystercatcher	NT		
53	Muscicapidae	*Ficedula subrubra*	Kashmir Flycatcher	VU		Endemic
54	Otididae	*Ardeotis nigriceps*	Great Indian Bustard	CR		
55	Otididae	*Sypheotides indicus*	Lesser Florican	EN		
56	Pandionidae	*Pandion haliaetus*	Osprey		I	
57	Pelecanidae	*Pelecanus crispus*	Dalmatian Pelican	VU		
58	Pelecanidae	*Pelecanus philippensis*	Spot-billed Pelican	NT		
59	Phasianidae	*Catreus wallichii*	Cheer Pheasant	VU	I	Endemic
60	Phasianidae	*Lophophorus impejanus*	Monal		I	
61	Phasianidae	*Tragopan melanocephalus*	Western Tragopan	VU	I	Endemic
62	Podicipedidae	*Podiceps auritus*	Slavonian Grebe	VU		
63	Psittacidae	*Psittacula eupatria*	Alexandrine Parakeet	NT		
64	Scolopacidae	*Calidris ferruginea*	Curlew Sandpiper	NT		
65	Scolopacidae	*Gallinago nemoricola*	Wood Snipe	VU		
66	Scolopacidae	*Limosa limosa*	Black-tailed Godwit	NT		
67	Scolopacidae	*Numenius arquata*	Eurasian Curlew	NT		
68	Sittidae	*Sitta cashmirensis*	Kashmir Nuthatch			Endemic
69	Sylviidae	*Phylloscopus tytleri*	Tytler's Leaf Warbler	NT		Endemic
70	Threskiornithidae	*Threskiornis melanocephalus*	Oriental white ibis	NT		

CR=Critically Endangered; EN=Endangered; VU=Vulnerable; NT=Near Threatened

Species richness in different sub-basins ranges from 117 to 418 with minimum in Beas sub-basin I and maximum in Beas sub-basin IV (**Table 6.26**). Maximum number of bird species reported from Beas IV sub-basin is owing to the presence of Pong Dam Lake which is a suitable wintering habitat for migratory birds. Bar-headed geese is one of the most dominant waterfowl species that is found in Pong Dam lake. Majority of the species are generalists while a few of them are confined to upper reaches (Himalayan Snowcock - *Tetraogallus himalayensis*, Monal Pheasant - *Lophophorus impejanus*, Horned Lark - *Eremophila alpestris*, Himalayan Yellow-billed Chough- *Pyrrhocorax graculus*, Himalayan Red-billed Chough - *Pyrrhocorax pyrrhocorax*, Western Greenish Leaf-Warbler - *Phylloscopus trochiloides*, etc. and lower reaches (Grebs, Herons, Storks, Egrets, Ducks, etc). In general, species richness decreases along the elevational gradients, the sub-basin extend from lower reaches harbour relatively high species richness. Considerably high species richness in Beas sub-basin IV is attributed to the presence of a large wetland – Pong dam reservoir which is home of a large number of aquatic bird species.

Table 6.26: Sub-basin wise bird species richness

Sub-basins	Total species richness	No. of threatened species	No. of Schedule I species
Beas I	117	4	7
Beas II	123	4	7
Malana	121	4	7
Parbati Upper	120	4	7

Sub-basins	Total species richness	No. of threatened species	No. of Schedule I species
Parbati Lower	123	4	7
Sainj Khad	123	4	7
Tirthan	123	4	6
Beas III	136	7	7
Uhl	137	7	7
Beas IV	418	21	5
Beas V	145	3	1

Endemic Species

The species that are endemic to Western Himalaya and found in Beas basin are White-throated Tit (*Aegithalos niveogularis*), Western Tragopan (*Tragopan melanocephalus*), Cheer Pheasant (*Catreus wallichi*), Spectacled finch (*Callacanthis burtoni*), Orange Bullfinch (*Pyrrhula aurantiaca*), Kashmir flycatcher (*Ficedula subrubra*), Kashmir nuthatch (*Sitta cashmirensis*), Tytlers' leaf warbler (*Phylloscopus tytleri*) and Brooks's Leaf-Warbler (*Phylloscopus subviridis*).

Distribution and Migratory Habit

Nearly 66% of the total bird species in Beas basin are residents. Of the total resident bird 14.5% species perform local movement and 13.5% are seasonal migrants (**Figure 6.12**). About 25% of the total bird species are summer and winter visitors, which perform their movement for breeding purpose. The passage migrant species include Pale Grasshopper-Warbler, Lesser Whitethroat, Yellow Wagtail, Brambling, Black-headed Bunting and Red-headed Bunting.

The wetland of Pong dam reservoir (Pong Dam Lake Wildlife Sanctuary) in the basin (Beas sub-basin IV) provides a good niche for the migratory birds. As many as 418 bird species have been recorded from the Pong dam reservoir area only according to Status Paper on Pong Wetland published by Randhawa (2014) under HP State Centre on Climate Change. Many migratory birds like Bar Headed Geese (*Anser indicus*), Northern Pintail (*Anas acuta*), Common Pochard (*Aythya farina*), Red Necked Grebe (*Podiceps grseigena*), Mallard (*Anas platyrhynchos*), etc. visit this site in winter from trans-Himalayan region.

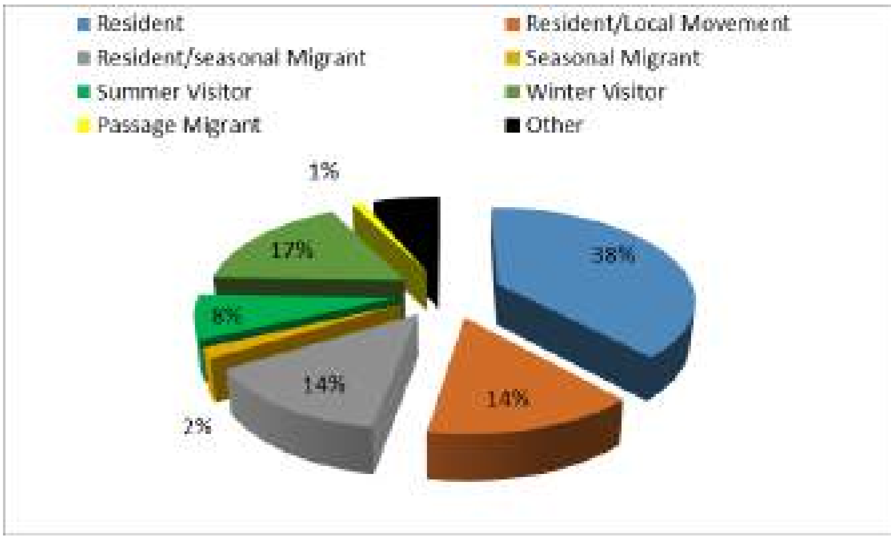


Figure 6.12: Distribution and migratory habit of birds in Beas basin

6.4.3 Butterflies

The mountainous landscape and forest cover of Himachal Pradesh provides good climatic conditions for the butterflies. Based upon the data compiled from secondary sources, Forest Working Plans, Management Plans of Protected areas, published literature viz. Uniyal and Mathur, (1998), Uniyal (2007), Bhardwaj and Uniyal (2009), Chandel *et al*. (2014) a list of butterflies was prepared. A total of 150 species of butterflies along with their sub-basin wise distribution and conservation status have been located in Beas river basin (**Annexure-VI** of **Volume II** of the report**)**. All species of butterflies reported from the basin are grouped under 7 families.

Species richness in different sub-basins ranges from 76 to 137 with minimum in Beas sub-basin I and maximum in Beas sub-basin IV**.** Majority of the species are common in distribution in all sub-basin while a few of them are restricted to upper reaches (Red Apollo - *Parnassius charltonius*, Common Blue Apollo - *Parnassius hardwickei*, Painted Lady- *Vanessa cardui*, Mountain Argus - *Erebia shallada*) and lower reaches (Spangle-*Papilio protenor*, Tawny Mime-*Chilasa agestor*, Psyche - *Leptosia nina nina*, Common Jezebel - *Delias eucharis*, Pale Hedge Blue - *Udara dilecta*, Purple Hedge Blue - *Heliophorus epicles*, Common Baron - *Euthalia aconthea*, Common Jester - *Symbrenthia hippoclus*, Common Bush Brown - *Mycalesis perseus*, Dark Blue Tiger - *Tirumala septentrionis* etc).

Likewise other taxa in Beas river basin, the richness of butterflies decreases along the elevational gradients (**Figure 6.13**). Thus, the sub-basins extend from the lower reaches harbour relatively high butterfly richness.

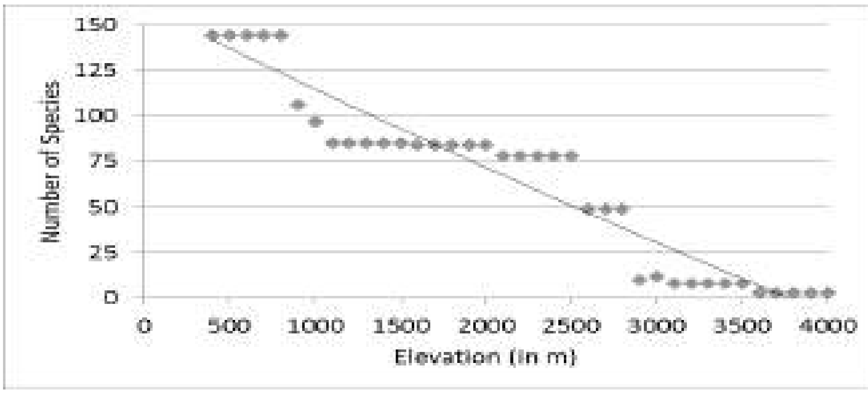


Figure 6.13: Distribution of butterfly species in Beas basin along the elevational gradient

Sub-basin wise number of butterfly species is given at **Table 6.27**.

Table 6.27: Sub-basin wise number of butterfly species richness

Sub-basins	Total species richness	No. of Threatened species	No. of Schedule I species
Beas I	76	0	0
Beas II	79	0	0
Malana	84	0	0
Parbati Upper	84	0	0
Parbati II	82	0	0
Sainj Khad	84	0	0
Tirthan	84	0	0
Beas III	135	0	1

Sub-basins	Total species richness	No. of Threatened species	No. of Schedule I species
Uhl	137	0	1
Beas IV	136	0	1
Beas V	120	0	1

Conservation Status: Out of 150 species invetorized for Beas river basin, only 5 species, viz. Bath White (*Pontia daplidice*), Small Grass Yellow (*Eurema brigitta*), Peacock Pansy (*Junonia almanac*), Yellow Pansy (*Junonia hierta*) and Common Crow (*Euploea core*) are assessed under the IUCN Redlist (2017-2) and listed under 'Least Concern' category. Similarly, only a few species are included in the list of scheduled species as per IWPA (1972). Only one species – Common Pierrot (*Castalius rosimon*) in Beas river basin is included in Schedule I. A total of 8 species like Common Yellow Swallowtail (*Papilio machaon*), Regal Apollo (*Parnassius charltonius*), Common Onyx (*Horaga onyx*), Pea Blue (*Lampides boeticus*), Common Beak (*Libythea lepita*), Danaid Eggfly (*Hypolimnas misippus*), Veined Labyrinth (*Lethe pulaha*), Common Fiorester (*Lethe insana insane*) are listed in Schedule II.

6.4.4 Herpetofauna

Herpetofauna comprise of amphibians that include frogs, toads, newts, salamanders, etc. and reptiles which include snakes, lizards, turtles, terrapins, tortoises, etc. An inventory of herpetofauna comprising reptiles and amphibians was prepared from the Forest Working Plans, management plans of Protected Area and published literature by Jaswant Singh, Murari Lal Thakur and H S Banyal (2015), and the same is given at **Table 6.28**. Total 59 species are reported from the Beas basin of which 51 species are of reptiles and 8 species are of amphibians.

6.4.5 Reptiles

Reptilian fauna is comprised of 51 species belonging to 12 families (**Table 6.28**). Colubridae is the largest family represented by sixteen species followed by Agamidae, Scincidae and Geoemydidae with 5 species each. IUCN Red List (2017-2) has kept Indian Rock Python (*Python molurus*), Spotted Pond Turtle (*Geoclemys hamiltonii*) and Gangetic Soft-shell Turtle (*Nilssonia gangetica*) under Vulnerable category. Eleven species are under Least Concern category and rest of the species are yet not evaluated under IUCN Red List (2017-2).

6.4.6 Amphibia

From the Beas basin 8 species of Amphibians are reported which belong to 4 families, which comprises of toads and frogs. Bufonidae is the largest family with 3 species (see **Table 6.28**).

Table 6.28: List of herpetofauna reported from Beas basin

S.No.	Family	Scientific Name	Common Name
Reptiles			
1	Agamidae	*Calotes versicolor*	Garden lizard
2	Agamidae	*Laudakia tuberculata*	Kashmir rock agama
3	Agamidae	*Oriotaris major*	Large Mountain Lizard
4	Agamidae	*Sitana ponticeriana*	Fan throated Lizard
5	Agamidae	*Zootoca vivipara*	Common lizard
6	Boidae	*Eryx johnii*	Eastern Red Sand Boa
7	Boidae	*Gongylophis conicus*	Common Sand Boa

S.No.	Family	Scientific Name	Common Name
8	Colubridae	*Ahaetulla nasuta*	Green Vine Snake
9	Colubridae	*Amphiesma platyceps*	Eastern Keelback
10	Colubridae	*Amphiesma stolatum*	Buff-striped Keelback
11	Colubridae	*Boiga multifasciata*	Many Banded Cat Snake
12	Colubridae	*Coelognathus helena*	Indian Trinket Snake
13	Colubridae	*Liopeltis rappi*	Himalayan Stripe-necked Snake
14	Colubridae	*Lycodon aulicus*	Common Wolf Snake
15	Colubridae	*Lycodon flavomaculatus*	Yellow Spotted Wolf Snake
16	Colubridae	*Lycodon striatus*	Barred Wolf Snake
17	Colubridae	*Oligodon arnensis*	Banded Kukri Snake
18	Colubridae	*Orthriophis hodgsonii*	Himalayan Trinket Snake
19	Colubridae	*Platyceps rhodorachis*	Braid Snake
20	Colubridae	*Ptyas mucosus*	Indian Rat Snake
21	Colubridae	*Spalerosophis atriceps*	Black headed Royal Snake
22	Colubridae	*Xenochrophis piscator*	Checkered Keelback Water Snake
23	Colubridae	*Xenochrophis sanctijohannis*	Keelback Water Snake
24	Elapidae	*Bungarus caeruleus*	Common Indian crait
25	Elapidae	*Naja naja*	Indian Cobra
26	Elapidae	*Naja oxiana*	Central Asian Cobra
27	Gekkonidae	*Cyrtodactylus lawderanus*	Lawder's Bent-toed Gecko
28	Gekkonidae	*Cyrtodactylus stoliczkai*	Kashmir rock gecko
29	Gekkonidae	*Hemidactylus brookii*	Brook's House Gecko
30	Gekkonidae	*Hemidactylus flaviviridis*	Yellow Green House Gecko
31	Pythonidae	*Python molurus*	Indian Rock Paython
32	Scincidae	*Ablepharus pannonicus*	Mediterranean Dwarf Skink
33	Scincidae	*Eurylepis taeniolatus*	Yellow bellied Mole Skink
34	Scincidae	*Lygosoma punctata*	Spotted Supple Skink
35	Scincidae	*Scincella himalayanus* (*Asymblepharus himalayanum*)	Himalayan Ground Skink
36	Scincidae	*Scincella ladacense*	Ladakh Ground Skink
37	Typhlopidae	*Myriopholis algeriensis*	Largebeaked Thread Snake
38	Typhlopidae	*Ramphotyphlops braminus*	Brahminy Blind Snake
39	Typhlopidae	*Typhlops porrectus*	Slender Blind Snake
40	Varanidae	*Varanus bengalensis*	Bengal Monitor
41	Viperidae	*Cryptelytrops albolabris*	White-lipped pit Viper
42	Viperidae	*Daboia russelii*	Russell’s Viper
43	Viperidae	*Echis carinatus*	Saw Scaled Viper
44	Viperidae	*Gloydius himalayanus*	Himalayan pit viper
Turtles			
45	Geoemydidae	*Geoclemys hamiltonii*	Spotted Pond Turtle
46	Geoemydidae	*Melanochelys trijuga*	Indian Black Turtle
47	Geoemydidae	*Nilssonia gangetica*	Gangetic Soft-shell Turtle
48	Geoemydidae	*Pangshura smithii*	Brown Roofed Turtle
49	Geoemydidae	*Pangshura tentoria*	Indian tent turtle
50	Trionychidae	*Lissemys punctata*	Indian Flap- shelled turtle
51	Trionychidae	*Lissemys punctata andersoni*	North Indian Flapshell
Amphibia			
52	Bufonidae	*Duttaphrynus melanostictus*	Common Asian toad
53	Bufonidae	*Duttaphrynus himalayanus*	Himalayan toad
54	Bufonidae	*Bufotes viridis*	Green Toad
55	Dicroglossidae	*Nanorana minica*	Himalaya tiny frog
56	Dicroglossidae	*Nanorana vicina*	Himalaya paa frog
57	Megophryidae	*Scutiger nyingchiensis*	-
58	Ranidae	*Rana cascadae*	Cascade frog
59	Ranidae	*Amolops formosus*	Stream frog

Sub-basin wise herpetofaunal species richness is given at **Table 6.29.**

Table 6.29: Sub-basin wise herpetofaunal species richness in Beas river basin

Sub-basins	Total species richness	No. of Threatened species	No. of Schedule I species
Beas I	26	1	0
Beas II	28	1	0
Malana	27	1	0
Parbati Upper	27	1	0
Parbati Lower	28	1	0
Sainj Khad	29	1	0
Tirthan	29	1	0
Beas III	32	2	1
Uhl	32	2	1
Beas IV	38	4	2
Beas V	30	4	2

Conservation Status: Most of the assessed species are listed in 'Least Concern' category. Only Tiny Frog is categorised under 'Vulnerable' category. Tiny Frog is widely distributed in the basin. Under the Schedule list of IWPA (1972) only Indian Flapshell Turtle are included under Schedule I. It is confined to the Shivalik hills (Beas IV and V) of of the basin.

6.5 PROTECTED AREAS

There are 10 Wildlife Sanctuaries and 3 National Parks in the basin covering an area of 3236 sq km (**see Table 6.30** and **Figure 6.14**).

Table 6.30: List of Protected Areas located within Beas Basin and status of ESZ Notifications*

S. No.	PROTECTED AREAS	Area (Sq km)	Status of ESZ Notification
Wildlife Sanctuaries			
1	Dhauladhar Wildlife Sanctuary	982.86	Draft Notification (13/01/2016)
2	Kanawar Wildlife Sanctuary	107.29	Draft Notification (28/04/2016)
3	Khokhan Wildlife Sanctuary	14.94	Draft Notification (04/03/2016)
4	Manali Wildlife Sanctuary	29.00	Draft Notification (04/03/2016)
5	Sainj Wildlife Sanctuary**	90.00	-
6	Pong Dam Lake Wildlife Sanctuary	207.59	Draft Notification (17/11/2016)
7	Tirthan Wildlife Sanctuary**	61.00	-
8	Shikari Devi Wildlife Sanctuary	29.94	Draft Notification (04/03/2016)
9	Nargu Wildlife Sanctuary	132.37	Draft Notification (08/03/2016)
10	Kais Wildlife Sanctuary	12.61	Draft

			Notification (24/04/2016)
National Parks			
11	Great Himalayan National Park**	754.40	-
12	Khirganga National Park**	710.00	Draft Notification (25/07/2016)
13	Indrakilla National Park	104.00	Final Notification Issued (17.01.2018)
Great Himalayan National Park Conservation Area (GHNPCA)**		1615.40	Draft Notification (22/08/2016)

*http://envfor.nic.in/content/esz-notifications

** *Great Himalayan National park Conservation Area includes Sainj WLS, Tirthan WLS Great Himalayan National Park and Khirganga National park*

All the above-mentioned Protected Areas (PAs) are located entirely within Beas basin except for Dhauladhar WLS as large part of it is located within Ravi river basin. The boundaries of all the PAs were generated using extents and maps given in their Gazette notifications in addition to the notifications issued by MoEF&CC, GoI regarding Eco Sensitive Zone around these PAs. In addition ESZ were also delineated for each PA using the coordinates given in notifications downloaded from http://envfor.nic.in/content/esz-notifications. Except for Inderkilla National Park only Draft notifications have been issued till date all other PAs in the basin. Draft notification of Great Himalayan National Park Conservation Area (GHNPCA) covers ESZ around Khirganga National Pak, Great Himalyan National Park, Sainj Wilflife Sanctuary and Tirthan Wildlife Sanctuary. In a 24th Expert Committee meeting for declaration of Eco Sensitive Zones aroung Wildlife Sanctuaries/National Parks on 27-28 February 2017 at MoEF&CC recmmended the finalisation of of the notification subject to resolving of issue of geo-coordinates of boundaries of PAs and ESZ.

A description of key features of PAs in the basin are given in following paragraphs.

6.5.1 Great Himalayan National Park Conservation Area (GHNPCA)

As discussed above draft notification on 25.07.2016 bu MoEF&CC, GoI regarding delineation of Eco Sensitive Zone with an area of 417 sq km with an extent from 500 m up to 6 km around the boundary of Great Himalayan National Park Conservation Area (GHNPCA) covering GHNP, Khirganga National Park, Sainj Wildlife Sanctuary and Tirthan Wildlife Sanctuary which is spread over an area of 1615.40 sq km.

Great Himalayan National Park (GHNP) is the most important Protected Area in the basin. The park was established in 1984 and is spread over an area of 1,171 km^2. The park was declared as a National Park in 1999. Total area of the park is about 754.4 sq km. It is comprised of the catchments of Jiwa, Sainj and Tirthan rivers. It is bounded Rupi Bhaba, Sainj and Kanawar WLS and Pin Valley National Park. GHNP constitutes North-West Himalaya (Biogeographic Zone 2A). Biogeographically, it is at the junction of world's two major faunal realms, i.e. the oriental to the south and palaearctic to the north makes it an important site.

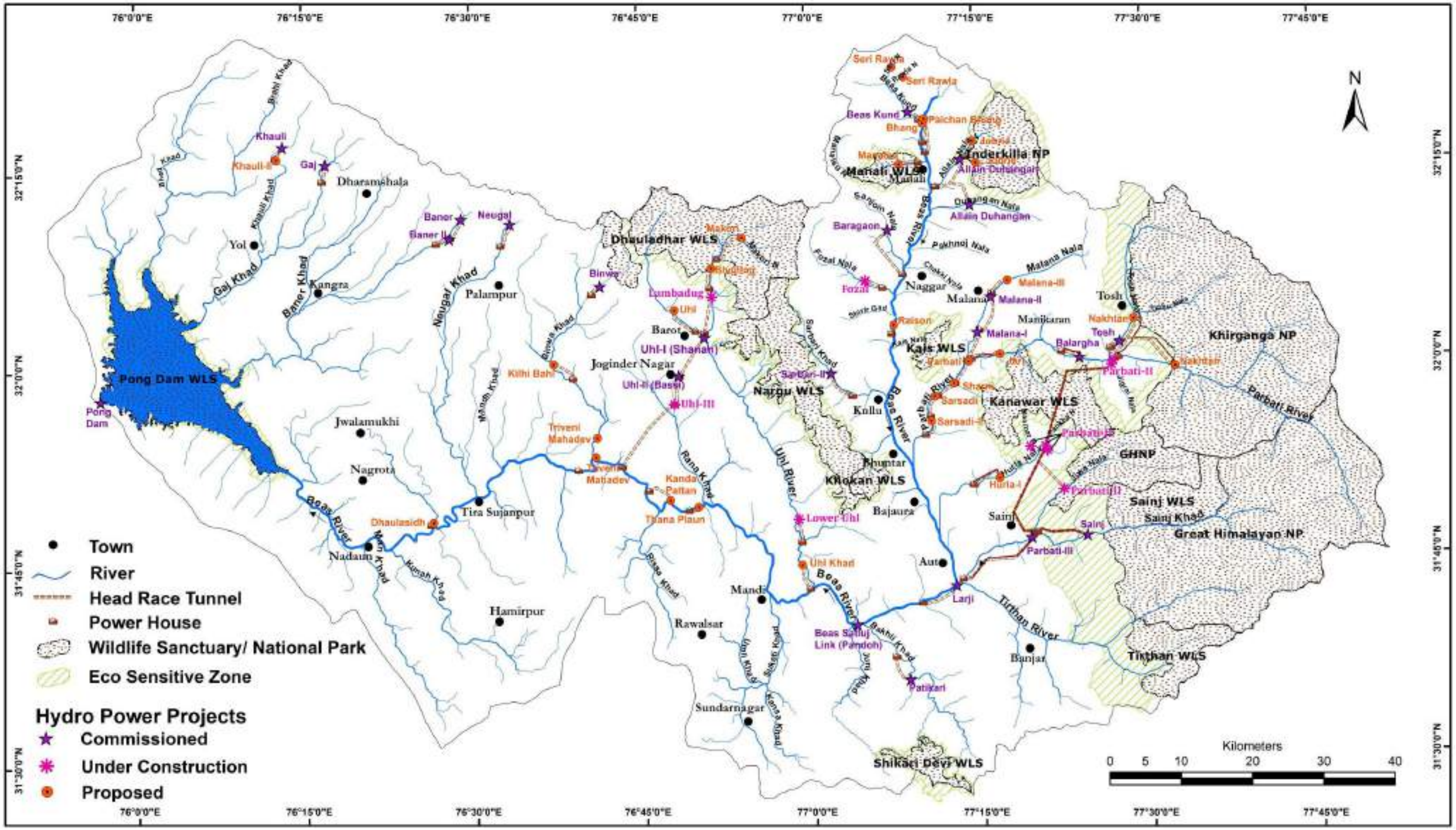


Figure 6.14: Map showing Protected areas and National Parks in Beas basin

While Khirganga NP was established in July 28, 2010 covering an area of 710 sq km. Sainj WLS was notified in October 23, 1999 while Tirthan WLS was established in November 1, 1999.

GHNP is most important component of GHNPCA. Great Himalayn NP harbours forest of Oak (*Quercus semecarpifolia*), Blue Pine (*Pinus wallichiana*), West Himalayan Silver Fir (*Abies pindrow*), West Himalayan Spruce (*Picea smithiana*) and Himalayan Cedar (*Cedrus deodara*). The broad-leaf forests contain Horse Chestnut (*Aesculus indica*), *Rhododendron arboreum*, *Quercus leucotrichophora*, *Q. floribunda* at the lower altitudes and pure patches of Birch (*Betula utilis*) at higher altitudes. Yew (*Taxus baccata*) is an important medicinal tree of the understorey. A rich variety of shrubs and patches of ringal bamboo (*Arundinaria spathiflora*) are found as a dense understorey. The shrubs of (*Rhododendron campanulatum*) form the Krummholz patch in the sub-alpine zone. Other shrubs that are found about 3700 m are *Juniperus communis*, *J. pseudosabina*, *Lonicera*, *Berberis*, *Cotoneaster*, *Vibernum*, *Rosa* occur extensively about 3700 m. There are a number of man-made (by graziers) clearings/grasslands within the forest areas locally known as **thach** used as grazing and camping ground for the migratory livestock (cattle, sheep and goats). The alpine flora occurring above 4,000 m is characterised by species rich meadows with medicinal and economical values. They include *Aconitum violaceum*, *Salvia moorcroftiana*, *Viola serpens*, *Jurinea macrocephala*, *Rheum emodi*, *Berginia ciliata*, *Picrorhiza kurroo*, *Saussurea graminifolia*, etc.
A total of 832 plant species belonging to 427 genera and 128 families of higher plants are reported from GHNP.

Thirty-one mammalian species were recorded in the area by Gaston et al., 1981. Main mammal species found are:

- Serow (*Capricornis sumatraensis*)
- Himalayan Tahr (*Hemitragus jemlahicus*)
- Goral (*Nemorhaedus goral*)
- Blue Sheep (*Pseudois nayaur*)
- Himalayan Black Bear (*Selenarctos thibetanus*)
- Himalayan Brown Bear (*Ursus arctos*)
- Himalayan Red Fox (*Vulpes vulpes*)
- Musk Deer (*Moschus chrysogaster*)

The Great Himalayan National Park is home to 209 bird species, which include the endangered Western tragopan and four other pheasant species.
GHNP was awarded UNESCO World Heritage Site status in 2014, in recognition of its outstanding significance for biodiversity conservation.

6.5.2 Other Protected Areas

Inderkilla NP

Inderkila NP is comprised of ctachments of Hamtah Nala, Jobrie Nala and Allain Nala. It comprises that habitat of Snow leopard (*Uncia uncia),* Himalayan Brown Bear *(Ursus arctos),* Himalayan Tahr *(Hemitragus jemlahicus),* Black bear *(Ursus thibetanus),* Himalayan Ibex *(Capra ibex),* Musk Deer *(Moschus chrysogaster),* Himalayan Griffon (*Gyps himalayensis),* Rakhal (*Taxus baccata)*, Bhojpatara (*Betula utilis)*, Maple (*Acer pictum)*, Shingli mingli *(Dioscorea deltoidea)*, Patish (*Aconitum* spp.*)*, Dhoop (*Jurinea macrocephala)*, Artemisias (*Artemisia* spp.*)*, Salam panja *(Dactylorhiza hatageria)*, Banaksha (*Viola* spp.*)* etc. are the important rare, endangered, threatened flora and fauna of the National Park.

Final notification of ESZ of Inderkilla NP was issued on 17 January 2018. The project components of proposed Jobrie HEP are located within the National Park boundary. One intake of operational Allain Duhangan HE project (Allain Nala intake) is located within ESZ of the NP.

Manali WLS

Manali WLS is comprised of catchment of Manalsu Nal upstream of Kaland village which is a right bank tributary of Beas river joining at Manali town. The sanctuary harbours rich floral and faunal diversity. Biological significance of the area is charcterised by forests of Deodar, Fir, Spruce and Kail among conifers and a variety of broad leaved species like *Prunus, Acer, Juglans, Buxus, Rhododendron, Celtis, Betula, Ulmus, Aesculus, Alnus, Myrica*, etc.

The proposed Manalsu HE project is located within the sanctuary.

Kanawar Wildlife Sanctuary

Kanawar WLS comprises of upper catchments of Dolang Nala and Hurla Nala. Dolang Nala drains into Parbati river on its left bank while Hurla Nala drains into Beas river. The Head Race Tunnel of Parbati-II HE project passes through Kanawar WLS. No project falls within the WLS or its ESZ.

Khokhan WLS & Nargu WLS

Nargu and Khokan WLS comprise of part catchments of Uhl river and Sarbari Khad. Biodiversity significance of this area is charcaterised by avi-fauna like Western Tragopan (*Tragopan melanocephalus*) Himalayan Monal (*Lophophorus impejanus*), Chukor (*Alectoris chukar*), Koklas (*Pucrasia macrolopha*) and Kalij (*Lophophorus leucomelanus*) and among mammals Musk Deer *(Moschus chrysogaster)*, Barking Deer, Leopard, Leopard Cat, Jungle Cat, Himalayan yellow throated marten, Black bear, Brown bear, Porcupine are the important faunal elements inhabiting the WLS. It has Dense forests of Deodar, Fir, Spruce, Kail and rhododendrons.

No project falls within WLS or ESZ.

Kais WLS

It is small sanctuary comprising of catchment of Kais nala located on left bank of Beas river. Important faunal elements of the sanctuary are Himalyan monal (*Lophophorus impejanus*), Kalij (*Lophophorus leucomelanus*), Chukor and Grey partridge among birds and Black bear, Goral, Leopard cat and Himalayan yeloow throated marten. The forests are comprised of Ban oak forest, Moist deodar forest, Wesren mixed coniferous forest, Moist temperate and Kharsu forests.

No project falls within WLS or ESZ.

Dhauladhar WLS

Large part of Dhauladhar WLS falls in Ravi river catchment and only southern part of the sanctuary falls in upper catchment of Uhl river a tributary of Beas river. Biological significance of the sanctuary is comprised of mammals like Himalyan tahr, Himalyan ibex, Musk deer, Serow and Brown bear. The area is rich in avi-faunal diversity comprised of species like Rock bunting, Wren, Western tragopan, Himalyan Monal, Kalij and Koklas pheasant. The area is rich in butterflies also.

Two proposed projects viz. Bhujling and Makori HEPs fall within Dhauladhar WLS.

Shikari Devi WLS

Northen part of the sanctuary is comprised of upper catchment of Deola Nala draining into Beas river while its southern part of drains into Sutlej river. The area is rich in avi-faunal diversity.

No project falls with WLS and ESZ.

Pong Dam Lake WLS

It is comprised of reservoir formed by Pong dam. Pong Dam Lake WLS is very rich in bird diversity. The details of the same is given in next section.

6.6 IMPORTANT BIRDING AREAS

BirdLife International is the world's largest nature conservation partnership. It identifies Important Birding Areas worldwide for conservation action. The Bombay Natural History Society (BNHS) is the BirdLife Partner for India and is responsible for coordinating the IBA programme in the country. Of the 467 IBAs identified so far in India, 191 are Wildlife Sanctuaries, 52 are National Parks, 23 are Tiger Reserves and one is a Conservation Reserve (Birdlife International, 2017). India's IBAs are host to 75 species of globally threatened birds of which eight are Critically Endangered, 10 are Endangered and 57 are Vulnerable. A total of 199 IBAs (almost 43%) are located outside the Protected Area Network (PAN) and have no official protection. In Himachal Pradesh 27 IBAs have been and of these 24 are sanctuaries and 2 are national parks and only one is non-protected area (Islam and Rahmani, 2004). In Beas basin 9 IBAs have been identified based upon the criteria defined by Birdlife International (**see Table 6.31**). Most of the IBAs harbor critically endangered Western targopan and Vulnerable Cheer pheasant.

6.6.1 Criteria for Identification of Important Birding Areas

A1. Globally threatened species

The site is known or thought regularly to hold significant numbers of a globally threatened species.

Notes: The site qualifies if it is known, estimated or thought to hold a population of a species categorized by the IUCN Red List (2017-2) as Critically Endangered, Endangered or Vulnerable. In general, the regular presence of a Critical or Endangered species, irrespective of population size, at a site may be sufficient for a site to qualify as an IBA. For Vulnerable species, the presence of more than threshold numbers at a site is necessary to trigger selection.

A2. Restricted-range species

The site is known or thought to hold a significant component of a group of species whose breeding distributions define an Endemic Bird Area (EBA) or Secondary Area (SA).

A3. Biome-restricted species

The site is known or thought to hold a significant component of the group of species whose distributions are largely or wholly confined to one biome.

A4. Congregations

The site is known or thought to hold congregations of ≥1% of the global population of one or more species on a regular or predictable basis.

Table 6.31: List of IBAs identified in Beas basin

IBA Site Code	IBAs	Criteria	Important Species*
IN-HP-04	Dhauladhar Wildlife Sanctuary	A1, A2	Western tragopan
IN-HP-08	Great Himalayan National Park	A1, A2	Western tragopan, Cheer pheasant
IN-HP-09	Kais Wildlife Sanctuary	A1, A2	Western tragopan, Cheer pheasant
IN-HP-11	Kanawar Wildlife Sanctuary	A1, A2	Western tragopan, Cheer pheasant
IN-HP-16	Manali Wildlife Sanctuary	A1, A2, A3	Western tragopan, Cheer pheasant
IN-HP-17	Nargu Wildlife Sanctuary	A3	-
IN-HP-19	Pong Dam Lake Wildlife Sanctuary	A1, A4iii	White-rumped vulture, Slender-billed vulture
IN-HP-24	Shikari Devi Wildlife Sanctuary	A1, A2, A3	Cheer pheasant
IN-HP-27	Tirthan Wildlife Sanctuary	A1, A2, A3	Western tragopan

**Western tragopan, White-rumped vulture and Slender-billed vulture are Critically Endangered; Cheer pheasant is Vulnerable*

Owing to rich avi-faunal diversity Pong dam reservoir has been declared as Ramsar site in 2002 spread over an area of 156.62 sq km. Pong dam lake is an important wintering ground for waterfowl. IBA report on Himachal Pradesh states that concentration of wintering waterfowl population has sharply increased over the years especially the populations of Northern Pintail, Bar-headed Geese, Common Teal, Eurasian Wigeon, Common Pochard and Great Cormorant. The report also says that almost 20% of Bar-headed Geese population occurs in Pong Dam only. No other IBA site in India holds such a large population of this species. The status paper on Pong dam has reported 415 species of birds from the Pong Dam lake. Pong Dam Lake also known as Maharana Pratap Sagar was declared Ramsar site on 19.8.2002 by Ramsar Convention.

CHAPTER-7
ECOLOGICAL ASPECTS- AQUATIC

7.1 WATER QUALITY

The chemical and physical sampling and analyses provide a broad picture of the parameters that define the aquatic environment. Biological parameters detect water quality changes that other methods might miss or underestimate. Resident biotic components in their environments are indicators of environmental quality for assessing the impacts that chemical sampling is unlikely to detect due to any modification of river course or flow pattern. Plankton (phytoplankton and zooplankton), benthic macro-invertebrates, and fish are the most commonly used in assessing biological integrity of any river ecosystem. The benthic macro-invertebrates are most often studied for wadeable riffles in streams and rivers while algae are often used in lakes to examine eutrophication. Therefore, the river water quality assessments are best analysed when these are based upon the biological together with physical and chemical assessments that provide a complete picture of the river water quality. In the description of physico-chemical and biological parameters the results have been discussed.

7.2 PHYSICO-CHEMICAL WATER QUALITY

Water quality of the Beas river and its tributary streams at different locations in the basin was assessed vis-à-vis Tolerance Limits for Inland Surface Waters (as per IS:2296:1982) (**refer Table 7.1**) and water quality standards prescribed by Central Pollution Control Board (CPCB) standards for drinking water (**refer Table 7.2**).

For water quality assessment water samples were collected from locations in Beas basin covering different project areas across the entire basin and details of each sampling site is given at **Table 7.3**. Some of the sites are located in the pristine area while some of the sites were located in the vicinity of towns located on the bank of Beas river or its tributaries.

Although data collection was done momthly, however in order to assess the water quality thoughout the basin the monthly data collected was averaged season-wise at each sampling site in different sub-basins. Therefore, seasonal variation across the sampling sites in sub-basins has been discussed in this chapter.

The detailed results of all the water quality parameters analyzed for water samples collected during various seasons (Winter, Pre-monsoon and Monsoon) and monthly (from May 2016 to December 2016) from Beas rivers and as well as their tributaries at different sampling locations are given at **Annexure-VII** of **Volume II** of the report.

Table 7.1: Tolerance Limits for Inland Surface Waters (as per IS:2296:1982)

S. No.	Parameter and Unit	Class-A	Class-B	Class-C	Class-D	Class-E
1	Colour (Hazen Units)	10	300	300	-	-
2	Odour	Unobjectionable	-	-	-	-

S. No.	Parameter and Unit	Class-A	Class-B	Class-C	Class-D	Class-E
3	Taste	Tasteless	-	-	-	-
4	pH (max) (min:6.5)	8.5	8.5	8.5	8.5	8.5
5	Conductivity (µS/cm))	-	-	-	1000	2250
6	DO (mg/L) (min)	6	5	4	4	-
7	BOD (3 days at 27^oC) (mg/L)	2	3	3	-	-
8	Total Coliforms (MPN/100 mL)	50	500	5000	-	-
9	TDS (mg/L)	500	-	1500	-	2100
10	Oil and Grease (mg/L)	-	-	0.1	0.1	-
11	Mineral Oil (mg/L)	0.01	-	-	-	-
12	Free Carbon Dioxide (mg/L CO_2)	-	-	-	6	-
13	Free Ammonia (mg/L as N)	-	-	-	1.2	-
14	Cyanide (mg/L as CN)	0.05	0.05	0.05	-	-
15	Phenol (mg/L C_6H_5OH)	0.002	0.005	0.005	-	-
16	Total Hardness (mg/L as $CaCO_3$)	300	-	-	-	-
17	Chloride (mg/L as Cl)	250	-	600	-	600
18	Sulphate (mg/L as SO_4)	400	-	400	-	1000
19	Nitrate (mg/L as NO_3)	20	-	50	-	-
20	Fluoride (mg/L as F)	1.5	1.5	1.5	-	-
21	Calcium (mg/L as Ca)	80	-	-	-	-
22	Magnesium (mg/L Mg)	24.4	-	-	-	-
23	Copper (mg/L as Cu)	1.5	-	1.5	-	-
24	Iron (mg/L as Fe)	0.3	-	50	-	-
25	Manganese (mg/L as Mn)	0.5	-	-	-	-
26	Zinc (mg/L as Zn)	15	-	15	-	-
27	Boron (mg/L as B)	-	-	-	-	2
28	Barium (mg/L as Ba)	1	-	-	-	-
29	Silver (mg/L as Ag)	0.05	-	-	-	-
30	Arsenic (mg/L as As)	0.05	0.2	0.2	-	-
31	Mercury (mg/L as Hg)	0.001	-	-	-	-
32	Lead (mg/L as Pb)	0.1	-	0.1	-	-
33	Cadmium (mg/L as Cd)	0.01	-	0.01	-	-
34	Chromium (VI) (mg/L as Cr)	0.05	0.05	0.05	-	-
35	Selenium (mg/L as Se)	0.01	-	0.05	-	-
36	Anionic Detergents (mg/L MBAS)	0.2	1	1	-	-

Class-A: *Drinking water source without conventional treatment but after disinfection*
Class-B: *Outdoor bathing*
Class-C: *Drinking water source with conventional treatment followed by disinfection*
Class-D: *Fish culture and wild life propagation*
Class-E: *Irrigation, industrial cooling and controlled waste disposal*

Table 7.2: Drinking Water Quality Standards (as per IS:10500:2012)

Parameters	Desirable Limit*	Permissible Limit**
Color (Hz)	5.0	25
Odour	Unobjectionable	-
Taste	Agreeable	-
Turbidity (ntu)	5	10
pH	5-8.5	No relaxation
Total Coliforms (MPN/100 ml)	0	-
TDS (mg/l)	500	2000

Parameters	Desirable Limit*	Permissible Limit**
Total hardness (mg/l) as $CaCO_3$	300	600
Total alkalinity (mg/l)	200	600
Chlorides (mg/l)	250	1000
Sulphates (mg/l)	200	400
Flourides (mg/l)	1.0	1.5
Nitrate (mg/l)	45	100
Calcium (mg/l)	75	200
Magnesium (mg/l)	30	100
Manganese (mg/l)	0.05	0.5
Copper (mg/l)	0.05	1.5
Zn (mg/l)	5.0	15.0
Iron (mg/l)	0.30	1.0
Lead (mg/l)	0.05	No relaxation
Cadmium (mg/l)	0.01	No relaxation
Chromium (mg/l)	0.05	0.05
Phenolic compounds as phenol (mg/l)	0.001	0.001
Anionic detergents as MBAS (mg/l)	0.001	0.002
Arsenic as As (mg/l)	0.05	0.05
Selenium as Se (mg/l)	0.01	0.01
Mercury total as Hg (mg/l)	0.001	0.001
Cyanides (mg/l)	0.05	0.05
Mineral oil (mg/l)	0.01	0.3
Polynuclear aromatic hydrocarbons (PAH)	0.02µg/l	0.02µg/l

*1 *The figures indicated under the column 'Acceptable' are the limits up to which water is generally acceptable to the consumers*

**2 *Figures in excess of those mentioned under 'Acceptable render the water not acceptable, but still may be tolerated in the absence of alternative and better source but up to the limits indicated under column "Cause for Rejection" above which are supply will have to be rejected.*

The results of all the water quality parameters analyzed for water samples collected from Beas river and their tributaries at different sampling locations are discussed below.

From the overview of the results of all the parameters analyzed it was observed that the concentration of parameters like Iron is <0.01 whereas all the heavy metals i.e. As, Pb, Cd, Hg, Cu, Cr, Zn, and Mn are either Not Detectable (ND) or Below Detectable Limits (BDL) except at few sampling sites. Therefore, keeping above results in mind the water quality objectives for Beas basin main emphasis was laid on a core indicator set of parameters that reflect their importance along a river stretch in a valley/basin. The key indicators like temperature, pH, electrical conductivity, total dissolved solids, total suspended solids, dissolved oxygen, total hardness, calcium, magnesium, chlorides, nitrites, sulphates, and phosphates, potassium and sodium have been discussed in the present report in addition to other parameters like Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), and Total Coliforms have also been discussed. Firstly, sub-basin-wise water quality has been discussed followed then by overall overview of the water quality across the basin.

Table 7.3: Details of water sampling sites and their location the different projects in Beas basin

S.No.	Sampling Site	Project	Remarks
1	**W1**	**Beas Kund**	Samples were collected from Solang Nala near Beas Kund SHEP Power House upstream of Palchan Village. Palchan village is located along the Highway connecting Manali to Lahaul valley via Rohtang Pass
2	**W2**	**Palchan Bhang**	Samples were collected Solang Nala near Palchan village
3	**W3**	**Bhang**	Samples collected from Beas river downstream of Solang Nala confluence near Bhang village
4	**W4**	**Jobrie**	Samples collected from Allain Nala downstream of Hamta Nala and Allain Nala confluence near Hamta village
5	**W5**	**Allain Duhangan**	Samples collected from Allain Nala left bank tributary of Beas River near Aleo village located along NH-21 (Kullu Manali Highway).
6	**W6**	**Allain Duhangan**	Samples collected from Duhangan Nala, a left bank tributary of Beas River near Jagatsukh village
7	**W7**	**Baragaon**	Samples collected from Sanjoin Nala, a right bank tributary of Beas River near PH of Baragoan HEP. Patlikuhl trout fish hatchery maintained by water supply from Sanjoin Nala.
8	**W8**	**Fozal**	Samples collected rom Fozal Nala, a right bank tributary of Beas River near Dobhi village located along NH21 (Kullu-Manali Highway)
9	**W9**	**Sarbari-II**	Samples collected from Sarbari Khad near Power House of Sarbari-II HEP. Sarbari Khad is right bank tributary of Beas River and meet Beas river upstream of Kullu town
10	**W10**	**Nakthan**	Samples collected from Tosh Nala upstream of diversion site of Tosh SHEP
11	**W11**	**Nakthan**	Samples collected from Tosh Nala upstream of Tosh nala confluence with Parbati river
12	**W12**	**Nakthan**	Samples collected from Parbati river near Nakthan village near Nakthan HEP dam site
13	**W13**	**Tosh**	Samples collected from Tosh Nala near Tosh SHEP Power House site
14	**W14**	**Parbati-II**	Samples collected from Parbati river upstream of diversion site of Parbati II HEP
15	**W15**	**Parbati-II**	Samples collected from Parbati river downstream of Parbati river-Tosh Nala confluence near diversion site of Parbati II HEP (Pulga Dam site)
16	**W16**	**Parbati-II**	Samples collected from Parbati river downstream of Pulga Dam Site
17	**W17**	**Balargha**	Samples collected from Parbati river near diversion site of under construction Balargha HEP
18	**W18**	**Malana-III**	Samples collected from Malana Nala upstream of Malana II HEP reservoir
19	**W19**	**Malana-II**	Samples collected from Malana Nala downstream of Malana II HEP Dam site near Malana village
20	**W20**	**Malana-II**	Samples collected from Malana Nala downstream of Malana-II HEP Power House site
21	**W21**	**Malana-I**	Samples collected from Malana Nala downstream of Malana-I HEP diversion site
22	**W22**	**Malana-I**	Samples collected from Malana nala near upstream of Malana-I Power house site
23	**W23**	**Parbati**	Samples collected from Parbati river near Jari village located near Malana and Parbati river

S.No.	Sampling Site	Project	Remarks
			confluence
24	**W24**	**Sharni**	Samples collected from Parbati river downstream of Malana nala confluence with Parbati river downstream of Jari village
25	**W25**	**Sarsadi**	Samples collected from Parbati river upstream of Sarsadi village located near the Highway connecting Kullu-Bhuntar to Parbati Valley
26	**W26**	**Sarsadi-II**	Samples collected from Parbati river downstream of Sarsadi village
27	**W27**	**Hurla-I**	Samples collected from Hurla nala near the confluence of Hurla nala with Beas river
28	**W28**	**Sainj**	Samples collected from Sainj Khad upstream of diversion site of Sainj HEP
29	**W29**	**Sainj**	Samples collected from Sainj Khad upstream of Power house site of Sainj HEP
30	**W30**	**Parbati-III**	Samples collected from Sainj Khad downstream of Jiwa nala confluence with Sainj Khad
31	**W31**	**Parbati-III**	Samples collected from Sainj Khad downstream of Parbati III HEP diversion site
32	**W32**	**Parbati-III**	Samples collected from Sainj Khad near Tail race outlet of Parbati III HEP
33	**W33**	**Patikari**	Samples collected from Bakhli Khad near Power house site of Patikari HEP
34	**W34**	**Larji**	Samples collected from Beas river near diversion site of Larji HEP near Aut village
35	**W35**	**Larji**	Samples collected from Beas river downstream of Larji HEP Power House site
36	**W36**	**BSL**	Samples collected from Beas river about 5000m upstream of Pandoh Dam reservoir tail
37	**W37**	**BSL**	Samples collected from Pandoh dam reservoir on Beas river
38	**W38**	**BSL**	Samples collected from Beas river about 500m downstream of Pandoh dam
39	**W39**	**Lambadug**	Samples collected from Lambadug Nala at Lambadug HEP diversion site near Lohardi village
40	**W40**	**Uhl**	Samples collected from Uhl river near Barot village a hilly tourist place. Barot Trout fish hatchery is dependent upon water from Uhl Khad and Lambagug Nala for water supply
41	**W41**	**Uhl-I**	Samples collected from Uhl river downstream of Uhl Khad and Lambadug Nala confluence near Uhl-I diversion site located near Barot village
42	**W42**	**Uhl-II**	Samples collected from Neri Khad a tributary of Rana Khad and is located near Bassi Power House (Uhl-II HEP) near Joginder Nagar town. Bassi Power House (Uhl-II HEP) is tailrace development of Shanon Power House (Uhl-I HEP)
43	**W43**	**Uhl-III**	Samples collected from Rana Khad a right bank tributary of Beas river near Joginder Nagar town in project area of Uhl-III HEP which is tailrace development of Bassi Power House (Uhl-II HEP).
44	**W44**	**Uhl-III**	Samples collected from Beas river downstream of confluence of Rana Khad with Beas river near the Power House of Uhl-III HEP is located in the right bank of Beas river
45	**W45**	**Lower Uhl**	Samples collected from Uhl river downstream of proposed Powerhouse site of Lower Uhl HEP near Kamand village
46	**W46**	**Uhl Khad**	Samples collected from Uhl river upstream of confluence of Uhl khad with Beas river at PH location of UHL Khad HEP which is lower most proposed project on Uhl river

S.No.	Sampling Site	Project	Remarks
47	**W47**	**Binwa**	Samples collected from Binwa Khad downstream of Power house site of Binwa HEP. Binwa Khad is right bank tributary of Beas river and near this site a Baijnath temple and Paprola Railway station is located on the bank of Binwa Khad.
48	**W48**	**Kilhi Bahl**	Samples collected from Binwa Khad near proposed diversion site of Kilhi Bahl HEP
49	**W49**	**Neogal**	Samples collected from Neugal Khad near Neugal HEP Power house site located nearby Palampur town. Neugal Khad is right bank tributary of Beas river. Water from Neugal khad is also utilized by villagers for irrigation purpose.
50	**W50**	**Baner**	Samples collected from Baner Khad near Baner HEP Power House site. Kangra town is adjacent to the Baner Khad. Villagers depend on Baner Khad for irrigation.
51	**W51**	**Baner-II**	Samples collected from Baner Khad downstream of Baner II HEP diversion site
52	**W52**	**Gaj**	Samples collected from Gaj Khad near diversion site of Gaj HEP
53	**W53**	**Khauli**	Samples collected from Khauli Khad near Power House site of Khauli HEP
54	**W54**	**Thana Plaun**	Samples collected from Beas river downstream of Mandi town
55	**W55**	**Thana Plaun**	Samples collected from Beas river upstream of confluence of Rana Khad with Beas river near proposed diversion site of Thana Palun HEP
56	**W56**	**Triveni Mahadev**	Samples collected from Beas river upstream of confluence of Binwa Khad with Beas river near proposed diversion site of Triveni Mahadev HEP
57	**W57**	**Dhaulasidh**	Samples collected from Beas river upstream of confluence of Kunah Khad with Beas river and downstream of proposed diversion site of Dhaulasidh HEP
58	**W58**	**Pong Dam**	Samples collected from Beas river 500m upstream of Pong dam reservoir tail near Dehra village
59	**W59**	**Pong Dam**	Samples collected from Beas river upstream of Pong dam reservoir

7.2.1 Beas I Sub-basin

The Beas I sub-basin is comprised of the catchment of Beas river up to its confluence with Duhangan near Jagatsukh village. Six water sampling sites were located in Beas river and its tributaries (Allain Nalah and Duhangan Nallah).

Temperature, Dissolved Oxygen and pH

Water temperature during surveys in Beas river and its tributary streams varied from season to season and ranged from -1.80°C to 8.3°C. Minimum water temperature was recorded from site W1 located near diversion site of Beas Kund HEP diversion site ranged from 1.8 to 2.0°C (**Figure 7.1).**

Dissolved Oxygen during the water sampling during monsoon season was recorded lowest (8.2 mg/l to 9.5 mg/l). Minimum DO value was observed from sampling site W3 (Beas River near proposed Bhang HEP) and highest (9.5 mg/l) at W5 (Allain nala), while during pre-monsoon it ranged from 8.4 mg/l to 9.7 mg/l (**Figure 7.1**). During the winter season sampling i.e. DO was recorded in range of 8.6- 9.4 mg/l at all the sampling sites (**Figure 7.1**).

The pH of water at most of the sampling sites during pre-monsoon was observed to be slightly alkaline in nature as it ranged between 6.3 to 7.46 and was highest at site W2 (Beas river near Palchan Bhang HEP) and lowest at W1 (Beas Kund HEP diversion site). The pH of water didn't vary much during Monsoon and Winter it varied from 6.62 to 7.87 and 6.0 to 7.65 respectively (**Figure 7.1**).

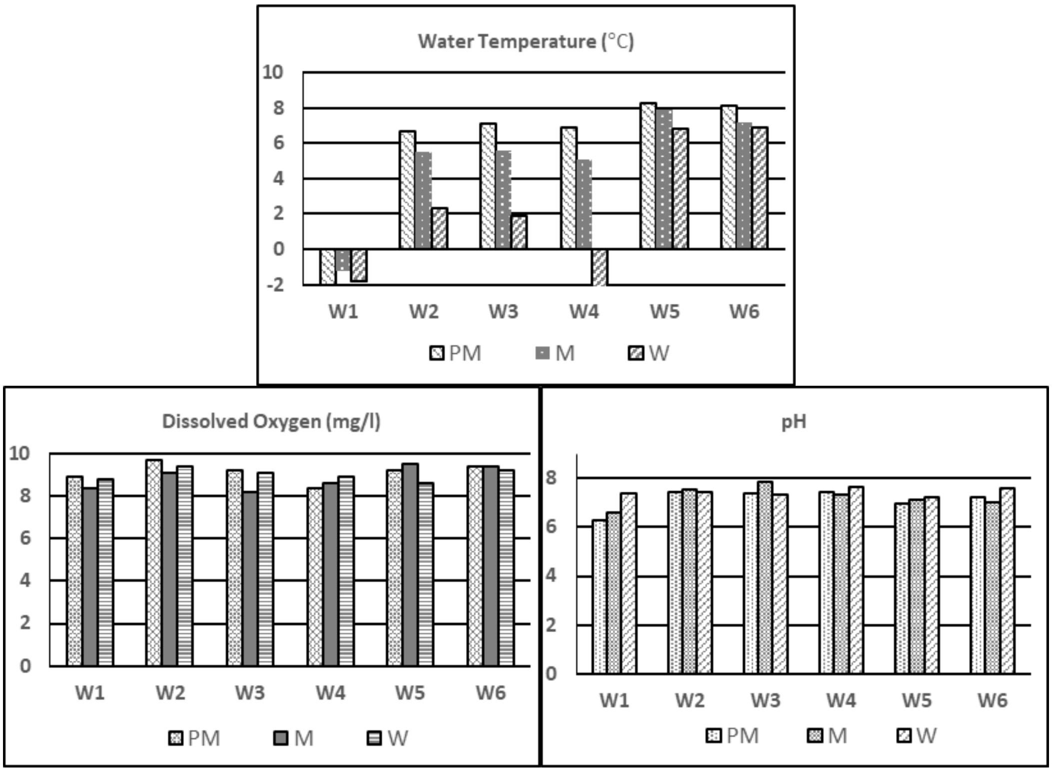


Figure 7.1: Seasonal variation in Water temperature, pH and DO in Beas I Sub-basin

(PM=Pre-monsoon; M=Monsoon; W=Winter; W1-W6 : Sampling sites)

Total Suspended Solids, Turbidity, Total Dissolved Solids and Electrical Conductivity

It can be seen from the (**Figure 7.2)** total suspended solids were higher during the monsoon season sampling period while Total suspended solids (TSS) ranged between 1.6 and 56 mg/l and Turbidity in the river water at all the sampling locations was quite low. The water of Beas river and its tributaries remains very clear and transparent throughout the year except during the occasional rains which brings silt into the river making it slightly turbid for few days only and there after which becomes clear again.

Total Dissolved Solids (TDS) and Electrical conductivity (EC) were higher during monsoon season sampling period when TDS was in the range of 50 to 81.7 mg/l (**Figure 7.2**) and EC was in the range of 82 to 134 μS.

Total Hardness, Calcium, Magnesium and Chlorides

Variation in Total Hardness, Calcium and Magnesium concentrations at different sampling sites during different sampling periods is given at (**Figure 7.3)**. Total hardness of water ranged from 9.8 mg/l (at W3 – Allain Nalah) during summer to 37.3 mg/l (at sampling site W1-Beas River) during winter season sampling. Calcium and Magnesium values followed the similar pattern as total hardness is sum total of calcium hardness and magnesium hardness.

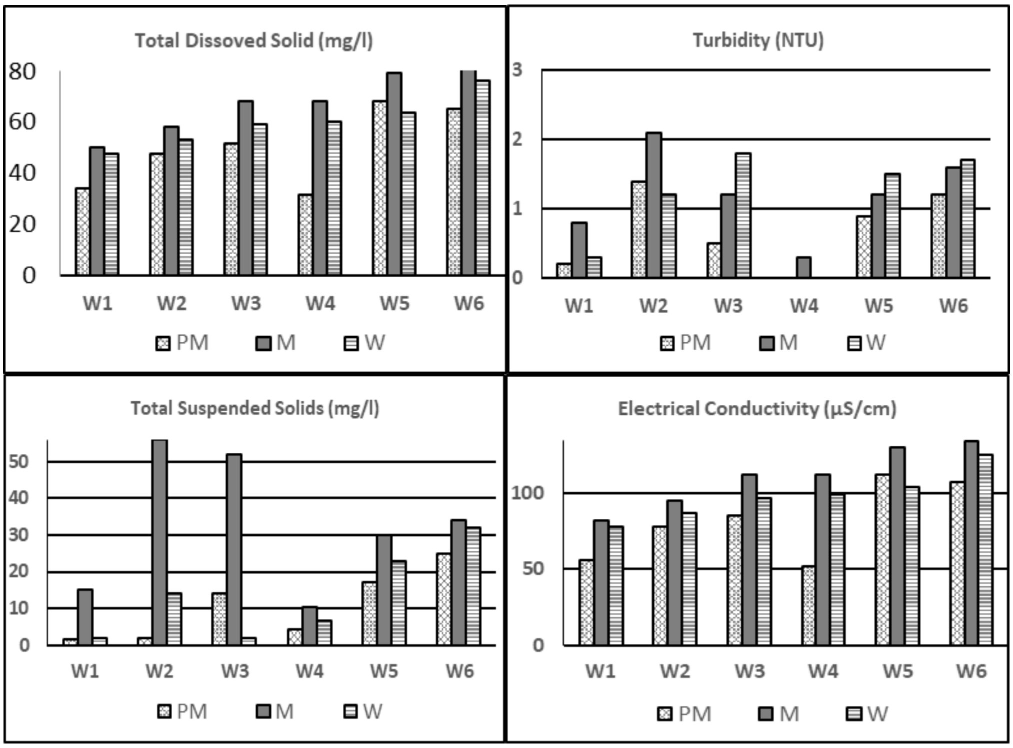


Figure 7.2: Seasonal variation in Total suspended solids, Turbidity, Total dissolved solids and Electrical conductivity in Beas I sub-basin

(PM=Pre-monsoon; M=Monsoon; W=Winter; W1-W6 : Sampling sites)

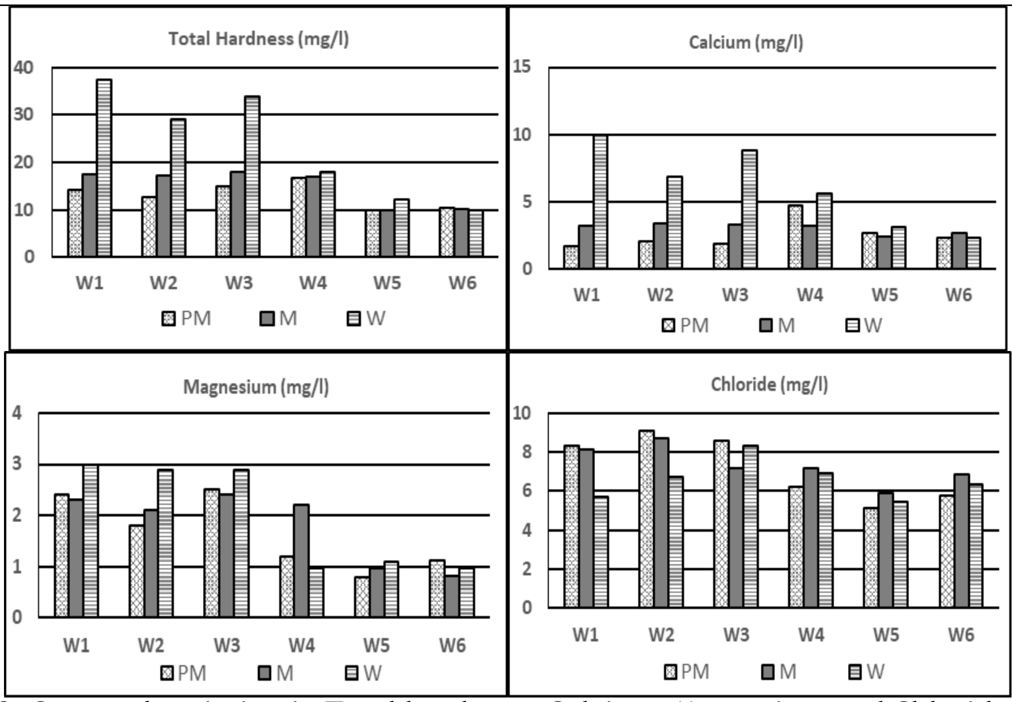


Figure 7.3: Seasonal variation in Total hardness, Calcium, Magnesium and Chlorides in Beas I sub-basin

(PM=Pre-monsoon; M=Monsoon; W=Winter; W1-W6 : Sampling sites)

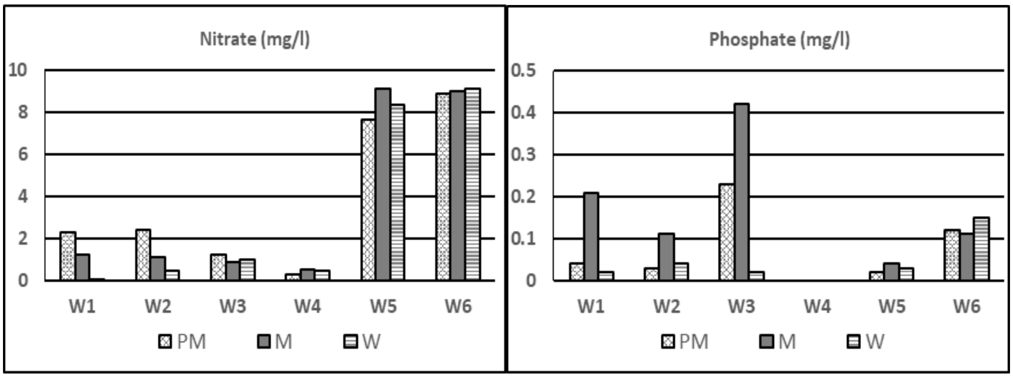
Nitrates, Phosphates, Potassium and Sodium

The nitrate concentration was quite low during the study period and it varied between 0.04 mg/l (lowest values recorded at sampling site W1-Beas kund during winter) and 9.15 mg/l (highest at site W5 – Allain Nalah during monsoon). In general nitrate concentrations throughout the study area were low (**Figure 7.4**).

Phosphates followed the pattern of nitrates and in fact were much lower than nitrate concentrations. While its concentration was negligible during post-monsoon period and maximum concentration was recorded during monsoon season varied from 0.04 to 0.042 mg/l (**Figure 7.4**).

Potassium was recorded with low concentrations at all the sampling sites during the study period (**Figure 7.4**). Its values varied from low of 0.11 mg/l (at W2- Palchan Bhang during monsoon season) to high of 1.0 mg/l (at W4 – Jobrie during winter season).

The concentrations of sodium were very low during the entire study period at all sampling sites and different seasons (**Figure 7.4**).



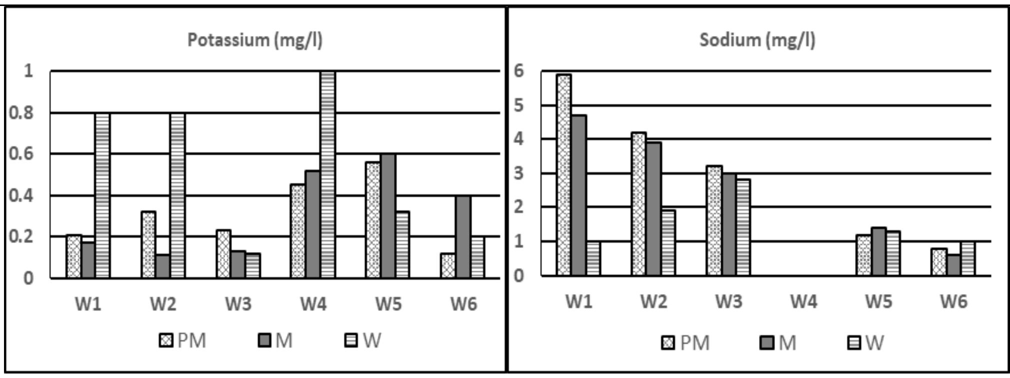


Figure 7.4: Seasonal pattern in values of Nitrates, Phosphates, Potassium and Sodium in Beas I Sub-basin

(PM=Pre-monsoon; M=Monsoon; W=Winter; W1-W6: Sampling sites)

BOD, COD and Total Coliforms

BOD at all sampling sites were varied from negiligible at W1- during all seasons to maximum of 1.5 mg/l (at W5 – Allain nalah during winter season and at W6-Duhangan nalah during monsoon season). COD also followed the pattern of BOD and it was nil at sites W1 & W3. Coliforms were detected only from W2-Palchan Bhang, W3- Beas river near Bhang Village and W5 Allain nalah near Jagatsukh village sampling sites. The qualtities of Coliforms were maximum during monsoon season i.e. 920 MPN/100 ml from sampling site W5 and minimum 47 MPN/100ml at sampling site W2 (**Figure 7.5**).

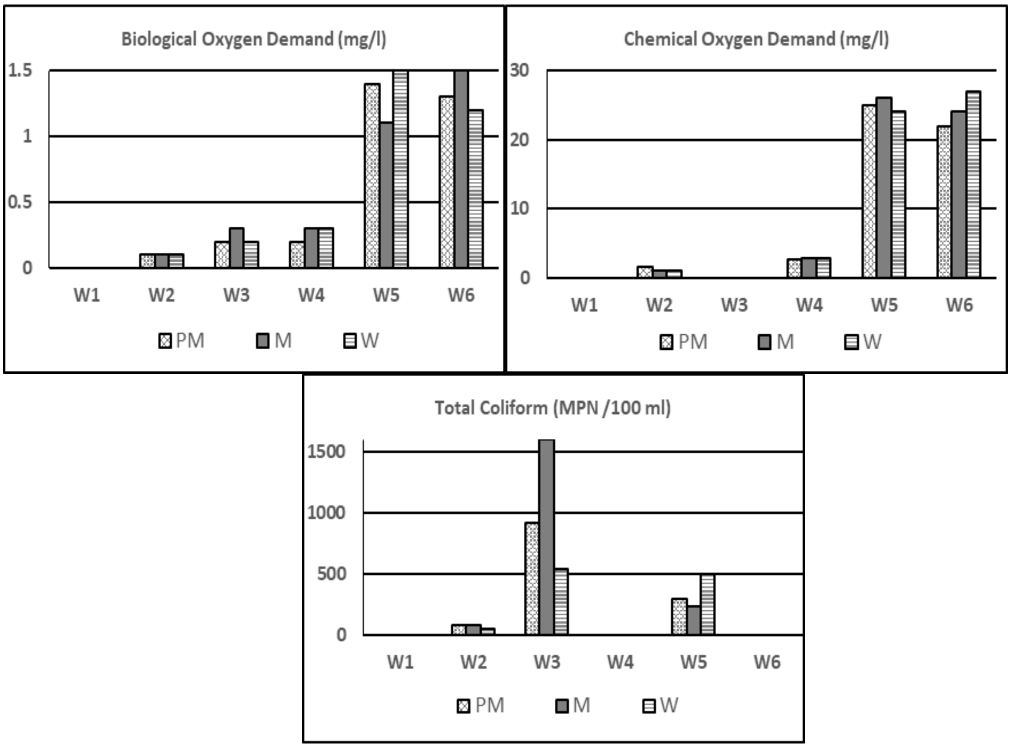


Figure 7.5: Seasonal pattern in BOD, COD and Total Coliforms in Beas I Sub-basin

(PM=Pre-monsoon; M=Monsoon; W=Winter; W1-W6 : Sampling sites)

7.2.2 Beas II Sub-basin

Beas II Sub-basin is comprised of catchment area of Beas River between the confluence point of Duhangan nala with river Beas near Jagatsukh village and confluence point of Parbati River with river Beas near Bhuntar in Kullu district. Sampling sites in Beas II sub-basin were located in Sanjoin Nalah, Fozal Nalah and Sarbari Khad (W7 to W9).

Temperature, Dissolved Oxygen and pH

Water temperature varied from season to season and ranged from 8.9°C to 14.3°C. Maximum water temperature was recorded at site W9 located in Sarbari Khad and minimum during winter at sampling site W7 located in Sanjoin Nalah (**Figure 7.6).**

Concentration of Dissolved Oxygen (DO) was recorded lowest (8.1 mg/l) during pre-monsoon season at sampling site W7 located in Sanjoin nalah and minimum DO value was observed from sampling site W9 (10 mg/l) at site W9-Sarbari khad during winter season (**Figure 7.6**).

The pH of water was slightly alkaline in nature at all sampling sites and didn't vary much during different seasons. pH value at all sites during different season ranged between 7.48 and 7.91 and was highest at site W7 (at Sanjoin Nala) during summer season and lowest at W8 during winter season (at Fozal Nala) (**Figure 7.6**).

Total Suspended Solids and Turbidity

It can be seen from the (**Figure 7.7)** total suspended solids in the river water recorded maximum (site W7-located in sanjoin nalah) during all the season but remain sampling locations was quite low resulting in negligible turbidity in the river and streams. The water of Beas river and its tributaries remains very clear and transparent throughout the year except during occasional rains which brings silt into the river making it slightly turbid for few days only and thereafter which becomes clear again.

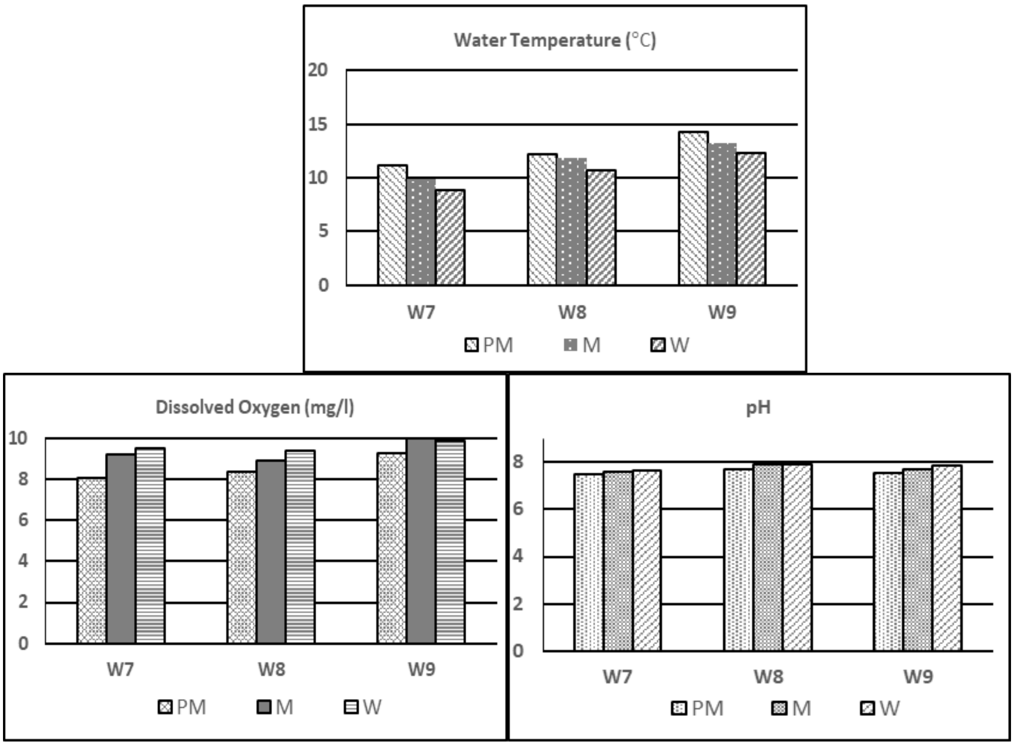


Figure 7.6: Seasonal variation in Water temperature, pH and DO at different sampling sites in Beas II sub-basin

(PM=Pre-monsoon; M=Monsoon; W=Winter; W7-W9: Sampling sites)

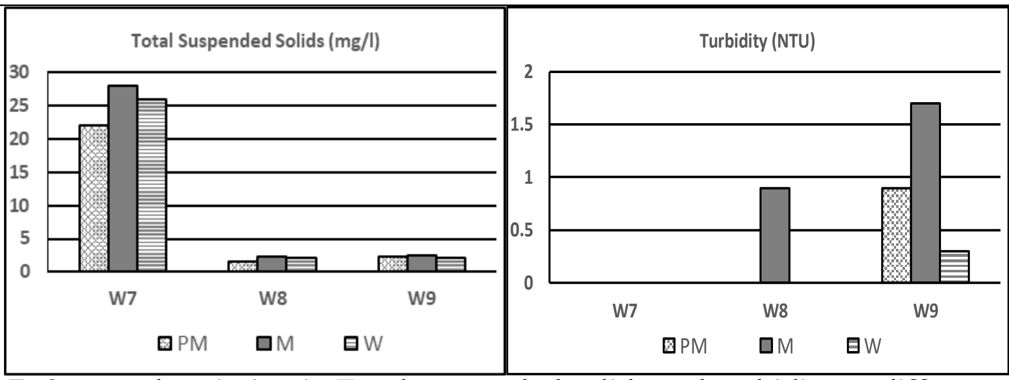


Figure 7.7: Seasonal variation in Total suspended solids and turbidity at different sampling sites in Beas II sub-basin

(PM=Pre-monsoon; M=Monsoon; W=Winter; W7-W9 : Sampling sites)

Total Dissolved Solids and Electrical Conductivity

Total Dissolved Solids (TDS) and Electrical conductivity (EC) were higher during monsoon season sampling when TDS was in the range of 54.3mg/l in Fozal nala to 60.4 mg/l in Sanjoin nalah and EC was in the range of 89 μS/cm in Fozal nala to 99μS/cm in Sanjoin nalah. Overall values of Total Dissolved Solids and Electrical varied from 45.1 mg/l – 60.4 mg/l and 74μS/cm–99μS/cm, respectively at different sampling locations during the study period (**Figure 7.8**).

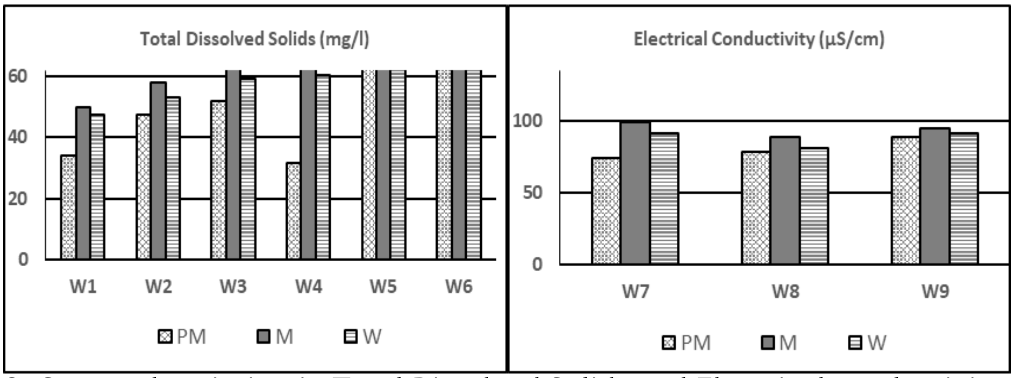


Figure 7.8: Seasonal variation in Total Dissolved Solids and Electrical conductivity in Beas II sub-basin

(PM=Pre-monsoon; M=Monsoon; W=Winter; W7-W9 : Sampling sites)

Total Hardness, Calcium, Magnesium and Chlorides

No seasonal variation in Total Hardness, Calcium and Magnesium concentrations was recorded in all three sampling sites (**Figure 7.9**). Total hardness of water ranged from 20.6 mg/l to (at W7 – Sanjoin nalah) to 29.4 mg/l (at sampling site W8-Fozal nalah) during pre-monsoon. Total Hardness varied between 23.4 mg/l (at sampling site W7-sanjoin nalah during monsoon) and 27.6 mg/l (at sampling site W9 – Sarbari khad). During winter total hardness were varied from low of 22.1 mg/l (at sampling site W7-sanjoin nalah) to high of 30.4 mg/l (at sampling site W8-Fozal nalah).

Calcium and Magnesium values followed the similar pattern and recorded highest at sampling site W8 (Fozal nalah) and lowest value was recorded for sampling site W7 (Sanjoin nalah).

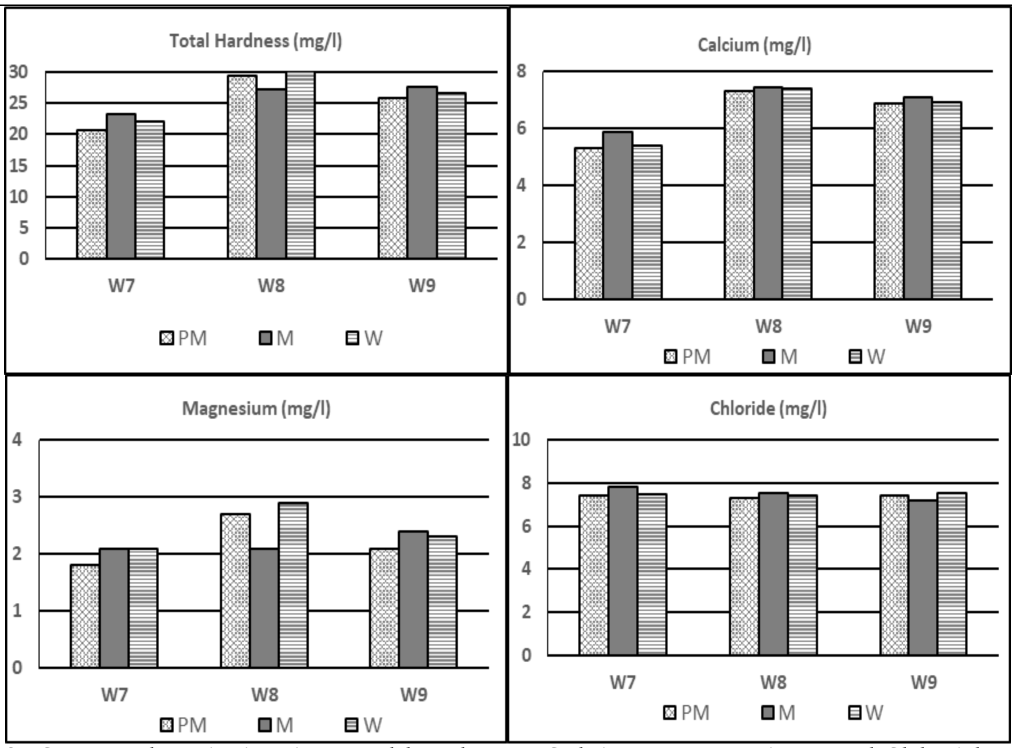


Figure 7.9: Seasonal variation in Total hardness, Calcium, Magnesium and Chlorides in Beas II sub-basin

(PM=Pre-monsoon; M=Monsoon; W=Winter; W7-W9 : Sampling sites)

Nitrates, Phosphates, Potassium and Sodium

The concentration of nitrate was low in all three sampling locations during the study period and it varied between 0.3 mg/l (lowest values recorded at sampling site W9-Sarbari khad during summer) and 0.8 mg/l (highest at site W7–Sanjoin Nalah during monsoon) (**Figure 7.10**). No seasonal variation in nitrate value was observed at all three sites.

Concentration of Phosphate was negligible at all the sampling sites varied from 0.02 mg/l to 0.07 mg/l (**Figure 7.10**). Potassium too was recorded with low concentrations at all the sampling sites during the study period (**Figure 7.10**). Its values varied from low of 0.3 mg/l (at W9-Sarbari khad during pre-monsoon season) to high of 1.3 mg/l (at W8– Fozal nalah during monsoon season). Maximum concentration was recorded from sampling site located in Fozal nalah (**Figure 7.10**).

The concentration of sodium was very low at sampling site located in Sanjoin Nalah, ranged between 0.6 mg/l (monsoon season) to 0.8 mg/l (pre monsoon season). While during the entire study period the maximum values for sodium was recorded from Fozal nalah and varied from 1.7 mg/l (summer and winter season) to 1.8 mg/l (monsoon season) (**Figure 7.10**).

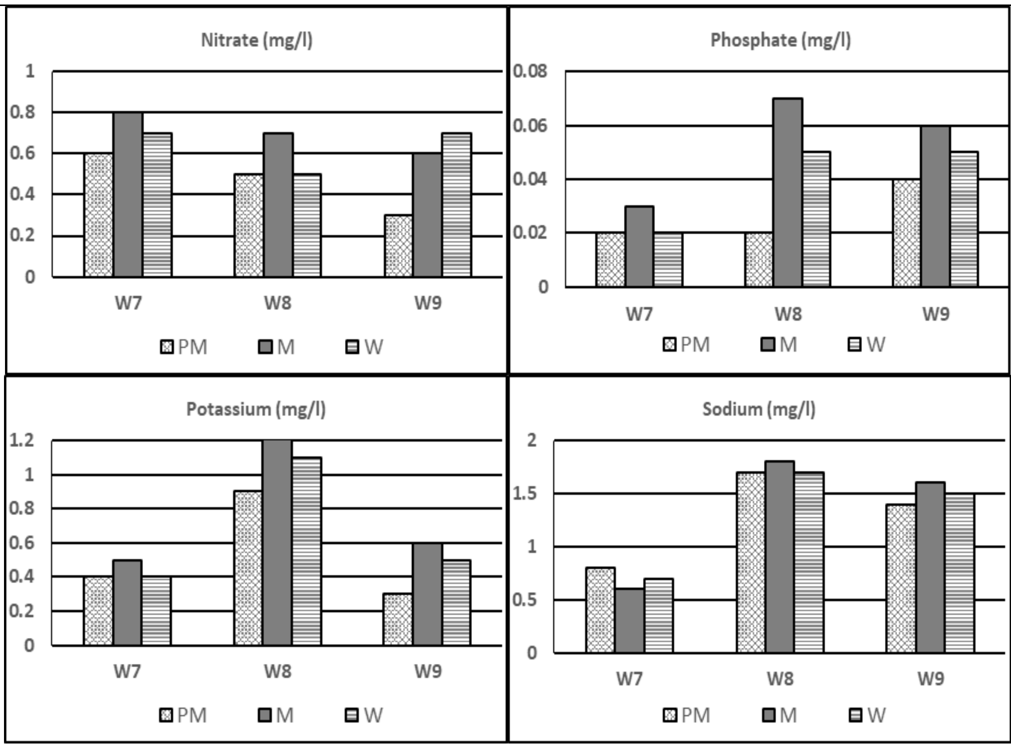


Figure 7.10: Seasonal variation in Nitrates, phosphates, potassium and sodium data in Beas II sub-basin

(PM=Pre-monsoon; M=Monsoon; W=Winter; W7-W9 : Sampling sites)

BOD, COD and Total Coliforms

BOD at all sampling sites varied from low of 0.1mg/l (at W9-Sarbari khad in winter season) to high of 0.89 mg/l (at W7 –Sanjoin nalah during monsoon season). COD values were higher at W7 and W8 and nil at W9. Coliforms were detected only at sampling sites W7 (Sanjoin nalah) and W8 (Fozal nalah). Coliforms were detected maximum quantities during winter season i.e. 220 MPN/100 ml at sampling site W8 (Fozal nalah) and minimum 110 MPN/100ml at sampling site W7 (Sanjoin Nalah). At sampling site W9 (Sarbari Khad) coliforms were absent during sampling period (**Figure 7.11**).

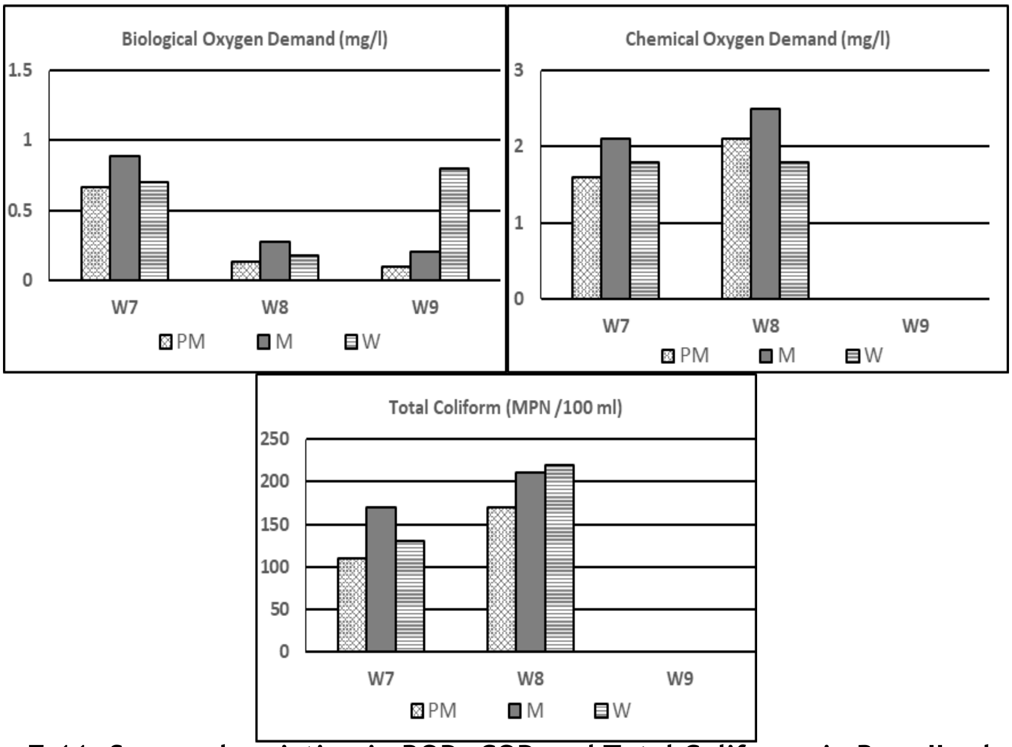


Figure 7.11: Seasonal variation in BOD, COD and Total Coliforms in Beas II sub-basin

(PM=Pre-monsoon; M=Monsoon; W=Winter; W7-W9 : Sampling sites)

7.2.3 Parbati Upper Sub-basin

This area consists of catchment of Parbati river up to Parbati and Malana Nala confluence. Water samples were collected from 8 sites located in Parbati river and Tosh Nala.

Temperature, Dissolved Oxygen and pH

The water temperature at all sampling sites varied from minimum 10.3°C at sampling site W12 (Tosh Nalah) during winter and maximum 17.6°C at sampling site W14 (Parbati River) during pre-monsoon season (**Figure 7.12**).

Dissolved oxygen values varied from minimum 7.5 mg/l to maximum 9.5 mg/l, as highest value of DO was found at sampling site W17 at Parbati river near diversion site of Balargah HEP in monsoon season (**Figure 7.12**). During sampling at different season the DO value varied from 7.6 mg/l to 8.5 mg/l during summer season, in monsoon season value of DO ranged between 7.5 to 9.5 mg/l at various sampling locations and during winter season sampling the value of DO varied from 7.8 to 8.9 mg/l.

The pH value of Tosh and Parbati river at all sampling sites shows slightly alkaline nature of water. It varied from 7.06- 7.98 during sampling period (**Figure 7.12**).

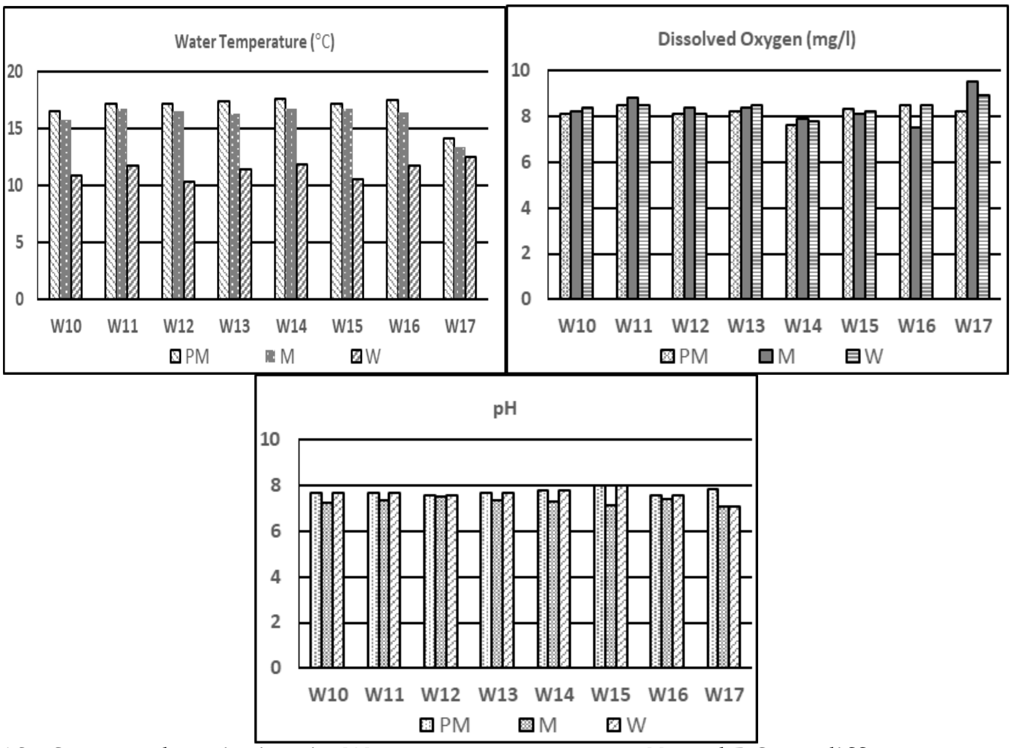


Figure 7.12: Seasonal variation in Water temperature, pH and DO at different sampling sites in Parbati Upper Sub-basin

(PM=Pre-monsoon; M=Monsoon; W=Winter; W10-W17 : Sampling sites)

Total Suspended Solids, Turbidity, Total Dissolved Solids and Electrical Conductivity

During winter season sampling Total suspended solids (TSS) in the Parbati river and Tosh Nalah water at all the sampling locations was quite low resulting in negligible turbidity in the river. During pre-monsoon and monsoon season water become slightly turbid and concentration of TSS was also increase. Maximum concentration of TSS was observed during monsoon season at sampling site W16 (34 mg/l) at Parbati river, while minimum (9mg/l) during winter season sampling from sample collected from Tosh Nalah (**Figure 7.13**).

Overall values of Total Dissolved Solids and Electrical Conductivity varied from 80.5 – 114.1 mg/l and 112μS/cm–187μS/cm, respectively at different sampling locations during the study period (**Figure 7.13**).

Total Dissolved Solids (TDS) and Electrical conductivity (EC) was higher during monsoon season sampling period when TDS was in the range of 34.10 to 183.43 mg/l and EC was in the range of 132 µS/cm to 187µS/cm (**Figure 7.13**).

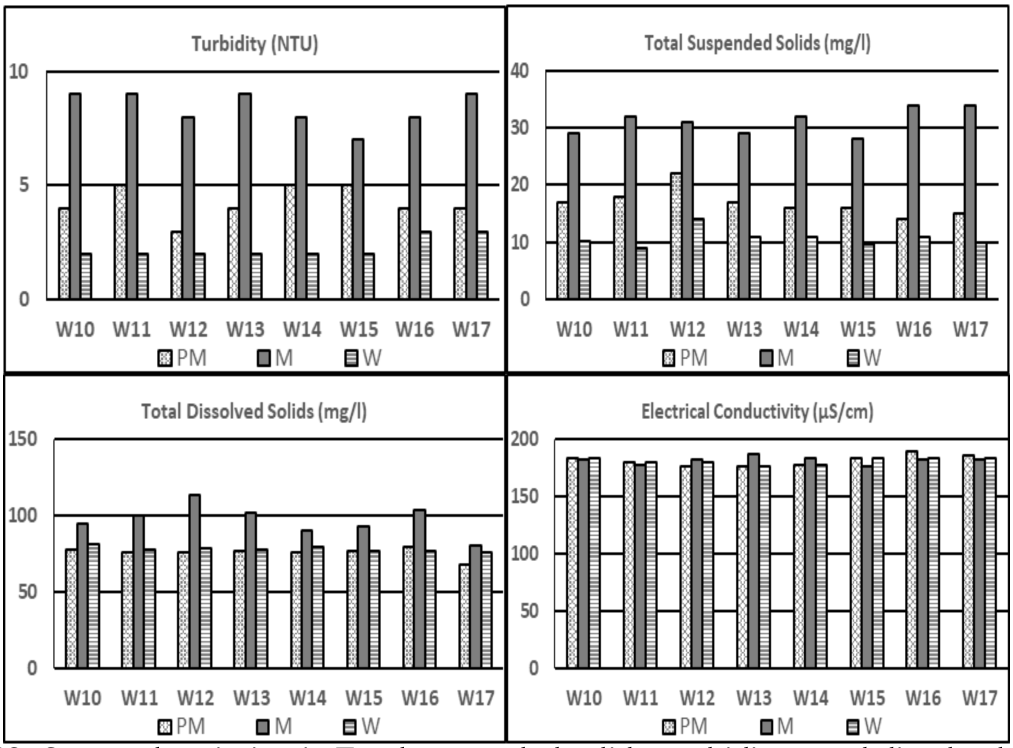


Figure 7.13: Seasonal variation in Total suspended solids, turbidity, total dissolved solids and Electrical conductivity at different sampling sites in Parbati Upper Sub-basin

(PM=Pre-monsoon; M=Monsoon; W=Winter; W10-W17 : Sampling sites)

Total Hardness, Calcium, Magnesium and Chlorides

Variation in Total Hardness, Calcium and Magnesium concentrations at different sampling sites during different sampling periods is given at (**Figure 7.14**). Total hardness of water ranged from 176.3 mg/l (at W13- Tosh nalah) to 190.3 mg/l (at W16- Parbati river, down stream of Parbati II HEP Dam site). Calcium and Magnesium values followed the similar pattern as total hardness is sum total of calcium and magnesium.

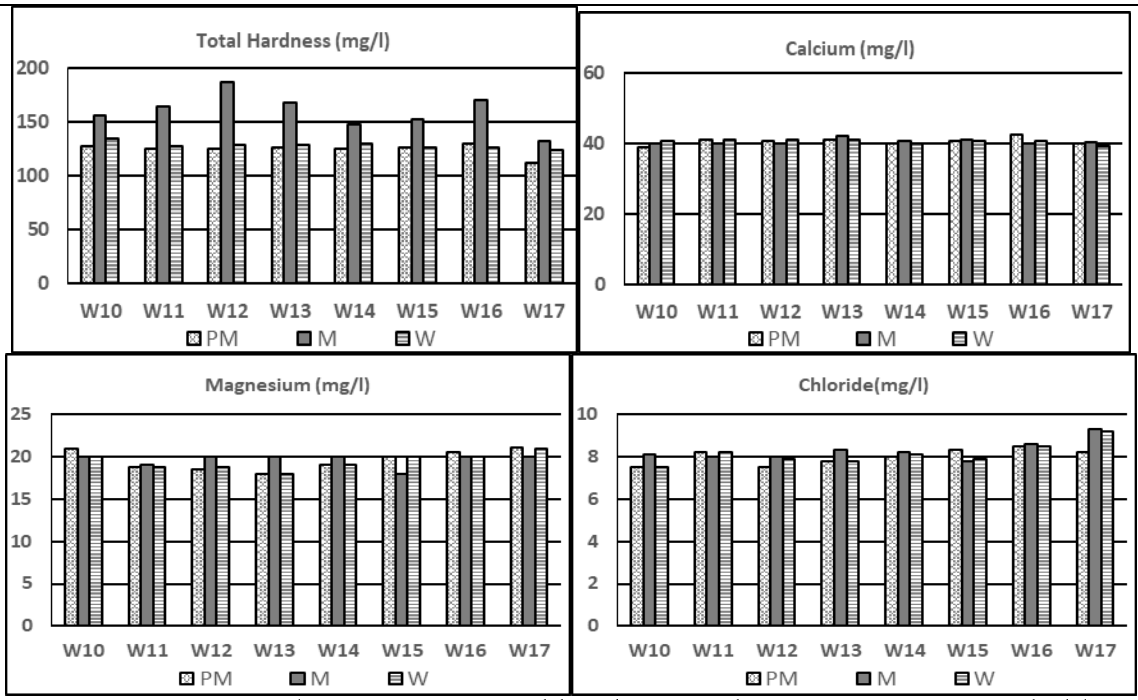


Figure 7.14: Seasonal variation in Total hardness, Calcium, Magnesium and Chlorides in Parbati Upper Sub-basin

(PM=Pre-monsoon; M=Monsoon; W=Winter; W10-W17: Sampling sites)

Nitrates, Phosphates, Potassium and Sodium

Phosphate and nitrate concentrations were observed very low in the water samples collected during the study (**Figure 7.15**). Potassium and sodium was recorded with low concentrations at all the sampling sites during the study period (**Figure 7.15**). Potassium values varied from low of 1.1 mg/l (at W14- Parbati river, upstream of parbati II HEP during pre-monsoon season) to high of 1.5 mg/l (at W15 upstream of parbati river during winter season). Concentration of Sodium in river water ranged from minimum 2.32 mg/l at sampling site W10-Nalthan and W13- Tosh nalah during pre-season to maximum 3.35 mg/l at sampling site W16-downstream of Parbati II HEP during monsoon season).

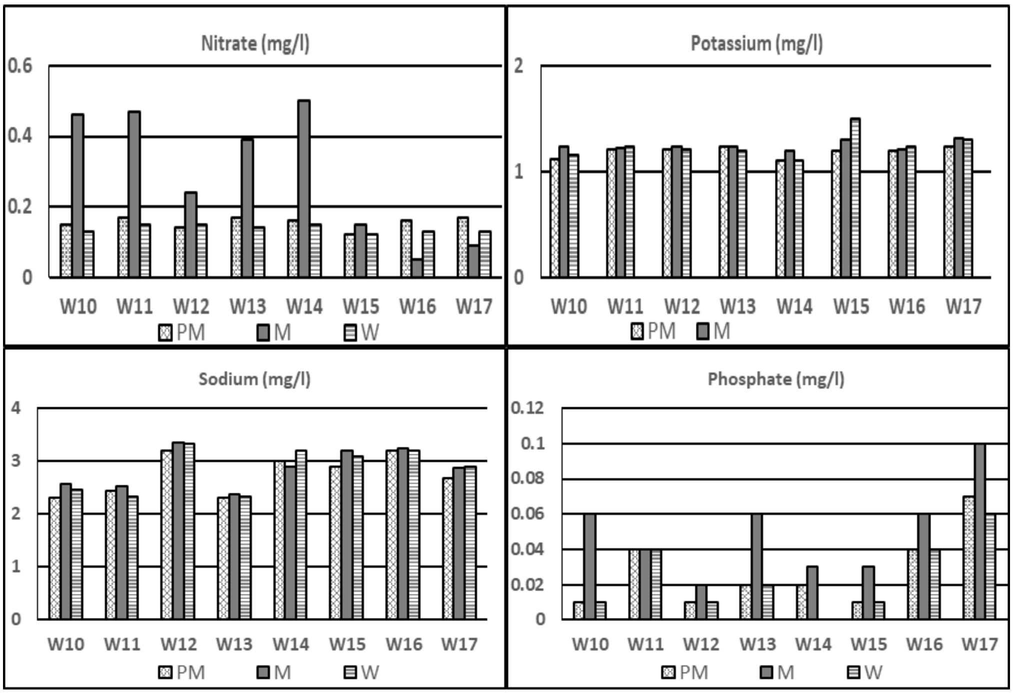


Figure 7.15: Seasonal variation in Nitrate, phosphate, sodium and potassium at different sampling sites in Parbati Upper Sub-basin

(PM=Pre-monsoon; M=Monsoon; W=Winter; W10-W17 : Sampling sites)

BOD, COD and Total Coliforms

BOD concentration was very low in varied from 0.1 mg/l to 1.8 mg/l. Similarly, Coliforms could only detected from sampling site W17 at Parbati river (near diversion site of Balargah HEP). The pattern of COD similar to BOD at all the sites. The count of Coliforms varied from 21 MPN/100ml during monsoon to 110 MPN/100ml during pre-monsoon season sampling (**Figure 7.16**).

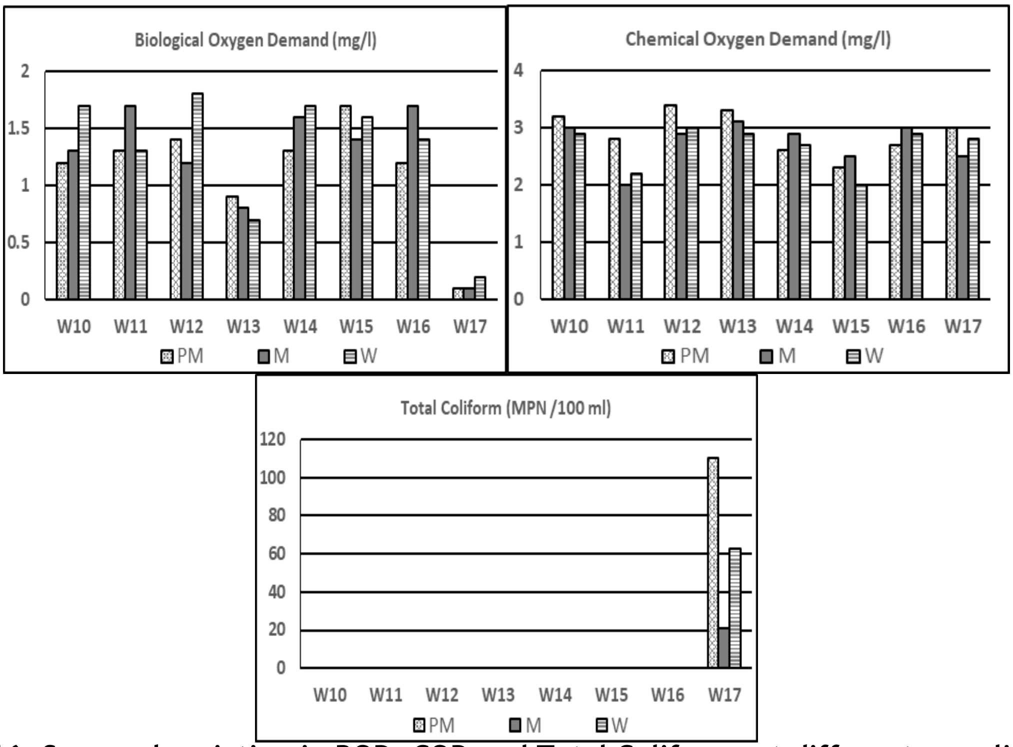


Figure 7.16: Seasonal variation in BOD, COD and Total Coliforms at different sampling sites in Parbati Upper Sub-basin

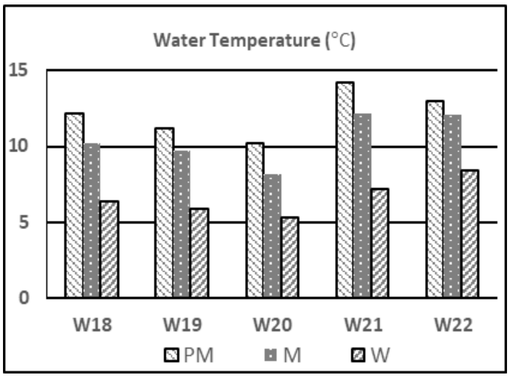
(PM=Pre-monsoon; M=Monsoon; W=Winter; W10-W17 : Sampling sites)

7.2.4 Malana Sub-basin

Malana Sub-basin comprises of the catchment area of Malana Nala, a right bank tributary of river Parbati.

Temperature, Dissolved Oxygen and pH

The temperature of the river water ranged from 5.3°C to 14.2°C during sampling. The pH of at most of the sampling sites was almost slightly alkaline. It varied from 6.7- 7.32. Dissolved Oxygen value ranged between 8.2 mg/l to 9.7 mg/l in various season (**Figure 7.17**).



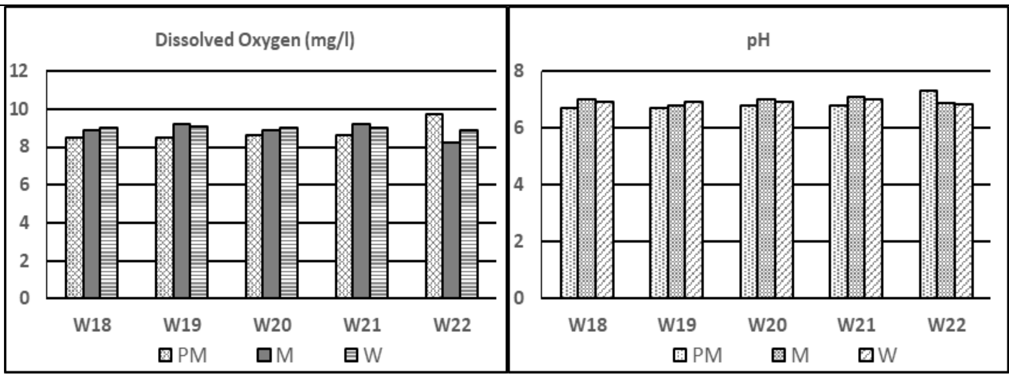


Figure 7.17: Seasonal variation in Water temperature, pH and DO at different sampling sites in Malana Sub-basin

(PM=Pre-monsoon; M=Monsoon; W=Winter; W18-W22 : Sampling sites)

<u>**Total Suspended Solids, Turbidity, Total Dissolved Solids and Electrical Conductivity**</u>

It can be seen from the Figure 7.17 total suspended solids in the river water at all the sampling locations was quite low resulting in negligible turbidity in the river. The water of Malana river and its tributaries remains very clear and transparent throughout the year except during occasional rains which brings silt into the river making it slightly turbid for few days only and thereafter which becomes clear again.

The Electrical conductivity (EC) and Total Dissolved Solids (TDS) values were observed between 10µS/cm to 29 µS/cm and 6.1 to 17.7 mg/l respectively. Total Suspended Solid (TSS) values were observed in lower side and varied between 1.01 mg/l and 6.2 mg/l (**Figure 7.18**).

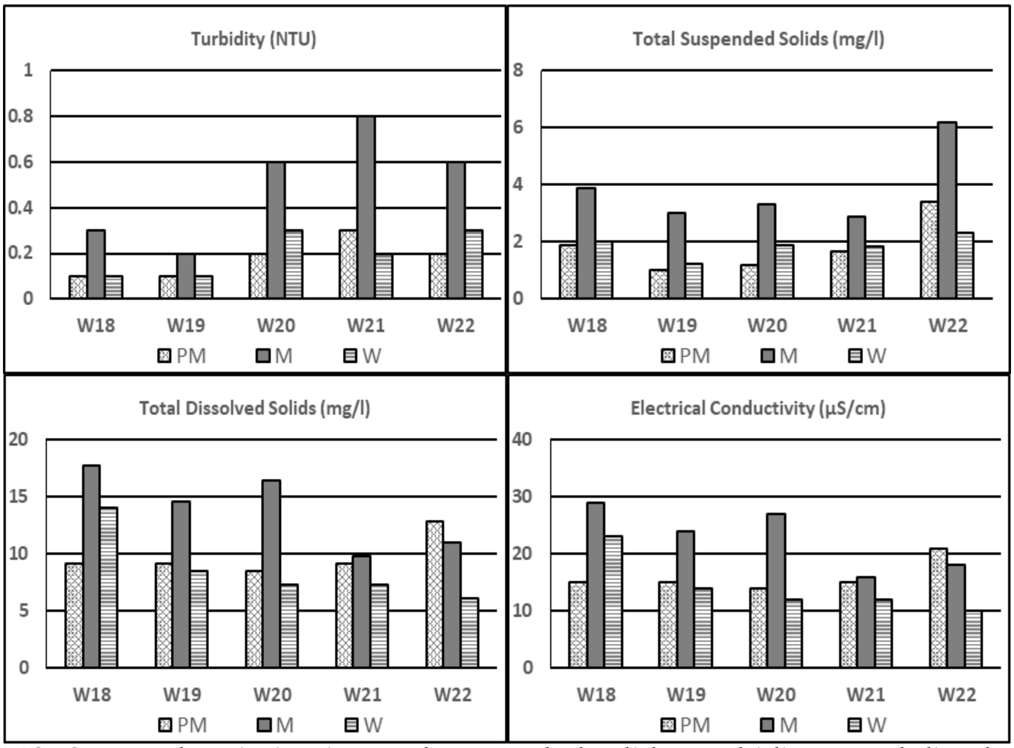


Figure 7.18: Seasonal variation in Total suspended solids, Turbidity, Total dissolved solids and Electrical conductivity at different sampling sites in Malana Sub-basin

(PM=Pre-monsoon; M=Monsoon; W=Winter; W18-W22 : Sampling sites)

Total Hardness, Calcium, Magnesium and Chlorides

Water hardness depends on concentration of Calcium and Magnesium ions in water. Concentration of Calcium and Magnesium varied from 2.9 mg/l to 3.9 mg/l and 0.1 mg/l to 0.8 mg/l respectively. Hardness in the river water ranged from 8.8 mg/l to 11.8 mg/l at various sampling locations (**Figure 7.19**).

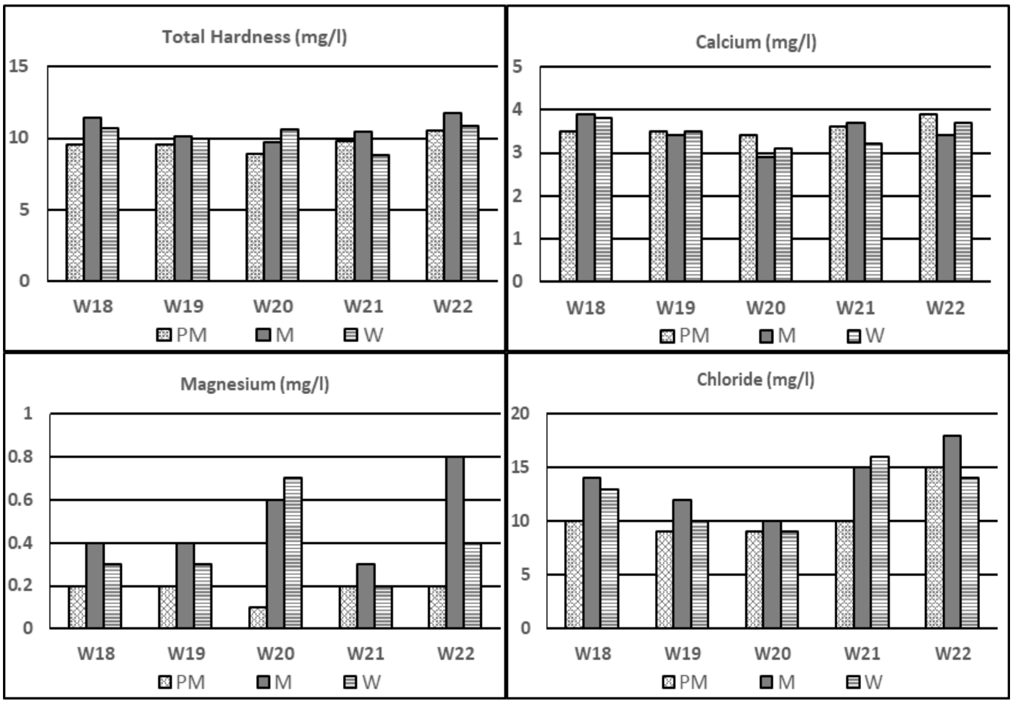
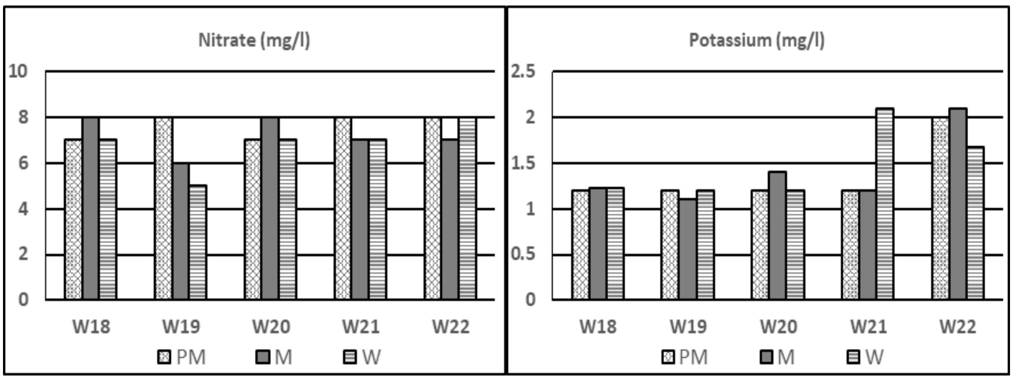


Figure 7.19: Seasonal variation in Total hardness, Calcium, Magnesium and Chlorides at different sampling sites in Malana Sub-basin

(PM=Pre-monsoon; M=Monsoon; W=Winter; W18-W22: Sampling sites)

Nitrates, Phosphates, Potassium and Sodium

A concentration of Phosphate in Malana was observed very low in the water samples collected during the study (**Figure 7.20**). Potassium was recorded with low concentration at all the sampling sites during the study period ranged from 1.1 to 2.1 mg/l and respectively (**Figure 7.20**). While values for nitrate varied low of 5.0 mg/l to high of 8 mg/l. Concentration of Sodium in river water ranged from minimum 2.6 to 4.1 mg/l.



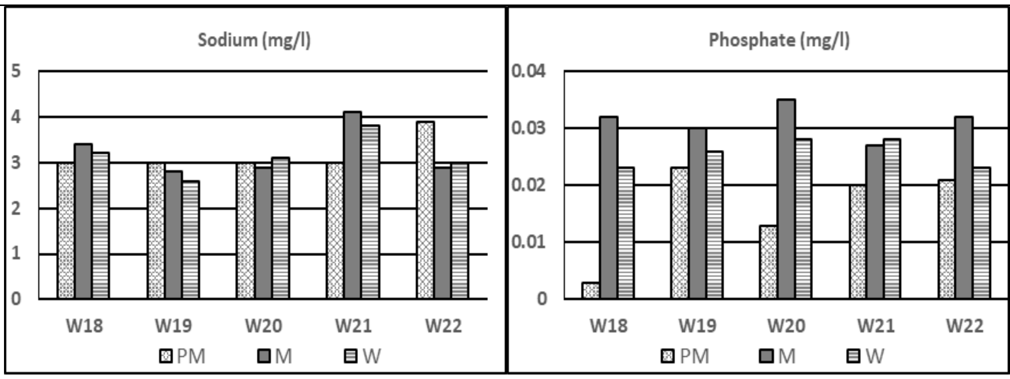


Figure 7.20: Seasonal variation in Nitrates, phosphates, potassium and sodium at different sampling sites in Malana Sub-basin

(PM=Pre-monsoon; M=Monsoon; W=Winter; W18-W22 : Sampling sites)

BOD, COD and Total Coliforms

Biological Oxygen Demand (BOD) values in the water samples collected during various seasons were found low during the study period, ranged between 0.1 mg/l to 1.40 mg/l (**Figure 7.21**). COD values were more or less similar to BOD. Coliforms were detected from all sampling sites their value varied from 2 MPN/100ml to 210 MPN/100ml. Highest quantities of coliforms were recorded from sampling site W22 (near confluence of Malana Nala with Parbati river) where it ranged between 120 MPN/100ml and 210 MPN/100ml.

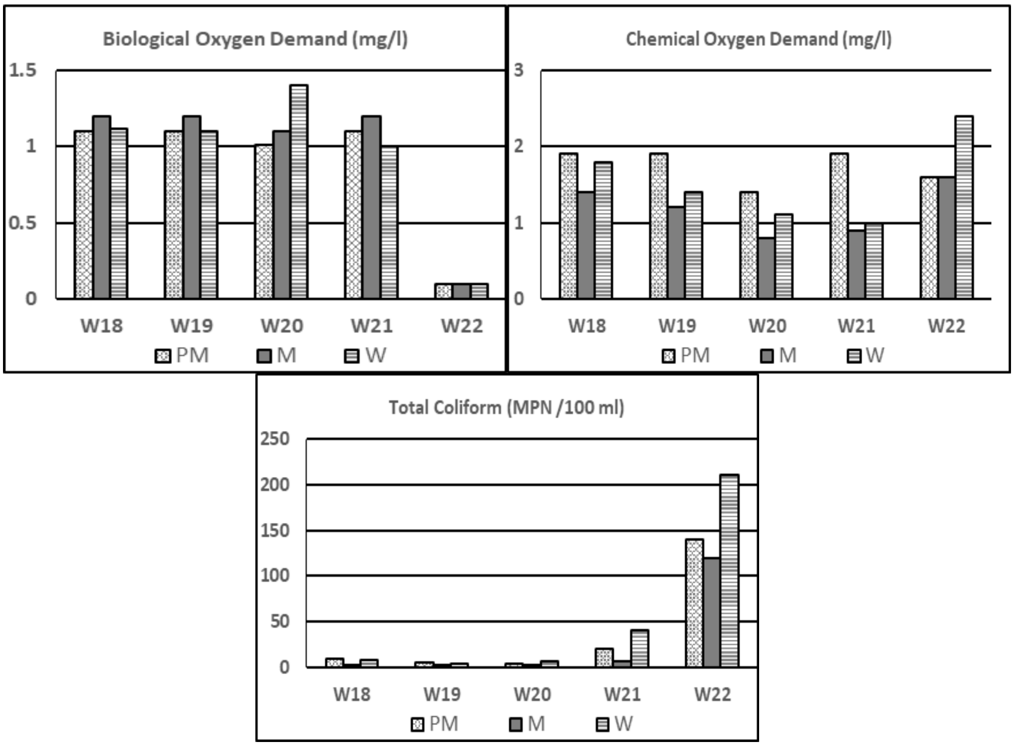


Figure 7.21: Seasonal variation in BOD, COD and Total Coliforms at different sampling sites in Malana Sub-basin

(PM=Pre-monsoon; M=Monsoon; W=Winter; W18-W22: Sampling sites)

7.2.5 Parbati Lower Sub-basin

Parbati Lower sub-basin comprises of the catchment area of Parbati river from its confluence with Malana nala till it meets river Beas at Bhuntar.

Temperature, Dissolved Oxygen and pH

The temperature of the river water ranged from 9.7°C to 14.8°C during sampling. The pH of water didn't vary much and during various sampling season. The pH at all sampling sites was almost slightly alkaline in nature. It varied from 6.4 to 7.86. Dissolved Oxygen (DO) value ranged between 8.2 mg/l to 9.5 mg/l in various months. Concentration of DO have similar pattern at sampling sites and no seasonal variation in DO was observed during sampling period (**Figure 7.22**).

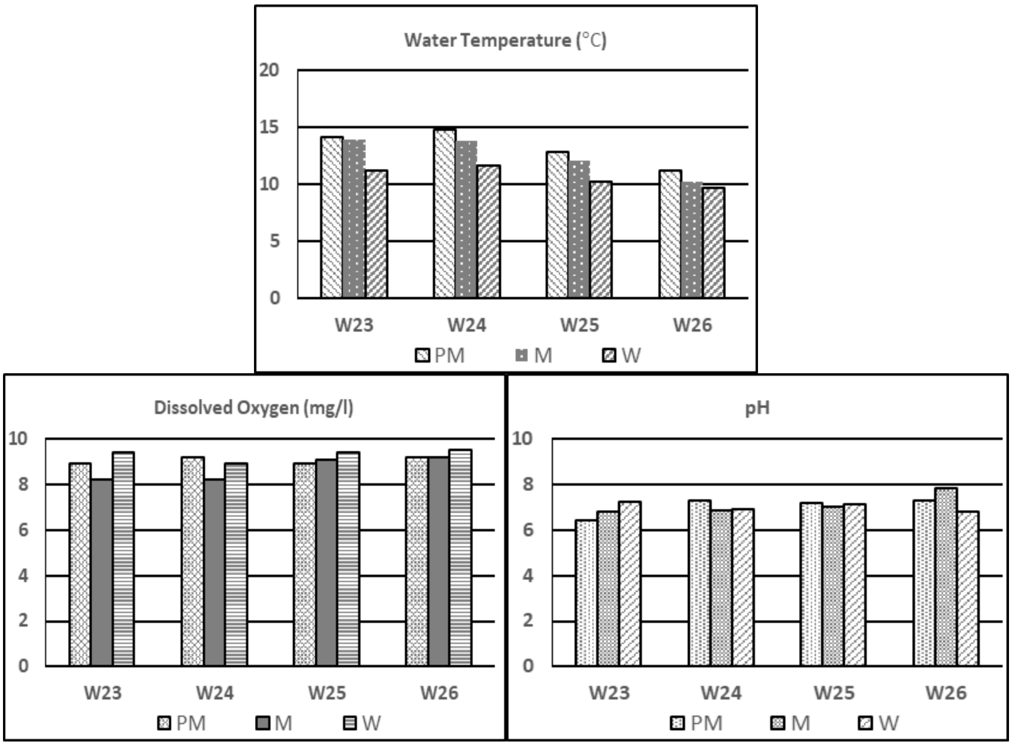
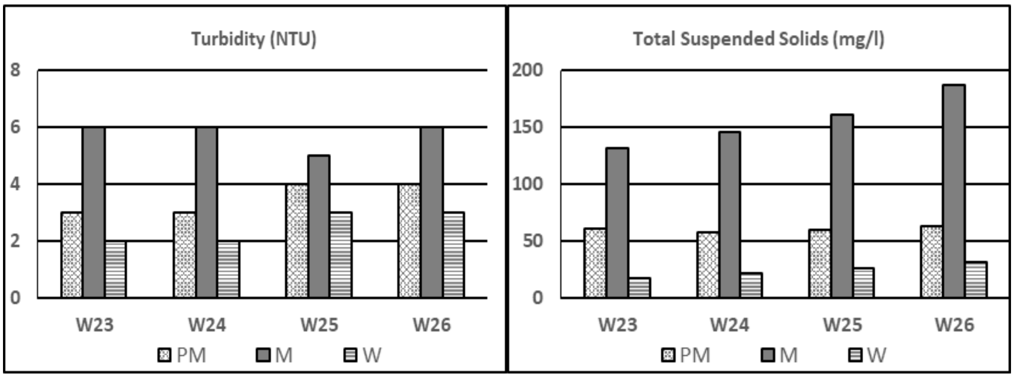


Figure 7.22: Seasonal variation in Water temperature, pH and DO at different sampling sites in Parbati Lower sub-basin

(PM=Pre-monsoon; M=Monsoon; W=Winter; W23-W26 : Sampling sites)

Total Suspended Solids, Turbidity, Total Dissolved Solids and Electrical Conductivity

The Electrical conductivity (EC) and Total Dissolved Solids (TDS) values were observed between 23µS/cm to 90 µS/cm and 14 mg/l to 54.9 mg/l respectively. Total Suspended Solid (TSS) values were observed in between 18 mg/l and 187 mg/l (**Figure 7.23**). Higher values of TSS were observed during monsoon season which varied from 132mg/l (W23-downstream conference of Malana and Parbati river) to 184 mg/l (W26- Parbati river, downstream of Sarsardi village).



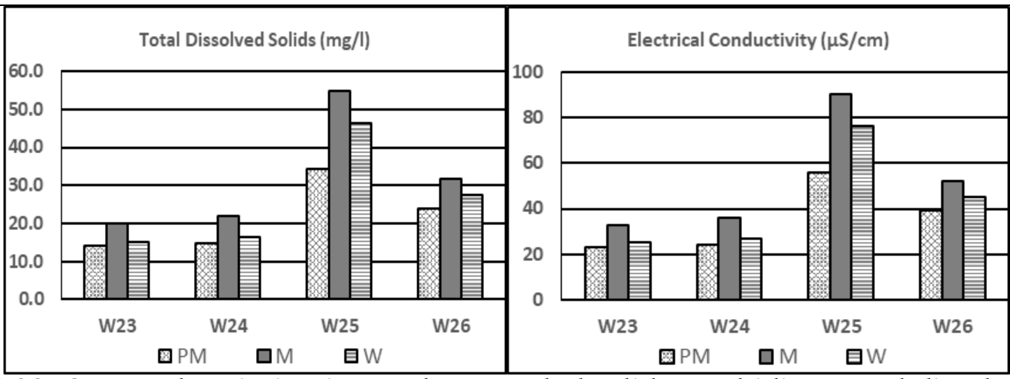


Figure 7.23: Seasonal variation in Total suspended solids, Turbidity, Total dissolved solids and Electrical conductivity at different sampling sites in Parbati Lower Sub-basin

(PM=Pre-monsoon; M=Monsoon; W=Winter; W23-W26 : Sampling sites)

Total Hardness, Calcium, Magnesium and Chlorides

Total hardness concentration varied from 26.2 mg/l to 55.0 mg/l in various seasons. Hardness value was observed in higher side in sampling sites in lower stretch of Parbati lower sub-basin comprising with sampling sites W25-Parbati river, near sarsadi village and W26- Parbati river, downstream of Sarsadi village. While no significant seasonal variation in hardness values was observed during sampling period. Calcium and Magnesium ion concentration varied between 5.9 mg/l to 16.9 mg/l and 2.3 mg/l to 4.1 mg/l, respectively (**Figure 7.24).**

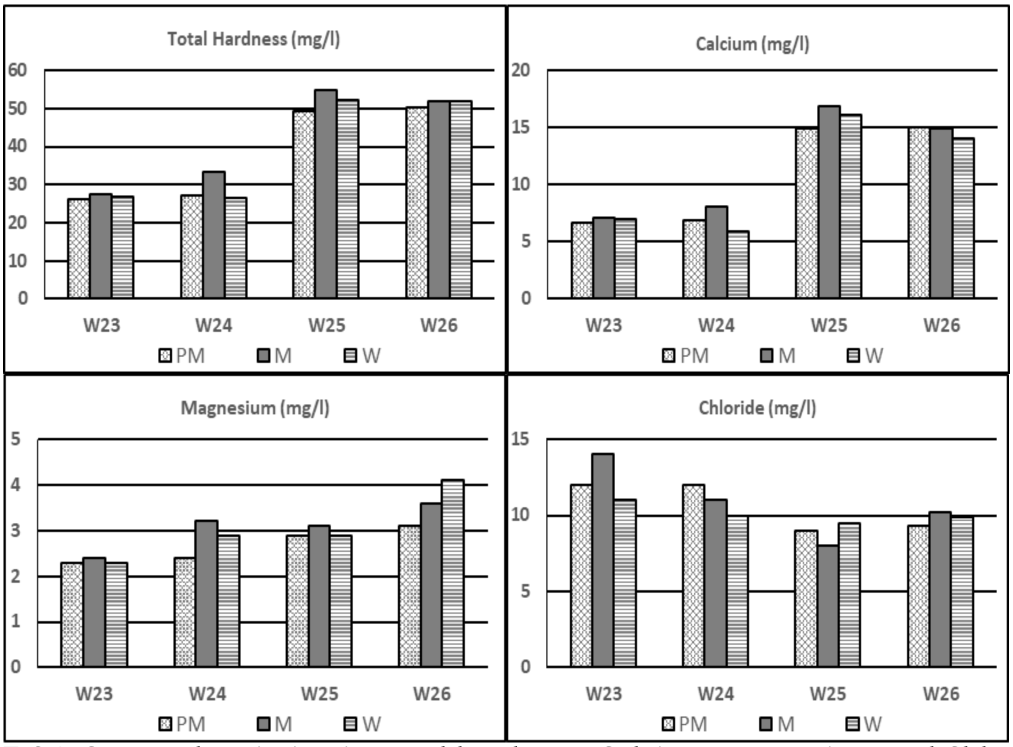


Figure 7.24: Seasonal variation in Total hardness, Calcium, Magnesium and Chlorides in Parbati Lower Sub-basin

(PM=Pre-monsoon; M=Monsoon; W=Winter; W23-W26 : Sampling sites)

Nitrates, Phosphates, Potassium and Sodium

Concentration of Phosphate, Sodium and Potassium were observed very low in the water samples collected during the study. While Nitrate concentration varied from 2.1 mg/l to 10 mg/l in the study area (**Figure 7.25).**

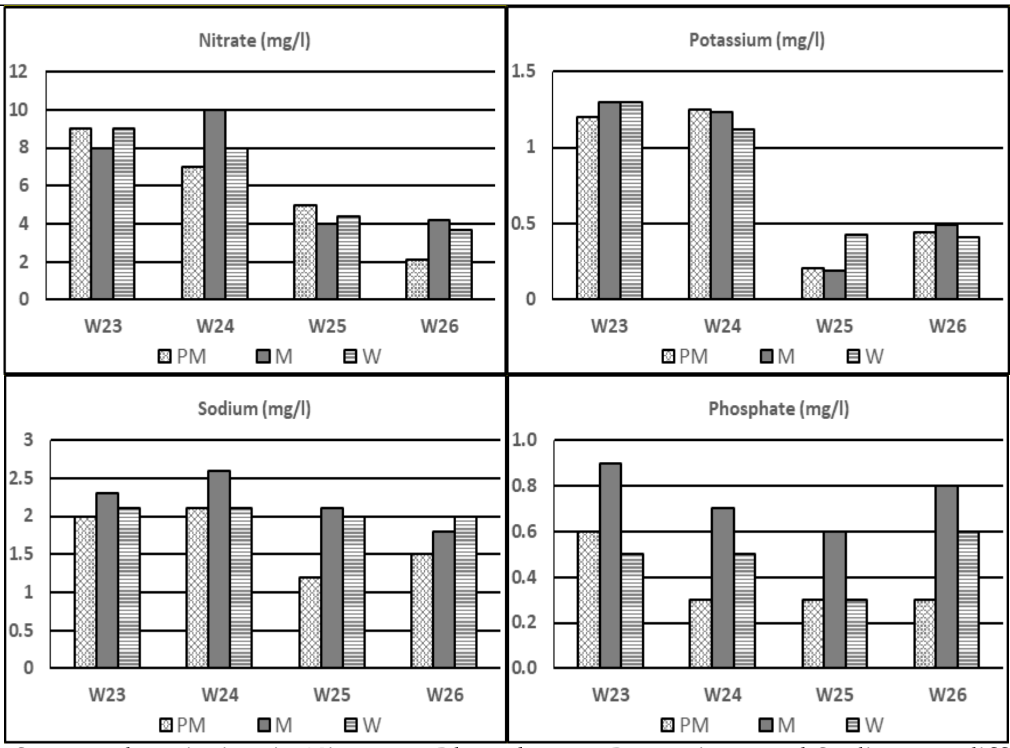


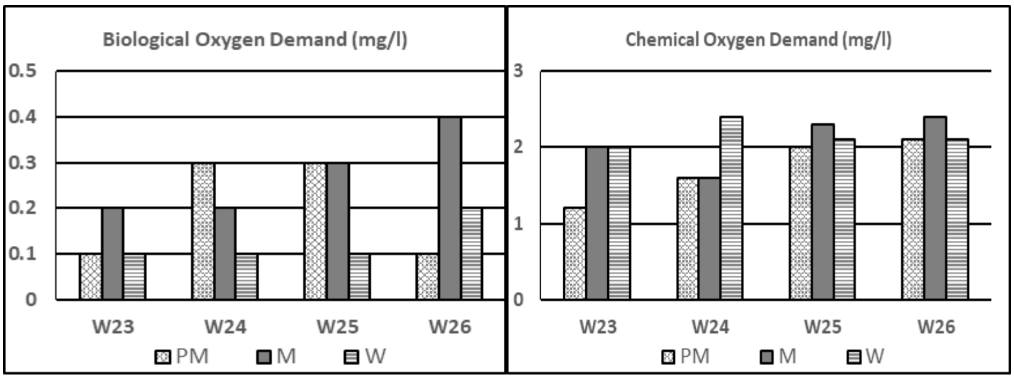
Figure 7.25: Seasonal variation in Nitrates, Phosphates, Potassium and Sodium at different sampling sites in Parbati Lower Sub-basin

(PM=Pre-monsoon; M=Monsoon; W=Winter; W23-W26 : Sampling sites)

BOD, COD and Total Coliforms

Biological Oxygen Demand (BOD) values in the samples were found low during the study, ranged between 0.1 mg/l to 04 mg/l (**Figure 7.26**). Count of Coliforms were detected maximum during winter season i.e. 210 MPN/100 ml from sampling site W26-Parbati river, near Sarsadi village and minimum 142 MPN/100ml from sampling site W23-downstream conference of malana and Parbati river (**Figure 7.26).**

Count of Coliforms were maximum during winter season i.e. 210 MPN/100 ml and minimum during monsoon 76 MPN/100 ml followed by sampling site W26-Parbati river, downstream of Sarsadi village and W24 (**Figure 7.26).**



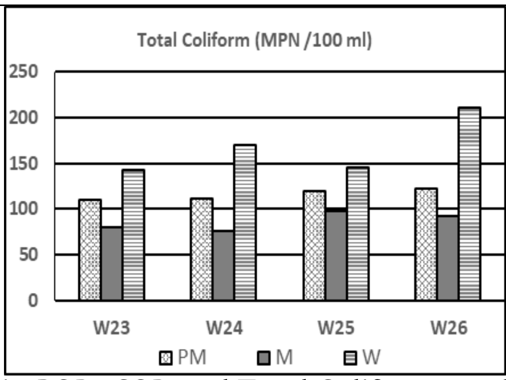


Figure 7.26: Seasonal variation in BOD, COD and Total Coliforms at different sampling sites in Parbati Lower Sub-basin

(PM=Pre-monsoon; M=Monsoon; W=Winter; W23-W26 : Sampling sites)

7.2.6 Sainj Sub-basin

Sainj sub-basin comprises of the catchment area of Beas river from its confluence with Parbati river and upto its confluence with Sainj khad near dam site of Larji HEP. In Sainj sub-basin Sampling sites were located in two major tributaries of Beas river i.e. Hurla Nala and Sainj khad.

The water temperature of Hurla Nala ranged from 10.3°C to 12.2°C during sampling. While in Sainj khad water temperature varied from minimum 10.1°C during winter to 14.2°C during summer season. The pH values of both Hurla and Sainj khad varied from 6.91 to 7.89. Dissolved Oxygen value ranged between 8.0 mg/l to 10.5 mg/l in various months (**Figure 7.27**).

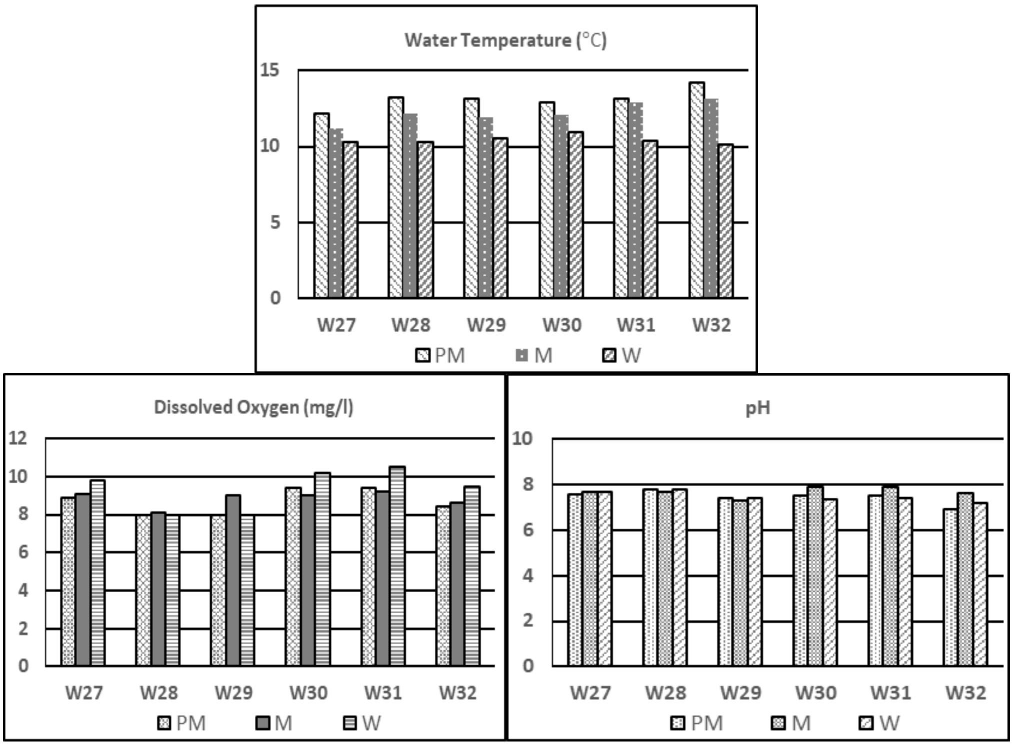


Figure 7.27: Seasonal variation in Water temperature, pH and DO at different sampling sites in Sainj Sub-basin

(PM=Pre-monsoon; M=Monsoon; W=Winter; W27-W32 : Sampling sites)

Total Suspended Solids, Turbidity, Total Dissolved Solids and Electrical Conductivity

The Electrical conductivity (EC) and Total Dissolved Solids (TDS) values for Hurla nala were observed between 32.0µS/cm to 84.0 µS/cm and 19.5 to 51.2 mg/l respectively. While in Sainjkhad value of EC varied from minimum 130 µS/cm during winter season sampling to 160 µS/cm during monsoon season. Similarly the TDS value was observed minimum in winter season (79.3 mg/l) and maximum during monsoon season (97.6 mg/l) (**Figure 7.28**).

Total Suspended Solids (TSS) values were observed in lower side for Hurla nala varied between 1.8 mg/l to 8.2 mg/l (**Figure 7.28**). In Sainj khad TSS values varied from 12.2 mg/l to 54.2 mg/l. The maximum value of TSS was observed during monsoon season at sampling site W30 near Jiwa nala confluence with Sainj khad and minimum during winter season near sampling site W28 in Sainj Khad (upstream of Sainj HEP Dam site).

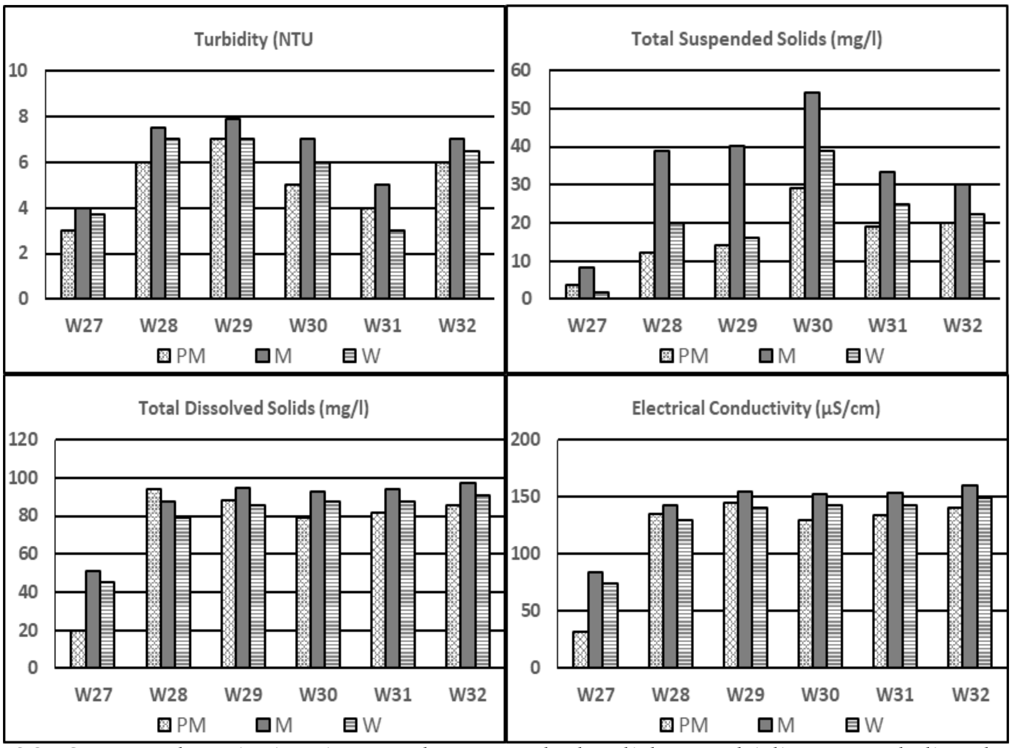


Figure 7.28: Seasonal variation in Total suspended solids, Turbidity, Total dissolved solids and Electrical conductivity at different sampling sites in Sainj sub-basin

(PM=Pre-monsoon; M=Monsoon; W=Winter; W27-W32 : Sampling sites)

Total Hardness, Calcium, Magnesium and Chlorides

Total Hardness in Sainj khad and Hurla nala waters varied from 41.9 mg/l to 61.4 mg/l at all sampling sites in all seasons. Maximum hardness value was recorded from water sample collected from Hurla nala during winter season (**Figure 7.29**). Calcium and Magnesium values ranged between 12 mg/l to 19 mg/l and 2.2 mg/l to 4.1 mg/l, respectively. Maximum concentration of Calcium was recorded from the water sample collected from Hurla nala, while maximum concentration of Magnesium was recorded from sampling site W30-located the downstream of Jiwa nala and Sainj khad confluence.

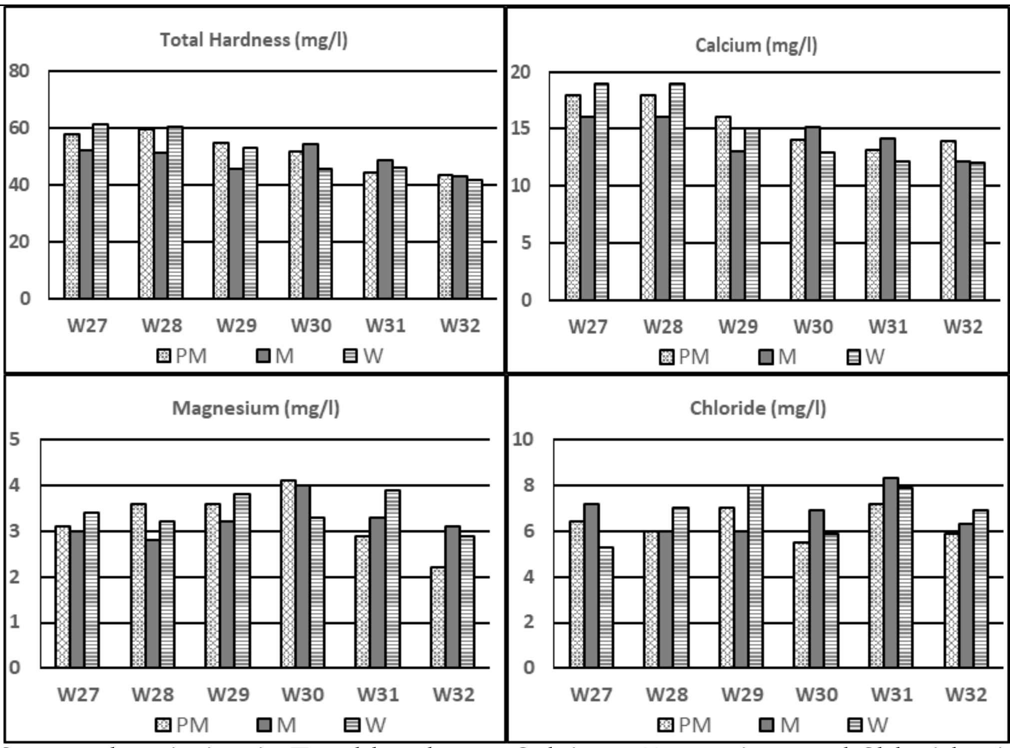


Figure 7.29: Seasonal variation in Total hardness, Calcium, Magnesium and Chlorides in Sainj Sub-basin

(PM=Pre-monsoon; M=Monsoon; W=Winter; W27-W32 : Sampling sites)

Nitrates, Phosphates, Potassium and Sodium

The concentration of Nitrate was recorded in the range of 1.67 mg/l to 2.89 mg/l (**Figure 7.29**). Phosphate and Potassium concentrations were quite low in the water samples collected during the study (**Figure 7.30**). While sodium concentration at all sampling sites varied from 4.2 mg/l to 14 mg/l in all seasons.

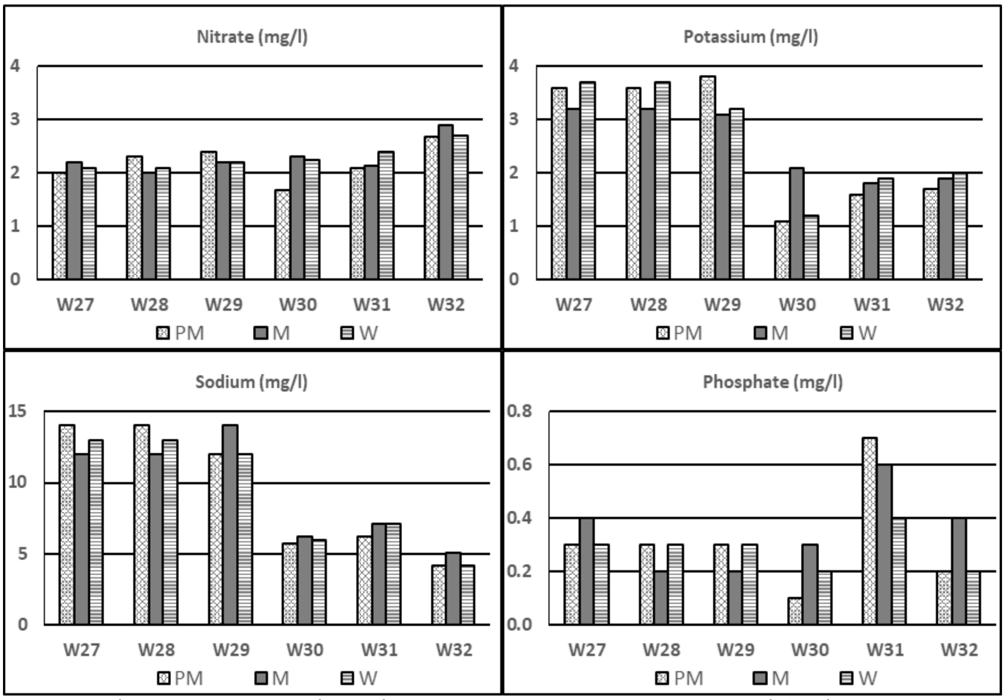


Figure 7.30: Seasonal variation in Phosphate, Nitrate, Potassium and Sodium concentration at different sampling sites in Sainj Sub-basin

(PM=Pre-monsoon; M=Monsoon; W=Winter; W27-W32: Sampling sites)

BOD, COD and Total Coliforms

Biological Oxygen Demand (BOD) concentration in Hurla nala ranged between 1.2 mg/l and 1.4 mg/l, while BOD values in the samples collected from Sainj khad were low at most of the sites during the study and ranged between 0.1 mg/l and 1.4 mg/l (**Figure 7.31**). COD was more than 1 at all the sampling sites while it was more than 2 at sites W27-W29. In Sainj Sub-basin Coliforms were absent in Hurla nala while in Sainj river presence of Coliforms was observed only at two sampling sites (W31 and W32 located in the downstream of Parbati III HEP Dam site). Maximum Coliforms were recorded during Monsoon season with 1340 MPN/100ml.

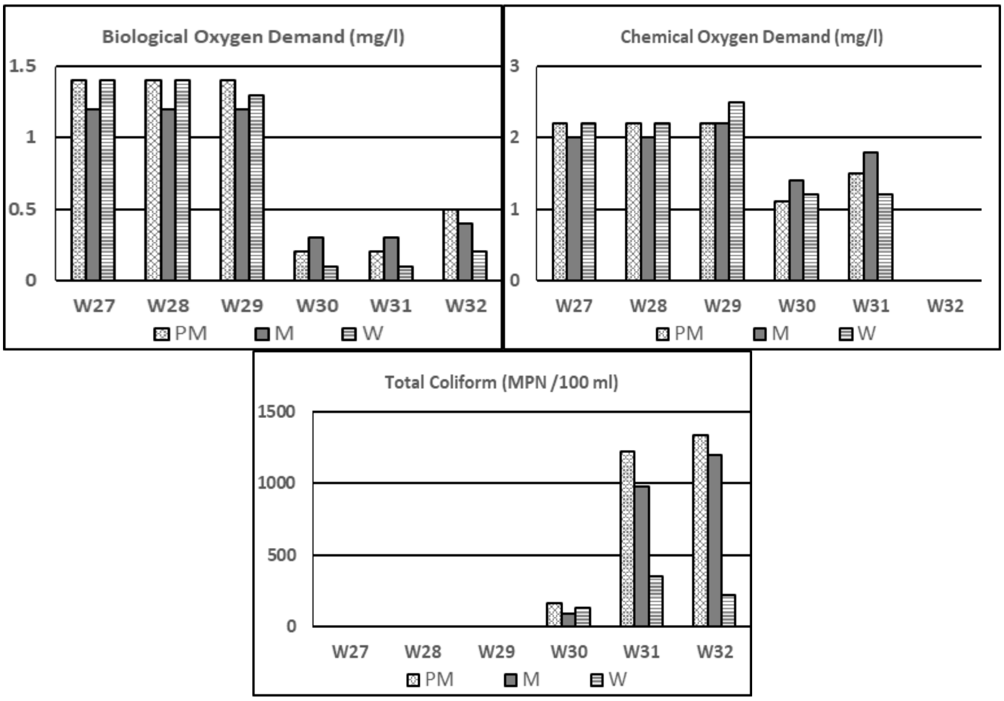


Figure 7.31: Seasonal variation in BOD, COD and Total Coliforms at different sampling sites in Sainj Sub-basin

(PM=Pre-monsoon; M=Monsoon; W=Winter; W27-W32 : Sampling sites)

7.2.7 Beas III Sub-basin

Beas III Sub-basin is comprised of catchment area of Beas river between the confluence point of Tirthan River with river Beas and upstream of Uhl River near Ghamun village. Larji HEP, Beas Satluj Link Project (Pandoh Dam) and Patikari SHEP are the three operational projects located in the sub-basin.

Temperature, Dissolved Oxygen and pH

The temperature of the Bakhli khad water ranged from 8.9°C to 15.6°C during sampling. Water temperature in Beas river in Beas III sub-basin varied from 8.9°C to 17.3°C. The pH at most of the sampling sites was slightly alkaline and varied from 6.98- 8.06. Dissolved Oxygen value ranged between 8.34 mg/l to 10.2 mg/l in various months (**Figure 7.32**).

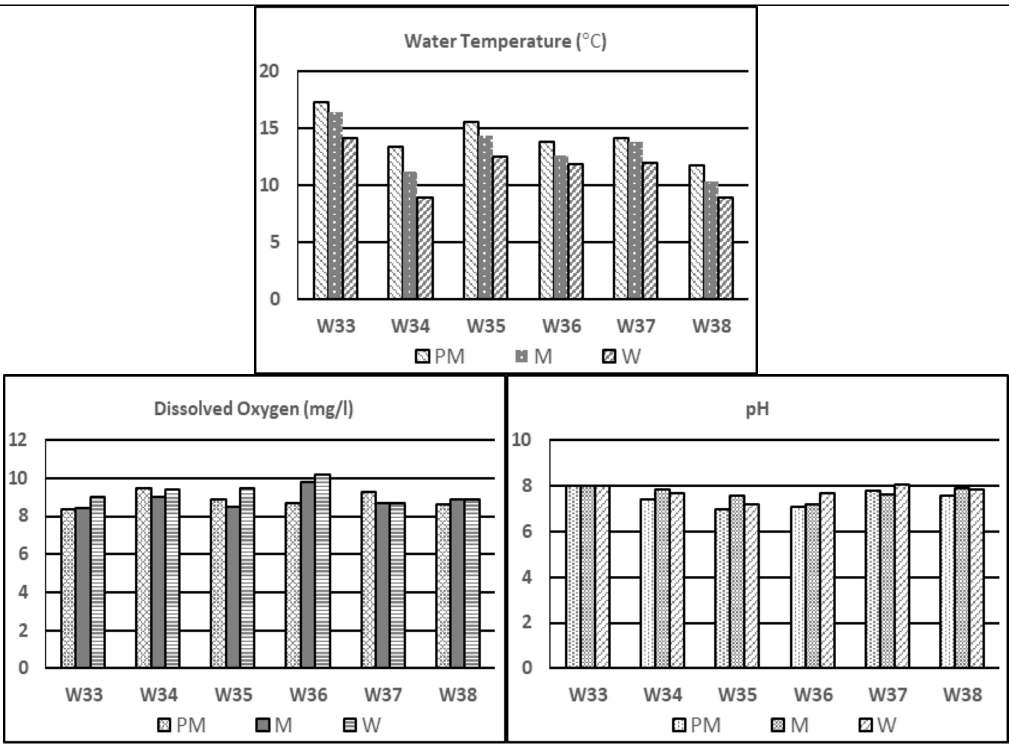


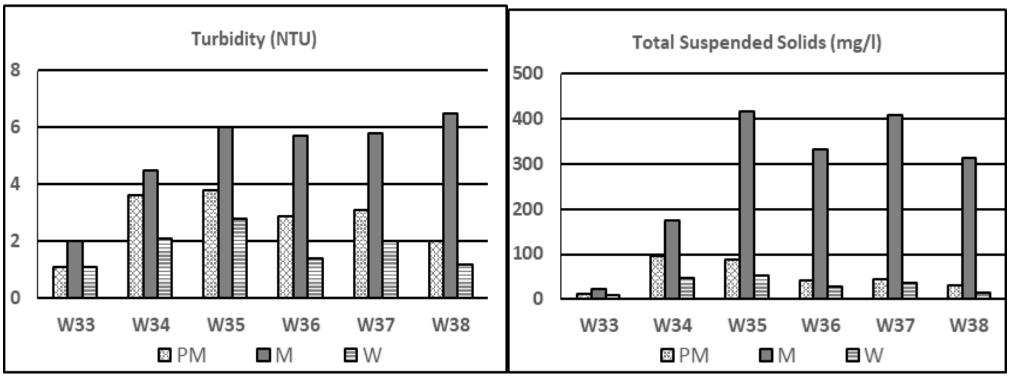
Figure 7.32: Seasonal variation in Water temperature, pH and DO at different sampling sites in Beas III Sub-basin

(PM=Pre-monsoon; M=Monsoon; W=Winter; W33-W38 : Sampling sites)

__Total Suspended Solids, Turbidity, Total Dissolved Solids and Electrical Conductivity__

The Electrical conductivity (EC) and Total Dissolved Solids (TDS) of the water samples from Bakhli khad were observed between 90 µS/cm to 112 µS/cm and 54.9 to 68.3 mg/l respectively. In Beas river the EC and TDS values varied from 78 µS/cm to 132 µS/cm and 47.6 to 80.5 mg/l, respectively.

Due to low turbidity Total Suspended Solids (TSS) values were low in Bakhli khad and varied from 8 mg/l to 12 mg/l. While in water samples collected from Beas river TSS was more during monsoon season with maximum 416 mg/l from sampling site W35 (located at the tailend of Larji HEP reservoir)(**Figure 7.33**).



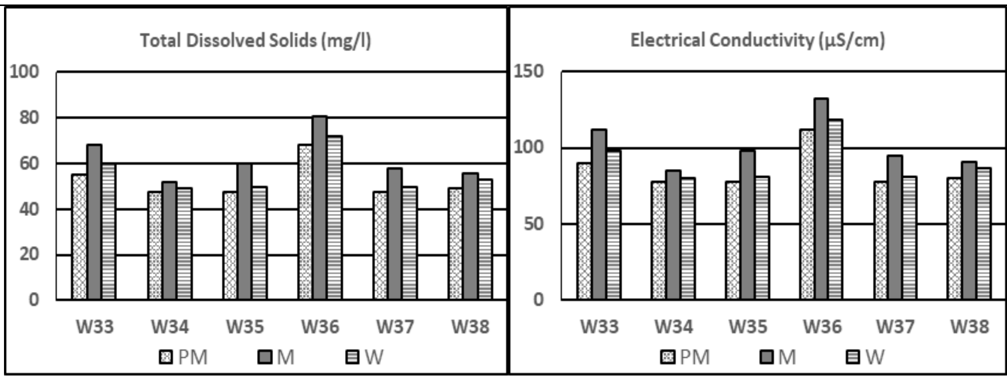


Figure 7.33: Seasonal variation in Total suspended solids, Turbidity, Total dissolved solids and Electrical conductivity at different sampling sites in Beas III sub-basin

(PM=Pre-monsoon; M=Monsoon; W=Winter; W27-W32 : Sampling sites)

Total Hardness, Calcium, Magnesium and Chlorides

Total Hardness, Calcium and Magnesium concentrations at different sampling sites during different sampling periods are given at (**Figure 7.34)**. Total hardness of water ranged from 23.9 mg/l to 32.6 mg/l in Bakheli khad and 25.6 mg/l to 70.1 mg/l in samples collected from Beas river. Calcium and Magnesium values followed the similar pattern.

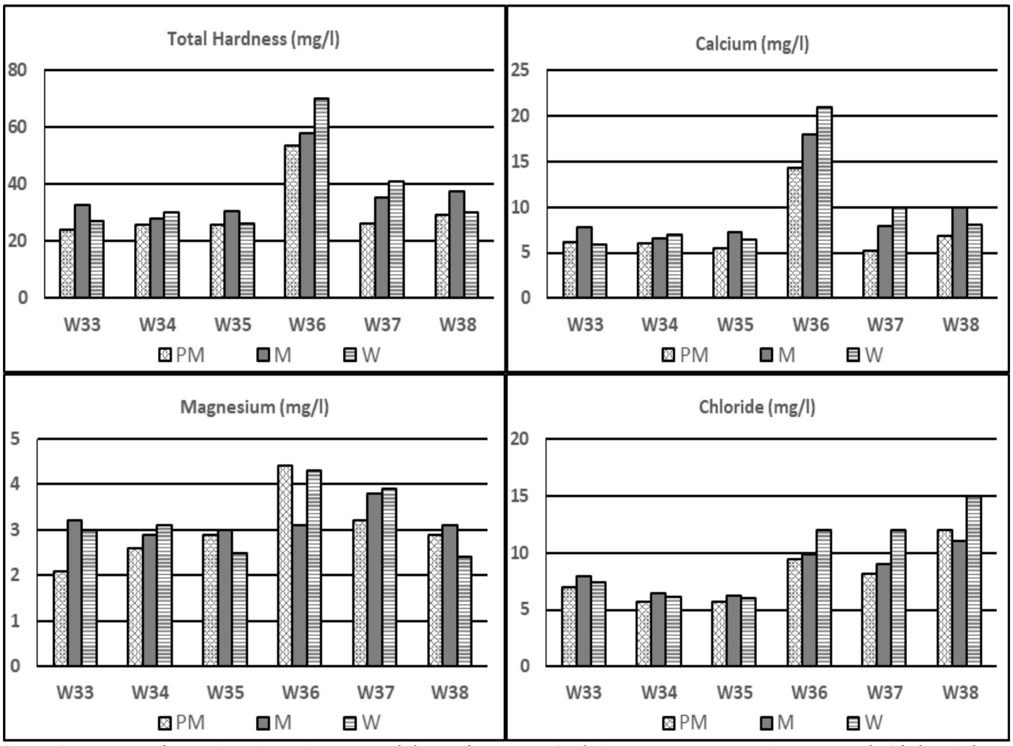


Figure 7.34: Seasonal variation in Total hardness, Calcium, Magnesium and Chlorides in Beas III Sub-basin

(PM=Pre-monsoon; M=Monsoon; W=Winter; W27-W32 : Sampling sites)

Nitrates, Phosphates, Potassium and Sodium

The concentration of Nitrate was recorded from 0.21 mg/l to 1.9 mg/l from all samples collected during various seasons (**Figure 7.35**). While sodium concentration at all sampling sites varied from 1.11 mg/l to 6.6 mg/l in all seasons. Concentration of Phosphate and Potassium was low in the water samples collected during the study period (**Figure 7.35**).

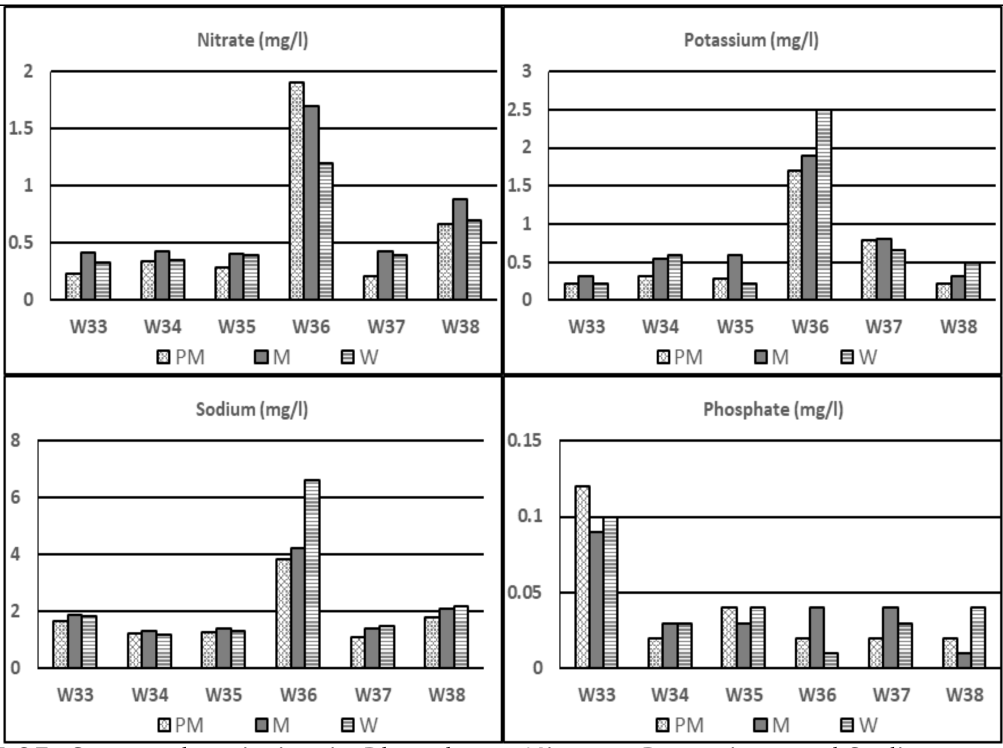
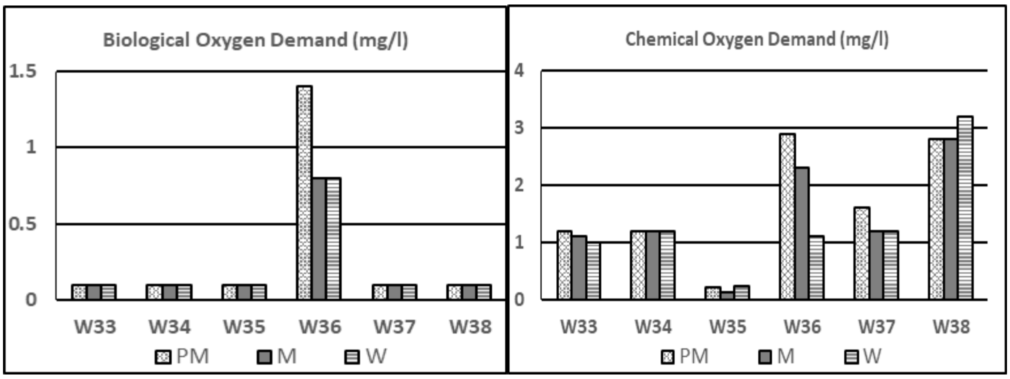


Figure 7.35: Seasonal variation in Phosphate, Nitrate, Potassium and Sodium at different sampling sites in Beas-III Sub-basin

(PM=Pre-monsoon; M=Monsoon; W=Winter; W27-W32 : Sampling sites)

<u>**Biological Oxygen Demand (BOD), COD and Total Coliforms**</u>

Biological Oxygen Demand (BOD) values in the water samples collected during various seasons were low during the study period and ranged between 0.1 mg/l and 1.40 mg/l (**Figure 7.36**). At all the sampling sites COD was more than 1 except for W35 where it was very low while at W36 & W38 sites it was more than 2 mg/l. Coliforms were detected from all sampling site varied from 110 MPN/100ml to 1600 MPN/100ml. Maximum count of Coliforms was recorded from sampling site W35 (near Aut: downstream of Larji Dam site) ranged from 270 MPN/100ml to 1600 MPN/100ml (**Figure 7.36**).



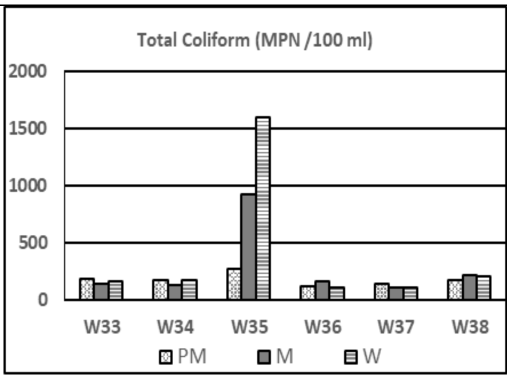


Figure 7.36: Seasonal variation in BOD, COD and Total Coliforms at different sampling sites in Beas III Sub-basin

(PM=Pre-monsoon; M=Monsoon; W=Winter; W27-W32 : Sampling sites)

7.2.8 Uhl Sub-basin

Uhl sub-basin comprises of the catchment area of Beas river from downstream of Pandoh Dam up to the confluence of Rana Khad and Arnodi Khad with river Beas in Mandi district (**Figure 7.37**). The major tributaries joining river Beas at its right bank in the sub-basin are Uhl river, Kushak nala, Dev Ki khad, Luni khad and Rana khad, while the major tributaries joining river Beas on its left bank are Suketi khad, Kasani khad and Arnodi khad.

Temperature, Dissolved Oxygen and pH

The temperature of the river water ranged from 8.6°C to 19.2°C during sampling. The pH of at most of the sampling sites varied from 6.95 - 7.73. Dissolved Oxygen value ranged between 7.4 mg/l to 10.5 mg/l in various months (**Figure 7.37**).

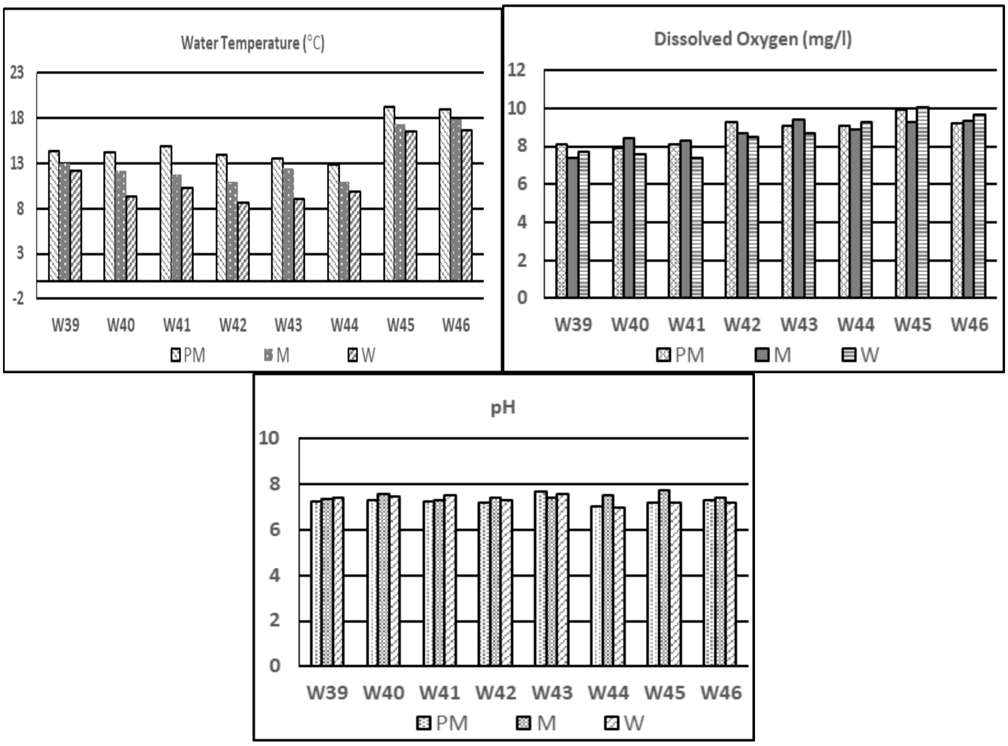


Figure 7.37: Seasonal variation in Water temperature, pH and DO at different sampling sites in Uhl Sub-basin

(PM=Pre-monsoon; M=Monsoon; W=Winter; W38-W46: Sampling sites)

Total Suspended Solids, Turbidity, Total Dissolved Solids and Electrical Conductivity

Total Suspended Solids (TSS) values for Beas river and Rana khad in Uhl Sub-basin were observed between 12 mg/l and 136 mg/l and turbidity was recorded between 0.2 mg/l and 8 mg/l (**Figure 7.38**). TSS value for Uhl river and its tributaries were low varying from 2 mg/l to 22 mg/l.

The Electrical conductivity (EC) and Total Dissolved Solids (TDS) values in Uhl sub-basin were observed between 136.4 µS/cm to 212.5 µS/cm and 83.2 to 129.6 mg/l, respectively.

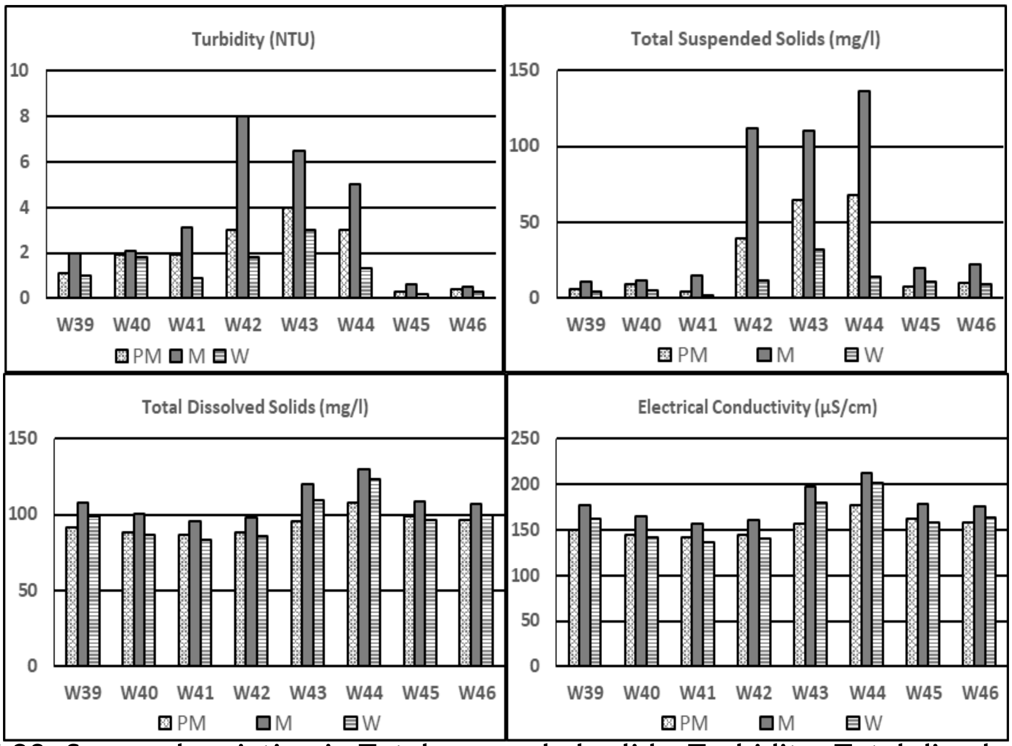
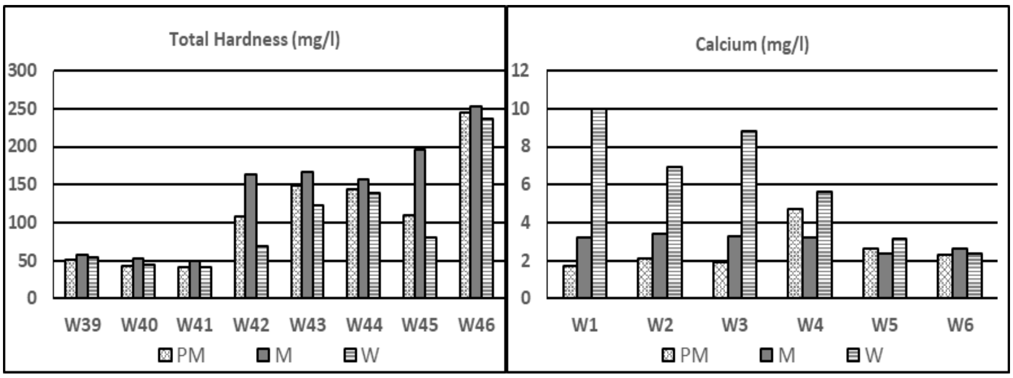


Figure 7.38: Seasonal variation in Total suspended solids, Turbidity, Total dissolved solids and Electrical conductivity at different sampling sites Uhl sub-basin

(PM=Pre-monsoon; M=Monsoon; W=Winter; W38-W46 : Sampling sites)

Total Hardness, Calcium, Magnesium and Chlorides

In general, the Hardness values from Uhl sub-basin ranged from 40.9 to 252.2 mg/l. Concentration of Calcium and Magnesium ions was maximum in the water samples collected from Beas river and Rana Khad. In the samples collected from different sites from Uhl khad the hardness value varied from 40.9 mg/l to 195.6 mg/l (**Figure 7.39).**



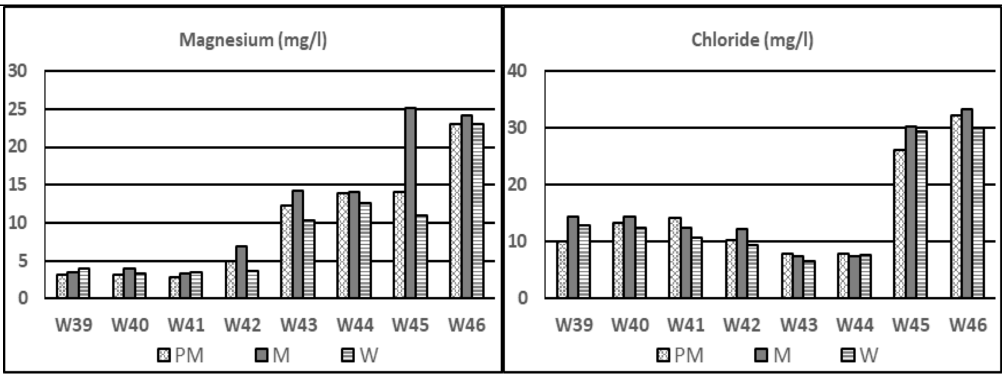


Figure 7.39: Seasonal variation in Total hardness, Calcium, Magnesium and Chlorides in Uhl Sub-basin

(PM=Pre-monsoon; M=Monsoon; W=Winter; W38-W46 : Sampling sites)

Nitrates, Phosphates, Potassium and Sodium

The concentration of Nitrate, Phosphate and Potassium were quite low in all samples collected during various seasons (**Figure 7.40**). The concentration of Sodium at all sampling sites varied from 1.2 mg/l to 9 mg/l in all seasons (**Figure 7.40**).

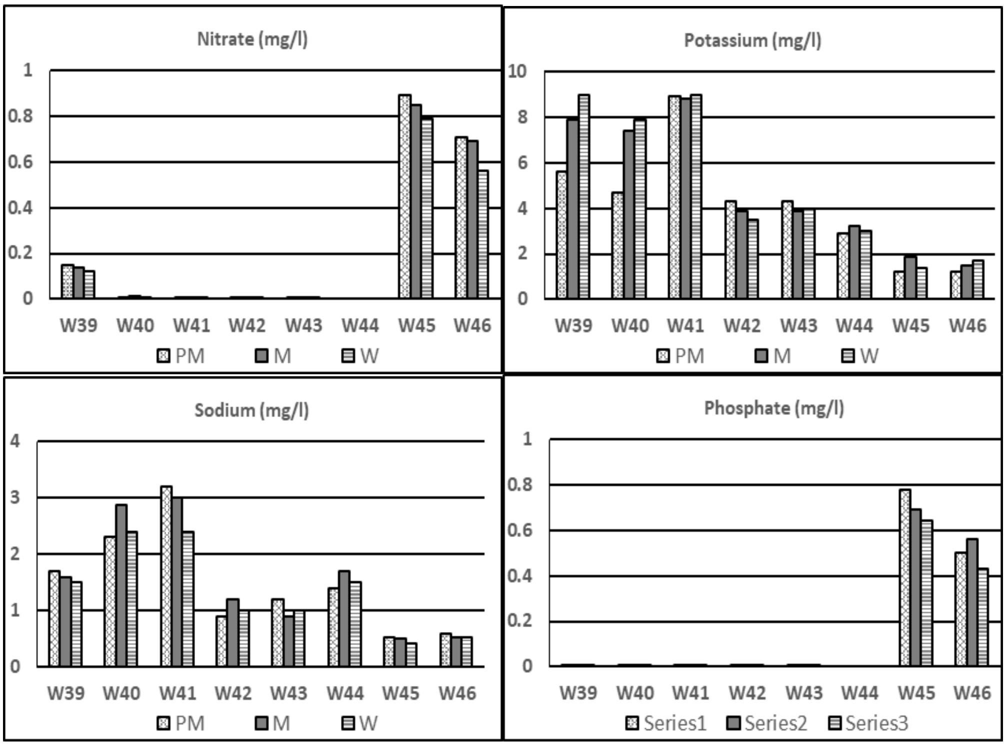


Figure 7.40: Seasonal variation in Phosphate, Nitrate, Potassium and Sodium concentrations at different sampling sites in Uhl Sub-basin

(PM=Pre-monsoon; M=Monsoon; W=Winter; W38-W46 : Sampling sites)

Biological Oxygen Demand (BOD), COD and Total Coliforms

Biological Oxygen Demand (BOD) in water samples collected from Beas river and Rana khad varied from 2.79 mg/l to 4.9 mg/l at all sampling sites during the study period.

BOD values in the Uhl sub-basin varied in different streams. While BOD was not detectable from the water samples collected from upper catchment of Uhl Khad, at sampling site located in Uhl khad near confluence of Uhl khad with Beas river, BOD was quite low and varied from

0.76mg/l to 0.82 mg/l **(Figure 7.41).** COD at almost all the sites was more than 10 mg/l at W42 and W43.

Maximum count of Coliforms was recorded from sampling site W42 (near Uhl-II) with maximum of 46 MPN/100ml (**Figure 7.41**).

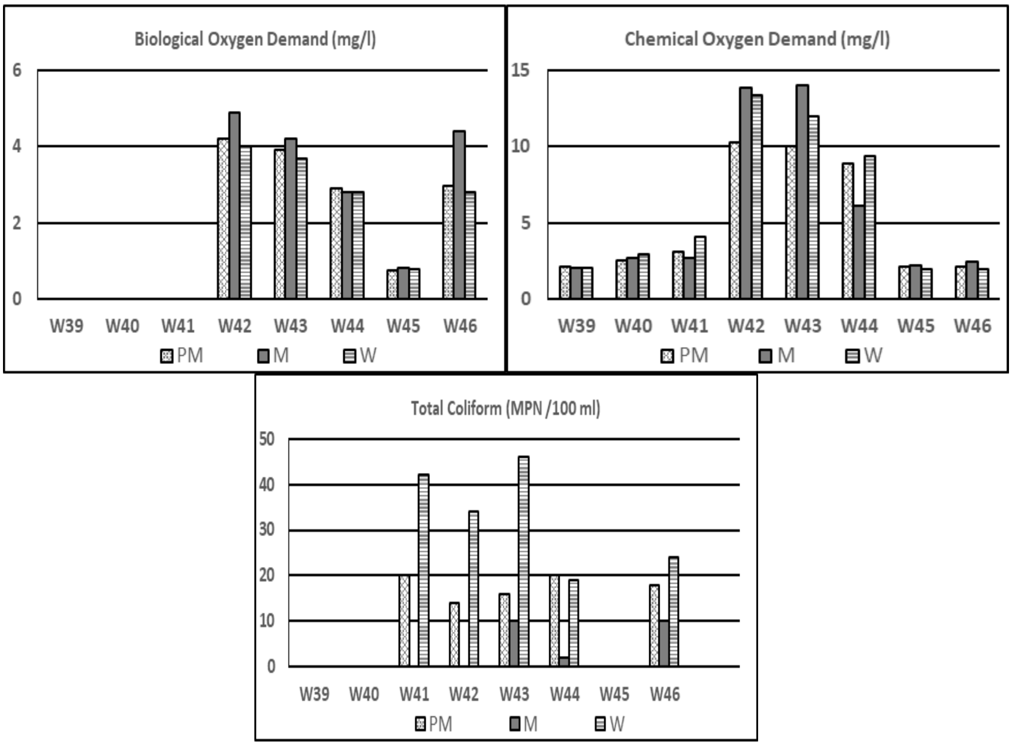


Figure 7.41: Seasonal variation in BOD, COD and Total Coliforms at different sampling sites in Uhl Sub-basin

(PM=Pre-monsoon; M=Monsoon; W=Winter; W38-W46 : Sampling sites)

7.2.9 Beas IV sub-basin

Beas IV sub-basin comprises of the right bank catchment area of Beas river from the confluence of Rana Khad with river Beas up to Pong Dam. Binwa khad, Neugal khad, Baner khad, Gaj khad and Khauli khad are the major right bank tributaries of river Beas in the sub-basin.

<u>Temperature, Dissolved Oxygen and pH</u>

The water temperature at all sampling sites varied from minimum 11.2°C at sampling site and maximum 16.4°C during study period **(Figure 7.42)**.

Dissolved oxygen values varied from minimum 7.1 mg/l to maximum 8.6 mg/l, as highest value of DO was found at sampling site W49 in NeugalKhad during winter season **(Figure 7.42)**.

The pH value at all sampling sites shows slightly alkaline nature of water. It varied from 7.05-8.41 during sampling period. Maximum value for pH was recorded from sampling site W49 during summer season from NeugalKhad **(Figure 7.42)**.

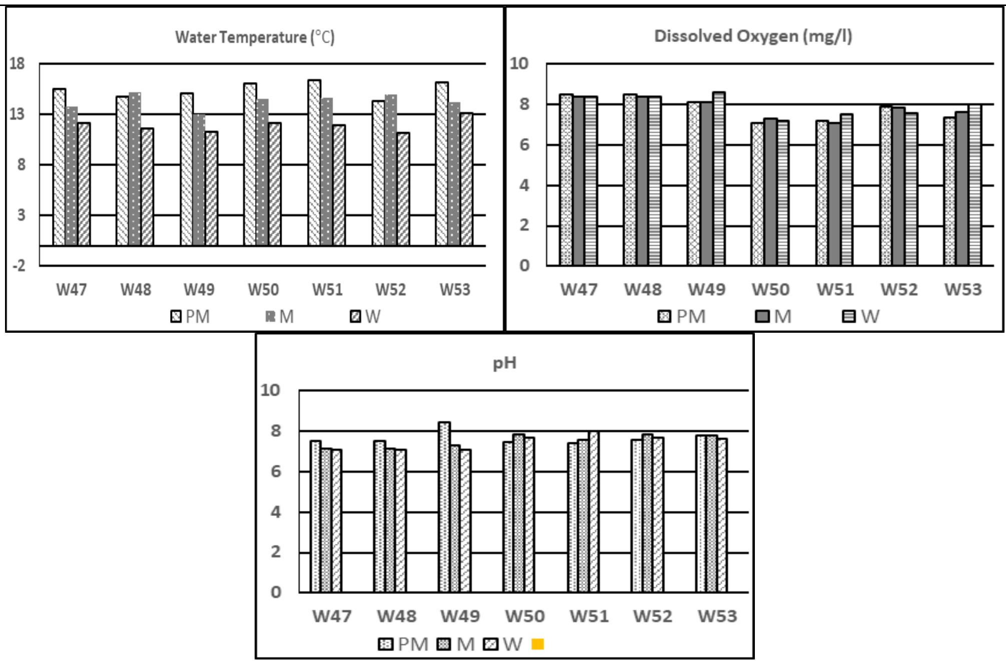


Figure 7.42: Seasonal variation in Water temperature, pH and DO at different sampling sites in Beas IV Sub-basin
(PM=Pre-monsoon; M=Monsoon; W=Winter; W47-W53 : Sampling sites)

Total Suspended Solids, Turbidity, Total Dissolved Solids and Electrical Conductivity

During winter season sampling Total suspended solids (TSS) in the at all the sampling locations was quite low resulting in negligible turbidity in the streams. During pre-monsoon and monsoon season water become slightly turbid and concentration of TSS was slightly increased. Maximum concentration of TSS was observed during monsoon season at sampling site W47 (18 mg/l) at Binwa khad, during monsoon season (**Figure 7.43**).

Electrical Conductivity at various sites varied seasonally with maximum 132µS/cm during winter season and minimum 52.6µS/cm during winter season. Similarly Total Dissolved Solids were maximum during monsoon season with 80.5 mg/l and minimum during winter season with 32.1 mg/l at different sampling locations during the study period (**Figure 7.43**).

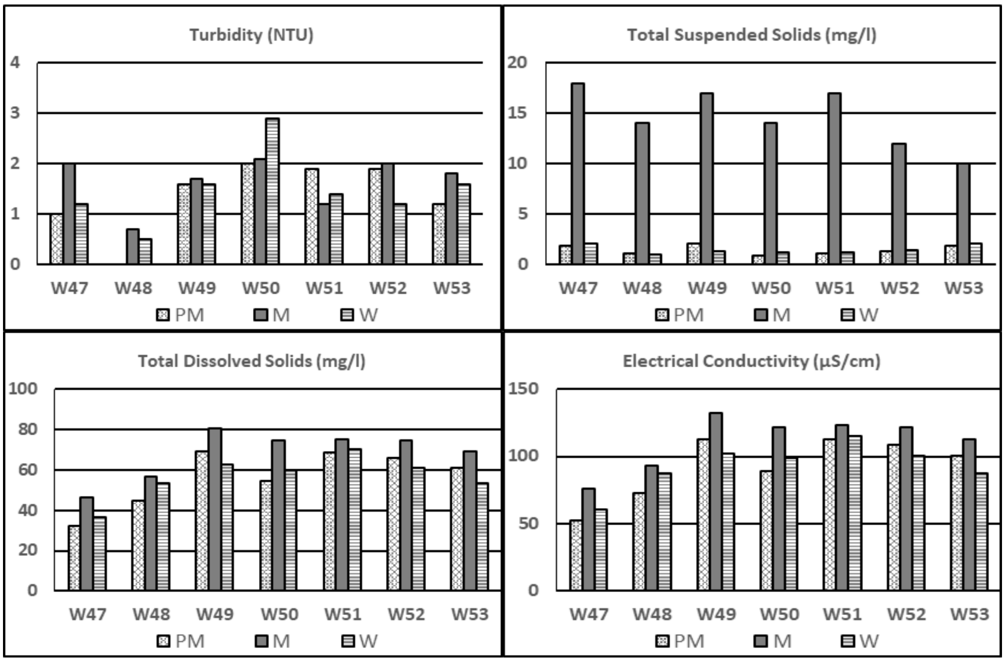


Figure 7.43: Seasonal variation in Total suspended solids, Turbidity, Total dissolved solids and Electrical conductivity at different sampling sites in Beas IV sub-basin
(PM=Pre-monsoon; M=Monsoon; W=Winter; W47-W53 : Sampling sites)

Total Hardness, Calcium, Magnesium and Chlorides

Variation in Total Hardness, Calcium and Magnesium concentrations at different sampling sites during different sampling periods is given at (**Figure 7.44)**. Total hardness varied from 22.3 mg/l to 139.9 mg/l. Maximum value of water hardness was observed from sampling site W49- located in Neugal Khad due to higher concentration of Calcium ion (varied from 30.1mg/l during winter season to 40.7 mg/l in monsoon season) and Magnesium ion (7.3 mg/l to 9.9 mg/l). At rest of the sampling sites concentration of calcium and magnesium varied from 5.34 mg/l to 10.2 mg/l and 1.2mg/l to 3.9 mg/l.

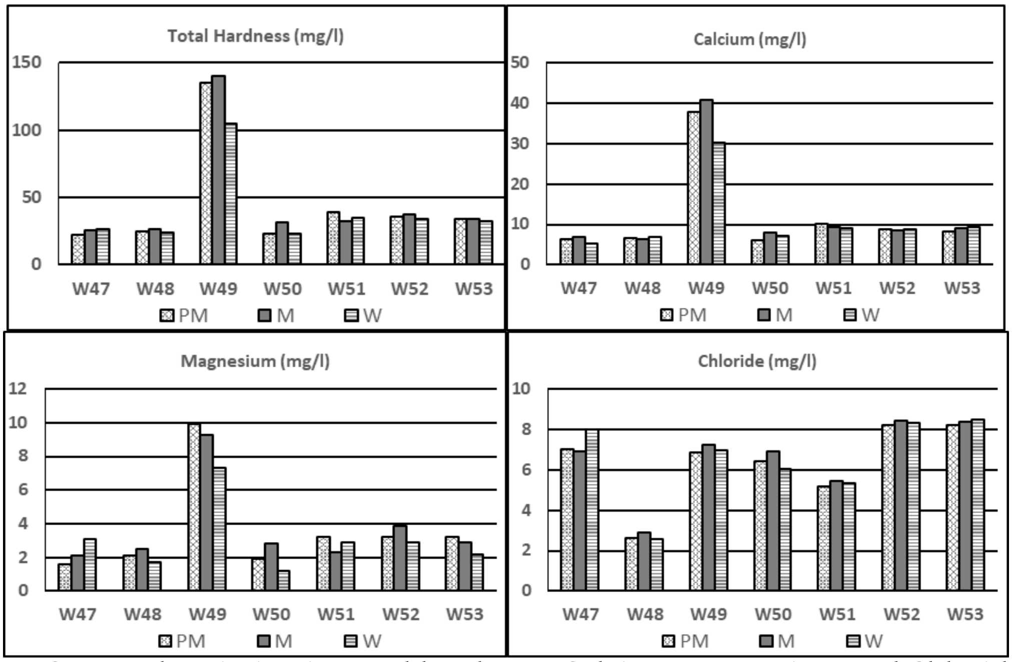
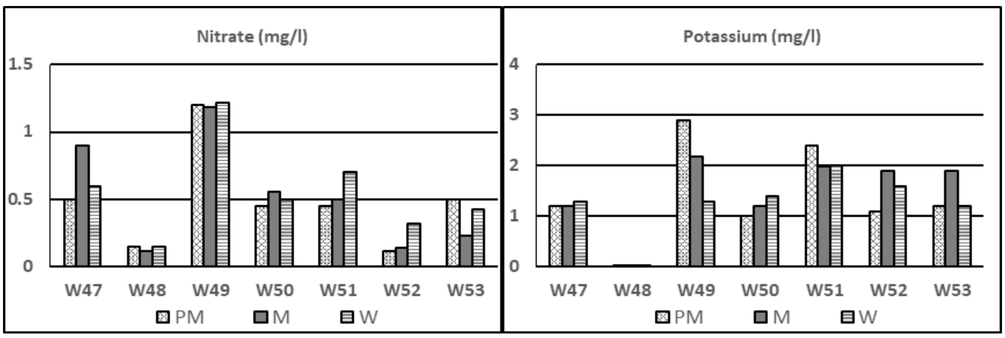


Figure 7.44: Seasonal variation in Total hardness, Calcium, Magnesium and Chlorides in Beas IV Sub-basin

(PM=Pre-monsoon; M=Monsoon; W=Winter; W47-W53 : Sampling sites)

Nitrates, Phosphates, Potassium and Sodium

Nitrate, Phosphate and Potassium concentrations were observed very low in the water samples (**Figure 7.45**). Sodium too was recorded with low concentrations (1.0 mg/l to 3.31 mg/l) at all the sampling sites during the study period (**Figure 7.45**).



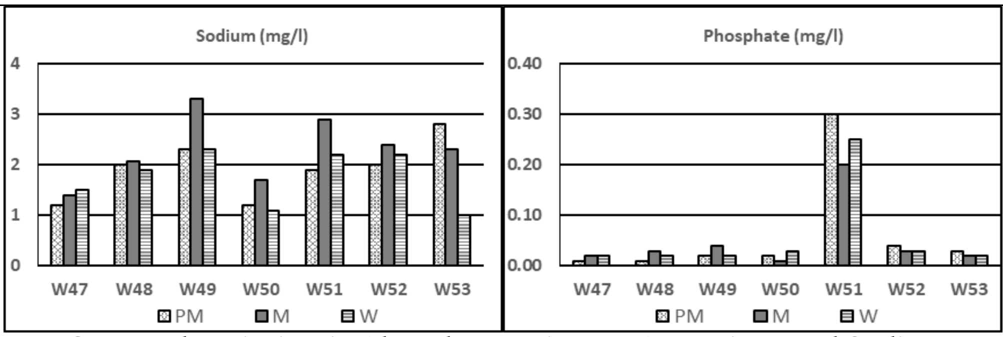


Figure 7.45: Seasonal variation in Phosphate, Nitrate, Potassium and Sodium at different sampling sites in Beas-IV Sub-basin

(PM=Pre-monsoon; M=Monsoon; W=Winter; W47-W53 : Sampling sites)

BOD, COD and Total Coliforms

Biological Oxygen Demand was very low at all sampling sites and varied from 0.1 mg/l to 1.22 mg/l. COD was in the range of 1 mg/l at sites W47 & W48 while it was negligible at rest of the sites. Total Coliforms were absent in sampling site W53 located in Khauli khad. At other sampling sites count of total coliforms varied from 17 MPN/100ml during monsoon from Gaj Khad to 350 MPN/100ml from Baner khad during winter season sampling **(Figure 7.46)**.

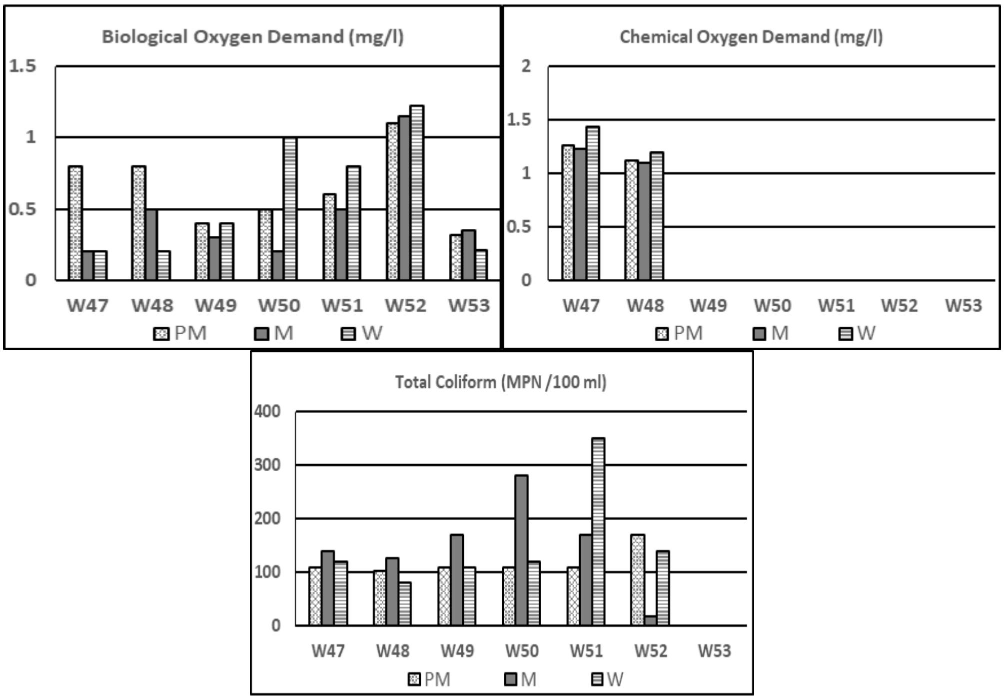


Figure 7.46: Seasonal variation in BOD, COD and Total Coliforms at different sampling sites in Beas IV Sub-basin

(PM=Pre-monsoon; M=Monsoon; W=Winter; W47-W53 : Sampling sites)

7.2.10 Beas V Sub-basin

Beas V sub-basin comprises of the left bank catchment area of Beas river from the confluence of Rana and Arnodi Khad with river Beas up to Pong Dam.

Temperature, Dissolved Oxygen and pH

The water temperature of Beas river in Beas-V sub-basin ranged from 12.2°C to 19.2°C during sampling. Maximum water temperature was observed from the sampling sites located in Pong dam reservoir. The pH value of river water in the sub-basin varied from 7.03 to 7.8. Dissolved

Oxygen value ranged between 8.0 mg/l and 8.9 mg/l. At sampling sites located in Pong dam reservoir DO ranged between 4.2 mg/l and 5.1 mg/l (**Figure 7.47**).

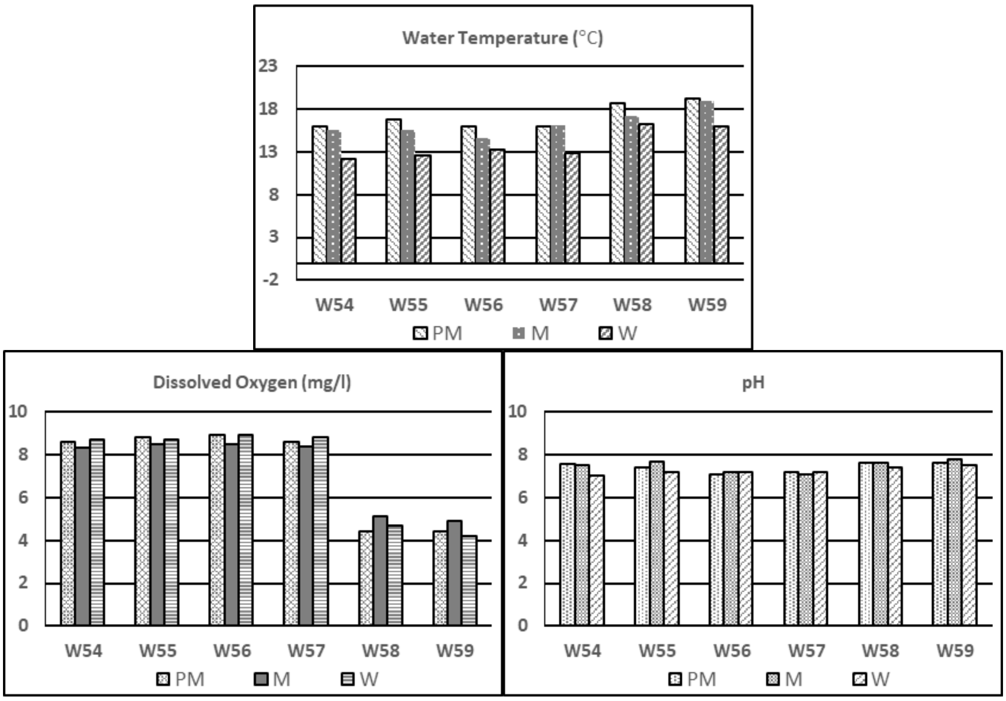


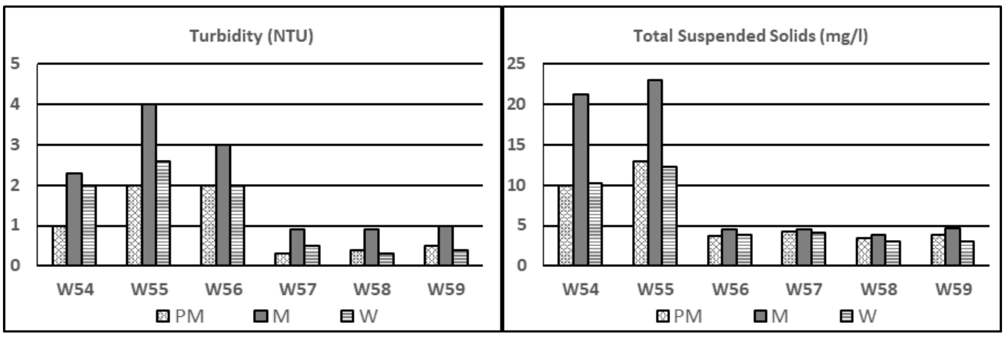
Figure 7.47: Seasonal variation in Water temperature, pH and DO at different sampling sites in Beas-V Sub-basin

(PM=Pre-monsoon; M=Monsoon; W=Winter; W54-W59 : Sampling sites)

Total Suspended Solids/Turbidity, Total Dissolved Solids and Electrical Conductivity

The Electrical conductivity (EC) and Total Dissolved Solids (TDS) values were observed between 90.0 µS/cm to 330.0 µS/cm and 54.9 mg/l to 183.0 mg/l, respectively. Maximum value for EC and TDS were observed from sampling site W54 downstream of Mandi town near Beas river confluence with Rana khad.

Total Suspended Solids (TSS) values varied between 3.1 mg/l and 23.0 mg/l (**Figure 7.48**). The maximum value of TSS was observed during monsoon season at sampling site W54 located downstream of Mandi town and minimum concentration of TSS was observed from the sampling sites W58 and W59 located in Pong Dam reservoir.



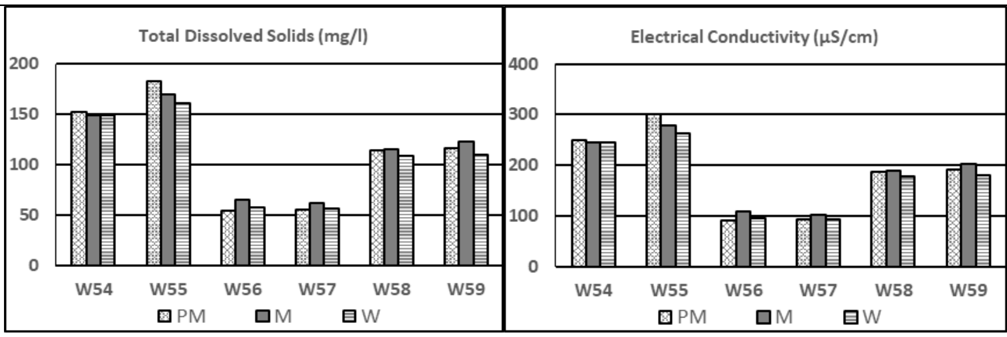


Figure 7.48: Seasonal variation in Total suspended solids, Turbidity, Total dissolved solids and Electrical conductivity at different sampling sites in Beas-V sub-basin

(PM=Pre-monsoon; M=Monsoon; W=Winter; W54-W59 : Sampling sites)

Total Hardness, Calcium, Magnesium and Chlorides

Total Hardness in water samples varied from 44.5 mg/l to 275.3 mg/l at all sampling sites during all seasons. Maximum hardness value was recorded from water sample collected from sampling site W54-Beas river, downstream of Mandi town during winter season (**Figure 7.49**). Calcium and Magnesium values ranged between 12.7 mg/l to 68 mg/l and 3.1 mg/l to 33 mg/l, respectively.

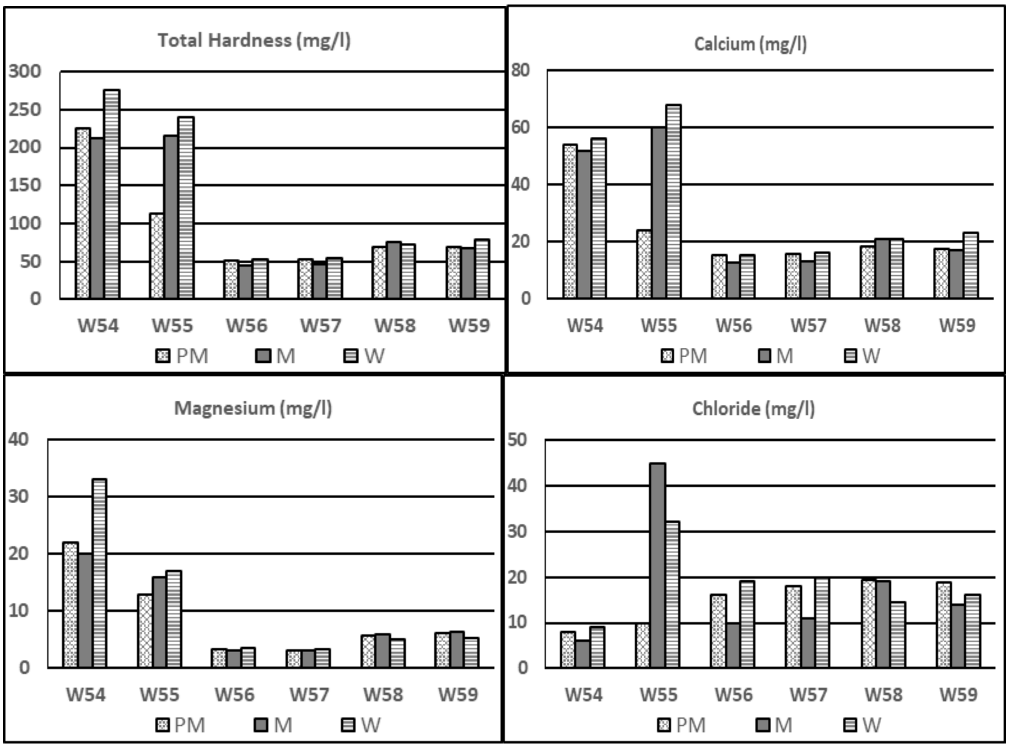


Figure 7.49: Seasonal variation in Total hardness, Calcium, Magnesium and Chlorides in Beas-V Sub-basin

(PM=Pre-monsoon; M=Monsoon; W=Winter; W54-W59 : Sampling sites)

Nitrates, Phosphates, Potassium and Sodium

The concentration of Nitrates varied from 0.11 mg/l to 3.5 mg/l (**Figure 7.50**). Phosphate concentration was low in the water samples collected during the study (**Figure 7.50**). Sodium and Potassium concentration at all sampling sites varied from 8.5 mg/l to 91.0 mg/l and 1.1mg/l to 6 mg/l in all seasons.

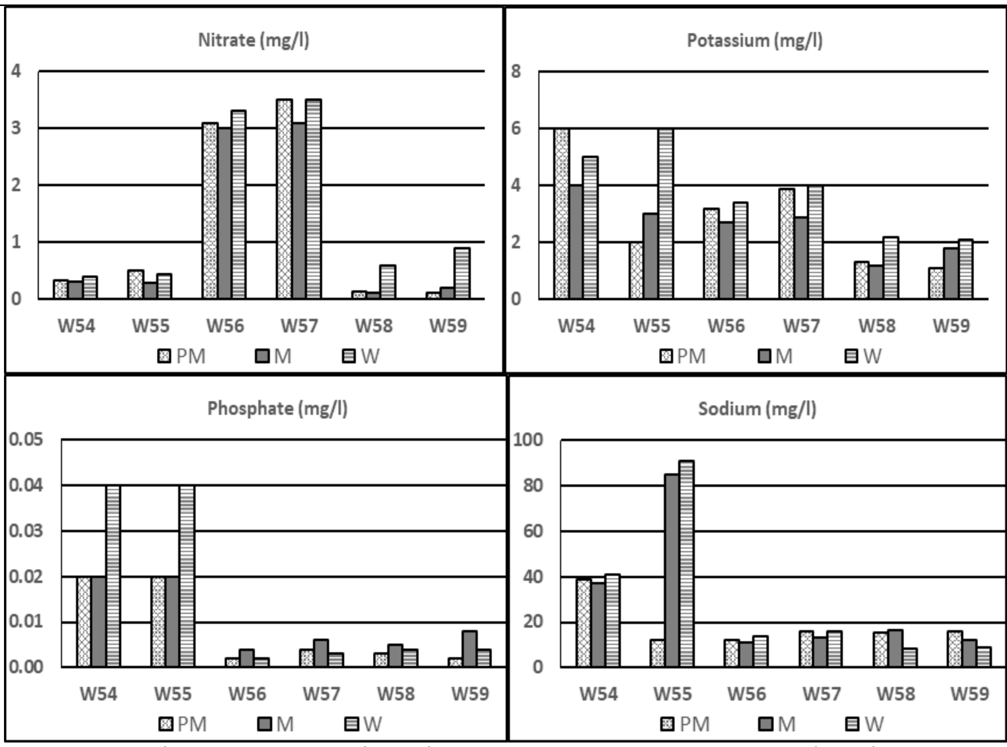
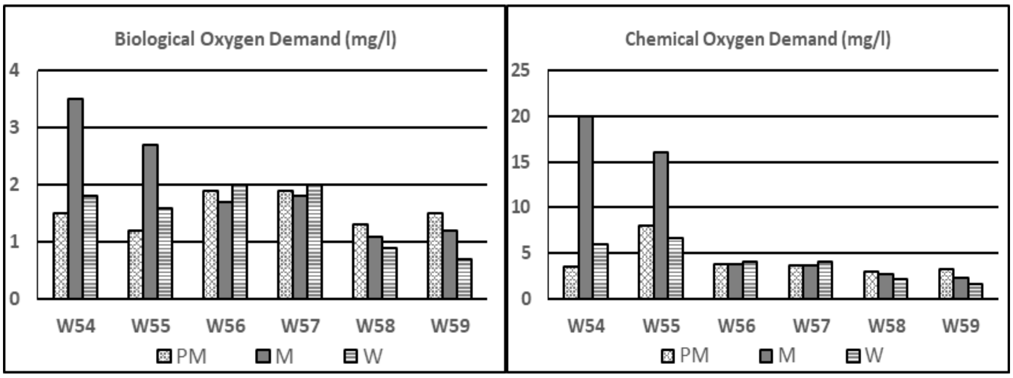


Figure 7.50: Seasonal variation in Phosphate, Nitrate, Potassium and Sodium concentrations at different sampling sites in Beas-V Sub-basin

(PM=Pre-monsoon; M=Monsoon; W=Winter; W54-W59 : Sampling sites)

BOD, COD and Total Coliforms

Biological Oxygen Demand (BOD) in water samples of river Beas ranged between 0.7 mg/l and 3.5 mg/l, minimum BOD values was observed from the samples collected from Pong dam reservoir during the study (**Figure 7.50**). COD at sites W54 & W55 was very high i.e. between 15 and 20 mg/l during monsoon. Coliforms were detected from all sampling sites in Beas-V sub-basin and ranged from 2 MPN/100ml to 65 MPN/100ml. Maximum count of Coliforms was recorded from sampling site W56 (near confluence of Binwa khad with Beas river) and minimum from sampling site W58 and W59 located in Pong dam reservoir (**Figure 7.50**).



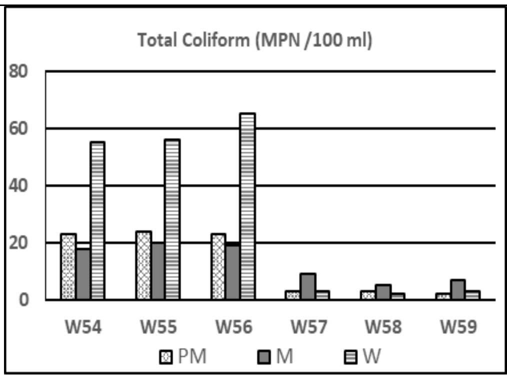


Figure 7.51: Seasonal variation in BOD, COD and Total Coliforms at different sampling sites in Beas-V Sub-basin

(PM=Pre-monsoon; M=Monsoon; W=Winter; W54-W59 : Sampling sites)

7.3 BIOLOGICAL CHARACTERISTICS

Rock surfaces, plant surfaces, leaf debris, logs, silt and sandy sediments and all other spaces in the stream provide habitats for different organisms. According to these habitats, organisms are divided into plankton, benthos, nektons and neuston. Benthic diatoms are found attached to the surface of substrates such as rock, boulders and any other bottom substrates of the water body.

7.3.1 Phytoplankton

The word "plankton" is an umbrella term for organisms that live their lives adrift in the water and are unable to move independently. The phytoplankton comprise of diatoms, dinoflagellates, cyanobacteria, and other groups of unicellular algae.

In all total 72 species of phytoplankton were recorded from all the sampling sites during different seasons from Beas river and its tributaries during the entire study period (**see Table 7.4**). While 70 species were recorded during pre-monsoon, winter season and 60 species were recorded in monsoon season ampling at all sampling sites. Most common genera which are found at almost all the sites are *Synedra, Melosira, Tabellaria, Cymbella, Navicula, Fragilaria, Gomphonema, Diatoma, Spirogyra* and *Nitzschia* were found at most of the sampling sites during the study period (**Table 7.4**).

Table 7.4: List of phytoplankton species found at different sampling sites in Study Area

S.No.	Class/ Name of Species	S.No.	Class/ Name of Species
Bacillariophyceae		40	*Pediastrum* sp.
1	*Tabellaria fenestris*	41	*Microspora* sp.
2	*Diatoma vulgaris*	42	*Ulva* sp.
3	*Fragilaria inflata*	43	*Oedogonium* spp.
4	*Nitzschia* sp.	44	*Cladophora*
5	*Navicula radiosa*	45	*Cosmarium*
6	*Cymbella cistula*	46	*Scendesmus* sp.
7	*Coconeis placetula*	47	*Chloromcoccum* sp.
8	*Synedra ulna*	48	*Stigeoclonium* sp.
9	*Cyclotella* sp.	49	*Oocystis* sp.
10	*Stauroneis* sp.	50	*Chlorogonium* sp.
11	*Ceratoneis* sp.	51	*Closterium* sp.
12	*Denticula* sp.	52	*Chlamydomonas* sp.

S.No.	Class/ Name of Species	S.No.	Class/ Name of Species
13	*Amphora* sp.	53	*Ankistrodesmus* sp.
14	*Synedra ulna*	54	*Clostoriopis* sp.
15	*Cocconeis placentula*	55	*Schroederia* sp.
16	*Gomphonema* sp.	56	*Selenastrum* sp.
17	*Gomphoneis* sp.	57	*Phyllobium* sp.
18	*Ceratoneis arcus*	**Myxophyceae**	
19	*Astrionella* sp.	58	*Oscillatoria tenuis*
20	*Achnanthes* sp.	59	*Rivularia* sp.
21	*Caloneis* sp.	60	*Phormidium* sp.
22	*Gyrosigma* sp.	61	*Rivularia* sp.
23	*Pinnuiaria* sp.	**Cynophyceae**	
24	*Cymbella* sp.	62	*Chroococcus* sp.
25	*Meridion* sp.	63	*Oscillatoria* sp.
26	*Surirella* sp.	64	*Nostoc* sp.
27	*Melosira* spp.	65	*Anabaena anacystis*
28	*Diatoma hiemale*	66	*Merismopedia* sp.
29	*Reimaria sinuata*	67	*Microcystic* sp.
30	*Encyonema minutum*	68	*Gomphospaeria* sp.
31	*Epithemia zebra*	69	*Aphnocapsa* sp.
32	*Eunotia* sp.	70	*Spirulina* sp.
33	*Planothidium lanceolata*	**Euglenophyceae**	
34	*Frustulia* sp.	71	*Chlamydomonas* sp.
Chlorophyceae		72	*Volvox* sp.
35	*Ulothrix zonata*		
36	*Closterium leibleinii*		
37	*Zygnema* sp.		
38	*Spirogyra* sp.		
39	*Chlorella* sp.		

Table 7.5: Total number of Phytoplankton species recorded during various seasons at different sampling sites

Sampling sites	Phytoplankton		
	Pre Monsoon	Monsoon	Winter
W1	17	8	9
W2	17	10	13
W3	23	10	13
W4	21	11	21
W5	21	12	17
W6	19	17	20
W7	15	13	18
W8	18	15	17
W9	16	12	18
W10	9	6	9
W11	9	5	9
W12	9	7	9
W13	14	10	14
W14	11	10	12
W15	10	7	11
W16	14	10	14
W17	11	8	11
W18	8	6	8
W19	8	7	8
W20	8	7	8
W21	8	7	8
W22	8	6	8
W23	17	15	17
W24	15	15	17
W25	17	15	17
W26	17	15	17
W27	11	9	12
W28	15	11	15
W29	14	12	15
W30	8	10	11
W31	10	10	11
W32	10	7	11
W33	15	11	15
W34	17	13	17
W35	17	13	17
W36	17	13	17
W37	16	12	16
W38	14	12	16
W39	6	4	7
W40	12	8	10
W41	11	7	12

W42	19	11	19	W51	43	20	41
W43	27	20	29	W52	33	17	35
W44	23	19	26	W53	27	14	33
W45	13	4	13	W54	21	17	14
W46	13	3	13	W55	21	18	14
W47	21	17	14	W56	22	13	19
W48	21	19	14	W57	12	8	10
W49	21	14	20	W58	11	7	12
W50	43	19	41	W59	19	11	19

7.3.2 Phytobenthos

Total 97 species of phytobenthos were identified in the samples collected from proposed study area (**Table 7.6**). In all 97 species, Bacillariophyceae represented by 51 species followed by Cyanophyceae with 18, Chlorophyceae with 24, Euglenophyceae with 2 and Myxophyceae represent by 2 species in the study area.

In all total 97 species of phytobenthos were recorded from the sampling sites during different seasons from Beas river and its tributaries during the entire study period. While 97 species were recorded during in pre-monsoon and winter season and 88 species were found in the monsoon season sampling for all sampling sites. Most common genuswhich are found at almost all the sites are *Synedra, Melosira, Tabellaria, Cymbella, Navicula, Fragilaria, Gomphonema, Diatoma, Spirogyra, Achnanthes, Oscillatoria* and *Nitzschia we*re found at most of the sampling sites during the study period (**Table 7.7**).

Table 7.6: Total number of Phytobenthos species recorded during vaious seasons in different sampling sites

Sampling sites	Phytobenthos			Sampling sites	Phytobenthos		
	Pre Monsoon	Monsoon	Winter		Pre Monsoon	Monsoon	Winter
W1	**25**	**14**	**8**	W26	25	12	23
W2	28	11	17	W27	25	20	25
W3	32	14	25	W28	23	19	26
W4	24	16	23	W29	22	16	25
W5	29	17	28	W30	22	11	24
W6	26	23	30	W31	20	15	23
W7	24	16	23	W32	20	14	22
W8	21	21	24	W33	18	13	21
W9	18	15	23	W34	25	19	28
W10	11	12	15	W35	24	20	27
W11	11	8	15	W36	27	19	27
W12	12	8	14	W37	21	17	26
W13	15	8	19	W38	23	20	25
W14	19	15	21	W39	8	4	9
W15	17	13	18	W40	20	11	19
W16	19	17	23	W41	18	12	20
W17	15	11	16	W42	22	16	28
W18	8	7	8	W43	44	30	46
W19	8	8	8	W44	39	22	42
W20	8	8	8	W45	17	8	23
W21	8	8	8	W46	20	10	22
W22	8	8	8	W47	32	20	27
W23	21	20	22	W48	24	26	23
W24	23	18	25	W49	27	16	32
W25	21	15	24	W50	20	11	19

Sampling sites	Phytobenthos		
	Pre Monsoon	Monsoon	Winter
W51	18	12	20
W52	22	16	28
W53	20	11	19
W54	18	12	20
W55	23	24	26
W56	24	20	29

Sampling sites	Phytobenthos		
	Pre Monsoon	Monsoon	Winter
W57	17	13	18
W58	19	17	23
W59	15	11	16

7.3.3 Zooplankton

The zooplankton population is represented by Protozoon, Rotifers, Cladoceron, *Branchipoda, Imbricatea and Lobosea* consisting of total 25 species in the study area. In all species, 9 and 8 species were represented by rotifers and protozoon followed by Cladocera and Copepods (**Table 7.8**).

In all total 25 species of zooplankton were recorded from the sampling sites. While 24 species were recorded during in pre-monsoon and monsoonseason and 25 species were found in the winter season sampling for all sampling sites. Most common genus which are found at almost all the sites are *Keratella, Moina, Trichocera, Arcella, Sexangularia,* and *Daphnia* are found most of the sampling sites during the study period (**Table 7.9**).

Table 7.7: Cumulative list of Zooplankton found at different sampling sites in study area

S.No.	Class/Name of species
Cladocera	
1	*Daphnia* sp.
2	*Moina* sp.
Rotifera	
3	*Keratella* sp.
4	*Brachionua* sp.
5	*Asplanchan* sp.
6	*Ascomorpha* sp.
7	*Filinia pp.*
8	*Trichocera* sp.
9	*Monostyla* sp.
10	*Epiphanes* sp.
11	*Euchlanis* sp.
Copepoda	
12	*Cyclops* sp.
13	*Cypris* sp.
14	*Nauplib* sp.

S.No.	Class/Name of species
Protozoa	
15	*Difflugia* sp.
16	*Vorticetta* sp.
17	*Arcella* sp.
18	*Thecamoeba* sp.
19	*Sexangularia* sp.
20	*Nebetla* spp.
21	*Peridiinium* sp.
22	*Ceratium* sp.
Branchipoda	
23	*Alona* sp.
Imbricatea	
24	*Euglypha* sp.
Lobosea	
25	*Centropyxis* sp.

Table 7.8: Total number of Zooplankton species recorded during various seasons at different sampling sites

Sampling sites	Zooplankton		
	Pre Monsoon	Monsoon	Winter
W1	11	3	8
W2	9	2	6
W3	9	1	5
W4	7	5	7
W5	8	4	8
W6	9	4	10
W7	8	5	10
W8	10	3	12
W9	7	1	9
W10	4	3	5
W11	4	2	5
W12	3	4	5
W13	3	1	5
W14	5	2	5
W15	5	2	5
W16	4	3	5
W17	3	2	5
W18	4	2	4
W19	4	3	4
W20	4	2	4
W21	4	1	4
W22	3	2	4
W23	7	5	7
W24	7	2	7
W25	7	3	7
W26	7	4	7
W27	6	1	7
W28	4	3	4
W29	5	2	6
W30	4	0	4
W31	4	2	4
W32	4	2	4
W33	7	4	7
W34	10	2	10
W35	11	4	10
W36	4	4	4
W37	4	2	4
W38	4	1	4
W39	3	1	3
W40	5	3	6
W41	4	1	5
W42	5	4	6
W43	5	4	6
W44	5	4	6
W45	5	4	5
W46	5	4	5
W47	5	3	5
W48	6	2	6
W49	10	2	9
W50	10	1	10
W51	9	1	10
W52	11	3	10
W53	11	2	13
W54	8	5	9
W55	8	5	9
W56	7	6	7
W57	8	6	8
W58	9	7	11
W59	9	9	11

7.3.4 Macro-Invertebrates

Macro-invertebrates are widely used to determine biological conditions and acts as an in-line monitoring system for pollution. They are important part of food chain especially for fish. During the study, macro-invertebrate fauna comprised of 64 species falling under 11 Orders belonging to 40 Families. Ephemeroptera was the dominant Order represented by six families and 17 genera followed by Order Diptera with 7 families and 11 genera (**Table 7.10**). *Chironomus* sp. was the most abundant species and was recorded from 50 sampling sites during the surveys followed by *Ephemerella ignita, Isoperla* sp. and *Nemouridae* sp. (**Table 7.11**).

Table 7.9: List of macro-invertebrates found at different sampling locations

S.No.	Order/Name of Species
Ephemeroptera	
1	*Baetis rhodani*
2	*Baetis niger*
3	*Baetis muticus*
4	*Rithrogena* sp.
5	*Heptagenia sulphurea*

S.No.	Order/Name of Species
6	*Baetidae* sp.
7	*Heptagenia lateratis*
8	*Caenis* sp.
9	*Ephemera* sp.
10	*Ecdynurus* sp.
11	*Centroptilum* sp.
12	*Ephemerella ignita*
13	*Ameletus* sp.
14	*Sipholonurus* sp.
15	*Emphemerella doris*
16	*Ephemerella aleghoniensis*
17	*Stenonema* sp.
Trichoptera	
18	*Glossosoma* sp.
19	*Hydropsychae* sp.
20	*Brachycentrus* sp.
21	*Leptoceridae* sp.
22	*Acroneuria* sp.
23	*Isoperla* sp.
24	*Rhyacophila* sp.
25	*Limnephildae* sp.
26	*Polycentropus* sp.
27	*Ochrotricha* sp.
Diptera	
28	*Tabanus* sp.
29	*Tendipes* sp.
30	*Simulium* sp.
31	*Dixa* sp.
32	*Chironomus* spp.
33	*Antocha* spp.
34	*Culex* spp.
35	*Psychodidae*
36	*Culicidae* sp.
37	*Tipula* sp.
38	*Maruina* spp.
Plecoptera	
39	*Isoperla* spp.
40	*Perla* spp.
41	*Perlidae* sp.
42	*Gerris* spp.
43	*Perlidae* sp.
44	*Nemouridae* sp.
45	*Hydropsyche* sp.
46	*Rhyacophila* sp.
47	*Polycentropus* sp.
48	*Brachycentrus* sp.
Hemiptera	
49	*Gerris lacustris*
50	*Belostomatidae* sp.
Coleoptera	
51	*Psephanus* sp.
52	*Gyrinus* spp.
53	*Dytiscus spp*

S.No.	Order/Name of Species
54	*Elmis* spp.
55	*Turbellaria* spp.
56	*Planaria* spp.
Odonata	
57	*Macromia* spp.
58	*Ophiogomphus* spp.
59	*Agrion* spp.
Oligochaeta	
60	*Pheretima posthuma*
Annelida	
61	*Glossiphonia* spp.
Gastropoda	
62	*Lymnea* spp.
Clitellata	
63	*Tubifex* sp.
64	*Aeolosoma* sp.

Table 7.10: Total number of Macro-invertebrates species recorded during various seasons at different sampling sites

Sampling sites	Macro-Invertebrates		
	Pre Monsoon	Monsoon	Winter
W1	25	13	20
W2	17	11	11
W3	15	12	15
W4	15	10	16
W5	13	9	14
W6	13	9	12
W7	14	11	14
W8	13	10	14
W9	17	5	18
W10	10	7	9
W11	10	7	9
W12	10	6	9
W13	10	6	9
W14	9	5	9
W15	9	6	9
W16	9	6	9
W17	9	6	9
W18	14	11	15
W19	16	15	15
W20	16	15	15
W21	15	12	15
W22	16	7	15
W23	20	9	23
W24	22	10	23
W25	22	14	23
W26	20	14	23
W27	19	13	17
W28	17	10	19
W29	15	7	16
0	18	10	20
W31	17	12	20
W32	18	11	20
W33	15	8	15
W34	23	12	26
W35	20	16	26
W36	23	12	26
W37	21	18	26
W38	23	12	26
W39	9	6	9
W40	17	12	16
W41	15	11	16
W42	5	1	4
W43	5	2	4
W44	5	0	4
W45	10	1	5
W46	10	6	9
W47	13	6	13
W48	13	9	13
W49	17	6	19
W50	15	2	11
W51	14	3	16
W52	16	5	18
W53	18	4	15
W54	12	8	12
W55	5	2	4
W56	5	0	4
W57	10	1	5
W58	10	6	9
W59	13	6	13

7.3.5 Water Quality Assessment

The analysis of most of the physico-chemical parameters in general reveals that there is hardly any significant variation in most of the parameters most of them are within prescribed standards. The absence of heavy metals is mainly attributed to absence of heavy industries in the basin except for medium and small enterprises in towns like Kullu, Mandi and Kangra comprising mainly of Agro and Food Processing, mechanical and engineering based, wood, woollen items, and wooden based industries and main exportable items are fabric and ayurvedic medicines (Source: Industrial Profile of Kullu, Mandi and Kangra towns). Main economic activities are comprised of tourism and its related activities. Being hilly and mountainous region industries have not developed in the basin. The heavy metals in Beas river and its tributary streams are either Not Detectable or Below Detectable Limits.

Basin level overall assessment of important attributes of water quality have been discussed in the following paragraohs.

i) Dissolved Oxygen and pH

It can be seen from the chart below (**Figure 7.52**) that DO and pH across the Beas basin does not vary much during different seasons. Only at sites located in Beas V sub-basin near Pong Dam DO values were in the range of 4-6 mg/l. However in general DO values throughout the basin ranged between 8 and 10 mg/l.

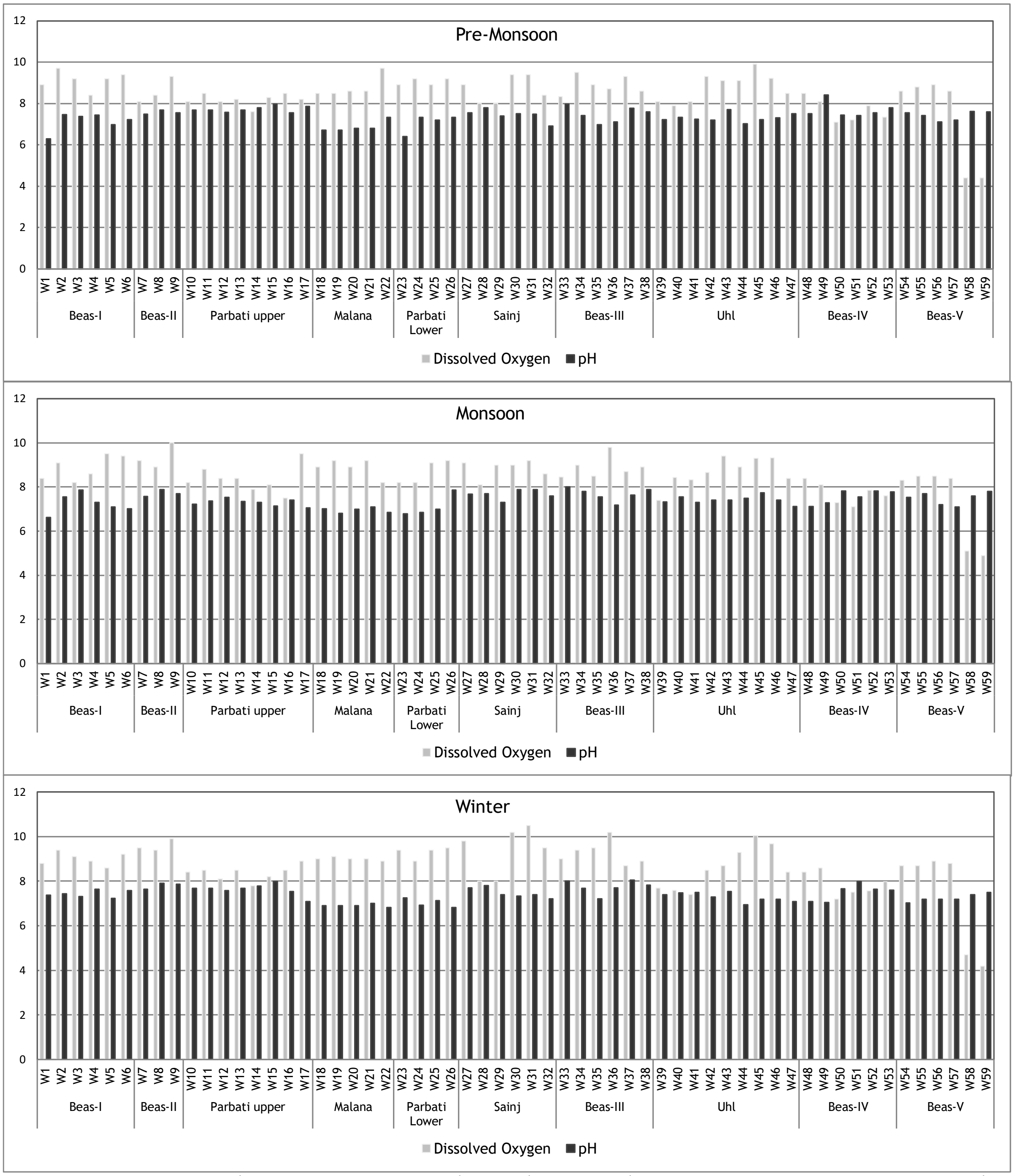


Figure 7.52: DO and pH in Beas river and its tributaries during pre-monsoon, monsoon and winter seasons in different sub-basins

ii) Total Dissolved Solids and Turbidity

Turbidity levels throughout the basin well within the acceptable limits in all the seasons. Only during monsoon are some places in the basin like Sainj sub-basin slightly higher levels of turbidity was observed in the waters of Sainj Khad (**see Figure 7.53**). Total Dissolved Solids were also within the permissible range for freshwater streams except in Beas V sub-basin where TDS in Beas and its tributaries was more than 100 ppm.

iii) Total Hardness, Magnesium and Chlorides

Overall scenario of Total Hardness, Magnesium and Chlorides is given at **Figure 7.54**. It can be seen from the **Figure 7.54** that Magnesium concentrations were much higher especially in Parbati river in Parbati Upper sub-basin and Uhl river water in Uhl sub-basin during all seasons. The chlorides were quite high in streams in Uhl and Beas V sub-basins in all seasons. Total hardness followed the pattern of Magnesium and Chlorides in the basin.

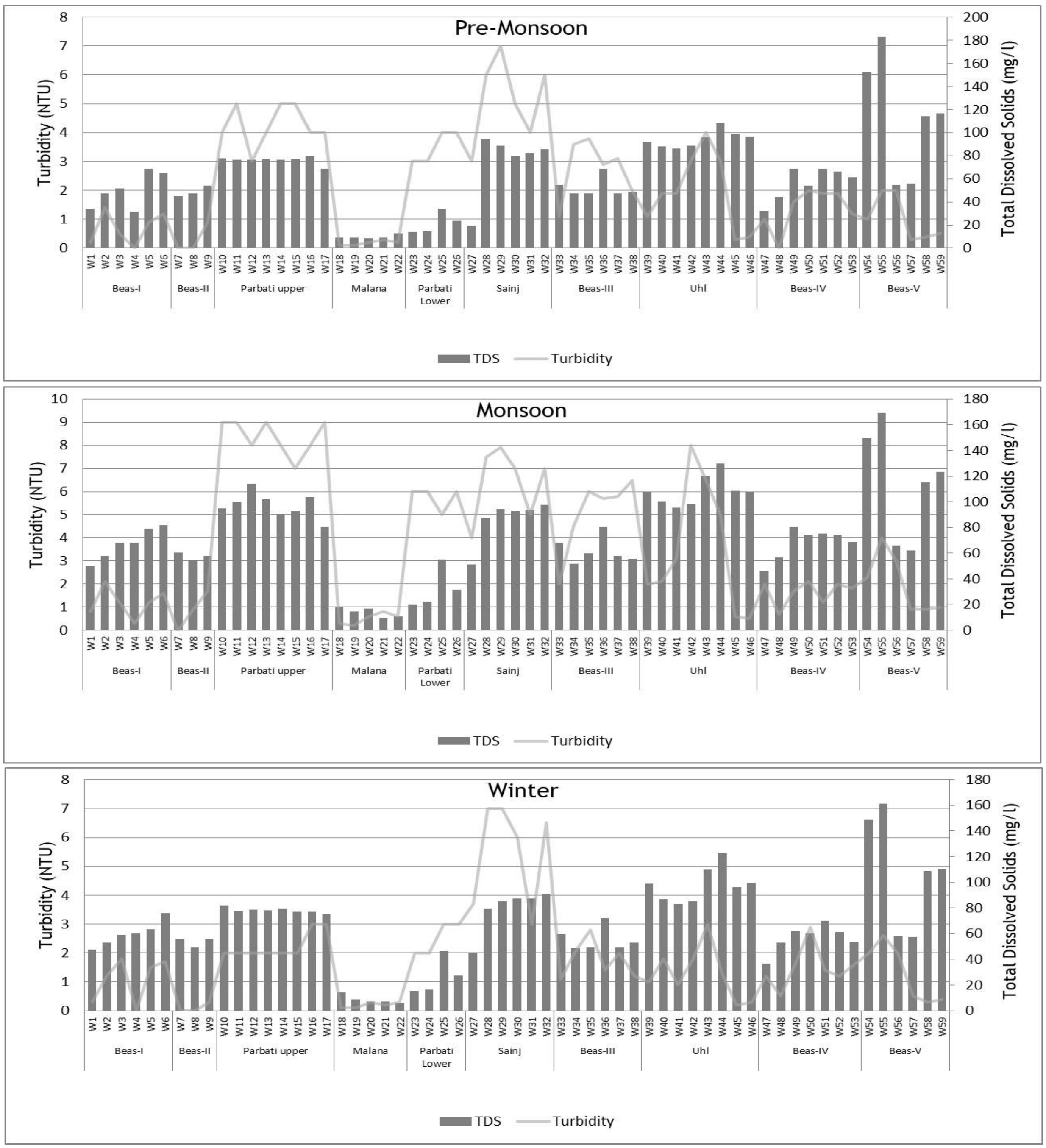


Figure 7.53: TDS and Turbidity in Beas river and its tributaries during pre-monsoon, monsoon and winter seasons in different sub-basins

iv) Biological Oxygen Demand, Chemical Oxygen Demand and Total Coliforms

The pollution levels in different streams in the basin can be assessed through BOD and presence of Total Coliforms at different locations in the basin. Biological oxygen demand throughout the entire basin except for Uhl and Beas V sub-basins was well within the permissible limits varying from 0.3 to 1.5 mg/L (**see Figure 7.55**). In Uhl and Beas V sub-basins BOD varied between 4 and 6 mg/L.

Chemical Oxygen Demand (COD) was quite high at some sampling sites in Beas I sub-basin (W5 & W6- project area of Allain Duhangan HEP). COD was high at 2 sampling sites in Uhl sub-basin at W42 & W43 i.e. Uhl II & Uhl III HE project area and 2 sites in Beas V sub-basin at W53 & W54 sampling sites in Thana Plaun HE project area.

The count of Total Coliforms in general in most of the streams throughout the basin was low. Only streams passing through Manali, Mandi, Joginder Nagar towns etc., had higher count of Total coliforms which might be due to sewage disposal into the streams. Total coliform count was high in Sainj river which is a tributary of Beas in Sainj sub-basin at sites W31 & W32 located in the Parbati III HE project area. However highest counts were recorded at Larji (W35) site during monsoon and winter seasons in Beas III sub-basin and at site W3 in the Bhang HE project area in Beas I sub-basin during monsoon.

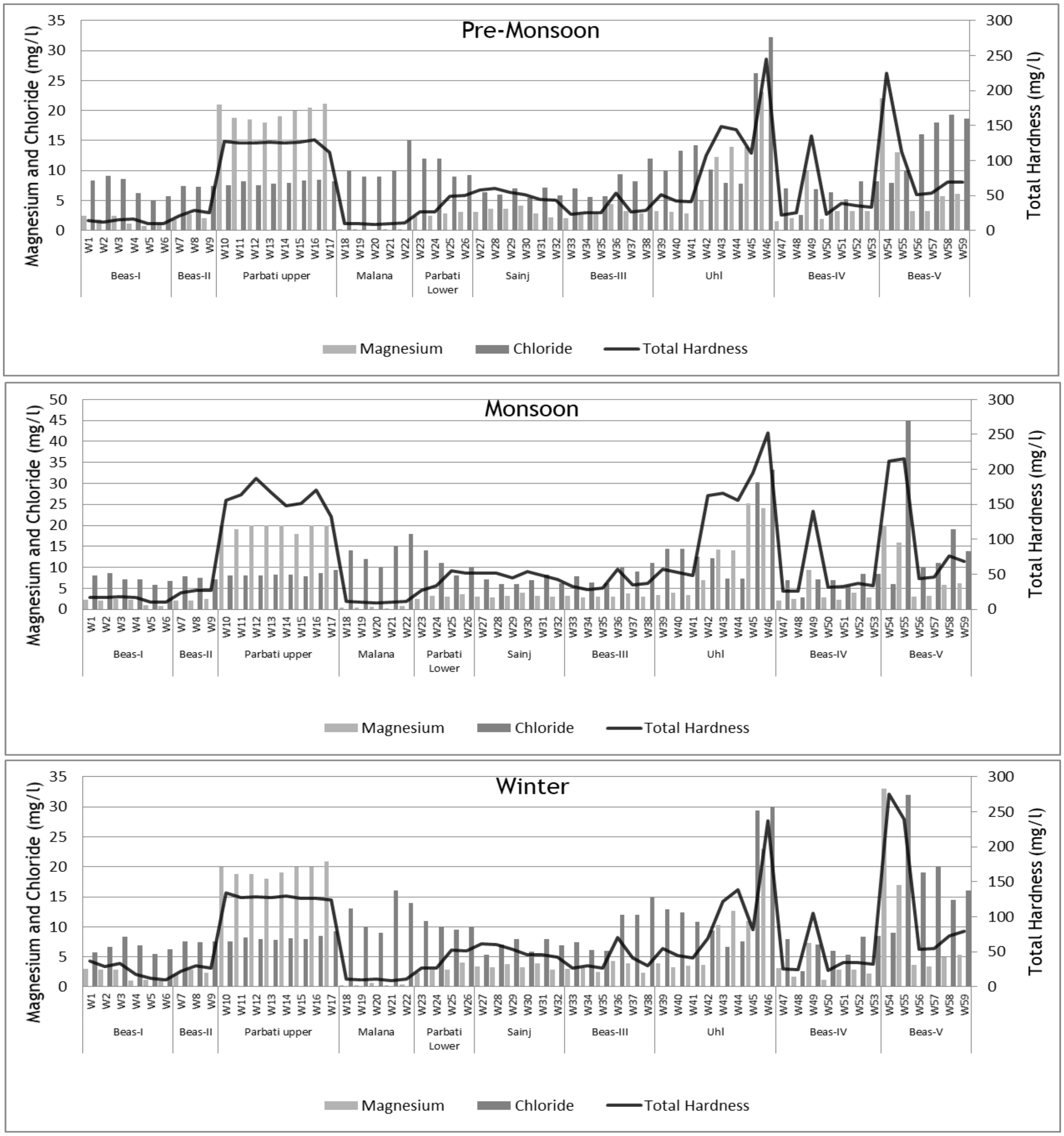


Figure 7.54: Chlorides, Total hardness and Magnesium in Beas river and its tributaries during pre-monsoon, monsoon and winter seasons in different sub-basins

In order to make an overall assessment of water quality of Beas river and its tributary streams water quality indicies like WQI for physico-chemical attributes and BMWP for biological attributes were used. Whereas WQI (Water Quality Index) based upon 9 different water quality parameters is used to measure the physico-chemical water quality in general while BMWP (Biological Monitoring Working Party) in indicative of biological richness of a particular river/stream which is based upon type of Macro-invertebrates inhabiting the particular stream.

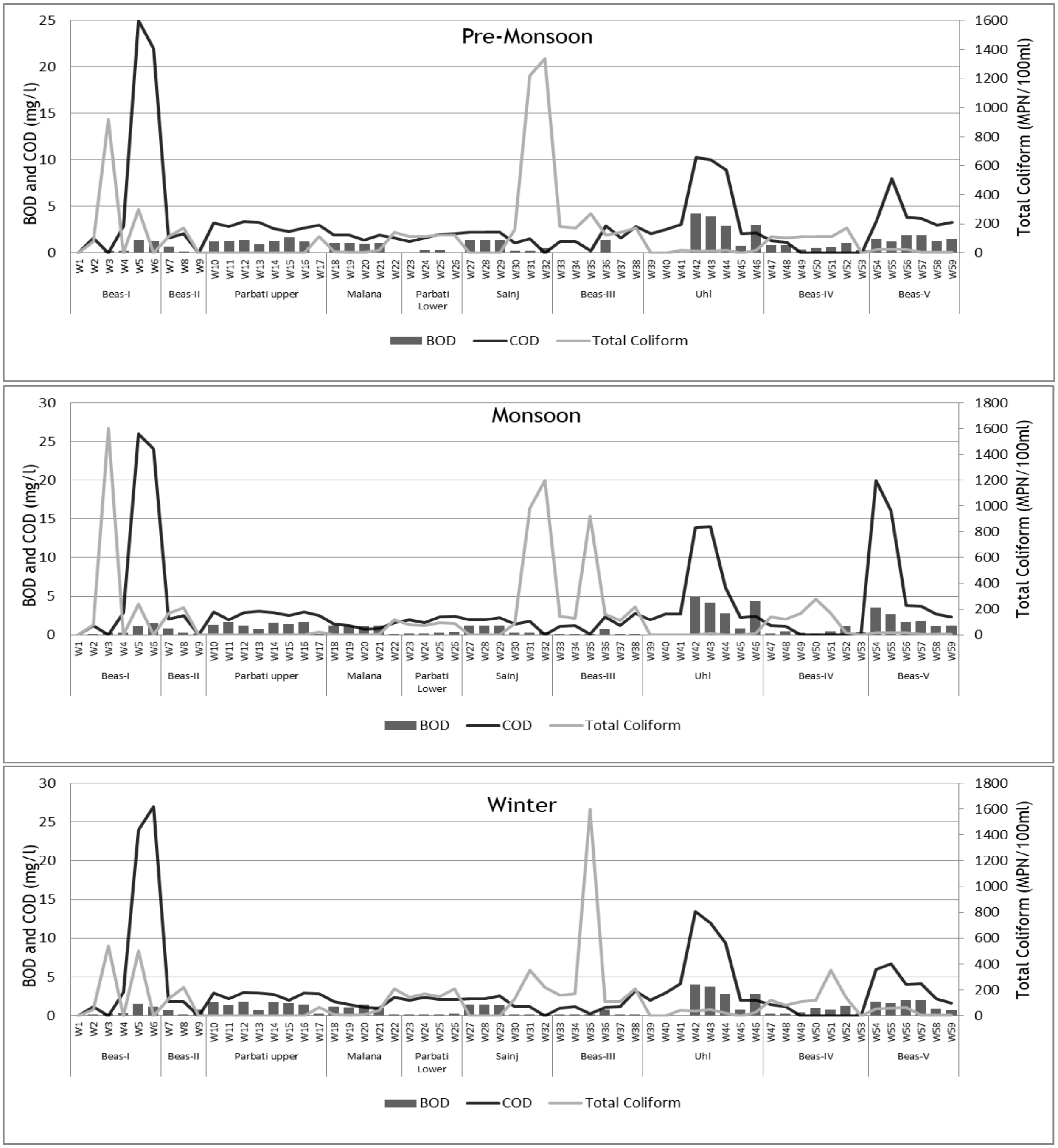


Figure 7.55: BOD, COD and Total Coliforms in Beas river and its tributaries during pre-monsoon, monsoon and winter seasons in different sub-basins

As already mentioned there is hardly any variation in some parameters and heavy metals are either Below Detectable Limits or Not Detectable at most of sites no detail discussion has been done on these aspects. However data compiled on these parameters is given at **Table 7.12**.

Table 7.11: Seasonal variation in Total alkalinity, sulphates and heavy metals at different sampling sites in Beas basin

Parameter	Season	Beas-I						Beas-II		
		W1	W2	W3	W4	W5	W6	W7	W8	W9
Total alkalinity (mg/l of $CaCO_3$)	PM	13	17	16	15	15	22	16	15	20
	M	11	19	18	18	19	19	18	17	24
	W	20	20	19	19	22	24	21	18	21

Parameter	Season	Beas-I						Beas-II		
		W1	W2	W3	W4	W5	W6	W7	W8	W9
Sulphate (mg/l)	PM	3.4	4.2	3.2	2.4	4.99	4.99	2.12	2.32	2.32
	M	5.4	5.1	4.4	3.7	5.66	5.19	2.45	2.43	2.56
	W	4.3	3.2	4.1	2.6	5.23	5.11	2.32	2.39	2.47
Iron (mg/l)	PM	0.07	0.08	0.03	0.21	<0.05	<0.05	<0.05	<0.1	<0.1
	M	0.09	0.07	0.02	0.41	<0.05	<0.05	<0.05	<0.1	<0.1
	W	0.03	0.05	0.04	0.3	<0.05	<0.05	<0.05	<0.1	<0.1
Cadmium (mg/l)	PM	0.004	0.002	0.004	N.D	0.021	0.03	N.D	N.D	N.D
	M	0.005	0.001	0.003	N.D	0.0	0.0832	N.D	N.D	N.D
	W	0.007	0.003	0.006	N.D	0.0	0.0212	N.D	N.D	N.D
Arsenic (mg/l)	PM	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	M	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	W	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Mercury (mg/l)	PM	N.D	N.D	N.D	N.D	0.06	0.043	N.D	N.D	N.D
	M	N.D	N.D	N.D	N.D	0.1	0.052	N.D	N.D	N.D
	W	N.D	N.D	N.D	N.D	0.1	0.055	N.D	N.D	N.D
Copper (mg/l)	PM	0.0002	0.004	0.003	N.D	<0.025	<0.025	N.D	N.D	N.D
	M	0.0004	0.005	0.005	N.D	<0.025	<0.025	N.D	N.D	N.D
	W	0.003	0.005	0.004	N.D	<0.025	<0.025	N.D	N.D	N.D
Zinc (mg/l)	PM	0.011	0.003	0.011	0.04	0.012	0.023	N.D	N.D	N.D
	M	0.012	0.009	0.005	0.02	0.0	0.011	N.D	N.D	N.D
	W	0.012	0.01	0.007	0.1	0.0	0.011	N.D	N.D	N.D
Total Chromium (mg/l)	PM	N.D	N.D	N.D	N.D	<0.025	<0.025	N.D	N.D	N.D
	M	N.D	N.D	N.D	N.D	<0.025	<0.025	N.D	N.D	N.D
	W	N.D	N.D	N.D	N.D	<0.025	<0.025	N.D	N.D	N.D
Manganese (mg/l)	PM	0.02	0.04	0.03	0.02	0.04	0.03	N.D	N.D	N.D
	M	0.04	0.03	0.03	0.03	0.0	0.04	N.D	N.D	N.D
	W	0.04	0.02	0.04	0.03	0.0	0.04	N.D	N.D	N.D
Lead (mg/l)	PM	0.0048	0.0043	0.0039	N.D	<0.06	<0.06	N.D	N.D	N.D
	M	0.005	0.0052	0.0042	N.D	<0.06	<0.06	N.D	N.D	N.D
	W	0.0395	0.0212	0.0323	N.D	<0.06	<0.06	N.D	N.D	N.D

Parameter	Season	Parbati Upper							
		W10	W11	W12	W13	W14	W15	W16	W17
Total alkalinity (mg/l of $CaCO_3$)	PM	32	35	38	36	31	32	29	18
	M	36	31	35	32	33	34	34	22
	W	32	32	30	32	29	27	26	20
Sulphate (mg/l)	PM	16	16	15.5	17.1	16	15.5	15.3	12.4
	M	12.3	13.1	12.5	14.1	13.5	12.2	13.1	11.9
	W	16	16	15.5	17.1	16	15.5	15.3	12.6
Iron (mg/l)	PM	0.16	0.16	0.16	0.16	0.15	0.17	0.15	0.13
	M	0.12	0.6	0.11	0.9	0.17	0.16	0.16	0.15
	W	0.11	0.11	0.12	0.12	0.11	0.12	0.12	0.12
Cadmium (mg/l)	PM	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D
	M	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D
	W	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D
Arsenic (mg/l)	PM	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	M	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	W	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Mercury (mg/l)	PM	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D
	M	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D
	W	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D
Copper (mg/l)	PM	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D
	M	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D
	W	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D
Zinc (mg/l)	PM	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

Parameter	Season	Parbati Upper							
		W10	W11	W12	W13	W14	W15	W16	W17
	M	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	W	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Total Chromium (mg/l)	PM	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D
	M	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D
	W	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D
Manganese (mg/l)	PM	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D
	M	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D
	W	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D
Lead (mg/l)	PM	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D
	M	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D
	W	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D

Parameter	Season	Malana					Parbati Lower			
		W18	W19	W20	W21	W22	W23	W24	W25	W26
Total alkalinity (mg/l of $CaCO_3$)	PM	12	13	15	18	22	23	22	12	14
	M	14	14	16	20	20	22	21	17	18
	W	11	13	14	22	22	26	22	18	13
Sulphate (mg/l)	PM	<0.1	<0.1	<0.1	<1	<1	<1	<1	<1	<1
	M	<0.1	<0.1	<0.1	<1	<1	<1	<1	<1	<1
	W	<0.1	<0.1	<0.1	<1	<1	<1	<1	<1	<1
Iron (mg/l)	PM	0.13	0.12	0.12	0.12	0.1	0.15	0.15	0.21	0.23
	M	0.15	0.11	0.13	0.12	0.12	0.17	0.19	0.23	0.24
	W	0.13	0.12	0.12	0.13	0.13	0.12	0.14	0.22	0.26
Cadmium (mg/l)	PM	<0.01	<0.01	<0.01	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	M	<0.01	<0.01	<0.01	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	W	<0.01	<0.01	<0.01	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Arsenic (mg/l)	PM	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D
	M	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D
	W	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D
Mercury (mg/l)	PM	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D
	M	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D
	W	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D
Copper (mg/l)	PM	N.D	0.008	0.008	0.009	0.009	0.01	0.02	N.D	N.D
	M	N.D	0.005	0.009	0.005	0.008	0.02	0.04	N.D	N.D
	W	N.D	0.009	0.008	0.009	0.004	0.01	0.03	N.D	N.D
Zinc (mg/l)	PM	N.D	0.01	0.01	0.01	0.02	0.01	0.01	<0.02	<0.02
	M	N.D	0.01	0.01	0.02	0.01	0.03	0.03	<0.02	<0.02
	W	N.D	0.01	0.01	0.01	0.01	0.02	0.02	<0.02	<0.02
Total Chromium (mg/l)	PM	N.D	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	M	N.D	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	W	N.D	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Manganese (mg/l)	PM	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.02	0.01
	M	0.08	0.04	0.05	0.04	0.07	0.08	0.6	0.03	0.02
	W	0.07	0.05	0.05	0.05	0.05	0.04	0.05	0.04	0.03
Lead (mg/l)	PM	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D
	M	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D
	W	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D

Parameter	Season	Sainj						Beas III					
		W27	W28	W29	W30	W31	W32	W33	W34	W35	W36	W37	W38
Total alkalinity (mg/l of	PM	11	12	12.9	12.4	10.2	12.1	20	20	21	22	19	18
	M	14	14	14.2	14.1	12.1	13.3	24	21	25	24	21	22
	W	16	15	15.3	17.9	13.2	14.5	21.9	22	22	26	22	21

Parameter	Season	Sainj						Beas III					
		W27	W28	W29	W30	W31	W32	W33	W34	W35	W36	W37	W38
$CaCO_3$)													
Sulphate (mg/l)	PM	<1	<1.0	<1.0	<1.0	<1.0	<1.0	4.23	2.12	2.25	4.23	3.22	4.12
	M	<1	<1.0	<1.0	<1.0	<1.0	<1.0	4.4	2.84	2.7	5.01	4.12	4.8
	W	<1	<1.0	<1.0	<1.0	<1.0	<1.0	4.37	2.42	2.44	4.87	3.87	3.87
Iron (mg/l)	PM	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.12	0.11	0.12	<0.1	<0.1	<0.1
	M	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.2	0.1	0.2	<0.1	<0.1	<0.1
	W	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.14	0.12	0.19	<0.1	<0.1	<0.1
Cadmium (mg/l)	PM	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	M	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	W	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Arsenic (mg/l)	PM	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D
	M	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D
	W	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D
Mercury (mg/l)	PM	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	M	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	W	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Copper (mg/l)	PM	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.0003	0.0045	<0.1
	M	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.0002	0.0012	<0.1
	W	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.0031	0.0002	<0.1
Zinc (mg/l)	PM	0.15	0.15	0.14	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D
	M	0.15	0.15	0.14	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D
	W	0.24	0.24	0.12	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D
Total Chromium (mg/l)	PM	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	M	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	W	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Manganese (mg/l)	PM	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	M	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	W	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Lead (mg/l)	PM	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	M	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	W	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

Parameter	Season	Uhl							
		W39	W40	W41	W42	W43	W44	W45	W46
Total alkalinity (mg/l of $CaCO_3$)	PM	89.3	82	90.32	89.3	78	67.5	78	63.7
	M	91.2	84.21	94.23	93.3	94.3	78.06	77.32	75.2
	W	81.68	81.94	89.45	80	90	70	69.67	60.67
Sulphate (mg/l)	PM	8.3	12.9	9.3	10.3	9.2	10.3	12.2	10.2
	M	10.4	9.32	9.87	11.2	10.8	11.3	10.2	13.2
	W	14	9.42	10.84	10.2	9.4	10.8	15.2	12.9
Iron (mg/l)	PM	0.007	0.07	0.008	0.18	0.2	0.21	A	A
	M	0.009	0.09	0.01	0.2	0.18	0.23	A	A
	W	0.08	0.04	0.006	0.16	0.14	0.19	A	A
Cadmium (mg/l)	PM	<0.1	<0.1	<0.1	BDL	BDL	BDL	A	A
	M	<0.1	<0.1	<0.1	BDL	BDL	BDL	A	A
	W	<0.1	<0.1	<0.1	BDL	BDL	BDL	A	A
Arsenic (mg/l)	PM	N.D	N.D	N.D	BDL	BDL	BDL	A	A
	M	N.D	N.D	N.D	BDL	BDL	BDL	A	A
	W	N.D	N.D	N.D	BDL	BDL	BDL	A	A
Mercury (mg/l)	PM	<0.1	<0.1	<0.1	BDL	BDL	BDL	A	A
	M	<0.1	<0.1	<0.1	BDL	BDL	BDL	A	A
	W	<0.1	<0.1	<0.1	BDL	BDL	BDL	A	A
Copper (mg/l)	PM	<0.005	<0.005	<0.005	BDL	BDL	BDL	A	A
	M	<0.005	<0.005	<0.005	BDL	BDL	BDL	A	A

Parameter	Season	Uhl							
		W39	W40	W41	W42	W43	W44	W45	W46
	W	<0.005	<0.005	<0.005	BDL	BDL	BDL	A	A
Zinc (mg/l)	PM	<0.001	<0.001	<0.001	BDL	BDL	BDL	A	A
	M	<0.001	<0.001	<0.001	BDL	BDL	BDL	A	A
	W	<0.001	<0.001	<0.001	BDL	BDL	BDL	A	A
Total Chromium (mg/l)	PM	ND	ND	ND	BDL	BDL	BDL	A	A
	M	ND	ND	ND	BDL	BDL	BDL	A	A
	W	ND	ND	ND	BDL	BDL	BDL	A	A
Manganese (mg/l)	PM	<0.1	<0.1	<0.1	BDL	BDL	BDL	N.D	N.D
	M	<0.1	<0.1	<0.1	BDL	BDL	BDL	N.D	N.D
	W	<0.1	<0.1	<0.1	BDL	BDL	BDL	N.D	N.D
Lead (mg/l)	PM	<0.001	<0.001	<0.001	BDL	BDL	BDL	A	A
	M	<0.001	<0.001	<0.001	BDL	BDL	BDL	A	A
	W	<0.001	<0.001	<0.001	BDL	BDL	BDL	A	A

Parameter	Season	Beas IV							Beas V					
		W47	W48	W49	W50	W51	W52	W53	W54	W55	W56	W57	W58	W59
Total alkalinity (mg/l of $CaCO_3$)	PM	18	32	32	29	33	30	29.4	77	79	67	71	69	68
	M	20	30	33	27	34	28	26.9	75	85	71	77	67	61
	W	21	32	28	30	36	24	24.5	75	75	75	79	71	77
Sulphate (mg/l)	PM	4.3	3.2	6.01	5.32	3.9	6.8	7.9	14	11	4	5	4.2	3.9
	M	4.2	3	5.87	5.7	3.5	6.8	7.21	10	9	4	3.5	4.3	4.1
	W	4.9	3.9	5.89	5.32	4.3	6.9	7.23	12	15	5	6	3.9	4
Iron (mg/l)	PM	0.24	<0.01	1.7	0.2	0.2	0.1	0.12	0.02	0.02	0.5	0.6	0.31	0.3
	M	0.21	<0.01	1.6	0.12	0.3	0.12	0.11	0.025	0.03	0.3	0.8	0.32	0.5
	W	0.23	<0.01	1.2	0.13	0.3	0.13	0.13	0.033	0.028	0.7	0.8	0.3	0.1
Cadmium (mg/l)	PM	N.D	N.D	0.01	N.D	N.D	N.D	N.D	<0.01	<0.01	<0.01	<0.01	0.009	0.008
	M	N.D	N.D	0.01	N.D	N.D	N.D	N.D	<0.01	<0.01	<0.01	<0.01	0.007	0.007
	W	N.D	N.D	0.01	N.D	N.D	N.D	N.D	<0.01	<0.01	<0.01	<0.01	0	0
Arsenic (mg/l)	PM	N.D	<0.001	N.D	N.D	N.D	N.D	N.D	<0.05	<0.05	<0.001	<0.001	<0.001	<0.001
	M	N.D	<0.001	N.D	N.D	N.D	N.D	N.D	<0.05	<0.05	<0.001	<0.001	<0.001	<0.001
	W	N.D	<0.001	N.D	N.D	N.D	N.D	N.D	<0.05	<0.05	<0.001	<0.001	<0.001	<0.001
Mercury (mg/l)	PM	N.D	<0.1	N.D	N.D	N.D	N.D	N.D	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	M	N.D	<0.1	N.D	N.D	N.D	N.D	N.D	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	W	N.D	<0.1	N.D	N.D	N.D	N.D	N.D	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Copper (mg/l)	PM	N.D	<0.1	N.D	N.D	N.D	N.D	N.D	<0.01	<0.01	<0.001	<0.02	<0.02	<0.02
	M	N.D	<0.1	N.D	N.D	N.D	N.D	N.D	<0.01	<0.01	<0.001	<0.02	<0.02	<0.02
	W	N.D	<0.1	N.D	N.D	N.D	N.D	N.D	<0.01	<0.01	<0.001	<0.02	<0.02	<0.02
Zinc (mg/l)	PM	N.D	<0.05	N.D	N.D	N.D	N.D	N.D	<0.01	<0.01	<0.02	<0.05	<0.05	<0.05
	M	N.D	<0.05	N.D	N.D	N.D	N.D	N.D	<0.01	<0.01	<0.02	<0.05	<0.05	<0.05
	W	N.D	<0.05	N.D	N.D	N.D	N.D	N.D	<0.01	<0.01	<0.02	<0.05	<0.05	<0.05
Total Chromium (mg/l)	PM	N.D	N.D	N.D	N.D	N.D	N.D	N.D	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
	M	N.D	N.D	N.D	N.D	N.D	N.D	N.D	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
	W	N.D	N.D	N.D	N.D	N.D	N.D	N.D	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Manganese (mg/l)	PM	N.D	<0.1	N.D	N.D	N.D	N.D	N.D	N.D	N.D	0.02	0.02	0.01	0.14
	M	N.D	<0.1	N.D	N.D	N.D	N.D	N.D	N.D	N.D	0.03	0.04	0.02	0.2
	W	N.D	<0.1	N.D	N.D	N.D	N.D	N.D	N.D	N.D	0.02	0.01	0.12	0.21
Lead (mg/l)	PM	N.D	0.76	N.D	N.D	N.D	N.D	N.D	<0.05	<0.05	<0.01	<0.01	0.31	0.36
	M	N.D	0.87	N.D	N.D	N.D	N.D	N.D	<0.05	<0.05	<0.01	<0.01	0.32	0.021
	W	N.D	0.56	N.D	N.D	N.D	N.D	N.D	<0.05	<0.05	<0.01	<0.01	0.0257	0.0263

7.3.5.1 WQI (Water Quality Index)

In order to assess the overall physico-chemical water quality of Beas river as well as its tributaries a WQI (Water Quality Index) was used which has been developed at Washington State Department of Ecology, Environmental Assessment Programme. The WQI used in the report is a unitless number ranging from 1 to 100. A higher number is indicative of better water quality. For temperature, pH, coliforms and dissolved oxygen, the index expresses result relative to levels required to maintain beneficial uses (based on criteria in Washington's Water Quality Standards, WAC 173-201A).

Water quality index is a 100-point scale that summarizes results from a total of 9 different parameters listed below in the table.

pH	Temerature Change ^{0}C	Total Phosphates mg/L
Dissolved Oxygen (DO) Saturation (%)	Total Coliforms MPN/100mL	Nitrates mg/L
Turbidity NTU	Biochemical Oxygen Demand (BOD) mg/L	Total Suspended Solids (TSS) m/L

The analysis of water quality therefore has been based upon 9 parameters as defined for WQI above and based upon the score at each sampling site water quality has been designated as Excellent, Good, Medium, etc. as per the range defined in the tabe below. The analysis of river water quality in Beas basin and its tributary streams throughout the basin based upon WQI is given in the following paragraphs.

Water Quality Index	
Range	**Quality**
90-100	Excellent
70-90	Good
50-70	Medium
25-50	Bad
0-25	Very bad

As discussed earlier in order to assess the physico-chemical water quality of Beas river and its tributary streams WQI was calculated and results of the same are shown in **Figure 7.56**. As seen from the chart WQI varied from 64.94 to 93.49. The chart shows that WQI at majority of sampling sites in different sub-basins during all seasons ranges from Good to Excellent as the values in general range between 70 and 94 which indicates that water quality based upon above parameters is largely Good or Excellent. Only at some of the sampling sites in Parbati Lower (W23 – W26 Parbati, Sharni and Sarsadi HE project areas is in Medium category. It was also seen that BOD values were higher than the normal range and Total Coliforms were also on high side presumably due to discharge of untreated discharge of domestic sewage directly into Beas river where towns like Manali, Kullu and Mandi.

Similarly, biological water quality of Beas river as well its tributary streams was also estimated. Macro-invertebrates are one of the indicators of water quality of freshwater streams. The water quality assessment of Beas river and its tributaries was assessed by calculating BMWP and ASPT values which are based upon type of species found in the water which are an indicative of river water quality. There are certain genera which are pollution sensitive and their presence in a particular streams indicates Excellent water quality whereas presence of pollution tolerant genera is indicative of polluted waters of the streams. The methodology to calculate these indices has been given in Chapter 3-Methodology of this report.

For ease of interpretation, the BMWP cumulative total scores thus calculated have been banded to distinguish broad categories of water quality as shown in table below.

Description	Score Band
Excellent	>150
Very Good	101 - 150
Good	51 – 100
Moderate	26 – 50
Poor	<25

BMWP score calculated for different sampling sites in different sub-basins during various seasons is given at **Figure 7.57**. It varied from lowest value of 24 to highest value of 144. Water quality during monsoon in general was Poor to Good in most of water sampling sites in Parbati Lower, Uhl, Sainj, Beas III, Beas IV and Beas V sub-basins. Water quality however was in Good category during winters at all the above sites. Water quality scenario was almost similar to winters in pre-monsoon season at all these sites. At majority of the sampling sites water quality is in 'Very Good' category at sampling sites located in Parbati Upper and Parbati Lower sub-basins especially during pre-monsoon and winters.

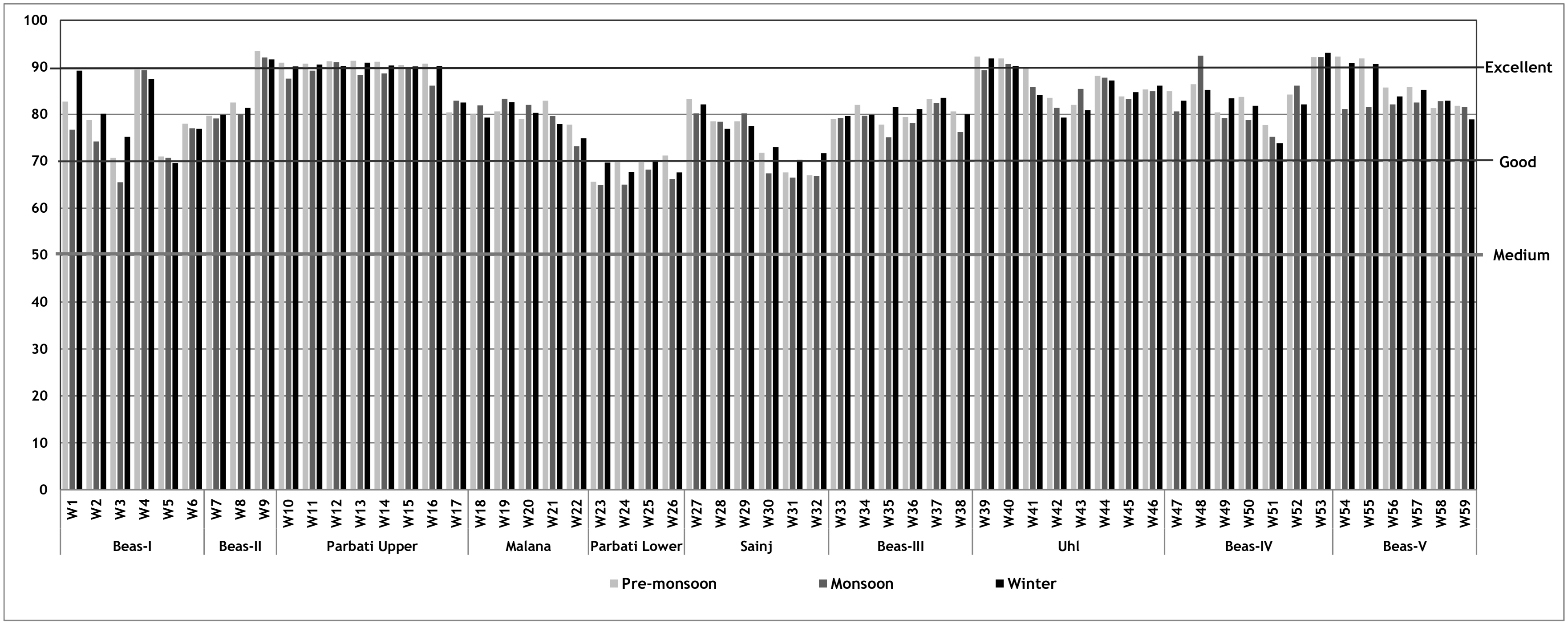


Figure 7.56: WQI in Beas river and its tributaries during pre-monsoon, monsoon and winter seasons in different sub-basins

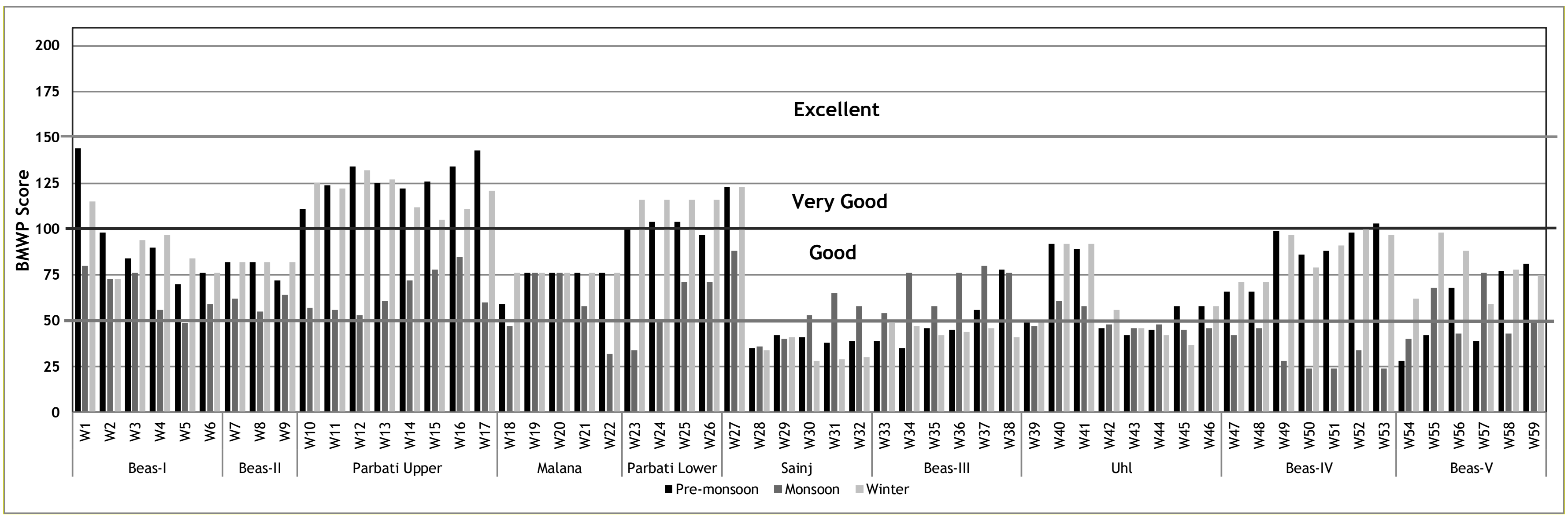


Figure 7.57: BMWP Score in Beas river and its tributaries during pre-monsoon, monsoon and winter seasons in different sub-basins

The average sensitivity of the families of the organisms present is known as the Average Score per Taxon (ASPT). The ASPT index gives an indication of the evenness of community diversity. ASPT is calculated by dividing the BMWP score for each site by the total number of scoring families found there, so it is independent of sample size. The ASPT score varied from 3.0 to 8 (see Figure 7.58). ASPT scores are higher at sites located at higher elevations in Beas I, Beas II, Parbati Upper, Malana and Parbati Lower sub-basins.

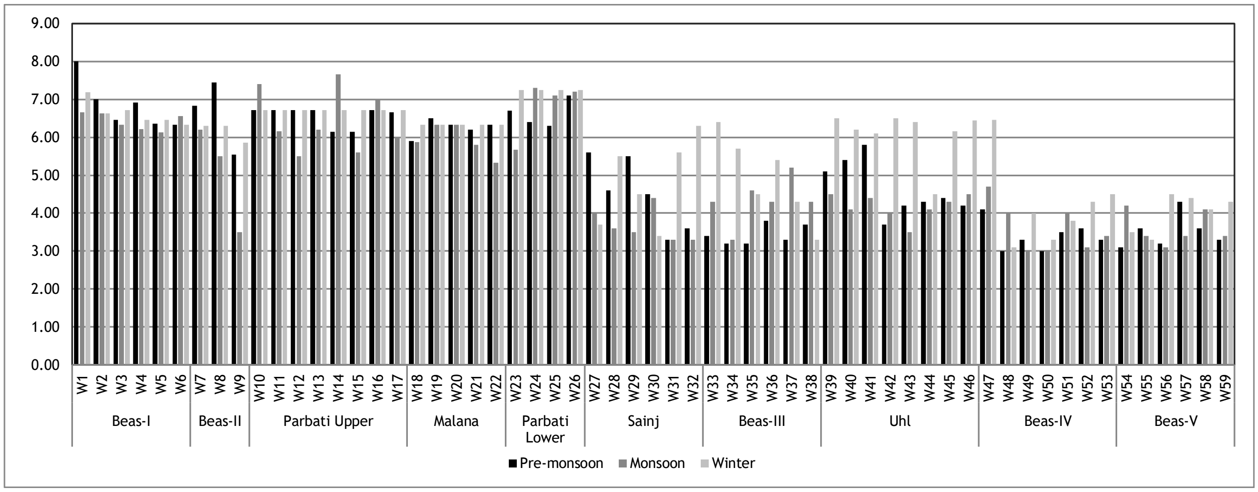


Figure 7.58: ASPT Scores in Beas river and its tributaries during pre-monsoon, monsoon and winter seasons in different sub-basins

7.4 FISHES

Fishes have great significance in the life of mankind, being an important natural source of protein, and also providing certain other useful products as well as economic sustenance. The Himalaya from south to north exhibits a variety of physiographic features, climate, and rock types belonging to the long geological history. These characteristics affect the physical, chemical and biological properties of the stream and river water alongwith their respective gradients. These features are also reflected in the habitat of the fish fauna. The Himalayan streams are well known for their cold-water fisheries, particularly at the higher elevations. The fish density and diversity gradually decreases from lower to upper reaches, because it mainly depends on the water current velocity, water temperature, dissolved oxygen and food availability.

The state of Himachal Pradesh is a mountainous region spread over an area of 55,673 sq km. It is drained by rivers like Ravi, Beas, Sutlej and Chenab with elevation ranging from 450 m to 6,500 m (Jagtap, 2013). Beas river is a one of the largest glacierfed rivers in the state flowing for a length of 470 km before joining the Sutlej River at Harike Pattan south of Amritsar in state of Punjab. The total catchment area of Beas river in Himachal Pradesh is 12,591 sq km and its length in the study area is about 274 km.

All these river basins in the state are well known for their cold-water fisheries. The fisheries in the state is well organized as compared to that of other Himalayan states like Uttarakhand, Jammu & Kashmir, Sikkim and Arunachal Pradesh. It addition to rivers the state also harbours

4 large reservoirs like Gobind Sagar, Maharana Pratap Sagar, Pandoh and Chamera. These reservoirs play a vital role in commercial fishery and state revenue (Jagtap, 2013).

7.4.1 Beas Drainage System Characteristics

Beas darainage system in Himachal Pradesh is spread over a length of more than 900 km, which is comprised of 274 km of Beas river and about 626 km of tributaries (Sehgal, 1983). Important from viewpoit of fishes are Baner, Binwa, Neugal, Dehar, Awa, Banganga, Gaj, Manuni, Parbati, Patlikuhl, Sainj, Suketi, Tirthan and Uhl. Northern and eastern tributaries are perennial and snow fed while southern tributaries are seasonal. Coldwater streams are characterized by high transparency and dissolved oxygen. Major cold-water fishes belong to Cyprinidae, Cobitidae and Sisoridae and these fishes are small in size. Most of the hill stream fishes live at the bottom or on the banks due to low water current than the main Beas river. Fishes living in torrential tributary streams have special organs for attachment. These fishes thrive in the hilly streams and have bottom dwelling habits.

According to classification of Rosgen (1996) Beas River can be divided into following categories on the basis of general features, substratum and altitude of the stream to know the adequate habitat of the fish.

1. Type A1 Stream (>1251 m): These type of streams are dominated by large boulders and have very steep gradient. Step pools are the main habitat of such streams. The streams are narrow with torrential flow of current with dense riparian vegetation. The depth to width ratio of the stream is more than 1.

2. Type A Stream (1250-951 m): These types of streams are also narrow but comparatively broader than ‘A’ type streams and are their bed is characterised by big and small boulders followed by cobbles and gravel. These are almost silt free. Rapids and riffles constitute the main habitats.

3. Type B Stream (950-751 m): These streams are wider than ‘A’ type of streams. The width and the depth ratio are almost same in these streams. Pools constitute the main habitat of these streams. Large and small boulders are almost in equal proportions followed by cobbles and gravel. Riffles constitute the main habitat followed by rapids and runs.

4. Type C (750-500 m): These streams are mostly of open type and the width of the streams is comparatively more than that of the depth. Their riverbed is dominated by cobbles and gravels. Boulders are scattered along the bank and in the stream. Runs and riffles are the main habitat of these streams.

5. Type F Stream (<500 m): These stream sites are wide and also of open type and mostly located in the meadows and urban areas. The streams are dominated by sand and cobbles while small stones are scattered. The streams are shallow and water flows smoothly in the stream.

Snow trout is the dominant species of A1, A and B streams while Mahseer is dominant fish species in Type B and C streams.

7.4.2 Fish Species Diversity

An inventory of fish fauna of Beas basin was prepared with the help of secondary literature. The secondary literature comprises Environment Master Plan of Government of Himachal Pradesh, Jindal *et al*. (2014), Jagtap (2013), Sharma (2007), Kumar (2010), Mehta and Uniyal (2004), Johal *et al*. (2001).

Mehta and Uniyal (2004) had reported 104 species of fishes grouped under 17 families in Himachal Pradesh whereas Environment Master Plan of State Government has mentioned 83 species from the state. Zoololgical Survey of India (ZSI) have published reports on fishes of Beas river which are by Sharma and Mehta (2010) and Sharma (2010). Other studies include studies by Kumar (2010). Sharma (2010) had listed 67 fish species from Beas river. Based upon the data compiled various secondary sorces cited above fish fauna in the Beas basin is comprised of 84 species belonging to 14 families (**Table 7.13**). Cyprinidae is the largest family represented by 43 species followed by Cobitidae and Sisoridae with 11 species each. As many as 57 species have been reported from Pong Dam reservoir itself. The conservation status of fish species was assessed with the help of IUCN Redlist, Conservation Assessment and Management Plan (CAMP) Workshops Report (1998) and Threatened Freshwater Fishes of India by National Bureau of Fish Genetic Resources, Lucknow (NBFGR, 2010).

The experimental fishing was carried out in different stretches of the Beas river and its tributaries to assess the fish composition in the Beas basin (Editor-Director, ZSI, 2009).

Table 7.12: List of Fishes reported from Beas basin

S. No.	Family	*Scientific name*	Common name	Conservation Status		
				IUCN Red List	CAMP	NBFGR
1	Ambassidae	*Chanda nama*	Chilwa	LC	-	-
2	Amblycipitidae	*Amblyceps mangois*	Sundal	LC	LRnt	EN
3	Bagridae	*Aorichthys seenghala*		LC	-	-
4	Bagridae	*Mystus bleekeri*		LC	VU	-
5	Bagridae	*Mystus vittatus*	Kingra	LC	VU	-
6	Bagridae	*Rita rita*	Khagga	LC	LRnt	-
7	Bagridae	*Sperata aor*		LC	-	VU
8	Chanidae	*Channa marulius*	Saul	LC	LRnt	-
9	Chanidae	*Channa orieltalis*		LC	VU	-
10	Chanidae	*Channa striatus*		LC	LRlc	-
11	Cobitidae	*Achanthocobitis botia*		LC	LRnt	-
12	Cobitidae	*Botia birdi*	Chipar	-	LRnt	-
13	Cobitidae	*Botia dario*		LC	LRnt	VU
14	Cobitidae	*Botia rostrata*		VU	-	-
15	Cobitidae	*Lepidocephalichthys guntea*	Jiwa	LC	-	-
16	Cobitidae	*Nemacheilus corica*	Talana	LC	LRnt	-
17	Cobitidae	*Paraschistura montana (=Nemacheilus kangrae)*		-	EN	-
18	Cobitidae	*Schistura carletoni*		-	EN	-
19	Cobitidae	*Schistura*		-	EN	-

S. No.	Family	Scientific name	Common name	Conservation Status		
				IUCN Red List	CAMP	NBFGR
		himanchalensis				
20	Cobitidae	*Schistura horai*		-	VU	-
21	Cobitidae	*Schistura rupecula*		-	LRnt	-
22	Cyprinidae	*Barilius barila*		LC	VU	-
23	Cyprinidae	*Barilius barna*	Patha	LC	LRnt	-
24	Cyprinidae	*Barilius bendelisis*	Patha	LC	LRnt	-
25	Cyprinidae	*Barilius modestus*	Chilwa	-	-	-
26	Cyprinidae	*Barilius vagra*	Lohari	LC	VU	-
27	Cyprinidae	*Catla catla*		-	VU	-
28	Cyprinidae	*Cirrhinus mrigala*	Mori/ Mrigal	LC	LRnt	-
29	Cyprinidae	*Cirrhinus reba*		LC	VU	-
30	Cyprinidae	*Crosscheilus diplochilus*		LC	DD	-
31	Cyprinidae	*Crossocheilus latius*	Tiller	LC	DD	VU
32	Cyprinidae	*Danio rerio*	Kangi	LC	LRnt	-
33	Cyprinidae	*Devario devario*	Parrandah	LC	LRnt	-
34	Cyprinidae	*Esomus danrica*	Makni	LC	LRlc	-
35	Cyprinidae	*Garra gotyla*	Sunni, Kurka	LC	VU	VU
36	Cyprinidae	*Garra lamta*		LC	-	VU
37	Cyprinidae	*Labeo bata*		LC	LRnt	-
38	Cyprinidae	*Labeo calbasu*	Kalbans	LC	LRnt	-
39	Cyprinidae	*Labeo dero*	Gid	LC	VU	-
40	Cyprinidae	*Labeo dyocheilus*	Kunni	LC	VU	-
41	Cyprinidae	*Labeo gonius*		LC	LRnt	-
42	Cyprinidae	*Labeo pangusia*		LC	LRnt	VU
43	Cyprinidae	*Labeo rohita*	Rohu	LC	LRnt	-
44	Cyprinidae	*Oreinus sinuatus*		-	LRnt	-
45	Cyprinidae	*Osteobrama cotio*		LC	LR	-
46	Cyprinidae	*Pethia conchonius*		LC	VU	-
47	Cyprinidae	*Pethia phutunio*		LC	LRlc	-
48	Cyprinidae	*Pethia ticto*	Puthi	LC	LRnt	-
49	Cyprinidae	*Puntius chola*	Chidu	LC	VU	VU
50	Cyprinidae	*Puntius sophore*	Chidu	LC	LRnt	-
51	Cyprinidae	*Raiamas bola*		LC	VU	-
52	Cyprinidae	*Rasbora daniconius*	Chindolachal	LC	-	-
53	Cyprinidae	*Salmophasia bacaila*		LC	-	-
54	Cyprinidae	*Salmophasia orrisaensis*		LC	-	-
55	Cyprinidae	*Schizothorax plagiostomus*	Gurgal, Googly	-	-	-
56	Cyprinidae	*Schizothorax richardsonii*	Gurgal, Googly	VU	VU	VU
57	Cyprinidae	*Systomus sarana*		LC	VU	VU
58	Cyprinidae	*Tor mosal*		-	EN	EN
59	Cyprinidae	*Tor putitora*	Mahseer, Chiniartu	EN	EN	EN
60	Cyprinidae	*Tor tor*	Mahseer	NT	EN	EN
61	Gobiidae	*Glossogobius giuris*		LC	LRnt	-
62	Mastacembelidae	*Mastacembelus armatus*	Bami	LC	-	-
63	Nemacheilidae	*Acanthocobitis botia*	Sundal	LC	LRnt	-
64	Notopteridae	*Notopterus notopterus*	Moh	LC	LRnt	-
65	Schibeidae	*Clupisoma garua*		LC	VU	-
66	Siluridae	*Wallago attu*	Malli	NT	LRnt	-
67	Sisoridae	*Bagarius bagarius*		NT	VU	VU
68	Sisoridae	*Glyptothorax brevipinnis*		DD	VU	-
69	Sisoridae	*Glyptothorax conirostris*		DD	-	-
70	Sisoridae	*Glyptothorax gracilis*		DD	-	-

S. No.	Family	*Scientific name*	Common name	Conservation Status		
				IUCN Red List	CAMP	NBFGR
71	Sisoridae	*Glyptothorax horai*		LC	-	-
72	Sisoridae	*Glyptothorax indicus*		LC	VU	-
73	Sisoridae	*Glyptothorax telchitta*		LC	LRnt	-
74	Sisoridae	*Glyptothrax garhwali*		LC	CR	-
75	Sisoridae	*Glyptothrax pectinopterus*		LC	LRnt	-
76	Sisoridae	*Glyptothrax stolickae*	Naiya	LC	CR	-
77	Sisoridae	*Pseudocheneis sulcatus*		LC	VU	VU
	Exotic					
78	Cyprinidae	*Amblypharyngodon mola*	Chilwa	LC	LRlc	-
79	Cyprinidae	*Carrasius auratus*		LC	-	-
80	Cyprinidae	*Ctenopharyngodon idella*		-	-	-
81	Cyprinidae	*Hypophthalmichthys molitrix*		NT	-	-
82	Salmonidae	*Cyprinus carpio*		VU	-	-
83	Salmonidae	*Oncorhynchus mykiss*	Rainbow trout	-	-	-
84	Salmonidae	*Salmo trutta fario*	Brown trout	-	-	-

CR= Critically Endangered; EN= Endangered; VU= Vulnerable; DD= Data Deficient; LC= Least Concern; LRnt= Low Risk near threatened; LRlc= Low Risk least concern

Out of 84 species a total of 77 are native/indigenous while remaining 7 fish viz. *Amblypharyngodon mola* (Mola Carplet), *Hypophthalmichthys molitrix* (Silver Carp), *Ctenopharyngodon idella* (Grass carp), *Carassius auratus* (Gold Fish), *Cyprinus carpio* (Common Carp), *Salmo trutta fario* (Brown Trout) and *Oncorhynchus mykiss* (Rainbow Trout) are exotic. Fish diversity decreases along the elevational gradient, thus lower reaches of basin/sub-basins harbour relatively high species richness.

Sub-basin wise distribution pattern of fish indicates that Beas IV sub-basin harbours the highest number of species while lowest richness computed for Beas I sub-basin (**Table 2**). Rich fish fauna of Beas IV sub-basin can be attributed to the presence of Pong Dam reservoir at the foot of the basin and many perennial tributaries like Baner Khad, Gaj Khad and Dehar Khad. These tributaries are considered as sanctuaries of fish. Baner is one of the known spawning ground of *Tor putitora* (Golden Mahseer). The seeds of Golden mahseer had been collected by Joshi (1980) from Baner Khad successfully. The sub-basins like Uhl, Beas III and Beas IV extend in lower reaches are dominated by carp fishes like *Labeo* spp., *Tor putitora*, *Catla catla* (Main river) and minor carp like *Barilius* spp., *Puntius* spp., *Nemacheilus* spp., etc. (in tributaries). Sub-basins in upper reaches like Beas I, Beas II, Sainj Khad, Tirthan, Parbati I, Parbati II and Malana II are dominated by Snow Trout (*Schizothorax richardsonii*). However, due to regular introduction of Brown Trout (*Salmo trutta fario* and Rainbow Trout (*Onchorhynchus myskiss*), the native populations have been adversely affected and some of the river stretches are dominated by these exotic trout.

Table 7.16: Distribution of fish species in Beas Basin and their conservation status

Sub-basin	Projects	River/Stream	No. of Fish species	No of RET Species	
				IUCN	CAMP
Beas I	Beas Kund	Beas Kund Nala	11	1	3
	Palchan Bhang	Kothi Nala/Beas river			
	Bhang	Beas River			
	Jobrie	Jobrie & Allain Nala			
	Allain Duhangan	Allain & Duhangan Nala			
Beas II	Baragaon	Sanjoin & Bijara Nala	22	1	5
	Fozal	Fozal Nala			
	Raison	Beas			
	Sarbari II	Sarbari Khad			
Malana	Malana I	Malana Nala	17	1	3
	Malana II	Malana Nala			
	Malana III	Malana Nala			
Parbati Upper	Nakhtan	Tosh Nala & Parbati	12	1	3
	Tosh	Tosh Nala			
	Jari	Parbati			
	Balargha	Parbati			
	Parbati II	Parbati			
	Parbati	Parbati			
Parbati Lower	Sharni	Parbati	20	1	3
	Sarsadi	Parbati			
	Sarsadi II	Parbati			
Sainj	Sainj	Sainj	20	1	4
	Parbati III	Sainj			
	Hurla I	Hurla Nala			
Tirthan	-	Tirthan	18	1	4
Beas III	Patikari	Bakhli Khad	22	2	13
	Pandoh	Beas			
	Larji	Beas			
Uhl	Lambadug	Lambadug Khad	24	2	13
	Uhl	Uhl			
	Uhl I (Shanan)	Uhl			
	Uhl II (Bassi)	Rana & Neri Khad			
	Uhl III	Rana & Neri Khad			
	Lower Uhl	Uhl			
	Uhl Khad	Uhl			
Beas IV	Gaj	Gaj Khad	57	2	22
	Khauli	Khauli Khad			
	Baner	Baner Khad			
	Neugal	Neugal Khad			
	Baner II	Baner Khad			
	Binwa	Binwa Khad			
	Kilhi Bahl	Binwa & Awa Nala			
	Pong Dam	Beas			
Beas V	Triveni Mahadev	Beas	41	2	17
	Dhaulasidh	Beas			
	Thana Plaun	Beas			

7.4.3 Conservation Status

The conservation of fish species in Beas basin was assessed by using the criteria of IUCN (2016), CAMP (1998) and National Bureau of Fish Genetic Resources (NBFGR, 2010). Out of 84 fish species reported from the basin, 70 species have been evaluated by IUCN Redlist and 59 species are under Least Concern category. Under the IUCN redlist 8 species have been included in different threat categories. Only one species *Tor putitora* is listed as Endangered, 4 species are listed as Near Threatened viz. *Bagarius bagarius, Hypophthalmichthys molitrix, Tor tor* and *Wallagu attu.* CAMP (1998) have evaluated 63 species and a total of 29 species are categorised as 'Vulnerable', 'Endangered' and 'Critically Endangered' species out of which 6 are Endangered and 21 are under 'Vulnerable' category (**Table 7.15**). Two species namely *Glyptothorax garhwali* and *Glyptothorax stolickae* are listed as Critically Endangered and are confined to the lower reaches of Beas basin and prefer to inhabit lower reaches of Beas river tributaries. Fifteen species have been included in list of frsehwater threatened fishspecies of India by NBFGR, out of which 4 are listed as Endangered while 11 species are listed under Vulnerable category. *Amblyceps mangois, Tor mosal, Tor putitora* and *Tor tor* have been listed as Endangered species.

7.4.4 Fish Migration & Spawning

The migration of fish in Himalayan rivers are generally attributed to their spawning habit. In Beas basin, two species viz. *Tor putitora* and *Tor tor* are relatively long distance migratory species, which ascend and spawn in tributaries. *Tor putitora* is periodic and specific in migration and spawning and span in tributaries of mid elevations while *Tor tor* spawns in low land tributaries. Sehgal (1990) stated that prior to construction of Pandoh dam, *Tor putitora* used to migrate in Beas river up to Sultanpur and Kullu but Pandoh dam has hampered its migration and presently it is restricted to downstream of Pandoh dam only.

Clupisoma garua is another long distance migratory fish. It performs upstream migration during July to September and downstream migration in October-November.

Labeo dero and *Schizothorax richardsonii* (Snow trout) are medium distance migratory species. *Labeo dero* is known to migrate upstream from March to August and it comes down in September. Snow trout performs upstream migration from March to May and moves downstream during November-December.

Snow trout in Beas river migrates upstream during breeding where the temperature is less. It is known to breed twice, in the summer (May-June) and in (July-October), in the shallow water along the bank of the streams (Sharma, 2010) up to November. Juni stream (a left bank tributary of Beas, upstream of Pandoh dam) once was one of the potential spawning ground of *Tor putitora* but due to construction of Pandoh dam, the population of Golden mahseer has disappeared from this tributary. In the downstream stretch various tributaries of Beas river have been identified by different workers as spawning grounds of mahseer. Baner stream is one of the spawning ground of Golden mahseer. Uhl is one of the largest tributary of Beas in lower reaches. Machchiyal lake (825 m) fed by Uhl river is known as a temple sanctuary of fish and population of Golden mahseer in known to occur in this lake and is considered to be spawning ground of Golden mahseer. There is a temple of Machendru Devta on the lake bank with ancient idols of fish-god. Fishes are fed and worshipped here regularly and fishing is strictly prohibited in the lake.

In order to understand various fisheries related aspects a fisheries map of Beas basin was prepared and the same is given at **Figure 7.59**.

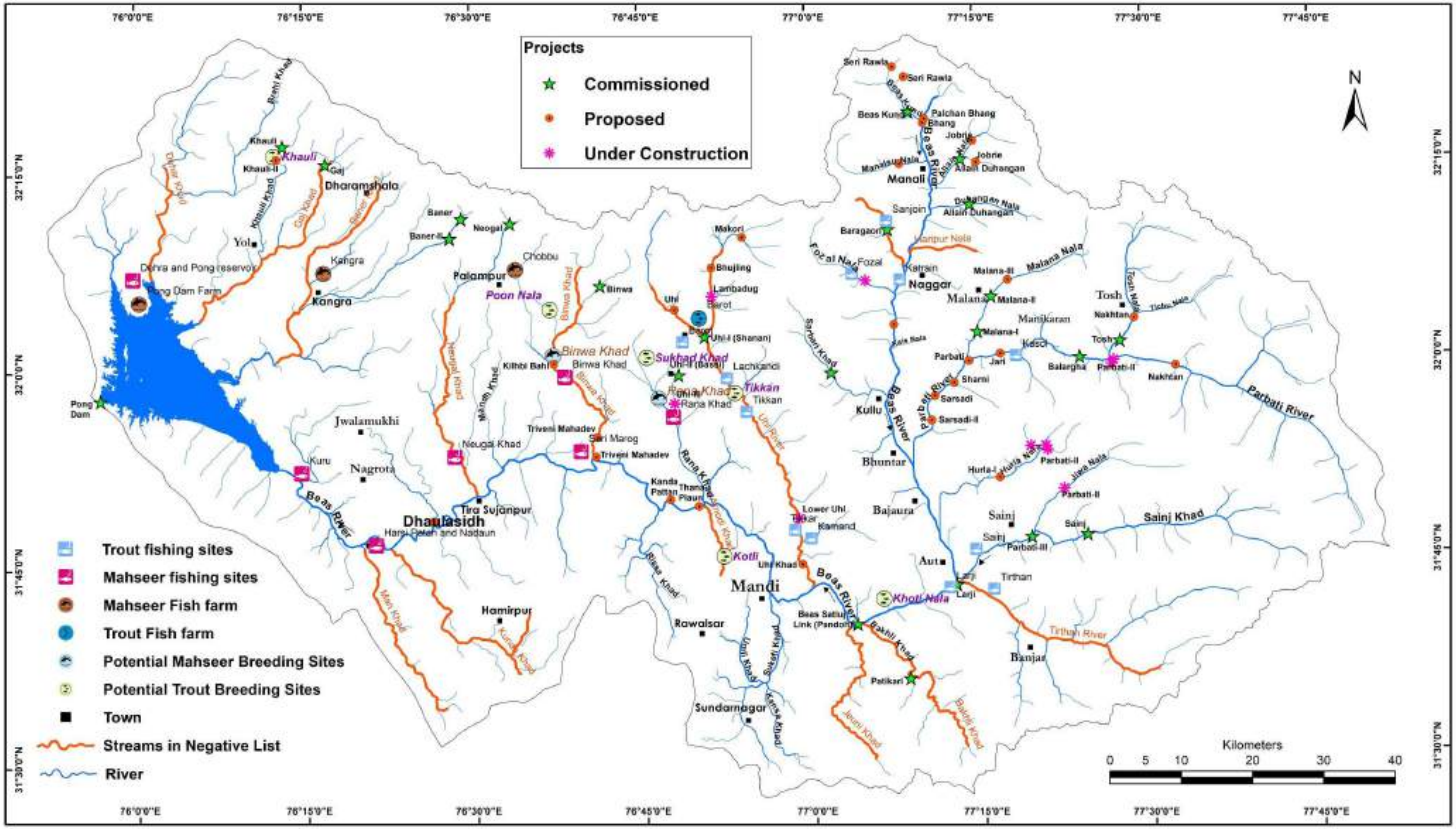


Figure 7.59: Fisheries map of Beas basin

7.4.5 Potential Streams for Spawning and Breeding in Beas basin

Zoological Survey of India (ZSI) has identified number of potential streams for breeding of snow trout especially and the same have been matked as potential breeding sites for trout amd mahseer in **Figure 7.59**. The following sites have been recognized as the potential sites for the breeding of the snow trout and mahseer fishery.

<u>**Potential Trout Sites**</u>

i) **Uhl Khad (1500 m)**

This potential site is located in Uhl Khad near village Tikkan about 13 Km from Ghatasni village in Mandi district. The site is characterized by large hillocks on the left side while right bank slopes are covered with good vegetation cover. The bottom of the stream is irregular with big boulders, stones and pebbles. Different sizes of *Schizothorax richardsonii* are found in this stream. This site is more potential than other streams.

ii) **Khauli (1160 m)**

This site is located near Darini village about 14 km north of Shahpur in Kangra district. The stream is of closed type having dense trees of chir pines on the hillocks and is dominated by big boulders.

iii) **Arnodi Khad (1090 m)**

This potential trout site is located near Kotli village about 40 km far from Dharampur, in district Mandi. The site is open and wide. There are pools in the stream harbouring snow trout. It is a good site for the breeding of the fish.

iv) **Sukhad Khad (975 m)**

This site is located near Sainthal village at distance of about 7 km from Chauntra town in Mandi district. The stream site is open and wide. There are pools in the stream. The fishes here are protected in this pool due to religious reasons. Therefore, the site provides a congenial environment for the snow trout breeding.

v) **Khoti Nala (990 m)**

This potential trout site is located near Khoti village about 9 km from Pandoh in district Mandi. Khoti Nala is bordered on both the sides by large hills. The site is deep gorge with stony bottom. Step pool habitats are also found at this stream site.

vi) **Poon Nala (990 m)**

The site is 10 km from Baijnath towards the right side of the main National highway. This stream site is located at Sarsowa near Neelkanth Mahadev, district Kangra. The stream site is surrounded by hillock and by dense vegetation. The bottom bed is irregular, stony and dominated by boulders. There is a pool locally called 'Machyal' of snow trout fishes near the site. Due to the presence of this pool, also the fries of fish it is provides suitable environment for the breeding of snow trout.

All the above mentioned streams can be classified as Type A streams and harbor good populations of snow trouts.

The streams with lot of shaded area with dense vegetation are favorable for the breeding of trout fish. Highly oxygenated water i.e. high DO values and rapid current are pre-requisite for the fish. It has been found that an alkaline pH, high DO with water velocity more than 1.8 m/s is the most suitable habitats for snow trout.

<u>**Potential Mahseer Sites**</u>

vii) Binwa Khad (810 m)

This site on Binwa Khad is located at a distance of 7 km from Baijnath on the way to Panchrukhi. The stream at this site is open and the bottom is irregular with big boulders, stones and pebbles. It is one of the potential breeding ground of snow trout as well as mahseer.

viii) Rana Khad (860 m)

The Rana Khad potential site near village Tikru about 15 km from Chautra in district Mandi. Three tributaries of the Beas River i.e. Sukhad, Bajgar and Gugali known as Triveni join in this area. This site is dominated by riffles and rapids with thick vegetation along the bank of the stream.

Both these streams can be termed as Type B streams and are more suitable for spawning and breeding of Mahseer.

7.4.6 List of Streams for Fish Conservation, GoHP

Man Khad, Kunah Khad and Gasoti Khad in Hamirpur district, Binwa Khad, Gaj Khad, Neugal Khad, Baner Khad and Dehar Khad streams in Kangra district, Haripur Nala, Sujan/Sanjoin Nala and Tirthan river in Kullu district and Rana Khad and its tributaries, Lambadug/ Uhl, Arnodi Khad, Bakhli Khad and Jeuni Khad in Mandi district have been put in negative list for setting up of hydroelectric projects and recommended for *in situ* conservation of fisheries by the Government of HP (http://hpfisheries.nic.in/pdf/RiversKhadsNegList.pdf).

Based upon the number studies undertaken by different researchers and the present field surveys, Beas river and its tributary streams can be classified into trout and mahseer streams. There are number of streams in Beas where one can easily find trouts and mahseers. Brief description of these is given in the following paragraphs.

7.4.7 Trout Streams

Barot is one of the important areas in Beas basin where trout farming is done. It is located in Uhl sub-basin in Mandi district at a distance of about 75 km from the Mandi town. It is known not only for its reservoir and landscape but also for trout fishing which is abundant in the Uhl river, a right bank tributary of river Beas. Some of the finest fishing spots are located at Luhandi, Puran hatchery, Lachkkandi, Tikkar, Balh and Kamand in this sub-basin. Besides Barot the entire stretch of Beas river from Pandoh Dam to Aut on the Mandi-Manali national highway is also considered good for trout fishing.

The Beas river meanders through Kullu valley and along with its tributaries like Sarbari, Sanjoin and Phojal offers ideal habitats for trout and provides ample opportunities for fishing. Sainj and Tirthan rivers which form a tri-junction with Beas river about 100m downstream near Larji are also known trout streams. The main Kullu valley right from Manali to Bhuntar provides some excellent pools for fishing especially at Patlikuhl, Katrain and Raison. Trout hatcheries have also been developed at Patlikuhl and Bathad.

Parbati river another large tributary is also suitable habitat for trout in Parbati Lower sub-basin and is famous for trout fishing at places like Kasol. The Parbati river valley with its slopes covered with dense forest along the hillsides, offers some excellent trout prospects throughout the course of the river Parbati from Manikaran to the confluence at Bhuin, Kasol, 5 km downstream of Manikaran where slopes lead down to sandy riverbed of Parbati river providing excellent places for game fishing.

7.4.8 Mahseer Streams

While Kullu and Mandi districts are known for trout fishing, Kangra valley abutting Dhauladhar ranges, is drained by streams which descend from perennial snow. Kangra is known as the home of mighty mahseer for which fairly large account of evidence is available. The river Beas and the Pong Dam reservoir provide attractive fisingh grounds to the anglers. Besides mahseer, the other fishes which are found here are malhi, soal, bachwa, god shingara, etc. Although there are many places and rivers and streams where mahseer is available, the following forested areas are known as the best.

Different streams which are known for mahseer fisheries according to locals and HP Fisheries Department are described as follows:

a) Sari Marog

Sari Marog is located at the confluence of the Binwa Khad with the river Beas. It known for large size of fish catch, with deep pools and many stones and hiding places.

b) The stretch between Harsi Pattan and Nadaun

In this Beas river stretch there are number of beats, easily accessible from the Palampur-Bhawarana-Thural road. The famous spots are the Man Khad confluence, Lambagaon pool, Neugal Khad confluence near Alampur and Ambter, 2 km from Nadaun itself.

c) Kuru

Kuru village offers two fishing spots, both of which are accessible from one of the two river banks. At Kuru a pool is formed at the confluence of a small Khad with the Beas river, joining about 1 km above the village and forming a small bay, harboring good fish populations.

d) Dehra and Pong Dam Reservoir

Pong reservoir from Dehra to the Dam proper offers excellent fishing for mahseer almost round the year when fishing is open.

e) Larji

Larji is located at a distance of about 7 km from Aut on National Highway-21 is an ideal trout area on river Tirthan. Larji HE project is located immediately downstream of the confluence of Tirthan river with Beas. There is a provision for fish movement in the Larji dam which is however is in bad shape.

Himachal Government has specifically declared Tirthan river as an angling reserve and not to allow any hydropower project on this river as well as its tributaries in order to maintain its aquatic biodiversity. Every year fingerlings of brown as well as rainbow trout are stocked in this river by the department.

7.4.9 Commercial Fisheries

Commercial fisheries in Himachal Pradesh is well developed as compared to other Himalayan states. In order to enhance the commercial fisheries in the state, various exotic fishes (Brown Trout, Rainbow Trout, Grass Carp, Common Carp, Silver Carp) were introduced in the reservoirs and farms in past. The introduction of exotic species led to changes in the fish species composition especially in reservoirs. Reservoirs contribute significantly in commercial fishery as compared to the rivers. To understand the fish production trend, **Table 7.14** gives detailed fish production in four districts like Kangra, Hamirpur, Mandi and Kullu, which lie entirely or partly in the Beas river basin. In Beas river basin Pong and Pandoh are major reservoirs.

A report of Directorate, State Fishery Department (http://himachal.nic.in/WriteReadData/l892s/4_l892s/1467788386.pdf) indicates that fish catch in Pong reservoir increased from 311.6 tonnes in 2006-07 to 415.42 to tonnes in 2016-16. It contributed Rs. 4137.80 lakhs to the state revenue during these years. *Mystus* (*Aorichthys*) *seenghala* dominates the fish catch in Pong reservoir. Pandoh lacks the organized fishery, however, capture fishery is under operation. In 1978 Common Carp (exotic) had been introduced in Pandoh reservoir, but later it was discontinued (Sugunan, 1995). Exotic Trout plays an important role in commercial fishery of Kullu district.

Table 7.13: Fish Production (in MT) in Beas basin

District	2007			2008			2009		
	River	Pond	Reservoir	River	Pond	Reservoir	River	Pond	Reservoir
Hamirpur	318	201	0	251.5	235.8	0	256	244	0
Kangra	1465	706.5	311.6	1470.6	742.5	375	1481.7	775	283
Mandi	618	100.5	0	593.9	100	0	608.2	87	0
Kullu	242.7	15.5	0	275.4	13	0	252	15	0

Source: Environment Master Plan, Govt of Himachal Pradesh

In order to conserve the fish HP fisheries Department has established number of Fish Farms in the basin. These are:

Trout Farms are located at Patli Kuhl in Kullu and Barot in Mandi.
Mahseer Farms have been established at Chobbu in Palampur and at Kangra.

CHAPTER-8

ENVIRONMENTAL FLOWS

8.1 INTRODUCTION

The environmental flow is an important aspect in the development of hydropower projects. Release of environmental flow is to be ensured immediately downstream of the diversion structure at all times to sustain the ecology and environment of project area. Protecting and maintaining river flow regimes and hence the ecosystems they support by providing adequate environmental flows have become a critical aspect of hydropower development. Ecological systems supported by the rivers are too complicated to be summarized by a single minimum flow requirement but require comprehensive environmental flow regimes to be defined. "Environmental flow regime" means a schedule of flow quantities that reflects seasonal fluctuations and should be adequate to support a sound ecological environment to maintain productivity, extent, and persistence of key aquatic habitats in and along the affected water bodies.

The aquatic biota in Himalayan glacier-fed rivers has adapted to annual flow pulses, which vary from a gradual increase in discharge in summer, through floods in the monsoon period, and reduce to low flows in winter. During the dry season, the waters become clear, allowing algae (primarily diatoms) to obtain necessary light and carbon dioxide for photosynthesis. Effective quantification of flow includes the ecologically important range of flow magnitudes (low flows, high flow pulses, and floods), as well as the timing, duration, frequency, and rate of change of these flow conditions. Globally, these flows are most commonly referred to as “environmental flows”.

The most critical reach for assessing release of environmental flow is immediately downstream of diversion structure till first significant tributary meets river.

8.2 CURRENT NORMS BEING FOLLOWED FOR ENVIRONMENTAL FLOW

There are no set norms for minimum releases to be maintained at all times on account of ecology and environment and to address issues concerning riparian rights, drinking water, health, aquatic life, wildlife, fisheries, silt and even to honour the sensitive religious issues like cremation and other religious rites, etc. on the river banks.

Expert Appraisal Committee (EAC) for River Valley and Hydroelectric Projects of Ministry of Environment, Forests and Climate Change (MoEF&CC) recommends minimum environmental flow during lean season as 20% of the average discharge in four leanest months in 90% dependable year of the water availability series used to design the project. They have also been discussing the requirement of varied environmental flow during monsoon and other months as discharge available in the river and flow requirement cannot be the same as that of lean season. In absence of any site specific study or unless a site specific study specifies otherwise, EAC has been generally recommending ecological releases for monsoon months should be maintained as 30% of flows in monsoon months of 90% dependable year and for non-lean and non-monsoon months, environmental flow provision should be kept between 20-30%.

Scope of present study requires suggesting approach to be adopted for determining environmental flows and to determine environmental releases for various planned projects and river reaches in the Beas basin.

Himachal Pradesh state government has declared its policy regarding ensuring minimum flow of water in HEPs vide communication no. MPP-F(2)-16/2008 of Department of MPP and Power, Government of Himachal Pradesh (copy enclosed as **Annexure VIII** of **Volume II** of the report). As per this policy, the ROR projects shall ensure minimum flow of 15% water immediately downstream of the diversion structure of the project throughout the year. For the purpose of determination of minimum discharge, the average discharge in the lean months i.e. from December to February shall be considered.

THE NATIONAL GREEN TRIBUNAL, PRINCIPAL BENCH, NEW DELHI in Original Application No. 498 of 2015 (M.A. No. 628/2016) Item No 21, August 09, 2017 has directed that all the rivers in the Country shall maintain minimum 15 % to 20% of the average lean season flow of that river. (copy enclosed as **Annexure IX** of **Volume II** of the report).

8.3 DESCRIPTION OF VARIOUS METHODOLOGIES FOR E-FLOW

There are four relatively discrete types of environmental flow methodologies: (1) hydrological, (2) hydraulic rating, (3) habitat simulation and (4) holistic methodologies; among other techniques occasionally applied during Environmental flow Assessment. The four types are briefly described below.

8.3.1 Hydrological Methodologies

These represent the simplest set of techniques where, at a desktop level, hydrological data, as naturalized, historical monthly or average daily flow records are analysed to derive standard flow indices, which then become the recommended environmental flows.

Hydrological Index Methods provide a relatively rapid, non-resource intensive, but low-resolution estimate of environmental flows. The methods are most appropriate at the planning level of water resources development, or in low controversy situations where they may be used as preliminary estimates. Hydrological Index methods may be used as tools within habitat simulation, holistic or combination environmental flow methodologies. They have been applied in developed and developing countries. Commonly, the EFR is represented as a proportion of flow (often termed the ‘minimum flow’) intended to maintain river health, fisheries or other highlighted ecological features at some acceptable level, usually on an annual, seasonal or monthly basis. As a result of the rapid and non-resource intensive provision of low resolution flow estimates, hydrological methodologies are generally used mainly at the planning stage of water resource developments, or in situations where preliminary flow targets and exploratory water allocation trade-offs are required.

Environmental flow is usually given as a percentage of average annual flow or as a percentile from the flow duration curve, on an annual, seasonal or monthly basis.

The most frequently used methods under this category are:

(i) Tennant Method

Donald Tennant developed this method in Montana, USA through several field observations and measurements. The Tennant study used 58 cross sections from 11 streams in Montana, Nebraska and Wyoming (Mann, 2006). The technique utilizes only the Mean Annual Flow (MAF) for the stream. It then states that certain flows relate to the qualitative fish habitat rating, which is used to define the flow needed to protect fish habitat, expressed in tabular form. Tennant concluded that 10% of MAF is the minimum for short-term fish survival, 30% of MAF is considered to be able to sustain fair survival conditions and 60% of MAF is excellent to outstanding habitat (Tennant, 1975).

	Flow to be released during	
Description of Flow	April to September	October to March
Flushing flow (from 48 – 96 hours)	200% MAF (Mean Annual Flow)	Not Applicable
Optimum range of flow	60-100% MAF	60-100% MAF
Outstanding habitat	60% MAF	40% MAF
Excellent habitat	50% MAF	30% MAF
Good habitat	40% MAF	20% MAF
Fair or degrading habitat	30% MAF	10% MAF
Poor or minimum habitat	10% MAF	10% MAF
Severe degradation	<10% MAF	<10% MAF

This means that if the quantity of water that the basin managers can provide for EFR is ≤ 20% of MAF (10% during April to September and 10% during October to March) then the environmental quality of the habitat in that reach will face “Severe Degradation”. If a “Good” habitat is desired, then at least 60% of the MAF must be allocated for EFR, 40% during April-September and 20% during October to March.

Tessman modified the Tennant method and it resulted in an approach called as Modified Tennant Method or Tessman Method. Tessman adopted Tennant seasonal flow recommendation to calibrate the percentage of Mean Annual flow (MAF) to local hydrologic and biological conditions including monthly variability in terms of Minimum Monthly Flow (MMF).

Under these changes, the following rules were formulated.

- If MMF < 40% of MAF, then monthly minimum equals the MMF
- If MMF > 40% MAF, then monthly minimum equals 40% MAF
- If 40% MMF > 40% MAF, then monthly minimum equals 40% MAF
- The flushing flow criterion is still a requirement to be met on an annual basis.

(ii) Index Method

This method defined the value of the Minimum In-stream Flow (MIF) that must be maintained downstream of water diversion in order to maintain vital conditions of ecosystem functionality and quality (Maran, 2007). Based on Q355 (the flow not exceeded more than 355 days per year) this means that, on average, the natural flow is less than Q355 value only for 10 days in a year (Maran, 2007).

MIF = Ka*Kb*Kc* Q355 where:

- Ka is corrective coefficient for different environmental sensitive of the interested river stretch [0.7 to 1.0]

- Kb = implementation factor [0.25 to 1.0]
- Kc is corrective coefficient to account for different level of protection due to the naturalistic value of the interested area [1.0 to 1.5].

The concept of "environmental sensitive" is linked with Flow Duration Curve (FDC). When the slope of the FDC is flat, for example when Q90 ≥ 30% AAF, the flow in the river is very stable thought the year, and the ecosystem is getting used to have a constant rate of flow in the river most of the time. This type of ecosystem is more sensitive to any change in river flow regime and the value of Ka will be taken as 1 (one). On other hand, when the FDC slope is steep, say Q90 < 10% AAF, the river flow is very unstable and present high extreme values (floods and droughts). Under this condition, ecosystem is getting used to water scarcity during some periods of the year, therefore this ecosystem is less sensitive to changes in flow regime, because the river naturally present a wide variability in flow regime. In this case, the value of Ka can be taken as 0.7.

The implementation factor refers to upgrade a degraded river condition, in which the quantity of water in the river is very low, due to abstractions made for different purposes (domestic, industrial, agriculture, etc.). The recovery of natural conditions of the river flow must be done gradually, because another uses of water will be affected. In this case, the value of Kb could be 0.25. In the case of no significant abstractions, the value of Kb will be 1.

The Kc factor increases the value of MIF, for protection of special conditions in the river ecosystem like naturalistic and tourism values, fisheries development and medicinal or religious issues.

(iii) Desktop Analysis

Desktop analysis can be sub-divided into (i) those based purely on hydrological data, and (ii) those that employ both hydrological and ecological data.

Desktop methods based on hydrological data

(a) Flow Duration Curve Based Method

A flow duration curve (FDC) is a plot of flow vs. percentage time equalled or exceeded. FDC can be prepared using the entire time series data of flow or the flow data pertaining to a specific period (such as a month) in different years. Further, it can be developed for a particular site or combining data for different sites on per unit catchment area basis in a hydro meteorologically homogeneous region.

(b) Environmental Management Class (EMC) based FDC Approach

Smakhtin and Anputhas (2006) reviewed various hydrology based environmental flow assessment methodologies and their applicability in Indian context. Based on the study, they suggested a flow duration curve based approach which links environmental flow requirement with environmental management classes.

This EFA method is built around a period-of-record FDC and includes several subsequent steps. The first step is the calculation of a representative FDC for each site where the environmental water requirement (EWR) is to be calculated. In this study, the sites where EF is calculated coincide with the major flow diversion. The sites with observed flow data are further referred to as 'source' sites. The sites where reference FDC and time series are needed for the EF estimation are referred to as 'destination' sites. All FDCs are represented by a table of flows corresponding to the 17 fixed percentage points. For each destination site, a FDC table was calculated using a source FDC table from either the nearest or the only available observation flow station upstream. To account for land-use impacts, flow withdrawal, etc., and for the differences between the size of a source and a destination basin, the source FDC is scaled up by the ratio of 'natural' long term mean annual run-off (MAR) at the outlet and the actual MAR calculated from the source record.

(c) Defining Environmental Management Classes

EF aim to maintain an ecosystem in, or upgrade it to, some prescribed or negotiated condition/ status also referred to as "desired future state", "environmental management class"/ "ecological management category", "level of environmental protection", etc. (e.g., Acreman and Dunbar 2004; DWAF 1997). This report uses the term 'environmental management class' (EMC). The higher the EMC, the more water will need to be allocated for ecosystem maintenance or conservation and more flow variability will need to be preserved. Ideally, these classes should be based on empirical relationships between flow and ecological status/conditions associated with clearly identifiable thresholds. However, so far there is insufficient evidence for such thresholds (e.g., Beecher, 1990; Puckridge *et al.* 1998). These categories are therefore a management concept, which has been developed and used in the world because of a need to make decisions in the conditions of limited lucid knowledge. Placing a river into a certain EMC is normally accomplished by expert judgment using a scoring system. Alternatively, the EMCs may be used as default 'scenarios' of environmental protection and corresponding EWR and EF - as 'scenarios' of environmental water demand. Six EMCs are used generally and six corresponding default levels of EWR may be defined. The set of EMCs starts with the *unmodified and largely natural conditions* (rivers in classes A and B), where no or limited modification is present or should be allowed from the management perspective. In *moderately modified* river ecosystems (class C rivers), the modifications are such that they generally have not (or will not – from the management perspective) affected the ecosystem integrity. *Largely modified* ecosystems (class D rivers) correspond to considerable modification from the natural state where the sensitive biota is reduced in numbers and extent. *Seriously and critically modified* ecosystems (classes E and F) are normally in poor conditions where most of the ecosystem's functions and services are lost. Rivers which fall into classes C to F would normally be present in densely populated areas with multiple man-induced impacts. Poor ecosystem conditions (classes E or F) are sometimes not considered acceptable from the management perspective and the management intention is always to "move" such rivers up to the least acceptable class D through river rehabilitation measures (DWAF 1997). This restriction is not however applied here, primarily because the meaning of every EMC is somewhat arbitrary and needs to be filled with more ecological substance in the future. Some studies use transitional EMCs (e.g., A/B, B/C, etc.) to allow for more flexibility in EWR determinations. It can be noted, however, that ecosystems in class F are likely to be those which have been modified beyond rehabilitation to anything approaching a natural condition. It is possible to estimate EWR corresponding to all or any of the above EMCs and then consider which one is best suited/feasible for the river in question, given existing and future basin developments. On the other hand, it is possible to use expert judgment and available ecological information in order to place a river into the most probable/achievable EMC. The EMCs are described in **Table 8.1** as scenarios of aquatic ecosystem condition.

Table 8.1: Environment Management Classes

EMC	Ecological description	Management perspective
A: Natural	Pristine condition or minor modification of in-stream and riparian habitat	Protected rivers and basins. Reserves and national parks. No new water projects (dams, diversions, etc.) allowed
B: Slightly modified	Largely intact biodiversity and habitats despite water resources development and/or basin modifications	Water supply schemes or irrigation development present and/or allowed
C: Moderately	The habitats and dynamics of the modified biota have been disturbed, but basic ecosystem functions are still intact. Some sensitive species are lost and/or reduced in extent. Alien species present	Multiple disturbances associated with the need for socio-economic development, e.g., dams, diversions, habitat modification and reduced water quality
D: Largely modified	Large changes in natural habitat, biota and basic ecosystem functions have occurred. A clearly lower than expected species richness. Much lowered presence of intolerant species. Alien species prevail	Significant and clearly visible disturbances associated with basin and water resources development, including dams, diversions, transfers, habitat modification and water quality degradation
E: Seriously modified	Habitat diversity and availability have declined. A strikingly lower than expected species richness. Only tolerant species remain. Indigenous species can no longer breed. Alien species have invaded the ecosystem	High human population density and extensive water resources exploitation
F: Critically modified	Modifications have reached a critical level and ecosystem has been completely modified with almost total loss of natural habitat and biota. In the worst case, the basic ecosystem functions have been destroyed and the changes are irreversible	This status is not acceptable from the management perspective. Management interventions are necessary to restore flow pattern, river habitats, etc. (if still possible/feasible) – to 'move' a river to a higher management category

8.3.2 Hydraulic Rating Methodologies

Hydraulic rating methodologies use changes in simple hydraulic variables, such as wetted perimeter or maximum depth, usually measured across single, flow-limited river cross-sections (commonly riffles), as a surrogate for habitat factors known or assumed to be limiting to target biota. Environmental flows are determined from a plot of the hydraulic variable(s) against discharge, commonly by identifying curve breakpoints where significant percentage reductions in habitat quality occur with decreases in discharge. It is assumed that ensuring some threshold value of the selected hydraulic parameter at a particular level of altered flow will maintain aquatic biota and thus, ecosystem integrity. These relatively low-resolution hydraulic techniques have been superseded by more advanced habitat modeling tools, or assimilated into holistic methodologies (Tharme, 1996; Jowett, 1997; Arthington and

Zalucki, 1998; Tharme, 2003). However, select approaches continue to be applied and evaluated, notably the Wetted Perimeter Method (e.g. Gippel and Stewardson, 1998).

8.3.3 Habitat Simulation or Micro-Habitat Modeling Methodologies

Habitat simulation methodologies also make use of hydraulic habitat-discharge relationships, but provide more detailed, modelled analyses of both the quantity and suitability of the physical river habitat for the target biota. Thus, environmental flow recommendations are based on the integration of hydrological, hydraulic and biological response data. Flow-related changes in physical microhabitat are modelled in various hydraulic programs, typically using data on depth, velocity, substratum composition and cover; and more recently, complex hydraulic indices (e.g. benthic shear stress), collected at multiple cross-sections within each representative river reach. Simulated information on available habitat is linked with seasonal information on the range of habitat conditions used by target fish or invertebrate species (or life-history stages, assemblages and/or activities), commonly using habitat suitability index curves (e.g. Groshens and Orth, 1994). The resultant outputs, in the form of habitat-discharge relationships for specific biota, or extended as habitat time and exceedance series, are used to derive optimum environmental flows. The habitat simulation-modeling package PHABSIM (Bovee, 1982, 1998; Milhous, 1998, 1982; Milhous *et al.*, 1989; Stalnaker *et al.*, 1994), housed within the In-stream Flow Incremental Methodology (IFIM), is the pre-eminent modeling platform of this type.

8.3.4 Holistic Methodologies

Over the past decade, river ecologists have increasingly made the case for a broader approach to the definition of environmental flows to sustain and conserve river ecosystems, rather than focusing on just a few target fish species (Arthington and Pusey, 1993; King and Tharme, 1994; Sparks, 1992, 1995; Richter *et al.*, 1996; Poff *et al.*, 1997). From the conceptual foundations of a holistic ecosystem approach, a wide range of holistic methodologies has been developed and applied, initially in Australia and South Africa and later in the United Kingdom. This type of approach reasons that if certain features of the natural hydrological regime can be identified and adequately incorporated into a modified flow regime, then, all other things being equal, the extant biota and functional integrity of the ecosystem should be maintained (Arthington *et al.*, 1992; King and Tharme 1994). Importantly, holistic methodologies aim to address the water requirements of the entire “riverine ecosystem” rather than the needs of only a few taxa (usually fish or invertebrates). These methodologies share a common objective - to maintain or restore the flow related biophysical components and ecological processes of in-stream and groundwater systems, floodplains and downstream receiving waters (e.g. terminal lakes and wetlands, estuaries and near-shore marine ecosystems). Ecosystem components that are commonly considered in holistic assessments include geomorphology, hydraulic habitat, water quality, riparian and aquatic vegetation, macro-invertebrates, fish and other vertebrates with some dependency upon the river/riparian ecosystem (i.e. amphibians, reptiles, birds, mammals). Each of these components can be evaluated using a range of field and desktop techniques and their flow requirements are then incorporated into EFA recommendations, using various systematic approaches.

Holistic approaches have been described as either ‘bottom-up’ methods, which are designed to ‘construct’ a modified flow regime by adding flow components to a baseline of zero flows;

or 'top-down' methods i.e. by assessing how much a river's flow regime can be modified before the aquatic ecosystem begins to noticeably change or degrade.

8.3.4.1 The Building Block Methodology (BBM)

The BBM is introduced in King & Tharme (1994) and King (1996), and is comprehensively described in Tharme & King (1998), and King & Louw (1998). The methodology is under on going development, and has been applied routinely in South Africa, with some application in Australia and UK. The methodology is based on the concept that some flows within the complete hydrological regime of a river are more important than others for maintenance of the riverine ecosystem, and that these flows can be identified, and described in terms of their magnitude, duration, timing, and frequency. In combination, these flows constitute the EFR as a river-specific modified flow regime, linked to a predetermined future state. A number of specialists in a workshop situation use hydrological base flow and flood data, including various hydrological indices, cross-section based hydraulic data, and information on the flow-related needs of ecosystem components, to identify specific flow elements for the EFR.

8.3.4.2 The Downstream Response to Imposed Flow Transformations Methodology

The DRIFT Methodology was developed in southern Africa for use in the Palmiet IFR study (Brown *et al.*, 2000) and Lesotho Highlands Water Project (Brown & King, 1999, 2000). It is an interactive, top-down holistic approach based on the same conceptual tenets and multidisciplinary, workshop-based interaction as the BBM and Holistic Approach. However, it focuses on the identification of a series of river water levels associated with a particular set of biophysical functions and of specific hydrological and hydraulic character. Specialists in each discipline describe the consequences of reducing discharges through these identified flow bands and their thresholds, in terms of deterioration in biotic and abiotic condition. The identification of the 'minimum degradation' reduction level and its consequences typically provides the starting point for the process. Once a wide range of flow reductions has been assessed, there is considerable scope for the comparative evaluation of a vast number of EFR scenarios, each reflecting the presence or absence of different flow bands with attendant consequences.

Holistic methodologies exhibit several advantages over other types of environmental flow methodology, most importantly in that they can potentially be used to address all components of the riverine ecosystem and have strong links with the natural hydrological regime. Also, they incorporate biological, geomorphological and hydrological data, and consider all aspects of the flow regime, such as the magnitude and timing of both base flow and flood events. However, holistic methodologies rely to a considerable extent on professional judgment, so care must be taken to apply them in a rigorous, well-structured manner, in order to ensure sufficiently reproducible results. The methodologies are firmly based on South African and Australian experiences of variable climate and hydrology, heterogeneous geomorphology, and of limited available information on biological flow dependencies of riverine biota (Growns & Kotlash, 1994; Tharme, 1996). As with most other current environmental flow methodologies, there are few applications of holistic methodologies other than in their place of origin.

For the purpose of environmental flow assessment in Beas basin, hydraulic modeling and habitat simulation methodologies is considered to be best suited as discussed in the following section.

8.4 ADOPTED METHODOLOGY TO ESTABLISH ENVIRONMENTAL FLOW

8.4.1 Basics of Environmental Flow Assessment Methods

Environmental flows (EF) are an ecologically acceptable flow regime designed to maintain a river in an agreed or predetermined state. Therefore, EF are a compromise between hydro development, on one hand, and river maintenance in a healthy or at least reasonable condition, on the other. Difficulties in the actual estimation of EF values arise primarily due to the inherent lack of both the understanding of and quantitative data on relationships between river flows and multiple components of river ecology. The major criteria for determining EF should include the maintenance of both spatial and temporal patterns of river flow, i.e., the flow variability, which affect the structural and functional diversity of rivers, and which in turn influence the species diversity of the river. All components of the hydrological regime have certain ecological significance. High flows of different frequency are important for channel maintenance, bird breeding, wetland flooding and maintenance of riparian vegetation. Moderate flows are critical for cycling of organic matter from river banks and for fish migration, while low flows of different magnitudes are important for algae control, water quality maintenance and the use of the river by local people. Therefore, many elements of flow variability have to be maintained in a modified-EF-regime.

The focus on maintenance of flow variability has several important implications. First, it moves away from a ‘minimum flow attitude’ to aquatic environment. Second, it effectively considers that aquatic environment is also ‘held accountable’ and valued similarly to other sectors – to allow informed trade-offs to be made in water deprived conditions. Because wetland and river ecosystems are naturally subjected to droughts or low flow periods and can recover from those, then building this variability into the picture of EFA may be seen as environmental water demand management. This brings us back to the issue of ‘compromise’ and implies that EF is a very pragmatic concept: it does not accept a bare minimum, but it is for a trade. Bunn and Arthington (2002) have formulated four basic principles that emphasize the role of flow regime in structuring aquatic life and show the link between flow and ecosystem changes:

- Flow is a major determinant of physical habitat in rivers, which in turn is the major determinant of biotic composition. Therefore, river flow modifications eventually lead to changes in the composition and diversity of aquatic communities.
- Aquatic species have evolved life history strategies primarily in response to the natural flow regimes. Therefore, flow regime alterations can lead to loss of biodiversity of native species.
- Maintenance of natural patterns of longitudinal and lateral connectivity in river systems determines the ability of many aquatic species to move between the main river and its tributaries. Loss of longitudinal and lateral connectivity can lead to local extinction of species.

In this report, hydraulic rating methodologies and habitat simulations or micro-habitat modeling methodologies have been used. The primary reason for using this method is objectivity of the methodology, availability of data including surveyed river cross-sections and limited timeframe available for the study.

Main reasons for not using Hydrological Index Methods is that though these provide a relatively rapid, non-resource intensive, but give low resolution estimate of environmental flows. The methods are only appropriate at the planning level where they may be used as preliminary estimates. These methods may be used as tools within habitat simulation, holistic or combination environmental flow methodologies. Commonly, the EFR is represented as a proportion of flow (often termed the 'minimum flow') intended to maintain river health, fisheries or other highlighted ecological features at some acceptable level, usually on an annual, seasonal or monthly basis.

Building Block Method (BBM) could not be used because of following reasons:

- The BBM is essentially a prescriptive approach, designed to construct a flow regime for maintaining a river in a predetermined condition. Building Block Method can use detailed data from different sectors and have the provision of consultation among the experts and stakeholders. However, application of BBM for large number of sites requires a lot of time and resources.
- The BBM has advanced the field of environmental flow assessment and being a holistic methodology it addresses the health (structure and functioning) of all components of the riverine ecosystem, rather than focusing on selected group or species. But in context of Beas basin study, the major stakeholder is only riverine ecology and fish. Hence adopting such rigorous exercise is neither needed nor practical within a limited time frame and resources.

Environmental flow regime would be worked out keeping annual occurrence of following main seasons in this region. These are:

(a) Season I: This season is considered as low or lean or dry flow season which covers the months from December to March or November to February or November to April depending upon the flow series used.

(b) Season II: It is considered as high flow season influenced by monsoon. It covers the months from June to September, generally for all the flow series.

(c) Season III: This season is considered as average flow period, covers the months of April, May and October, November or March, April, May and October or May and October depending upon the flow series used.

8.5 HYDRO-DYNAMIC MODELING

To assess environmental flow requirements, a flow simulation study is carried out using one dimensional mathematical model **MIKE 11** developed by Danish Hydraulic Institute of Denmark.

8.5.1 MIKE 11 Model

MIKE 11 is an integrated system of software, designed for interactive use in a multi-tasking environment. The system is comprised of a graphical user interface, separate hydraulic analysis components, data storage and management capabilities, graphics and reporting facilities. The core of the MIKE 11 system consists of the HD (hydrodynamic) module, which is capable of simulating unsteady flows in a network of open channels. The results of a HD simulation consist of time series of water levels, discharges, flow velocities, water widths etc. MIKE 11 hydrodynamic module is an implicit, finite difference model for unsteady flow computation. The model can describe sub-critical as well as supercritical flow conditions through a numerical description, which is altered according to the local flow conditions in time and space. The MIKE 11 system contains three one-dimensional hydraulic components for: i) Steady flow surface profile computations; ii) quasi-unsteady flow simulation and iii) unsteady flow simulation. The steady/unsteady flow components are capable of modeling subcritical, supercritical, and mixed flow regime water surface profiles. The system can handle a full network of channels, a dendritic system, or a single river reach. The basic computational procedure is based on the solution of one-dimensional energy equation. Energy losses are evaluated by friction (Manning's equation) and contraction/expansion (coefficient multiplied by the velocity head). The momentum equation is utilized in situations where the water surface profile is rapidly varied.

The graphics include X-Y plots of the river system schematic, cross-sections, profiles, rating curves, hydrographs, and many other hydraulic variables. Users can select from pre-defined tables or develop their own customized tables. All graphical and tabular output can be displayed on the screen, sent directly to a printer, or passed through the Windows clipboard to other software, such as word processor or spread sheet. Reports can be customized as to the amount and type of information desired.

The following approach has been used for various data inputs:

8.5.2 Hydropower Projects considered for e flow assessment/Modeling

There are 51 hydro projects in the Beas river basin, out of which 19 projects are with installed capacity of 25 MW or more i.e. projects which are covered under EIA notification and can be studied for environment flow assessment by habitat simulation and hydraulic modelling. Smaller projects (less than 25 MW installed capacity) do not give good results when subjected to modelling and therefore for all such projects environment flow is recommended based on present norms of EAC/MoEF&CC.

List of HEPs considered for modelling study is given at **Table 8.2**.

Table 8.2: HEPs considered for e-flow assessment

S. No.	Name of Project	Capacity (MW)	Status		River stretch affected (km)
1	Beas Satluj Link	990	Commissioned	Beas River	Inter-basin Transfer
2	Parbati-III HEP	520	Commissioned	Sainj River	13.7 Km
3	Allain Duhangan HEP	192	Commissioned	Allain and Duhangan Nalla	Allain 9.2 Km; Duhangan 5 Km
4	Larji HEP	126	Commissioned	Beas River	5.65 Km
5	Uhl-I (Shanan) HEP	110	Commissioned	Uhl River	40 Km of Uhl river downstream; water diverted ends in Beas after Uhl III
6	Malana-II HEP	100	Commissioned	Malana Nalla	5.2 Km
7	Sainj HEP	100	Commissioned	Sainj River	9 Km
8	Malana-I HEP	86	Commissioned	Malana Nalla	2.32 Km

S. No.	Name of Project	Capacity (MW)	Status		River stretch affected (km)
9	Uhl II	66	Commissioned	Tailrace of Uhl I	
10	Pong Dam	396	Commissioned	Beas	
11	Parbati-II HEP	800	Under Construction	Parbati River, Jigrai Nalla, Jiva Nalla, Hurla Nalla	Parbati – 5.28 Km upto Balargah HEP Jigrai – 800m; Hurla – 12 Km; Jiwa – 8.2 Km
12	Lambadug HEP	25	Under Construction	Lambadug	6.3 Km
13	Uhl III	100	Under Construction	Rana Khad and Neri Khad	
14	Nakhtan HEP	460	Under S&I	Toss and Parbati	Parbati – 8.9 Km; Tosh 4.4 Km (upto Tosh HEP)
15	Thana Plaun HEP	191	Under S&I	Beas River	Dam Toe; 12.7 Km upto TM
16	Triveni Mahadev HEP	96	Under S&I	Beas River and Binwa Khad	Beas 5.5 Km; Binwa 3.2 Km
17	Malana-III HEP	30	Under S&I	Malana Nalla	3.35 Km
18	Dhaulasidh	66	Under S&I	Beas River	Dam Toe; 37 Km upto Pong Reservoir
19	Kanda Pattan	40	Yet to be allotted	Beas River	

Out of 19 projects, considered for modelling study for the purpose of environment flow assessment, 10 are commissioned projects, 3 are under construction, 5 are under different stages of survey & investigations and one, Kanda Pattan, is a newly identified and yet to be allotted project. Downstream of Pong dam is outside the study area and therefore it was not considered for environment flow assessment. Similarly, Uhl II (Basi) is tailrace development of Uhl I without any additional diversion and therefore, the water release from Uhl I will remain in Uhl river and no additional release is considered from Uhl II. For Uhl III, in the absence of discharge data, assessment could not be carried out. Similarly, for Kanda Pattan, no discharge data is available and therefore, modeling could not be carried out.

Therefore, 15 projects were subjected to environment flow assessment based on modeling study. Data for following 10 projects have been made available by the respective project developers:

1. Nakhtan
2. Parbati II
3. Sainj
4. Parbati III
5. Malana I
6. Malana II
7. Than Plaun
8. Triveni Mahadev
9. Dhaulasidh
10. Allain Duhangan

Discharge series for following five projects have been derived based on catchment area proportions and taking into account relevant interception catchment proportions:

1. Malana III

2. Lambadug
3. Uhl I (Shanan)
4. Larji
5. Beas Satluj Link (Pandoh)

Hydro dynamic modelling has been carried out for above 15 projects. Input data used for present modeling study has been described below:

8.5.3 Discharge Data

Discharge data for all these projects for 90% dependable year has been shown in **Section 5.2** in Chapter 5, "Hydro-meteorology".

Out of the full year flow series, three average values have been calculated viz.

- Average of four leanest months
- Average of four monsoon months
- Average of remaining four months

Flow simulations have been carried out for 10%, 15%, 20%, 25%, 30%, 40%, 50% and 100% releases of the average discharge for each of above three scenarios for the identified projects. Various key parameters for establishing habitat requirement have been calculated which include water depth, flow velocity and top width of waterway.

Average discharge for four leanest months, monsoon months and other months have been calculated for entire year and is shown in **Tables below**.

	Nakhtan		**Parbati II**	**Parbati III**	**Sainj**
	Parbati river	**Tosh nala**	**Parbati river & Jigrai nala**	**Sainj Khad**	**Sainj khad**
	CA: 687.44 Km^2	**332.67 Km^2**	**CA: 1155 Km^2 + CA: 44 Km^2**	**CA: 650 Km^2**	**CA: 434.33 Km^2**
Year	**2006-07**		**2001-02**	**1992-93**	**1998-99**
	cumec	**cumec**	**cumec**	**cumec**	**cumec**
Monsoon (June-September)					
Average	39.19	26.16	108.64	56.42	22.30
10 % of average	3.92	2.62	10.86	5.64	2.23
15 % of average	5.88	3.92	16.3	8.46	3.34
20 % of average	7.84	5.23	21.73	11.28	4.46
25 % of average	9.8	6.54	27.16	14.1	5.57
30 % of average	11.76	7.85	32.59	16.93	6.69
40 % of average	15.68	10.47	43.46	22.57	8.92
50 % of average	19.6	13.08	54.32	28.21	11.15
Lean (December-March)					**Lean (Nov-Feb)**
Average	5.70	3.73	14.97	7.54	3.54
10 % of average	0.57	0.37	1.5	0.75	0.35
15 % of average	0.85	0.56	2.25	1.13	0.53
20 % of average	1.14	0.75	2.99	1.51	0.71
25 % of average	1.42	0.93	3.74	1.89	0.89
30 % of average	1.71	1.12	4.49	2.26	1.06
40 % of average	2.28	1.49	5.99	3.02	1.42
50 % of average	2.85	1.87	7.48	3.77	1.77
Non-monsoon, non-lean (April, May and October, November)					**Non-monsoon, non-lean (Mar-May and Oct)**
Average	14.7	9.95	25.30	18.89	10.73
10 % of average	1.47	1	2.53	1.89	1.07
15 % of average	2.21	1.49	3.79	2.83	1.61
20 % of average	2.94	1.99	5.06	3.78	2.15

25 % of average	3.68	2.49	6.32	4.72	2.68
30 % of average	4.41	2.99	7.59	5.67	3.22
40 % of average	5.88	3.98	10.12	7.55	4.29
50 % of average	7.35	4.98	12.65	9.44	5.36

	Malana-I	**Malana-II**	**Malana-III**
	Malana river	**Malana river**	**Malana river**
	CA: 178.50 Km^2	**CA: 158.00 Km^2**	**CA: 124.75 Km^2**
Year	**1998-99**	**1990-91**	**1992-93**
	cumec	**cumec**	**cumec**
Monsoon (June-September)			
Average	22.16	17.07	13.50
10 % of average	2.22	1.71	1.35
15 % of average	3.32	2.56	2.03
20 % of average	4.43	3.41	2.70
25 % of average	5.54	4.27	3.38
30 % of average	6.65	5.12	4.05
40 % of average	8.86	6.83	5.40
50 % of average	11.08	8.53	6.75
Lean (December-March)			
Average	2.45	2.61	2.07
10 % of average	0.24	0.26	0.21
15 % of average	0.37	0.39	0.31
20 % of average	0.49	0.52	0.41
25 % of average	0.61	0.65	0.52
30 % of average	0.73	0.78	0.62
40 % of average	0.98	1.04	0.83
50 % of average	1.22	1.31	1.03
Non-monsoon, non-lean (April, May and October, November)			
Average	8.30	7.97	6.30
10 % of average	0.83	0.80	0.63
15 % of average	1.24	1.20	0.95
20 % of average	1.66	1.59	1.26
25 % of average	2.07	1.99	1.58
30 % of average	2.49	2.39	1.89
40 % of average	3.32	3.19	2.52
50 % of average	4.15	3.98	3.15

	Larji	**Beas Satluj Link (Pandoh)**	**Thana Plaun**	**Triveni Mahadev**	
	Beas river	**Beas river**	**Beas river**	**Beas river**	**Binwa khad**
	CA: 4921 Km^2	**CA: 5280 Km^2**	**CA: 7378 Km^2**	**CA: 8155 (7740+415) Km^2**	
Year	**1998-99**	**1990-91**	**2002-03**	**2002-03**	**2007-08**
	cumec	**cumec**	**cumec**	**cumec**	**cumec**
Monsoon (June-September)					
Average	427.13	431.45	310.81	360.33	30.68
10 % of average	42.71	43.15	31.08	36.03	3.07
15 % of average	64.07	64.72	46.62	54.05	4.60
20 % of average	85.43	86.29	62.16	72.07	6.14
25 % of average	10.6.78	107.86	77.70	90.08	7.67
30 % of average	128.14	129.44	93.24	108.10	9.21
40 % of average	170.85	172.58	124.32	144.13	12.27
50 % of average	213.56	215.73	155.40	180.17	15.34
Lean (Dec-March)		**Lean (Nov-Feb)**			
Average	57.1	94.95	25.27	28.09	28.09
10 % of average	5.71	9.5	2.53	2.81	2.81

	Larji	Beas Satluj Link (Pandoh)	Thana Plaun	Triveni Mahadev	
	Beas river	Beas river	Beas river	Beas river	Binwa khad
	CA: 4921 Km^2	CA: 5280 Km^2	CA: 7378 Km^2	CA: 8155 (7740+415) Km^2	
Year	1998-99	1990-91	2002-03	2002-03	2007-08
	cumec	cumec	cumec	cumec	cumec
15 % of average	8.56	14.24	3.79	4.21	4.21
20 % of average	11.42	18.99	5.05	5.62	5.62
25 % of average	14.27	23.74	6.32	7.02	7.02
30 % of average	17.13	28.49	7.58	8.43	8.43
40 % of average	22.84	37.98	10.11	11.24	11.24
50 % of average	28.55	47.48	12.64	14.05	14.05
Non-monsoon, non-lean (April, May and October, November)		Non-monsoon, non-lean (Mar-May and Oct)			
Average	142.98	171.59	77.63	96.63	96.63
10 % of average	14.3	17.16	7.76	9.66	9.66
15 % of average	21.45	25.74	11.64	14.49	14.49
20 % of average	28.6	34.32	15.53	19.33	19.33
25 % of average	35.74	42.90	19.41	24.16	24.16
30 % of average	42.89	51.48	23.29	28.99	28.99
40 % of average	57.19	68.64	31.05	38.65	38.65
50 % of average	71.49	85.79	38.81	48.31	48.31

	Allain Duhangan		Lambadug	Uhl-I (Shanan)	Dhaulasidh
	Allain Nala	Duhangan Nala	Lambadug khad	Uhl River	Beas River
	CA: 128.90 (Allain Nala) + 66.2 (Duhangan Nala) sq km		CA: 197.00 sq km	CA: 365.00 sq km	CA: 9580 sq km
Year		1998-99	1990-91	2002-03	2003-04
	cumec	cumec	cumec	cumec	cumec
Monsoon (June-September)					
Average	16.18	6.42	8.52	15.78	302.63
10 % of average	1.62	0.64	0.85	1.58	30.26
15 % of average	2.43	0.96	1.28	2.37	45.39
20 % of average	3.24	1.28	1.7	3.16	60.53
25 % of average	4.04	1.60	2.13	3.95	75.66
30 % of average	4.85	1.92	2.56	4.74	90.79
40 % of average	6.47	2.57	3.41	6.31	121.05
50 % of average	8.09	3.21	4.26	7.89	151.32
Lean (Dec-March)			Lean (Nov-Feb)		Lean (Nov-Apr)
Average	2.11	0.77	1.18	2.18	31.18
10 % of average	0.21	0.08	0.12	0.22	3.12
15 % of average	0.32	0.11	0.18	0.33	4.68
20 % of average	0.42	0.15	0.24	0.44	6.24
25 % of average	0.53	0.19	0.29	0.54	7.80
30 % of average	0.63	0.23	0.35	0.65	9.36
40 % of average	0.84	0.31	0.47	0.87	12.47
50 % of average	1.05	0.38	0.59	1.09	15.59
Non-monsoon, non-lean (April, May and October, November)			Non-monsoon, non-lean (Mar-May and Oct)		Non-monsoon, non-lean (May & Oct)
Average	5.67	1.99	3.98	7.37	40.48
10 % of average	0.57	0.20	0.40	0.74	4.05
15 % of average	0.85	0.30	0.60	1.11	6.07
20 % of average	1.13	0.40	0.80	1.47	8.10

25 % of average	1.42	0.50	0.99	1.84	10.12
30 % of average	1.7	0.60	1.19	2.21	12.15
40 % of average	2.27	0.79	1.59	2.95	16.19
50 % of average	2.84	0.99	1.99	3.69	20.24

8.5.4 River cross sections

Environmental flow assessment is carried out for the stretch of river, which starts downstream of diversion structure and up to the tailrace channel outfall point; generally termed as intermediate stretch between dam and powerhouse. For each project this stretch is calculated. Out of this stretch initial 1-2 Km or the length up to which first major tributary meets the river is considered critical as for the rest of the stretch tributary will add to the environmental flow released from the diversion structure. Therefore, modeling exercise to work out the environmental flow to meet the habitat requirement for the initial critical stretch hold good for the rest of the river. Keeping this in view, 8-10 cross sections of the river were taken immediately downstream of the diversion structure for each project and used in the modeling exercise. These sections have been represented in MIKE 11 model set up.

No data on river profile is available. Therefore digital data available in public domain i.e. The Shuttle Radar Topography Mission (SRTM) elevation data on a near-global scale to generate Digital Elevation Model. SRTM data is the most complete high-resolution digital topographic database of Earth. SRTM consisted of a specially modified radar system that flew on-board the Space Shuttle Endeavour. SRTM is an international project spearheaded by the National Geospatial-Intelligence Agency (NGA), NASA, the Italian Space Agency (ASI) and the German Aerospace Center (DLR). As there are three resolution outputs available, 1 kilometer, 90 meter and a 30 meter resolution. For the present study 30 meter resolution data have been used. The cross-sections are being generated from DEM in GIS environment using GIS software. In order to check the accuracy of the cross-sections thus generated, random ground checks are performed in the field for different rivers wherever the field conditions permitted. In case of any error the cross-sections are reconciled based upon inputs of ground checks. This methodology has been consistently adopted by central agencies like Central Water Commission also.

8.5.5 Manning's roughness coefficient

Manning's roughness coefficient for different type of channels as suggested by Chow, 1959 is given in **Table 8.3**. For the present study the river reaches correspond to mountain stream with steep bank and bed consisting of cobbles and large boulders. For such type of river the value of Manning's n varies from 0.040 to 0.070. For a lower value of Manning's n the depth of water will be less in comparison to a higher value of Manning's n for the same discharge. Hence to have a conservative estimate of water depth the Manning's n has been adopted as varying from 0.045 to 0.06 for the study reach in different projects. For projects in lower reaches like Thana Plaun and Triveni Mahadev projects, Manning's n has been considered as 0.045, for projects in higher elevations like Nakhtan, Malana I and Malana II projects, a value of 0.06 has been taken while for other projects like Parbati II, Parbati III, Allain Duhangan and Sainj projects, Manning's n has been considered as 0.05. For Dhaulasidh HEP, Manning's n has been considered as 0.04.

Table 8.3: Manning's roughness coefficient

Manning's n for Channels (Chow, 1959).

Type of Channel and Description	Minimum	Normal	Maximum
Natural streams - minor streams (top width at floodstage < 100 ft)			
1. Main Channels			
a. clean, straight, full stage, no rifts or deep pools	0.025	0.030	0.033
b. same as above, but more stones and weeds	0.030	0.035	0.040
c. clean, winding, some pools and shoals	0.033	0.040	0.045
d. same as above, but some weeds and stones	0.035	0.045	0.050
e. same as above, lower stages, more ineffective slopes and sections	0.040	0.048	0.055
f. same as "d" with more stones	0.045	0.050	0.060
g. sluggish reaches, weedy, deep pools	0.050	0.070	0.080
h. very weedy reaches, deep pools, or floodways with heavy stand of timber and underbrush	0.075	0.100	0.150
2. Mountain streams, no vegetation in channel, banks usually steep, trees and brush along banks submerged at high stages			
a. bottom: gravels, cobbles, and few boulders	0.030	0.040	0.050
b. bottom: cobbles with large boulders	0.040	0.050	0.070
3. Floodplains			
a. Pasture, no brush			
1.short grass	0.025	0.030	0.035
2. high grass	0.030	0.035	0.050
b. Cultivated areas			
1. no crop	0.020	0.030	0.040
2. mature row crops	0.025	0.035	0.045
3. mature field crops	0.030	0.040	0.050
c. Brush			
1. scattered brush, heavy weeds	0.035	0.050	0.070
2. light brush and trees, in winter	0.035	0.050	0.060
3. light brush and trees, in summer	0.040	0.060	0.080
4. medium to dense brush, in winter	0.045	0.070	0.110
5. medium to dense brush, in summer	0.070	0.100	0.160
d. Trees			
1. dense willows, summer, straight	0.110	0.150	0.200
2. cleared land with tree stumps, no sprouts	0.030	0.040	0.050
3. same as above, but with heavy growth of sprouts	0.050	0.060	0.080
4. heavy stand of timber, a few down trees, little undergrowth, flood stage below branches	0.080	0.100	0.120
5. same as 4. with flood stage reaching branches	0.100	0.120	0.160

8.5.6 MIKE 11 Model set up

The MIKE 11 model set up for flow simulation study consist of a river reach, upstream boundary and a downstream boundary. The reach of rivers from diversion site of a hydroelectric project up to its confluence with first stream shall be represented in model by number of surveyed cross sections or derived using SRTM data as discussed already. The releases from the respective diversion sites are the upstream boundary of the model set up applied at upper most cross section. The normal depth is used as the downstream boundary for the model set up. In order to have independent results of water depth the downstream boundary is applied at the cross section of respective rivers at few hundred meters downstream of the study reach.

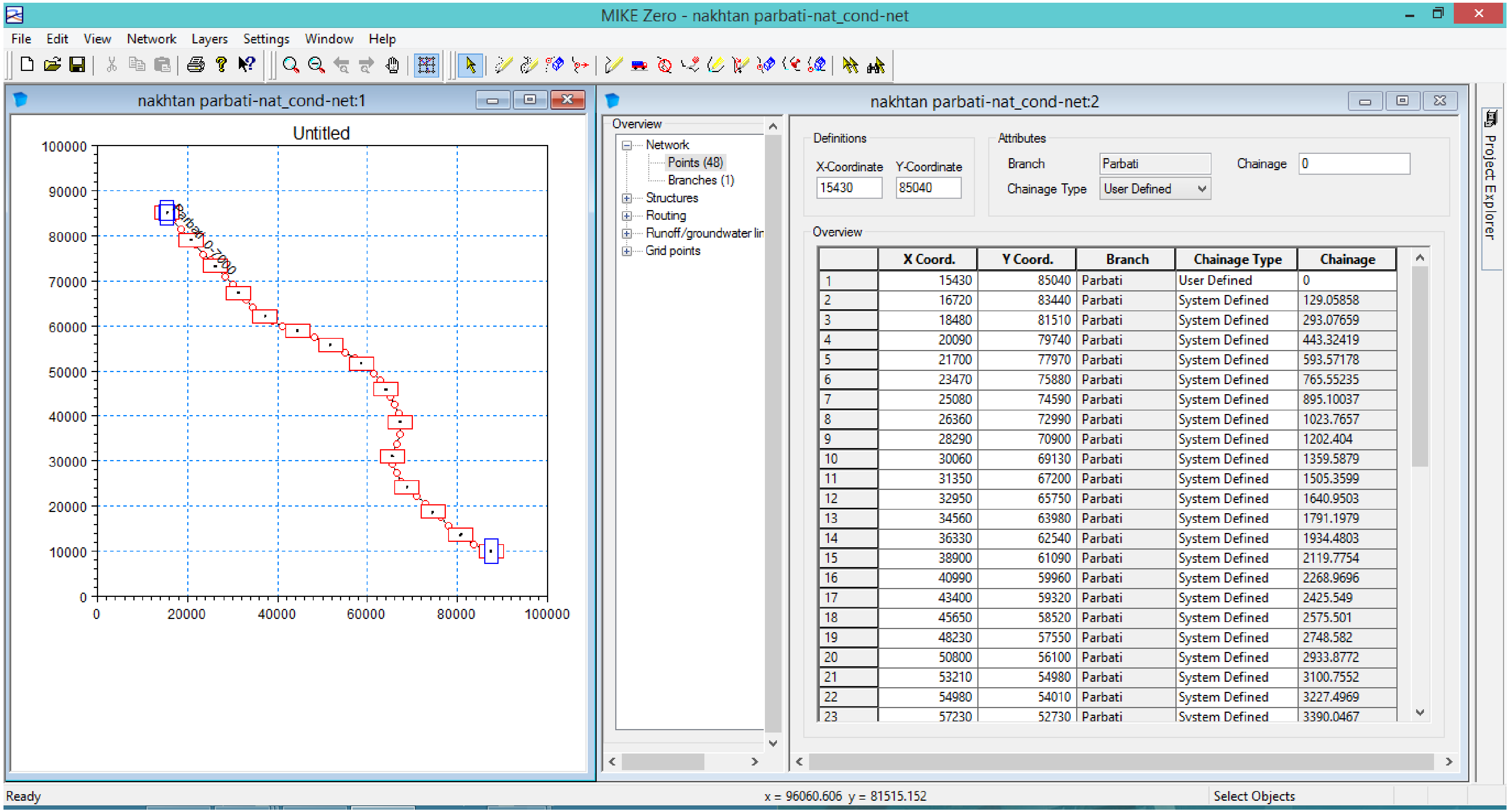


Figure 8.1: Location of various surveyed river cross sections (A typical MIKE 11 model set-up)

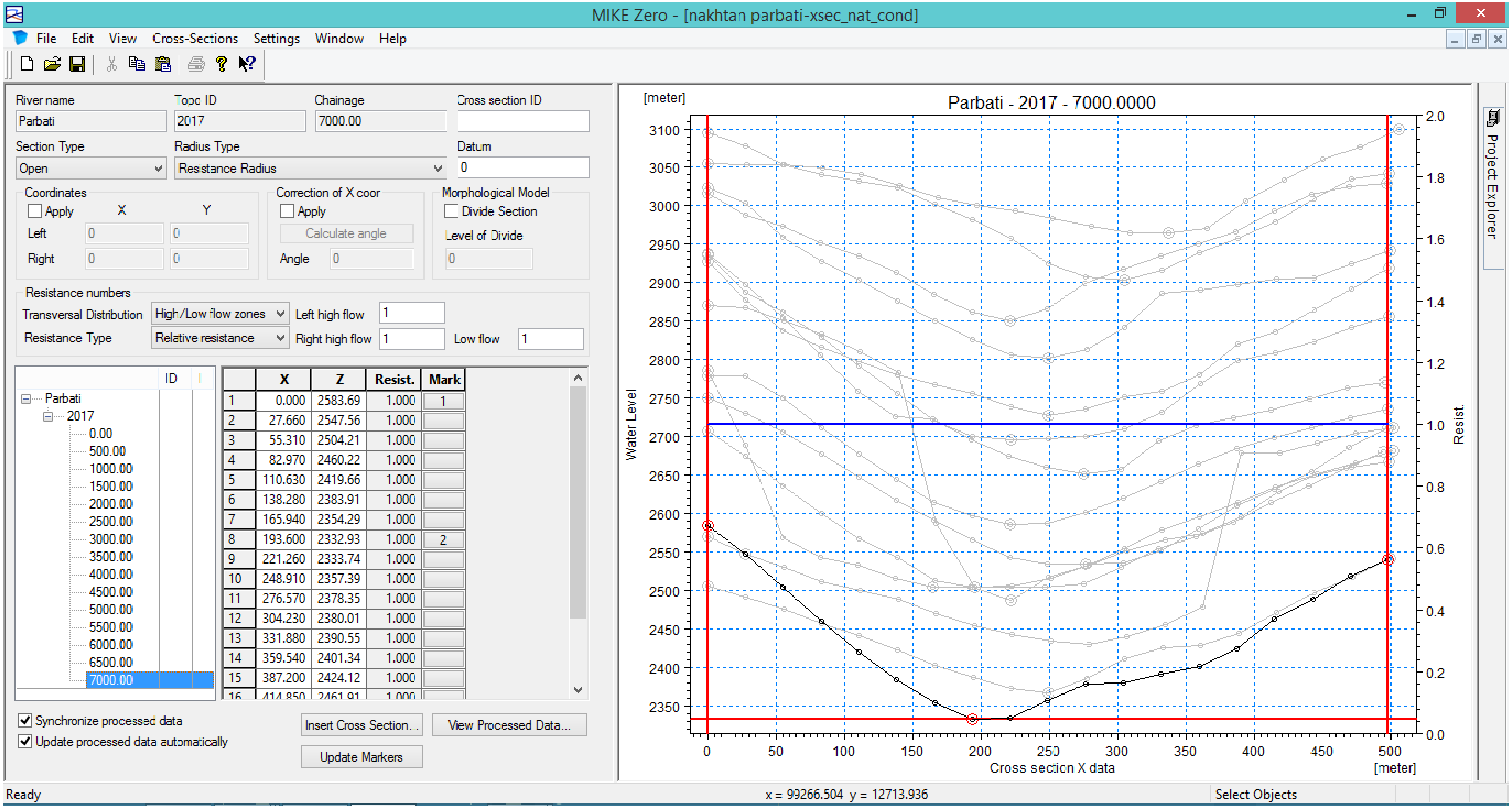


Figure 8.2: A typical view of surveyed river cross section considered for hydro-dynamic modeling (A typical MIKE 11 model set-up)

8.5.7 Model outputs

Model output for each HEP would be for three different scenario viz. monsoon average, lean season average and other four months average discharge values. For each scenario, output would be in the form of water depth, flow velocity and flow top width for each river cross-section considered in the critical reach i.e. from diversion structure to where first tributary meets the river. To discuss the results of the simulation modeling and assess the environmental flow requirement for each project separately, average values calculated for depth, velocity and flow top width for each scenario would be worked out.

Model Output for Different Release Scenarios for Parbati III HEP

Season	Release Scenario	River Bed (m)	Water Level (m)	Water depth (cm)	Flow Velocity (m/s)	Flow Width (m)
Low (Dec-March)	10% release (0.75 m^3/s)	1224.08	1224.21	13.32	0.69	21.28
	15% release (1.13 m^3/s)	1224.08	1224.24	15.97	0.77	22.44
	20% release (1.51 m^3/s)	1224.08	1224.27	18.92	0.83	23.64
	25% release (1.89 m^3/s)	1224.08	1224.29	20.75	0.89	24.49
	30% release (2.26 m^3/s)	1224.08	1224.30	22.32	0.95	25.22
	40% release (3.02 m^3/s)	1224.08	1224.35	26.81	1.04	27.22
	50% release (3.77 m^3/s)	1224.08	1224.38	30.16	1.11	28.81
	100% release (7.54 m^3/s)	1224.08	1224.48	39.98	1.34	33.12
High (June-Sept)	10% release (5.64 m^3/s)	1224.08	1224.44	35.53	1.24	31.24
	15% release (8.46 m^3/s)	1224.08	1224.50	41.89	1.39	33.84
	20% release (11.28 m^3/s)	1224.08	1224.55	47.11	1.51	35.62
	25% release (14.10 m^3/s)	1224.08	1224.60	51.61	1.61	37.07
	30% release (16.93 m^3/s)	1224.08	1224.64	55.66	1.70	38.36
	40% release (22.57 m^3/s)	1224.08	1224.71	62.72	1.85	40.60
	50% release (28.21 m^3/s)	1224.08	1224.77	68.86	1.98	42.42
	100% release (56.42 m^3/s)	1224.08	1225.01	92.52	2.43	48.56
Intermediate (Oct, Nov, Apr, May)	10% release (1.89 m^3/s)	1224.08	1224.29	20.75	0.89	24.49
	15% release (2.83 m^3/s)	1224.08	1224.34	25.59	1.02	26.65
	20% release (3.78 m^3/s)	1224.08	1224.38	30.18	1.11	28.83
	25% release (4.72 m^3/s)	1224.08	1224.41	33.04	1.18	30.12
	30% release (5.67 m^3/s)	1224.08	1224.44	35.63	1.24	31.28
	40% release (7.55 m^3/s)	1224.08	1224.48	40.00	1.34	33.13
	50% release (9.44 m^3/s)	1224.08	1224.52	43.79	1.43	34.49
	100% release (18.89 m^3/s)	1224.08	1224.66	58.23	1.75	39.18

Model Output for Different Release Scenarios for Allain Duhangan HEP (Allain Nala)

Season	Release Scenario	River Bed (m)	Water Level (m)	Water depth (cm)	Flow Velocity (m/s)	Flow Width (m)
Low (Dec-March)	10% release (0.21 m^3/s)	2313.90	2314.03	12.93	1.25	3.51
	15% release (0.32 m^3/s)	2313.90	2314.07	16.10	1.43	3.81
	20% release (0.42 m^3/s)	2313.90	2314.09	18.53	1.54	4.08
	25% release (0.53 m^3/s)	2313.90	2314.11	20.38	1.65	4.39
	30% release (0.63 m^3/s)	2313.90	2314.12	21.77	1.73	4.62
	40% release (0.84 m^3/s)	2313.90	2314.15	24.26	1.87	5.04
	50% release (1.05 m^3/s)	2313.90	2314.17	26.37	1.98	5.48
	100% release (2.11 m^3/s)	2313.90	2314.25	34.27	2.35	7.13

High (June-Sept)	10% release (1.62 m^3/s)	2313.90	2314.21	31.04	2.20	6.45
	15% release (2.43 m^3/s)	2313.90	2314.27	36.14	2.44	7.51
	20% release (3.24 m^3/s)	2313.90	2314.31	40.24	2.62	8.37
	25% release (4.04 m^3/s)	2313.90	2314.34	43.72	2.77	9.09
	30% release (4.85 m^3/s)	2313.90	2314.37	46.83	2.90	9.66
	40% release (6.47 m^3/s)	2313.90	2314.43	52.17	3.12	10.51
	50% release (8.09 m^3/s)	2313.90	2314.47	56.72	3.30	11.22
	100% release (16.18 m^3/s)	2313.90	2314.64	73.66	3.95	13.22
Intermediate (Oct, Nov, Apr, May)	10% release (0.57 m^3/s)	2313.90	2314.11	20.98	1.68	4.49
	15% release (0.85 m^3/s)	2313.90	2314.15	24.37	1.88	5.07
	20% release (1.13 m^3/s)	2313.90	2314.18	27.11	2.01	5.64
	25% release (1.42 m^3/s)	2313.90	2314.20	29.55	2.13	6.14
	30% release (1.70 m^3/s)	2313.90	2314.22	31.59	2.23	6.57
	40% release (2.27 m^3/s)	2313.90	2314.26	35.23	2.40	7.32
	50% release (2.84 m^3/s)	2313.90	2314.29	38.31	2.54	7.97
	100% release (5.67 m^3/s)	2313.90	2314.40	49.66	3.02	10.11

Model Output for Different Release Scenarios for Allain Duhangan HEP (Duhangan Nala)

Season	Release Scenario	River Bed (m)	Water Level (m)	Water depth (cm)	Flow Velocity (m/s)	Flow Width (m)
Low (Dec-March)	10% release (0.08m^3/s)	2181.64	2181.71	6.39	0.98	3.11
	15% release (0.11 m^3/s)	2181.64	2181.74	9.36	1.09	3.21
	20% release (0.15 m^3/s)	2181.64	2181.75	10.95	1.20	3.38
	25% release (0.19 m^3/s)	2181.64	2181.76	12.02	1.28	3.49
	30% release (0.23 m^3/s)	2181.64	2181.77	12.94	1.36	3.59
	40% release (0.31 m^3/s)	2181.64	2181.79	14.56	1.50	3.76
	50% release (0.38 m^3/s)	2181.64	2181.81	16.65	1.60	3.94
	100% release (0.77 m^3/s)	2181.64	2181.86	21.75	1.96	4.77
High (June-Sept)	10% release (0.64 m^3/s)	2181.64	2181.85	20.25	1.86	4.52
	15% release (0.96 m^3/s)	2181.64	2181.89	24.53	2.08	5.25
	20% release (1.28 m^3/s)	2181.64	2181.92	27.34	2.23	5.84
	25% release (1.60 m^3/s)	2181.64	2181.94	29.72	2.36	6.35
	30% release (1.92 m^3/s)	2181.64	2181.96	31.83	2.47	6.80
	40% release (2.57 m^3/s)	2181.64	2182.00	35.48	2.66	7.59
	50% release (3.21 m^3/s)	2181.64	2182.03	38.59	2.81	8.25
	100% release (6.42 m^3/s)	2181.64	2182.14	50.02	3.35	10.63
Intermediate (April, May, Oct and Nov)	10% release (0.20 m^3/s)	2181.64	2181.77	12.25	1.30	3.51
	15% release (0.30 m^3/s)	2181.64	2181.79	14.37	1.48	3.74
	20% release (0.40 m^3/s)	2181.64	2181.81	16.96	1.63	3.98
	25% release (0.50 m^3/s)	2181.64	2181.83	18.45	1.74	4.21
	30% release (0.60 m^3/s)	2181.64	2181.84	19.79	1.83	4.43
	40% release (0.79 m^3/s)	2181.64	2181.86	21.97	1.98	4.81
	50% release (0.99 m^3/s)	2181.64	2181.89	24.82	2.10	5.31
	100% release (1.99 m^3/s)	2181.64	2181.97	32.25	2.50	6.90

Model Output for Different Release Scenarios for Nakhtan HEP (Parbati River)

Season	Release Scenario	River Bed (m)	Water Level (m)	Water depth (cm)	Flow Velocity (m/s)	Flow Width (m)
(Dec-Ma	10% release (0.57 m^3/s)	2622.66	2622.85	18.82	1.23	9.03

	15% release (0.85 m^3/s)	2622.66	2622.91	24.47	1.44	9.75
	20% release (1.14 m^3/s)	2622.66	2622.95	28.83	1.60	10.42
	25% release (1.42 m^3/s)	2622.66	2622.98	32.42	1.72	10.97
	30% release (1.71 m^3/s)	2622.66	2623.02	35.65	1.83	11.47
	40% release (2.28 m^3/s)	2622.66	2623.07	40.97	1.99	12.29
	50% release (2.85 m^3/s)	2622.66	2623.11	45.37	2.13	12.90
	100% release (5.70 m^3/s)	2622.66	2623.26	60.40	2.56	14.77
High (June-Sept)	10% release (3.92 m^3/s)	2622.66	2623.18	51.95	2.32	13.72
	15% release (5.88 m^3/s)	2622.66	2623.27	61.12	2.58	14.86
	20% release (7.84 m^3/s)	2622.66	2623.34	68.33	2.77	15.76
	25% release (9.80 m^3/s)	2622.66	2623.40	74.43	2.93	16.53
	30% release (11.76 m^3/s)	2622.66	2623.46	79.79	3.07	17.20
	40% release (15.68 m^3/s)	2622.66	2623.55	89.01	3.30	18.36
	50% release (19.60 m^3/s)	2622.66	2623.63	96.89	3.49	19.35
	100% release (39.19 m^3/s)	2622.66	2623.92	126.13	4.16	23.00
Intermediate (Oct, Nov, Apr, May)	10% release (1.47 m^3/s)	2622.66	2622.99	33.00	1.74	11.06
	15% release (2.21 m^3/s)	2622.66	2623.06	40.39	1.98	12.20
	20% release (2.94 m^3/s)	2622.66	2623.12	45.98	2.14	12.98
	25% release (3.68 m^3/s)	2622.66	2623.17	50.63	2.28	13.55
	30% release (4.41 m^3/s)	2622.66	2623.21	54.51	2.39	14.04
	40% release (5.88 m^3/s)	2622.66	2623.27	61.12	2.58	14.86
	50% release (7.35 m^3/s)	2622.66	2623.33	66.67	2.73	15.55
	100% release (14.70 m^3/s)	2622.66	2623.53	86.87	3.25	18.09

Model Output for Different Release Scenarios for Nakhtan HEP (Tosh Nala)

Season	Release Scenario	River Bed (m)	Water Level (m)	Water depth (cm)	Flow Velocity (m/s)	Flow Width (m)
Low (Dec-March)	10% release (0.37 m^3/s)	2812.66	2812.77	10.46	0.94	16.41
	15% release (0.56 m^3/s)	2812.66	2812.79	12.52	1.02	16.74
	20% release (0.75 m^3/s)	2812.66	2812.82	15.23	1.09	17.37
	25% release (0.93 m^3/s)	2812.66	2812.83	16.62	1.14	17.80
	30% release (1.12 m^3/s)	2812.66	2812.84	17.92	1.19	18.21
	40% release (1.49 m^3/s)	2812.66	2812.87	20.11	1.28	18.93
	50% release (1.87 m^3/s)	2812.66	2812.89	22.07	1.36	19.36
	100% release (3.73 m^3/s)	2812.66	2812.97	30.48	1.68	20.89
High (June-Sept)	10% release (2.62 m^3/s)	2812.66	2812.93	26.39	1.50	20.18
	15% release (3.92 m^3/s)	2812.66	2812.98	31.13	1.71	21.01
	20% release (5.23 m^3/s)	2812.66	2813.04	37.17	1.86	22.66
	25% release (6.54 m^3/s)	2812.66	2813.07	40.66	1.98	23.41
	30% release (7.85 m^3/s)	2812.66	2813.10	43.73	2.08	24.08
	40% release (10.47 m^3/s)	2812.66	2813.16	49.14	2.25	25.25
	50% release (13.08 m^3/s)	2812.66	2813.20	53.77	2.40	26.26
	100% release (26.16 m^3/s)	2812.66	2813.38	71.34	2.91	29.59
Intermediate (Oct, Nov, Apr, May)	10% release (1.00 m^3/s)	2812.66	2812.84	17.12	1.16	17.96
	15% release (1.49 m^3/s)	2812.66	2812.87	20.11	1.28	18.93
	20% release (1.99 m^3/s)	2812.66	2812.89	22.64	1.39	19.45
	25% release (2.49 m^3/s)	2812.66	2812.92	25.83	1.48	20.08
	30% release (2.99 m^3/s)	2812.66	2812.94	27.83	1.56	20.43
	40% release (3.98 m^3/s)	2812.66	2812.98	31.33	1.71	21.06

	50% release (4.98 m^3/s)	2812.66	2813.03	36.42	1.83	22.50
	100% release (9.95 m^3/s)	2812.66	2813.15	48.13	2.22	25.03

Model Output for Different Release Scenarios for Malana-I HEP

Season	Release Scenario	River Bed (m)	Water Level (m)	Water depth (cm)	Flow Velocity (m/s)	Flow Width (m)
Low (Dec-March)	10% release (0.24 m^3/s)	1622.92	1623.08	16.55	1.34	9.55
	15% release (0.37 m^3/s)	1622.92	1623.11	19.44	1.58	9.80
	20% release (0.49 m^3/s)	1622.92	1623.15	22.92	1.73	10.05
	25% release (0.61 m^3/s)	1622.92	1623.17	24.94	1.81	10.26
	30% release (0.73 m^3/s)	1622.92	1623.18	26.71	1.88	10.46
	40% release (0.98 m^3/s)	1622.92	1623.22	29.86	2.00	10.80
	50% release (1.22 m^3/s)	1622.92	1623.24	32.45	2.09	11.08
	100% release (2.45 m^3/s)	1622.92	1623.34	42.28	2.46	12.17
High (June-Sept)	10% release (2.22 m^3/s)	1622.92	1623.32	40.74	2.41	12.00
	15% release (3.32 m^3/s)	1622.92	1623.39	47.41	2.66	12.74
	20% release (4.43 m^3/s)	1622.92	1623.45	52.85	2.86	13.35
	25% release (5.54 m^3/s)	1622.92	1623.49	57.51	3.03	13.88
	30% release (6.65 m^3/s)	1622.92	1623.53	61.60	3.18	14.35
	40% release (8.86 m^3/s)	1622.92	1623.60	68.61	1623.60	15.15
	50% release (11.08 m^3/s)	1622.92	1623.66	74.57	3.65	15.92
	100% release (22.16 m^3/s)	1622.92	1623.88	96.43	4.36	18.92
Intermediate (Oct, Nov, Apr, May)	10% release (0.83 m^3/s)	1622.92	1623.20	28.05	1.93	10.60
	15% release (1.24 m^3/s)	1622.92	1623.24	32.66	2.10	11.11
	20% release (1.66 m^3/s)	1622.92	1623.31	39.65	2.37	11.88
	25% release (2.07 m^3/s)	1622.92	1623.34	42.54	2.47	12.20
	30% release (2.49 m^3/s)	1622.92	1623.34	42.54	2.47	12.20
	40% release (3.32 m^3/s)	1622.92	1623.39	47.41	2.66	12.74
	50% release (4.15 m^3/s)	1622.92	1623.43	51.58	2.81	13.21
	100% release (8.30 m^3/s)	1622.92	1623.59	66.94	3.38	14.96

Model Output for Different Release Scenarios for Malana II HEP

Season	Release Scenario	River Bed (m)	Water Level (m)	Water depth (cm)	Flow Velocity (m/s)	Flow Width (m)
Low (Dec-March)	10% release (0.26 m^3/s)	2275.06	2275.21	14.84	1.36	2.87
	15% release (0.39 m^3/s)	2275.06	2275.24	18.08	1.51	3.15
	20% release (0.52 m^3/s)	2275.06	2275.26	20.22	1.64	3.41
	25% release (0.65 m^3/s)	2275.06	2275.28	22.06	1.75	3.62
	30% release (0.78 m^3/s)	2275.06	2275.29	23.67	1.85	3.81
	40% release (1.04 m^3/s)	2275.06	2275.33	27.41	2.00	4.30
	50% release (1.31 m^3/s)	2275.06	2275.35	29.75	2.11	4.67
	100% release (2.61 m^3/s)	2275.06	2275.44	38.58	2.51	6.06
High (June-Sept)	10% release (1.71 m^3/s)	2275.06	2275.43	37.20	2.45	5.85
	15% release (2.56 m^3/s)	2275.06	2275.49	43.30	2.71	6.80
	20% release (3.41 m^3/s)	2275.06	2275.54	48.21	2.91	7.58
	25% release (4.27 m^3/s)	2275.06	2275.58	52.43	3.08	8.24
	30% release (5.12 m^3/s)	2275.06	2275.62	56.14	3.22	8.82
	40% release (6.83 m^3/s)	2275.06	2275.68	62.57	3.47	9.77
	50% release (8.53 m^3/s)	2275.06	2275.74	68.03	3.67	10.39

	100% release (17.07 m^3/s)	2275.06	2275.94	88.25	4.38	12.66
Intermediate (Oct, Nov, Apr, May)	10% release (0.80 m^3/s)	2275.06	2275.31	24.82	1.91	3.95
	15% release (1.20 m^3/s)	2275.06	2275.36	29.94	2.12	4.70
	20% release (1.59 m^3/s)	2275.06	2275.39	33.38	2.28	5.24
	25% release (1.99 m^3/s)	2275.06	2275.42	36.33	2.41	5.71
	30% release (2.39 m^3/s)	2275.06	2275.45	38.82	2.52	6.10
	40% release (3.19 m^3/s)	2275.06	2275.49	43.30	2.71	6.80
	50% release (3.98 m^3/s)	2275.06	2275.53	47.04	2.87	7.39
	100% release (7.97 m^3/s)	2275.06	2275.67	61.03	3.41	9.56

Model Output for Different Release Scenarios for Sainj HEP

Season	Release Scenario	River Bed (m)	Water Level (m)	Water depth (cm)	Flow Velocity (m/s)	Flow Width (m)
Low (Nov-Feb)	10% release (0.35 m^3/s)	1522.91	1523.03	12.67	0.87	10.22
	15% release (0.53 m^3/s)	1522.91	1523.06	15.01	0.96	10.72
	20% release (0.71 m^3/s)	1522.91	1523.07	16.91	1.04	11.12
	25% release (0.89 m^3/s)	1522.91	1523.09	18.59	1.10	11.46
	30% release (1.06 m^3/s)	1522.91	1523.11	20.00	1.16	11.75
	40% release (1.42 m^3/s)	1522.91	1523.13	22.79	1.26	12.34
	50% release (1.77 m^3/s)	1522.91	1523.16	25.43	1.36	12.90
	100% release (3.54 m^3/s)	1522.91	1523.27	36.04	1.67	15.10
High (June-Sept)	10% release (2.23 m^3/s)	1522.91	1523.20	29.03	1.46	13.62
	15% release (3.34 m^3/s)	1522.91	1523.26	35.22	1.64	14.94
	20% release (4.46 m^3/s)	1522.91	1523.30	39.49	1.78	15.80
	25% release (5.57 m^3/s)	1522.91	1523.34	43.13	1.89	16.53
	30% release (6.69 m^3/s)	1522.91	1523.37	46.38	1.99	17.18
	40% release (8.92 m^3/s)	1522.91	1523.43	52.00	2.16	18.31
	50% release (11.15 m^3/s)	1522.91	1523.47	56.84	2.30	19.27
	100% release (22.30 m^3/s)	1522.91	1523.66	75.06	2.79	22.86
Intermediate (March-May and Oct)	10% release (1.07 m^3/s)	1522.91	1523.11	20.07	1.16	11.77
	15% release (1.61 m^3/s)	1522.91	1523.15	24.42	1.32	12.69
	20% release (2.15 m^3/s)	1522.91	1523.19	28.61	1.44	13.54
	25% release (2.68 m^3/s)	1522.91	1523.22	31.46	1.53	14.14
	30% release (3.22 m^3/s)	1522.91	1523.25	34.70	1.62	14.84
	40% release (4.29 m^3/s)	1522.91	1523.29	38.88	1.76	15.68
	50% release (5.36 m^3/s)	1522.91	1523.33	42.47	1.87	16.40
	100% release (10.73 m^3/s)	1522.91	1523.47	55.98	2.27	19.10

Model Output for Different Release Scenarios for Parbati II HEP

Season	Release Scenario	River Bed (m)	Water Level (m)	Water depth (cm)	Flow Velocity (m/s)	Flow Width (m)
Low (Dec-March)	10% release (1.50 m^3/s)	2040.60	2040.91	30.32	1.20	10.49
	15% release (2.25 m^3/s)	2040.60	2040.96	35.32	1.33	12.21
	20% release (2.99 m^3/s)	2040.60	2041.00	39.29	1.42	13.48
	25% release (3.74 m^3/s)	2040.60	2041.03	42.73	1.51	14.50
	30% release (4.49 m^3/s)	2040.60	2041.06	45.79	1.58	15.27
	40% release (5.99 m^3/s)	2040.60	2041.11	51.07	1.70	16.41
	50% release (7.48 m^3/s)	2040.60	2041.16	55.58	1.80	17.32

	100% release (14.97 m^3/s)	2040.60	2041.33	72.61	2.16	20.55
High (June-Sept)	10% release (10.86 m^3/s)	2040.60	2041.24	64.15	1.98	19.04
	15% release (16.30 m^3/s)	2040.60	2041.35	75.05	2.21	20.96
	20% release (21.73 m^3/s)	2040.60	2041.44	83.96	2.39	22.46
	25% release (27.16 m^3/s)	2040.60	2041.52	91.69	2.54	23.73
	30% release (32.59 m^3/s)	2040.60	2041.59	98.55	2.67	24.78
	40% release (43.46 m^3/s)	2040.60	2041.71	110.50	2.89	26.50
	50% release (54.32 m^3/s)	2040.60	2041.81	120.77	3.08	27.73
	100% release (108.64 m^3/s)	2040.60	2042.20	160.20	3.78	32.23
Intermediate (Oct, Nov, Apr, May)	10% release (2.5375 m^3/s)	2040.60	2040.97	36.91	1.37	12.73
	15% release (3.79 m^3/s)	2040.60	2041.03	42.95	1.51	14.56
	20% release (5.06 m^3/s)	2040.60	2041.08	47.91	1.63	15.76
	25% release (6.32 m^3/s)	2040.60	2041.12	52.12	1.72	16.62
	30% release (7.59 m^3/s)	2040.60	2041.16	55.90	1.80	17.39
	40% release (10.12 m^3/s)	2040.60	2041.23	62.40	1.95	18.70
	50% release (12.65 m^3/s)	2040.60	2041.28	68.03	2.06	19.77
	100% release (25.30 m^3/s)	2040.60	2041.49	89.17	2.49	23.33

Model Output for Different Release Scenarios for Thana Plaun HEP

Season	Release Scenario	River Bed (m)	Water Level (m)	Water depth (cm)	Flow Velocity (m/s)	Flow Width (m)
Low (Nov-Feb)	10% release (2.53 m^3/s)	622.99	623.38	38.86	0.63	22.28
	15% release (3.79 m^3/s)	622.99	623.45	45.69	0.70	24.33
	20% release (5.05 m^3/s)	622.99	623.50	51.27	0.76	25.92
	25% release (6.32 m^3/s)	622.99	623.55	56.17	0.81	27.30
	30% release (7.58 m^3/s)	622.99	623.60	60.47	0.86	28.52
	40% release (10.11 m^3/s)	622.99	623.67	68.02	0.93	30.65
	50% release (12.64 m^3/s)	622.99	623.74	74.51	0.99	32.48
	100% release (25.27 m^3/s)	622.99	623.98	98.92	1.21	39.13
High (June-Sept)	10% release (31.08 m^3/s)	622.99	624.07	107.66	1.28	42.01
	15% release (46.62 m^3/s)	622.99	624.26	127.03	1.44	46.75
	20% release (62.16 m^3/s)	622.99	624.42	142.89	1.57	50.90
	25% release (77.70 m^3/s)	622.99	624.56	156.54	1.67	55.18
	30% release (93.24 m^3/s)	622.99	624.68	168.65	1.76	58.40
	40% release (124.32 m^3/s)	622.99	624.89	189.58	1.91	67.56
	50% release (155.40 m^3/s)	622.99	625.06	207.29	2.03	70.62
	100% release (310.81 m^3/s)	622.99	625.73	274.27	2.51	80.03
Intermediate (March-May and Oct)	10% release (7.76 m^3/s)	622.99	623.60	61.07	0.86	28.69
	15% release (11.64 m^3/s)	622.99	623.71	72.03	0.97	31.79
	20% release (15.53 m^3/s)	622.99	623.80	81.04	1.05	34.32
	25% release (19.41 m^3/s)	622.99	623.88	88.78	1.12	36.50
	30% release (23.29 m^3/s)	622.99	623.95	95.66	1.18	38.30
	40% release (31.05 m^3/s)	622.99	624.07	107.62	1.28	42.00
	50% release (38.81 m^3/s)	622.99	624.17	117.86	1.37	44.53

	100% release (77.63 m^3/s)	622.99	624.56	156.49	1.67	55.16

Model Output for Different Release Scenarios for Triveni Mahadev HEP (Beas River)

Season	Release Scenario	River Bed (m)	Water Level (m)	Water depth (cm)	Flow Velocity (m/s)	Flow Width (m)
Low (Nov-Feb)	10% release (2.81 m^3/s)	555.95	556.24	28.81	0.42	30.74
	15% release (4.21 m^3/s)	555.95	556.34	38.98	0.50	35.55
	20% release (5.62 m^3/s)	555.95	556.42	46.94	0.57	38.21
	25% release (7.02 m^3/s)	555.95	556.47	51.93	0.61	39.62
	30% release (8.43 m^3/s)	555.95	556.51	56.42	0.65	40.85
	40% release (11.24 m^3/s)	555.95	556.59	64.44	0.71	43.06
	50% release (14.05 m^3/s)	555.95	556.66	71.48	0.76	45.00
	100% release (28.09 m^3/s)	555.95	556.94	98.53	0.94	52.03
High (June-Sept)	10% release (36.03 m^3/s)	555.95	557.06	110.55	1.01	55.12
	15% release (54.05 m^3/s)	555.95	557.28	133.33	1.15	60.95
	20% release (72.07 m^3/s)	555.95	557.47	152.12	1.25	66.22
	25% release (90.08 m^3/s)	555.95	557.63	168.31	1.33	71.89
	30% release (108.10 m^3/s)	555.95	557.78	182.60	1.40	77.88
	40% release (144.13 m^3/s)	555.95	558.02	207.15	1.51	89.66
	50% release (180.17 m^3/s)	555.95	558.23	228.04	1.60	96.08
	100% release (360.33 m^3/s)	555.95	559.01	306.41	1.96	110.97
Intermediate (March-May and Oct)	10% release (9.66 m^3/s)	555.95	556.55	60.07	0.68	41.85
	15% release (14.49 m^3/s)	555.95	556.67	72.50	0.77	45.28
	20% release (19.33 m^3/s)	555.95	556.78	82.85	0.84	47.99
	25% release (24.16 m^3/s)	555.95	556.87	91.89	0.90	50.31
	30% release (28.99 m^3/s)	555.95	556.95	99.97	0.95	52.40
	40% release (38.65 m^3/s)	555.95	557.09	114.21	1.04	56.06
	50% release (48.31 m^3/s)	555.95	557.22	126.59	1.11	59.24
	100% release (96.63 m^3/s)	555.95	557.69	173.69	1.36	74.35

Model Output for Different Release Scenarios for Triveni Mahadev HEP (Binwa River)

Season	Release Scenario	River Bed (m)	Water Level (m)	Water depth (cm)	Flow Velocity (m/s)	Flow Width (m)
Low (Nov-Feb)	10% release (0.46 m^3/s)	571.10	571.46	36.56	0.39	13.01
	15% release (0.70 m^3/s)	571.10	571.51	40.67	0.44	14.79
	20% release (0.93 m^3/s)	571.10	571.54	43.82	0.47	16.15
	25% release (1.16 m^3/s)	571.10	571.56	46.52	0.50	17.32
	30% release (1.39 m^3/s)	571.10	571.59	48.95	0.53	18.34
	40% release (1.85 m^3/s)	571.10	571.63	53.08	0.57	20.03
	50% release (2.32 m^3/s)	571.10	571.67	56.74	0.61	20.87
	100% release (4.63 m^3/s)	571.10	571.80	70.34	0.74	23.94
High (June-Sept)	10% release (3.07 m^3/s)	571.10	571.72	61.79	0.66	22.01
	15% release (4.60 m^3/s)	571.10	571.80	70.20	0.74	23.91
	20% release (6.14 m^3/s)	571.10	571.87	77.16	0.80	25.47

	25% release (7.67 m^3/s)	571.10	571.93	83.15	0.85	26.77
	30% release (9.21 m^3/s)	571.10	571.98	88.53	0.90	27.93
	40% release (12.27 m^3/s)	571.10	572.08	97.87	0.98	29.94
	50% release (15.34 m^3/s)	571.10	572.16	105.96	1.04	31.62
	100% release (30.68 m^3/s)	571.10	572.46	136.18	1.28	37.31
Intermediate (March-May and Oct)	10% release (1.00 m^3/s)	571.10	571.55	44.69	0.48	16.52
	15% release (1.50 m^3/s)	571.10	571.60	50.00	0.54	18.80
	20% release (2.01 m^3/s)	571.10	571.64	54.40	0.58	20.33
	25% release (2.51 m^3/s)	571.10	571.68	58.10	0.62	21.18
	30% release (3.01 m^3/s)	571.10	571.71	61.40	0.65	21.93
	40% release (4.01 m^3/s)	571.10	571.77	67.18	0.71	23.23
	50% release (5.02 m^3/s)	571.10	571.82	72.21	0.75	24.36
	100% release (10.03 m^3/s)	571.10	572.01	91.20	0.92	28.51

Model Output for Different Release Scenarios for Larji HEP

Season	Release Scenario	River Bed (m)	Water Level (m)	Water depth (cm)	Flow Velocity (m/s)	Flow Width (m)
Low (Dec-March)	10% release (5.71 m^3/s)	928.25	928.84	58.61	0.87	25.87
	15% release (8.56 m^3/s)	928.25	928.94	68.95	0.98	28.13
	20% release (11.42 m^3/s)	928.25	929.03	77.51	1.06	29.64
	25% release (14.27 m^3/s)	928.25	929.10	84.93	1.13	30.86
	30% release (17.13 m^3/s)	928.25	929.17	91.58	1.20	31.95
	40% release (22.84 m^3/s)	928.25	929.28	103.15	1.31	33.71
	50% release (28.55 m^3/s)	928.25	929.38	113.23	1.40	35.16
	100% release (57.10 m^3/s)	928.25	929.77	151.75	1.74	40.33
High (June-Sept)	10% release (42.71 m^3/s)	928.25	929.59	134.15	1.59	38.06
	15% release (64.07 m^3/s)	928.25	929.84	159.40	1.81	41.24
	20% release (85.43 m^3/s)	928.25	930.05	180.36	1.98	43.72
	25% release (106.78 m^3/s)	928.25	930.24	198.56	2.12	45.79
	30% release (128.14 m^3/s)	928.25	930.40	214.88	2.25	47.62
	40% release (170.85 m^3/s)	928.25	930.69	243.49	2.47	50.82
	50% release (213.56 m^3/s)	928.25	930.93	268.29	2.65	53.53
	100% release (427.13 m^3/s)	928.25	931.88	362.98	3.28	63.20
Intermediate (Oct, Nov, Apr, May)	10% release (14.30 m^3/s)	928.25	929.10	85.00	1.14	30.87
	15% release (21.45 m^3/s)	928.25	929.26	100.52	1.28	33.33
	20% release (28.60 m^3/s)	928.25	929.38	113.30	1.40	35.18
	25% release (35.74 m^3/s)	928.25	929.50	124.43	1.51	36.77
	30% release (42.89 m^3/s)	928.25	929.59	134.37	1.59	38.09
	40% release (57.19 m^3/s)	928.25	929.77	151.85	1.74	40.34
	50% release (71.49 m^3/s)	928.25	929.92	167.07	1.87	42.15

	100% release (142.98 m^3/s)	928.25	930.50	225.34	2.33	48.79

Model Output for Different Release Scenarios for Pandoh HEP

Season	Release Scenario	River Bed (m)	Water Level (m)	Water depth (cm)	Flow Velocity (m/s)	Flow Width (m)
Low (Nov-Feb)	10% release (9.50 m^3/s)	814.04	814.97	93.59	1.00	23.18
	15% release (14.24 m^3/s)	814.04	815.13	108.93	1.11	26.51
	20% release (18.99 m^3/s)	814.04	815.25	121.37	1.19	29.01
	25% release (23.74 m^3/s)	814.04	815.36	132.03	1.26	31.11
	30% release (28.49 m^3/s)	814.04	815.45	141.46	1.32	32.78
	40% release (37.98 m^3/s)	814.04	815.62	157.82	1.42	35.47
	50% release (47.48 m^3/s)	814.04	815.76	171.87	1.51	37.63
	100% release (94.95 m^3/s)	814.04	816.28	224.78	1.83	44.71
High (June-Sept)	10% release (43.15 m^3/s)	814.04	815.69	165.69	1.47	36.70
	15% release (64.72 m^3/s)	814.04	815.97	193.64	1.64	40.80
	20% release (86.29 m^3/s)	814.04	816.20	216.53	1.78	43.76
	25% release (107.86 m^3/s)	814.04	816.40	236.32	1.90	45.91
	30% release (129.44 m^3/s)	814.04	816.58	254.01	2.00	47.64
	40% release (172.58 m^3/s)	814.04	816.89	285.06	2.18	50.60
	50% release (215.73 m^3/s)	814.04	817.16	312.17	2.34	53.12
	100% release (431.45 m^3/s)	814.04	818.20	416.57	2.89	62.36
Intermediate (March-May and Oct)	10% release (17.16 m^3/s)	814.04	815.21	116.82	1.16	28.10
	15% release (25.74 m^3/s)	814.04	815.40	136.13	1.29	31.84
	20% release (34.32 m^3/s)	814.04	815.56	151.84	1.39	34.53
	25% release (42.90 m^3/s)	814.04	815.69	165.31	1.47	36.65
	30% release (51.48 m^3/s)	814.04	815.81	177.28	1.55	38.44
	40% release (68.64 m^3/s)	814.04	816.02	198.11	1.67	41.41
	50% release (85.79 m^3/s)	814.04	816.20	216.04	1.78	43.71
	100% release (171.59 m^3/s)	814.04	816.88	284.38	2.18	50.54

Model Output for Different Release Scenarios for Lambadug HEP

Season	Release Scenario	River Bed (m)	Water Level (m)	Water depth (cm)	Flow Velocity (m/s)	Flow Width (m)
Low (Nov-Feb)	10% release (0.12 m^3/s)	1977.20	1977.33	13.02	0.86	4.35
	15% release (0.18 m^3/s)	1977.20	1977.37	16.31	0.94	4.71
	20% release (0.24 m^3/s)	1977.20	1977.38	18.20	1.01	4.98
	25% release (0.29 m^3/s)	1977.20	1977.40	19.57	1.05	5.18
	30% release (0.35 m^3/s)	1977.20	1977.41	21.04	1.10	5.39
	40% release (0.47 m^3/s)	1977.20	1977.44	23.56	1.18	5.75
	50% release (0.59 m^3/s)	1977.20	1977.46	25.68	1.25	6.06
	100% release (1.18 m^3/s)	1977.20	1977.54	33.48	1.49	7.18
High (June-Sept)	10% release (0.85 m^3/s)	1977.20	1977.50	29.54	1.37	6.61
	15% release (1.28 m^3/s)	1977.20	1977.55	34.55	1.52	7.33

	20% release (1.70 m^3/s)	1977.20	1977.59	38.49	1.64	7.90
	25% release (2.13 m^3/s)	1977.20	1977.62	41.92	1.74	8.42
	30% release (2.56 m^3/s)	1977.20	1977.65	44.92	1.82	8.90
	40% release (3.41 m^3/s)	1977.20	1977.70	50.05	1.96	9.77
	50% release (4.26 m^3/s)	1977.20	1977.75	54.41	2.07	10.52
	100% release (8.52 m^3/s)	1977.20	1977.91	70.57	2.46	13.24
Intermediate (March-May and Oct)	10% release (0.40 m^3/s)	1977.20	1977.42	22.15	1.13	5.55
	15% release (0.60 m^3/s)	1977.20	1977.46	25.86	1.25	6.08
	20% release (0.80 m^3/s)	1977.20	1977.49	28.86	1.34	6.51
	25% release (0.99 m^3/s)	1977.20	1977.52	31.32	1.42	6.86
	30% release (1.19 m^3/s)	1977.20	1977.54	33.58	1.49	7.19
	40% release (1.59 m^3/s)	1977.20	1977.58	37.53	1.61	7.76
	50% release (1.99 m^3/s)	1977.20	1977.61	40.85	1.71	8.26
	100% release (3.98 m^3/s)	1977.20	1977.73	53.05	2.03	10.28

Model Output for Different Release Scenarios for Malana-III HEP

Season	Release Scenario	River Bed (m)	Water Level (m)	Water depth (cm)	Flow Velocity (m/s)	Flow Width (m)
Low (Dec-March)	10% release (0.21 m^3/s)	2736.92	2737.03	11.48	0.90	4.33
	15% release (0.31 m^3/s)	2736.92	2737.05	13.50	1.03	4.66
	20% release (0.41 m^3/s)	2736.92	2737.07	15.19	1.12	4.91
	25% release (0.52 m^3/s)	2736.92	2737.09	17.50	1.20	5.28
	30% release (0.62 m^3/s)	2736.92	2737.10	18.69	1.26	5.52
	40% release (0.82 m^3/s)	2736.92	2737.13	21.87	1.37	6.15
	50% release (1.03 m^3/s)	2736.92	2737.15	23.80	1.45	6.69
	100% release (2.06 m^3/s)	2736.92	2737.22	30.91	1.72	8.70
High (June-Sept)	10% release (1.35 m^3/s)	2736.92	2737.21	29.81	1.68	8.38
	15% release (2.02 m^3/s)	2736.92	2737.26	34.68	1.86	9.75
	20% release (2.70 m^3/s)	2736.92	2737.30	38.64	2.00	10.82
	25% release (3.37 m^3/s)	2736.92	2737.34	41.96	2.12	11.53
	30% release (4.04 m^3/s)	2736.92	2737.37	44.94	2.22	12.13
	40% release (5.39 m^3/s)	2736.92	2737.42	50.03	2.39	13.15
	50% release (6.74 m^3/s)	2736.92	2737.46	54.40	2.53	14.04
	100% release (13.48 m^3/s)	2736.92	2737.62	70.67	3.03	16.90
Intermediate (Oct, Nov, Apr, May)	10% release (0.63 m^3/s)	2736.92	2737.11	19.66	1.31	5.71
	15% release (0.94 m^3/s)	2736.92	2737.16	24.01	1.45	6.75
	20% release (1.26 m^3/s)	2736.92	2737.18	26.73	1.56	7.52
	25% release (1.57 m^3/s)	2736.92	2737.21	29.06	1.65	8.17
	30% release (1.89 m^3/s)	2736.92	2737.23	31.12	1.73	8.75
	40% release (2.52 m^3/s)	2736.92	2737.26	34.68	1.86	9.75
	50% release (3.15 m^3/s)	2736.92	2737.29	37.69	1.96	10.61
	100% release (6.29 m^3/s)	2736.92	2737.40	48.81	2.35	12.91

Model Output for Different Release Scenarios for Uhl (Shanan) HEP

Season	Release Scenario	River Bed (m)	Water Level (m)	Water depth (cm)	Flow Velocity (m/s)	Flow Width (m)
Low (Nov-Feb)	10% release (0.22 m^3/s)	1740.67	1740.76	9.34	0.53	4.02
	15% release (0.33 m^3/s)	1740.67	1740.81	13.98	0.65	5.03
	20% release (0.44 m^3/s)	1740.67	1740.87	19.77	0.80	5.99

	25% release (0.54 m^3/s)	1740.67	1740.90	23.43	0.82	6.78
	30% release (0.65 m^3/s)	1740.67	1740.92	25.39	0.87	7.33
	40% release (0.87 m^3/s)	1740.67	1740.95	28.27	0.93	8.17
	50% release (1.09 m^3/s)	1740.67	1740.98	30.79	0.98	8.89
	100% release (2.18 m^3/s)	1740.67	1741.07	39.94	1.17	11.53
High (June-Sept)	10% release (1.58 m^3/s)	1740.67	1741.02	35.38	1.08	10.22
	15% release (2.37 m^3/s)	1740.67	1741.08	41.21	1.20	11.90
	20% release (3.16 m^3/s)	1740.67	1741.13	45.91	1.28	13.25
	25% release (3.95 m^3/s)	1740.67	1741.17	49.92	1.36	14.41
	30% release (4.74 m^3/s)	1740.67	1741.20	53.43	1.42	15.38
	40% release (6.31 m^3/s)	1740.67	1741.26	59.48	1.53	17.03
	50% release (7.89 m^3/s)	1740.67	1741.32	64.68	1.62	18.44
	100% release (15.78 m^3/s)	1740.67	1741.51	83.90	1.93	23.52
Intermediate (March-May and Oct)	10% release (0.74 m^3/s)	1740.67	1740.93	26.63	0.89	7.69
	15% release (1.11 m^3/s)	1740.67	1740.98	30.99	0.99	8.95
	20% release (1.47 m^3/s)	1740.67	1741.01	34.46	1.06	9.94
	25% release (1.84 m^3/s)	1740.67	1741.04	37.47	1.12	10.82
	30% release (2.21 m^3/s)	1740.67	1741.07	40.14	1.17	11.59
	40% release (2.95 m^3/s)	1740.67	1741.12	44.73	1.26	12.91
	50% release (3.69 m^3/s)	1740.67	1741.16	48.65	1.34	14.05
	100% release (7.37 m^3/s)	1740.67	1741.30	63.06	1.59	18.00

Model Output for Different Release Scenarios for Dhaulasidh HEP

Season	Release Scenario	River Bed (m)	Water Level (m)	Water depth (cm)	Flow Velocity (m/s)	Flow Width (m)
Low (Nov-April)	10% release (3.12 m^3/s)	473.86	474.05	18.58	0.40	43.56
	15% release (4.68 m^3/s)	473.86	474.22	35.42	0.46	45.45
	20% release (6.24 m^3/s)	473.86	474.35	49.13	0.50	46.96
	25% release (7.80 m^3/s)	473.86	474.47	61.17	0.55	48.28
	30% release (9.36 m^3/s)	473.86	474.58	71.98	0.58	49.47
	40% release (12.47 m^3/s)	473.86	474.77	91.23	0.65	51.59
	50% release (15.59 m^3/s)	473.86	474.95	108.33	0.70	53.47
	100% release (31.18 m^3/s)	473.86	475.62	176.08	0.89	60.16
High (June-September)	10% release (30.26 m^3/s)	472.86	475.59	272.60	0.38	59.95
	15% release (45.39 m^3/s)	473.86	476.11	224.30	1.01	63.01
	20% release (60.53 m^3/s)	473.86	476.54	268.10	1.11	65.61
	25% release (75.66 m^3/s)	473.86	476.93	306.70	1.20	67.90
	30% release (90.79 m^3/s)	473.86	477.28	341.65	1.28	69.97
	40% release (121.05 m^3/s)	473.86	477.90	403.52	1.41	73.63
	50% release (151.32 m^3/s)	473.86	478.44	457.82	1.52	76.77
	100% release (302.63 m^3/s)	473.86	480.55	668.45	1.92	87.49
Intermediate (October and May)	10% release 4.05 m^3/s)	473.86	474.15	29.13	0.14	44.75
	15% release (6.07 m^3/s)	473.86	474.34	47.73	0.17	46.80
	20% release (8.10 m^3/s)	473.86	474.49	63.28	0.55	48.52
	25% release (10.12 m^3/s)	473.86	474.63	76.93	0.60	50.02
	30% release (12.15 m^3/s)	473.86	474.76	89.37	0.64	51.39
	40% release (16.19 m^3/s)	473.86	474.98	111.43	0.71	53.81
	50% release (20.24 m^3/s)	473.86	475.17	131.02	0.77	55.97
	100% release (40.48 m^3/s)	473.86	475.95	208.58	0.97	62.08

8.6 ENVIRONMENTAL FLOW ASSESSMENT

Environmental flows are flows that are to be released into a river system with the specific purpose of managing the modified river regime as close as possible to the natural state.

In Himalayan Rivers, annual discharges vary by orders of magnitude from year to year. Species that persist in such rivers generally survive, though not necessarily breed, during years when there is much less water than average. The presence of sequences of wet and dry years supports the suggestion that the biota can survive repeated years when the total annual discharge is less than the average, however, it may not remain unchanged in permanent drought conditions.

Studies in South African rivers (Weeks *et al.,* 1996) showed that major community shifts occur among the fish fauna during droughts, and also during normal low flow seasons. However, provided conditions do not drastically differ from those that have occurred in the past, recovery reflects in the short to medium term. Some studies have shown evidence that a lower than normal flow regime, which still incorporates all the major features of the natural regime, would not permanently change the biota of the river. It is therefore suggested that, other things such as catchment condition being equal, a carefully designed modified flow regime which maintains the ecologically important components of the natural flow regime should be able to maintain a river's natural biota.

Therefore, for assessment of environmental flow focus should be on the characteristic features of the natural flow regime of the river. The most important of these are degree of perenniality; magnitude of base flows in the dry and wet season; magnitude, timing and duration of floods in the wet season; and small pulses of higher flow, that occur between dry and wet months. Attention is then given to which flow features are considered most important for maintaining or achieving the desired future condition of the river, and thus should not be eradicated during development of the river's water resources.

Fish assemblages often include a range of species and reflect the integrated effects of environmental changes. Their presence is used to infer the presence of other aquatic organisms, since the adult fish occupy the top of the food chain in most aquatic systems. They also pass through most trophic levels above the primary producer stage during their development from larvae to adults. Fish can thus be regarded as reflecting the integrated environmental health of a river (Karr *et al.,* 1986). Fish species in river can guide to prepare specification of the flows necessary to meet their needs, and be useful in the monitoring and management of those flows. It is often surmised that if management of flows for fish maintenance is successful, then flow requirements for aquatic invertebrates will also be satisfied. This is because of the larger scale of fish habitat.

Therefore, the approach adopted for environmental flow assessment is based on the meeting the needs of dominant fish species with larger habitat requirement. Baseline data on fish fauna in Beas basin is discussed in **Chapter - 7;** where entire Beas basin can be divided in two predominant fish zones viz. Mahseer Zone and Trout Zone. Mahseer being a large fish requires more flow in all the seasons and this aspect has been kept in mind while recommending environmental flow for projects in Mahseer zone. Therefore, environmental flow assessment should be based on meeting its habitat requirement in lean, monsoon and pre/post monsoon period.

A minimum depth requirement of 40 cm and 50 cm is considered for trout and mahseer zones respectively to assess the environmental flow requirement in lean season. Higher depth is considered for intermediate period and monsoon period to ensure mimicking of natural discharge pattern. For intermediate period in Mahseer zone, a depth range of 60-75 cm is considered and for monsoon season a depth range of 85-100 cm is considered. Similarly, for intermediate period in trout zone, a depth range of 55-65 cm is considered and for monsoon season in trout zone, a depth range of 70-80 cm is considered as minimum requirement. However, some exceptions are considered, as many of the times, in small tributaries even in natural conditions such depths are not available. In such cases, recommendations are made to ensure that even during lower discharges giving lower depths and widths of water in the rivers, a part of it is maintained in the river as environment flow in such a manner that reduction in depth is restricted to about 50% of the natural river depth.

Keeping in view the EAC/MoEF&CC's requirement of minimum release in lean season as 20%, monsoon/peak season as 20-30% and other months also as 20-25%; calculated based on average discharge in four leanest months in 90% dependable year, the same is considered as the overriding criteria even if the modeling exercise is suggesting that a lower discharge can meet the depth requirement.

For Dam Toe power houses, where intermediate river stretch is very small, continuous release from the turbines can be used as the contribution towards environmental flow.

8.7 ENVIRONMENTAL FLOW RELEASE RECOMMENDATIONS

Based on the above criteria, environmental flow requirements is established for each project separately and final recommendations for the projects assessed by modeling exercise is tabulated below (**Table 8.4**). Values are given in percentage as per the prevalent norms, however, for the purpose of implementation absolute values (in cumec) should be used wherever, there is discrepancy.

For two projects, viz. Pong Dam and Uhl III, no recommendations is made as explained above.

For Uhl III and Kanda Pattan, in the absence of discharge data, assessment could not be carried out, therefore, it is recommended that Uhl III and Kanda Pattan maintains 20%, 30% and 25% of the average respective values of their 90% dependable year discharge (Year should be picked up from approved DPR used for project design) for lean, monsoon and other months as defined in the table.

For remaining 32 projects i.e. projects with less than 25 MW installed capacity, environment flow should be maintained based on the percentage of average values of discharge in lean, monsoon and other months based on 90% dependable year discharge series (year should be picked up from approved DPR used for project design) and following recommendations should be adopted:

- Lean Season (December to March) : 20% of average discharge in lean season in 90% DY
- Monsoon/Peak Season (June to September): 30% of average discharge in monsoon/peak season in 90% DY
- Remaining 4 months (October, November, April land May): 25% of average discharge in these months in 90% DY

Table 8.4: Environment Flow Release Recommendation

Sl No.	Project	River (Affected Stretch)	Recommended E-flow as % of average discharge in 90% DY			Recommended E-flow cumec		
			Lean Season	Peak Season	Other Months	Lean Season	Peak Season	Other Months
1	Beas Satluj Link	Beas River (25 km)	20	15	15	18.99	64.72	25.74
2	Parbati-III	Sainj River (13.7 Km)	20	15	15	1.51	8.46	2.83
3	Allain Duhangan	Allain (9.2 Km)	20	15	15	0.42	2.43	0.85
		Duhangan (5 Km)	20	15	20	0.15	0.96	0.4
4	Larji	Beas River (5.65 Km)	20	15	15	11.42	64.06	21.45
5	Uhl-I	Uhl River (40 Km)	20	15	15	0.44	2.37	1.11
6	Malana-II	Malana Nalla (5.2 Km)	20	15	15	0.52	2.56	1.20
7	Sainj	Sainj River (9 Km)	20	15	15	0.71	3.34	1.61
8	Malana-I	Malana Nalla (2.32 Km)	20	15	15	0.49	3.32	1.24
9	Uhl II	Tailrace of Uhl I	-	-	-	-	-	-
10	Pong Dam	Beas	-	-	-	-	-	-
11	Parbati-II	Parbati River (5.28 Km)	20	15	15	2.99	16.3	3.79
		Jigrai Nalla (0.8 Km)	20	30	25	0.2	1.16	0.54
		Jiva Nalla (8.2 Km)	20	30	25	1.19	6.2	2.53
		Hurla Nalla (12 Km)	20	30	25	0.57	3.12	1.28
12	Lambadug	Lambadug (6.3 Km)	20	15	15	0.25	1.28	0.6
13	Uhl III*	Rana Khad	20	30	25			
		Neri Khad	20	30	25			
14	Nakhtan	Toss (4.4 Km)	25	20	20	0.93	5.24	1.99
		Parbati (8.9 Km)	25	20	20	1.42	7.84	2.94
15	Thana Plaun	Beas River (12.7 Km)	20	15	15	5.05	46.62	11.64
16	Triveni Mahadev	Beas River (5.5 Km)	20	15	15	5.62	54.05	14.49
		Binwa Khad (3.2 Km)	20	15	15	0.93	4.6	1.5
17	Malana-III	Malana Nalla (3.35 Km)	20	15	15	0.31	2.02	0.94
18	Dhaulasidh	Beas River (37 Km)	20	30	20	6.24	90.79	8.10
19	Kanda Pattan	Beas River (8 Km)	20	30	25			

CHAPTER-9

CUMULATIVE IMPACT ASSESSMENT

9.1 INTRODUCTION

There is no universally accepted or adopted method for assessing cumulative impact of hydropower projects. Uncertainty in predicting effects and determining significance is imperative in this type of study which arises due to variations in natural systems, lack of information on historical data, knowledge or scientific agreement regarding cause-effect relationships, or the inability of predictive models to accurately represent the complex systems. The degree of uncertainty in addressing cumulative effects is greater than for conventional EIAs because of a longer time horizon and larger study area. Thus, the methods adopted and described in this write up were considered to deal with uncertainty. Precautionary principle is adopted on the conservative conclusions (i.e. assume that an effect is more rather than less adverse) were considered by compiling available data/ information with certain assumptions, data gaps and confidence in data quality and analysis to justify conclusions. However, paucity of long term baseline data and impact information generally limits the effectiveness of analysis.

The baseline data on various environmental parameters generated through field surveys as well compiled from secondary sources, the account of biodiversity for Beas basin was developed which is supplemented with expert knowledge of professionals working on different taxa and ecosystems, national and global database, published species records, researched information, etc. Information collected from all of the above sources was assessed for its adequacy and relevance and information gaps wherever observed were overcome by supplementing specific information through primary data collection efforts during the field visits undertaken during the study. Though lot of data was generated during field surveys however it was found insufficient to prepare an overall profile of the basin. Therefore, in order to overcome this limitation of field surveys as discussed above, for the preparation of baseline status of a large area like Beas basin extending over an area of 12591 sq km and considering the importance of biodiversity profile of the basin a comprehensive exercise was undertaken to collect, collate and complile available published data/ information sub-basin wise. This was essential as the coverage of Beas basin is quite large and diverse where altitudes vary from as low as 325m to more than 6600m with diverse ecosystems. As discussed already the biodiversity profile of the basin was assessed for each of the eleven sub-basins delineated for this purpose.

In order to understand broad eco-climatic conditions across the Beas basin, it was divided into four broad eco-zones and are shown in **Figure 9.1**. These are:

i) Shivalik/ Lower Montane Zone (Zone-I) with elavations up to 800m characterised by Tropical to Sub-tropical forest,

ii) Mid Hills/ Middle Montane Zone (Zone-II) with elevation ranging from 800 to 1600m characterised by Sub-tropical to Warm Temperate forests,

iii) High Hill/ Temperate Zone (Zone-III) with elevations ranging between 1600 and 2900m and characterised by Cold/ Moist Temperate forests, and

iv) Cold Dry Zone (Zone-IV) with elevations above 2900m comprised of Sub-Alpine to Alpine areas where Sub-alpine areas extend from 2900m to 3500m while Alpine areas extend beyond 3500m.

In the lowermost zone i.e. Eco-zone I, there are 4 projects out of which one i.e. Pong Dam is already operational while 3 projects viz. Dhaulasidh, Triveni Mahadev and Thana Plaun HEPs are under investigation and in proposal stage.

In Eco-Zone II i.e. Middle Montane zone 15 projects are located under different stages of development. Six projects (Pandoh Dam/ Beas Sutlej Link, Larji, Baner-II, Sainj, Parbati and Parbati-III HEPs) are already operational while 2 (Uhl-III and Lower Uhl) are under construction. Rest of the 8 projects are under proposal stage.

In Eco-Zone III, 18 projects are located out of which 11 projects are already commissioned while 4 are under construction. Only 3 projects are in proposal stage.

In Eco-Zone IV, 8 projects are located out of which 5 are operational and rest of the 3 are in proposal stage.

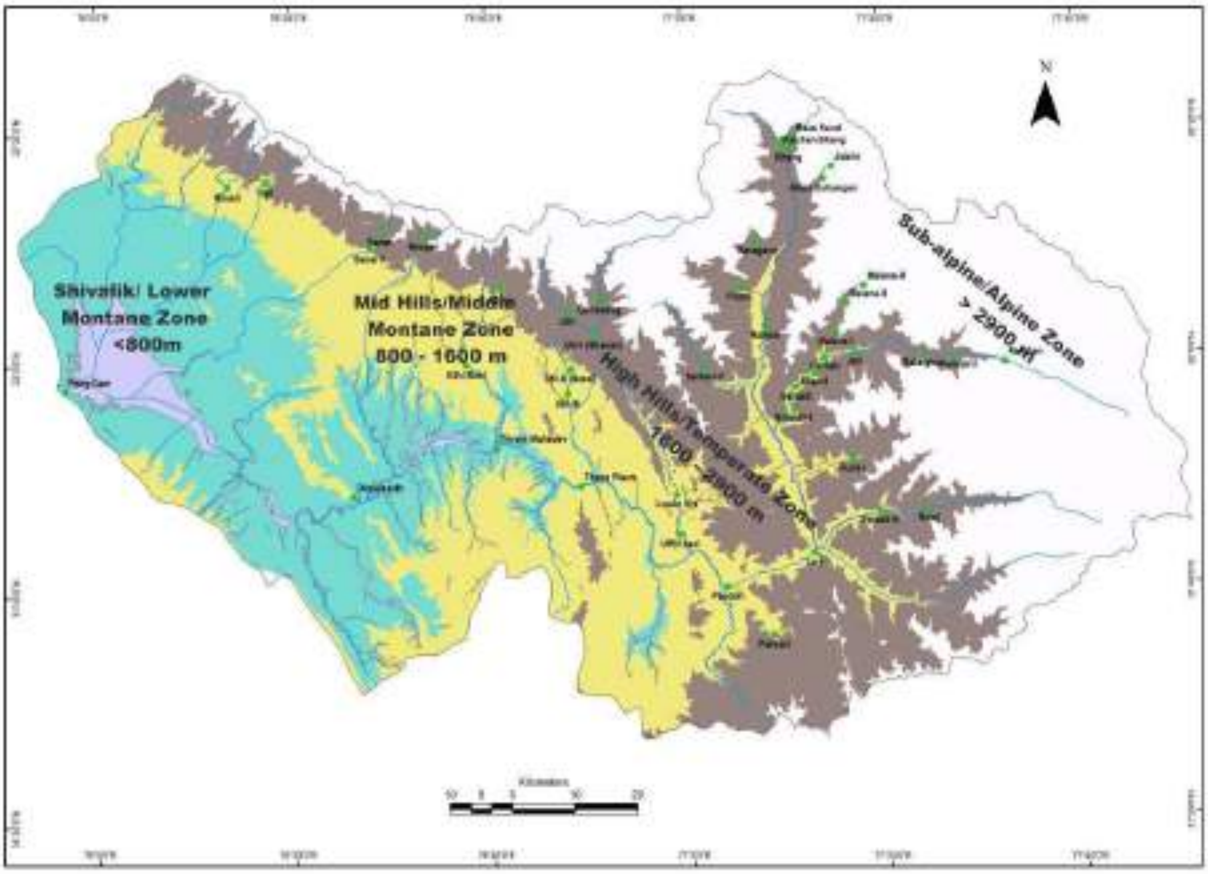


Figure 9.1: Broad Eco-zones identified in Beas basin

Now one by one different attributes of biodiversity of Beas basin is being discussed in the following sections.

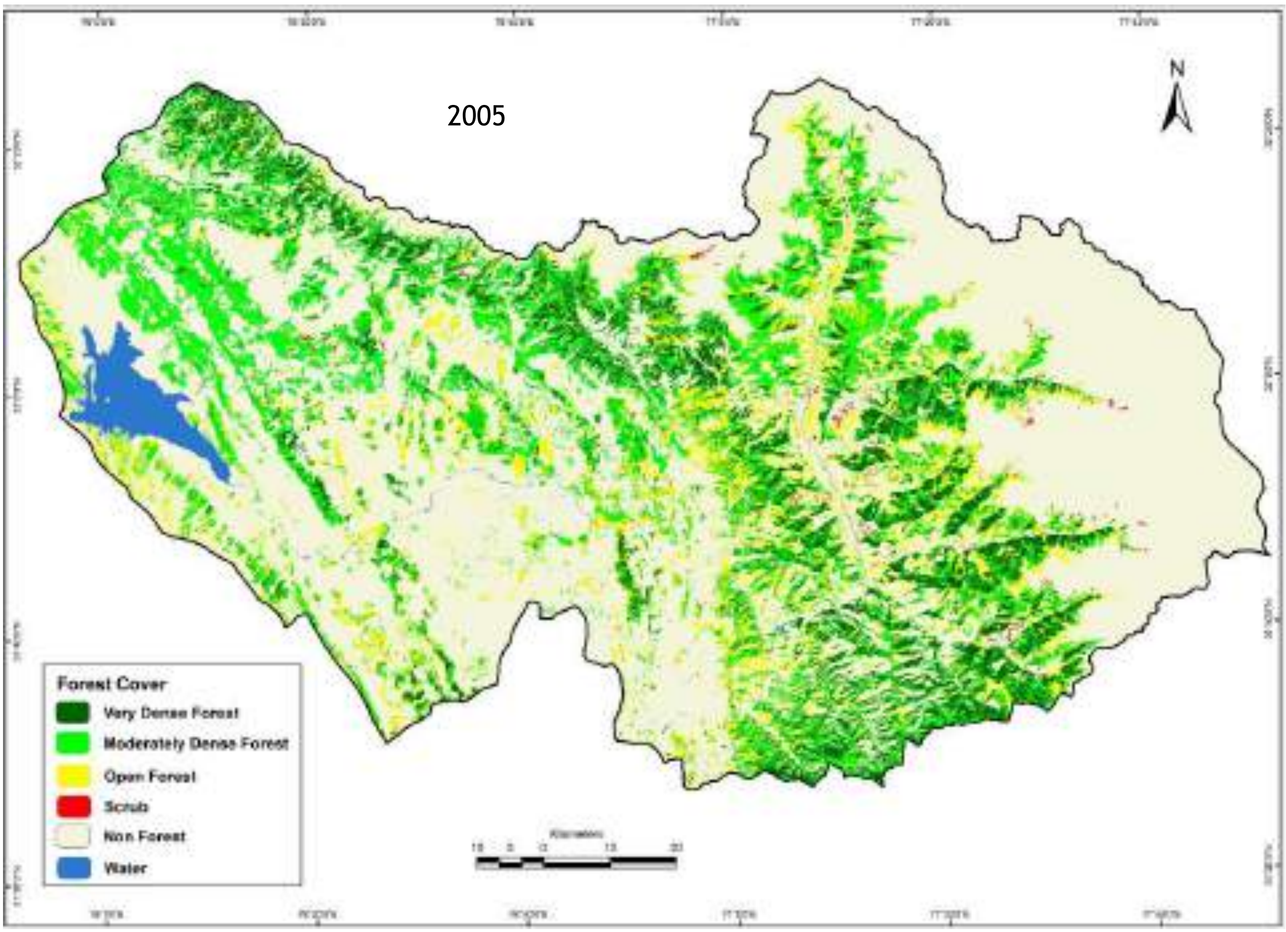
9.2 FOREST COVER

An assessment of forest cover change was made in last decade. For this data was procured from Forest Survey of India for the years 2005 and 2015. Maps for the overall forest cover change in the entire Beas basin were generated and the same have been given at **Figure 9.2**. The change in different forest cover classes from 2005 to 2015 has been compiled is given at **Table 9.1**.

Table 9.1: Temporal change in different forest cover classes in Beas basin

Class	2005		2015		Change	
	(ha)	(%)	(ha)	(%)	(ha)	(%)
Very Dense Forest	116490.84	9.25	117116.36	9.30	625.52	0.54
Moderately Dense Forest	222291.50	17.65	224020.68	17.79	1729.17	0.78
Open Forest	123421.75	9.80	125988.60	10.01	2566.85	2.08
Total Forest	**462204.09**	**36.71**	**467125.63**	**37.10**	4921.54	**1.06**
Scrub	2581.80	0.21	2142.98	0.17	-438.83	-17.00
Non Forest	**794374.06**	**63.09**	**789891.35**	**62.73**	**-4482.71**	**-0.56**
Total Geographic Area (ha)	**1259159.96**					

It can be seen from the map as well as tabulated data that total forest cover in the study area has marginally increased by about 49.22 sq km i.e. nearly 1% over a period of 10 years. The increase in forest cover is mainly in the open forest category where it increased by about 2.08% due to plantations and environmental awareness wherein non-forest areas have been brought under green cover.



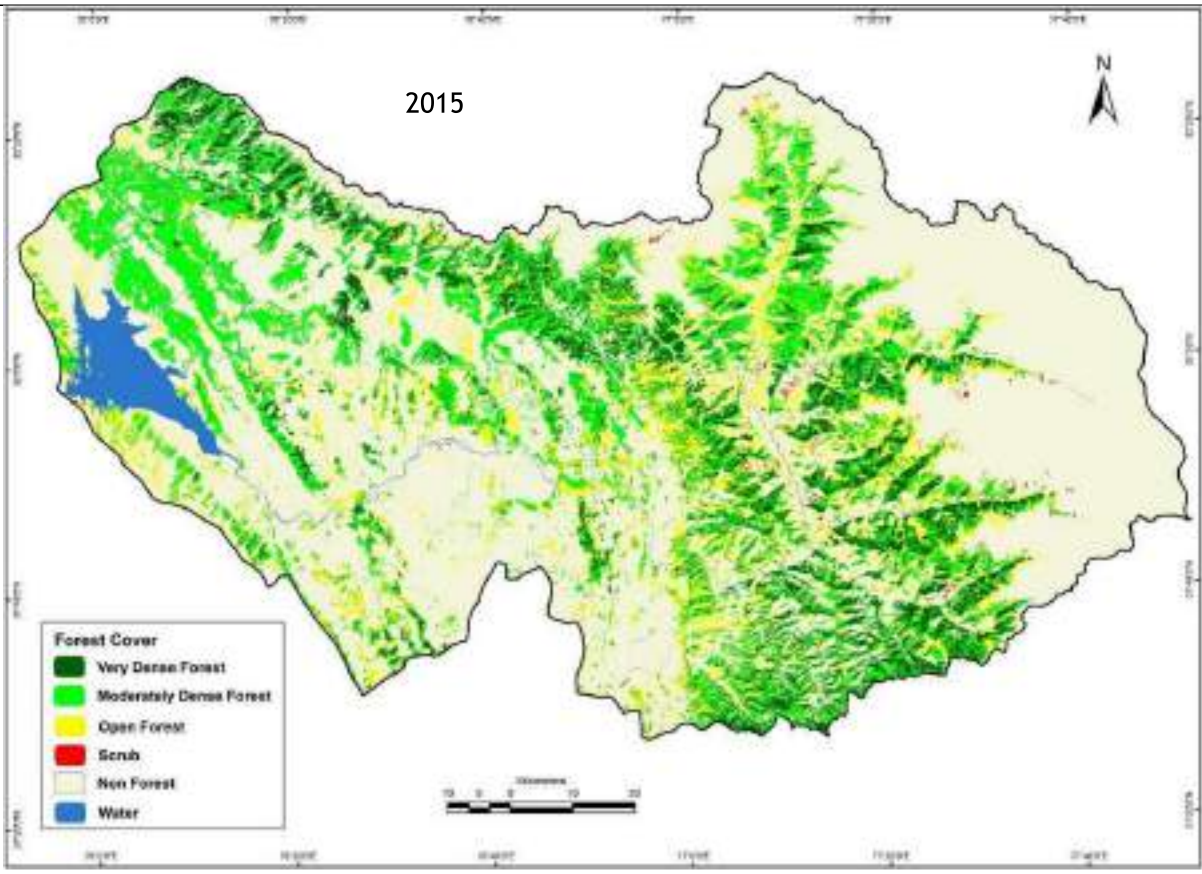


Figure 9.2: Map showing forest cover in the years 2005 and 2015 based upon FSI data

9.3 BIOLOGICAL RICHNESS

In order to understand the biodiversity profile of entire Beas basin Biological Richness map at the landscape level was generated using the maps procured as well as downloaded from Biological Information System portal (http://bis.iirs.gov.in) managed by Indian Institute of Remote Sensing (IIRS), Dehradun. It has been computed as a function of ecosystem uniqueness, species diversity, biodiversity value, terrain complexity, and Disturbance Index (NRSC, 2008). According to this index such areas depict the potential for harboring the maximum number of ecologically unique and important species which are then used in assigning conservation priorities to threatened, rare, endemic and taxonomically distinct species and to different types of habitats or landscape elements on the basis of the richness and significance of threatened species. As a part of this study, the biologically rich areas were spatially identified for the purpose of conservation and saving the existing gene pool from extinction. Similarly, disturbance index, which is a part of the ecosystem process and a function of the biological richness, was also generated.

Biological Richness map of the entire basin thus prepared is given at **Figure 9.3** and percent area under different categories is given in **Table 9.2.** More than 48% of the basin area is under Very High and High Richness Index category. These areas are mainly located in upper Beas catchment, Parbati, Sainj and Tirthan river catchments and higher elevations in catchments of Baner Khad, Neugal Khad, Binwa Khad, Uhl river which drain the southern slopes of Dhauladhar range.

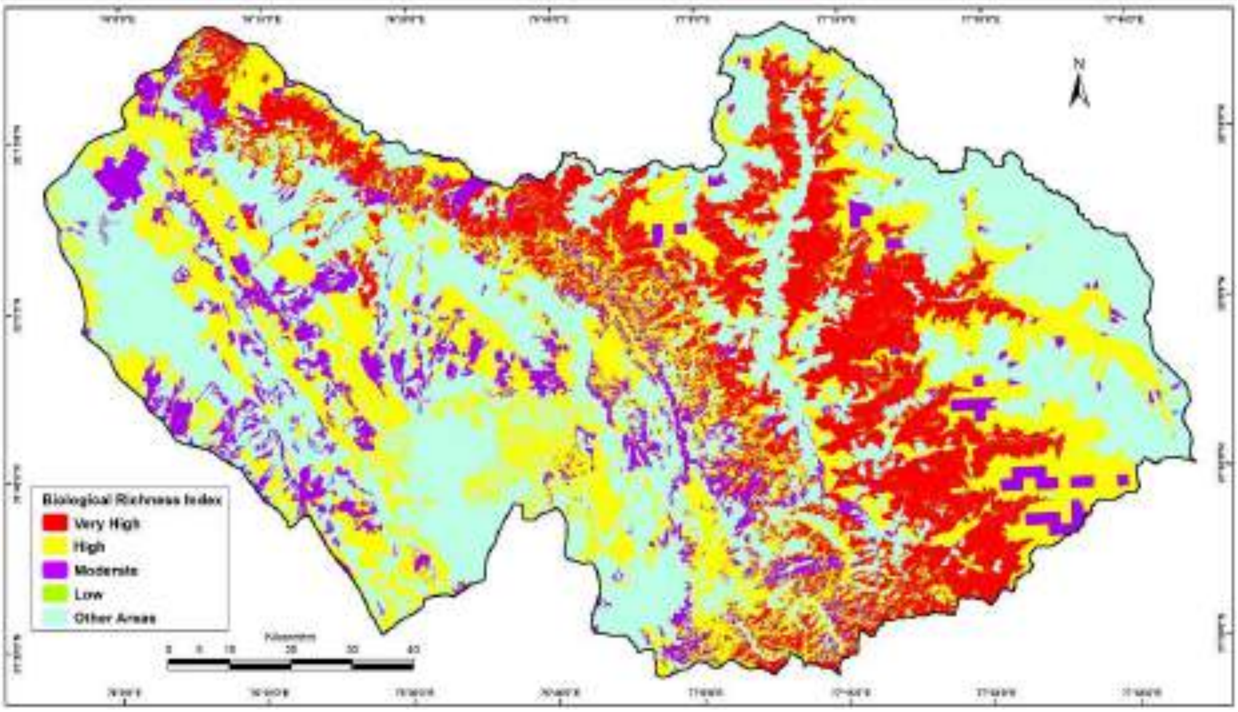


Figure 9.3: Biological Richness Index map of Beas basin

Table 9.2: Area under different Biological Richness Index categories in Beas basin

Biological Richness Index	Area (sq km)	(%)
Very High	2297.34	18.25
High	3750.09	29.78
Moderate	1228.42	9.76
Low	41.61	0.33
Other Areas (Water, Barren land, Snow, Glaciers, etc.)	5273.34	41.88
	12590.79	

In addition to Biological Richness Index Fragmentation Index map as well as Disturbance Index maps of the basin were also prepared to delineate areas with where landscape fragmentation has occurred over the years due to various developmental activities and urbanisation. Biotic disturbance attributes like proximity to roads and human settlements along with landscape parameters are combined to generate Disturbance Index. Fragmentaion Index and Disturbance Index maps prepared from the data downloaded from the portal http://bis.iirs.gov.in/ are given at **Figures 9.4 & 9.5**.

Looking at the Fragmentation Index map and **Table 9.2** it can be concluded that only about 2.39% of basin area is under category where landscape fragmentation is High while about 17.38% area is under Moderate category.

Disturbance Index map (**Figure 9.5**) and data given in th **Table 9.2** shows that disburbance index of Very High and High accounts for 14.34% of basin area while more than 18% of basin is under Moderate disturbance category.

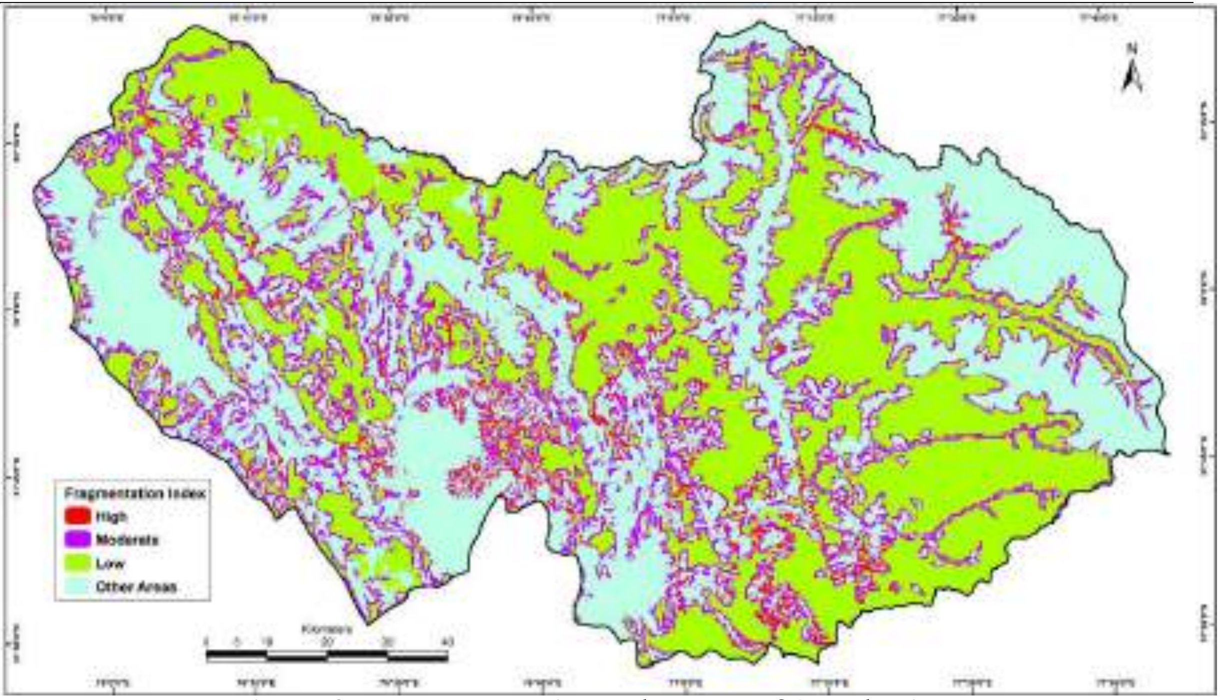


Figure 9.4: Fragmentation Index map of Beas basin

Table 9.3: Area under different categories of Fragmentation Index and Disturbance Index in Beas basin

Fragmentation Index	Area (sq km)	(%)	Disturbance Index	Area (sq km)	(%)
Very High	-	-	Very High	110.45	0.88
High	300.73	2.39	High	1705.37	13.54
Moderate	2188.88	17.38	Moderate	2314.58	18.38
Low	4832.84	38.38	Low	3188.05	25.32
Other Areas (Water, Barren land, Snow, Glaciers, etc.)	5268.33	41.84	Other Areas (Water, Barren land, Snow, Glaciers, etc.)	5272.34	41.87

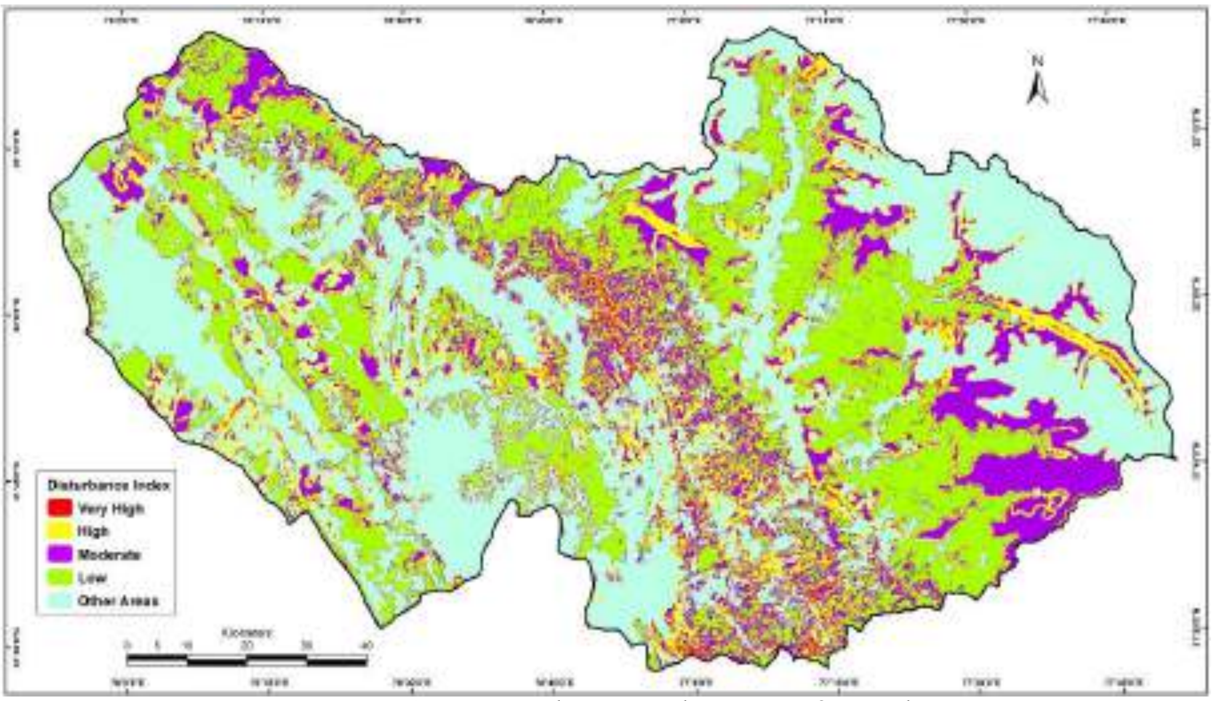


Figure 9.5: Disturbance Index map of Beas basin

Based upon the discussion above regarding Forest cover change, type of forest encountered Fragmentation Index and Disturbance Index categories in different sub-basins, along with ecological attrubutes of floral and faunal elements both terrstrial as well as aquatic, a sub-basin wise ecological assessment of all the above parameters has been made and is being discussed in the following paragraphs. Although most of the hydropower projects in the basin are either operational or are under construction whereas some more have been planned and are under investigation, current baseline scenario all the above shall help in evaluating the impact of already operational, under construction and planned projects which can then help in suggesting mitigations measures to be adopted.

9.4 SUB-BASIN-WISE IMPACT ASSESSMENT

Even though Eco-zones in the entire study area described above were defined broadly on the basis of altitudinal as well as major forest types occuring in the elevation band, however to in order to understand the biological profile of the study area with diverse terrain and elevation coupled with geographical attributes it was decided to make an impact assessment of operational, under construction and proposed hydropower projects vis-a-vis terrestrial and aquatic ecological values highlighting the overall biological profile of the particular sub-basin. The details of above mentioned attributes have already been described in Chapter 3 – Basin Charactersitics. This chapter essentially deals with assessment of impacts generated due to already operational projects, under construction projects and also also the projects in proposal stage along with total hydropower potential of each sub-basin and extent up to which it has already been harnessed or is being harnessed through under construction projects. In addition, the proposed projects have been assessed based upon the available resource and the impacts these may generate if implemented.

9.4.1 Beas I Sub-basin

Beas I Sub-basin is the northern-most sub-basin and constitutes the source of Beas river. It is comprised of the catchment area of Beas river up to its confluence with Duhangan Nala near Jagatsukh village with elevation ranging from 1671 m to about 6002 m. Four projects are located in this sub-basin viz. Seri Rawla, Beas Kund, Palchan Bhang, Bhang, Jobrie, Manalsu and Allain Duhangan of which only Beas Kund and Allain Duhangan are operational projects.

9.4.1.1 Forest Cover and Forest Types

Nearly one-fourth of the sub-basin is under forest cover (**see Table 9.4**). Though there has been an increase in forest cover in the sub-basin by about 2% from 2005 to 2015 but there has been substantial decrease in Very Dense forest category (20.45%) while area under other categories like Moderately Dense and Open forest has increased by 8.42%s and 2.05%, resectively. The area under scrub has more than doubled from about 58 ha to 129 ha.

Table 9.4: Temporal Forest cover change from 2005 to 2015 in Beas I sub-basin

Class	2005		2015		Change	
	(ha)	(%)	(ha)	(%)	(ha)	(%)
Very Dense Forest	2221.45	3.59	1767.16	2.86	-454.29	-20.45
Moderately Dense Forest	7531.17	12.18	8165.29	13.20	634.12	+8.42
Open Forest	5064.37	8.19	5168.2	8.36	103.83	+2.05

Class	2005		2015		Change	
	(ha)	(%)	(ha)	(%)	(ha)	(%)
Total Forest	**14816.99**	**23.95**	**15100.85**	**24.41**	**283.86**	**+1.92**
Scrub	57.86	0.09	132.21	0.21	74.35	+128.50
Non Forest	46979.7	75.95	46613.13	75.36	-366.57	-0.78
Total Geographic Area (ha)	**61854.55**					

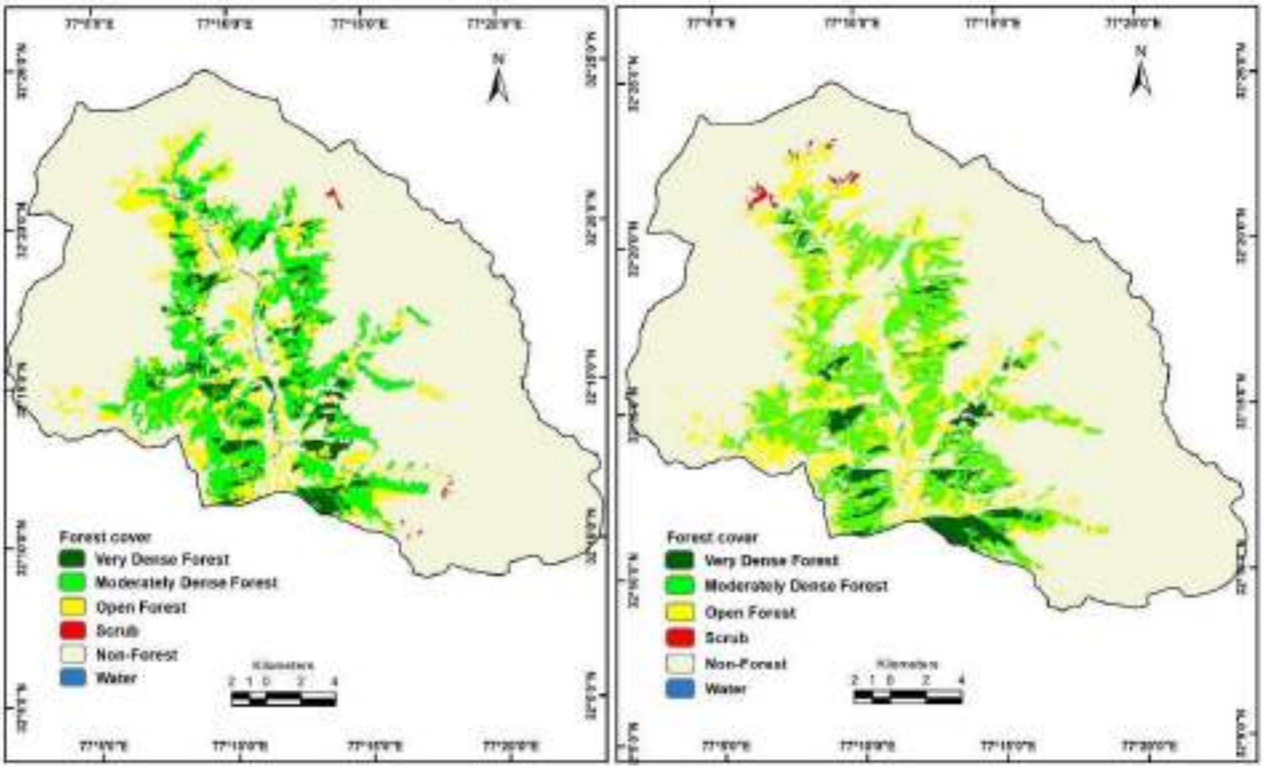


Figure 9.6: Forest cover map for the year 2005 and 2015 of Beas I Sub-basin

(Source: Indian State of Forest Report, 2005 and 2015, Forest Survey of India)

Forest type/ Vegetation map of the sub-basin (**see Figure 9.7**) shows that area at higher elevations are under snow and glaciers (more than 45%). The predominant vegetation type in the sub-basin is Moist alpine scrub and Semi-evergreen forest. The vegetation along the both the sides of Beas river valley are characterized by scrub forest. Higher up the slopes are covered by Semi-evergreen forest giving way to Moist alpine scrub further up on the higher elevations. These forests harbor rich biodiversity as indicated by large areas under Very High to High Biological Richness Index in these area (**refer Figure 9.8 & Table 9.5**). However, majority of the area is barren rocks or are under snow and glaciers.

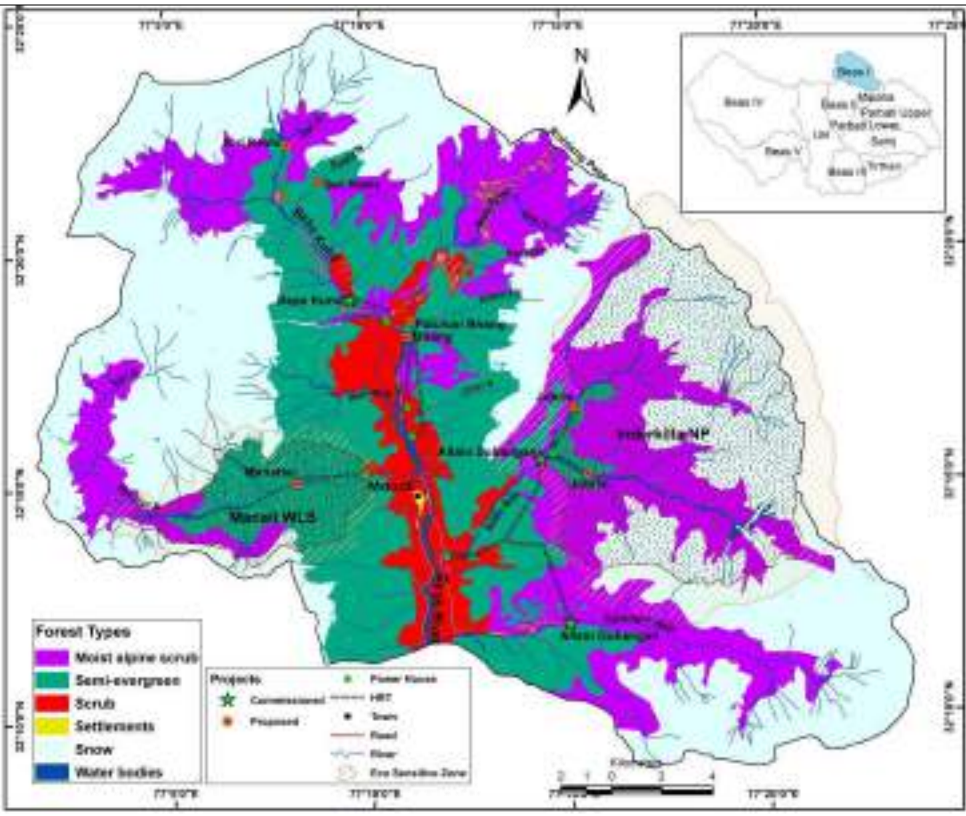


Figure 9.7: Forest type map of Beas-I sub-basin

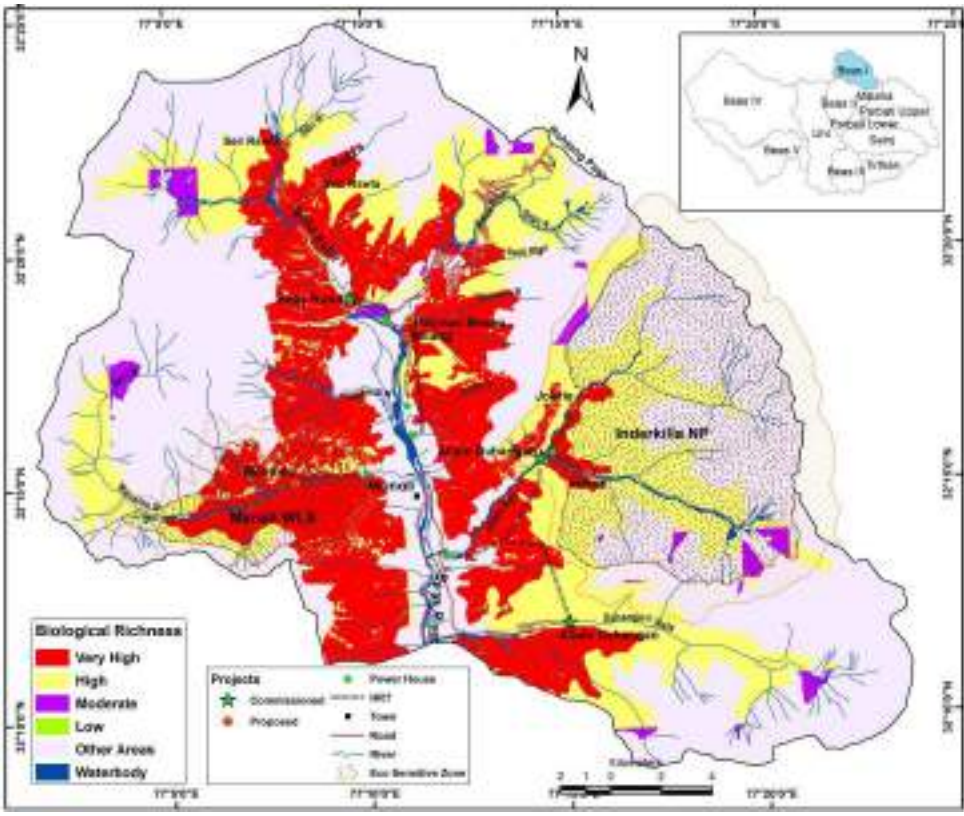


Figure 9.8: Biological Richness Index map of Beas-I sub-basin

Manali is the main urban settlement in the area. NH-21 passes through the sub-basin along the Beas river from Manali up to Rohtang Pass. Being on the main tourist route, settlements have come up mainly along the highway. Forests are in the form of Scrub in this tract all along the highway. Even then there is not much fragmentation of landscape in the sub-basin.

Fragmentation in general is low to moderate as shown in the **Table 9.6**. Disturbance due to anthropogenic activities also is restricted to lower valley areas and is reflected in Moderate to High Disturbance Index.

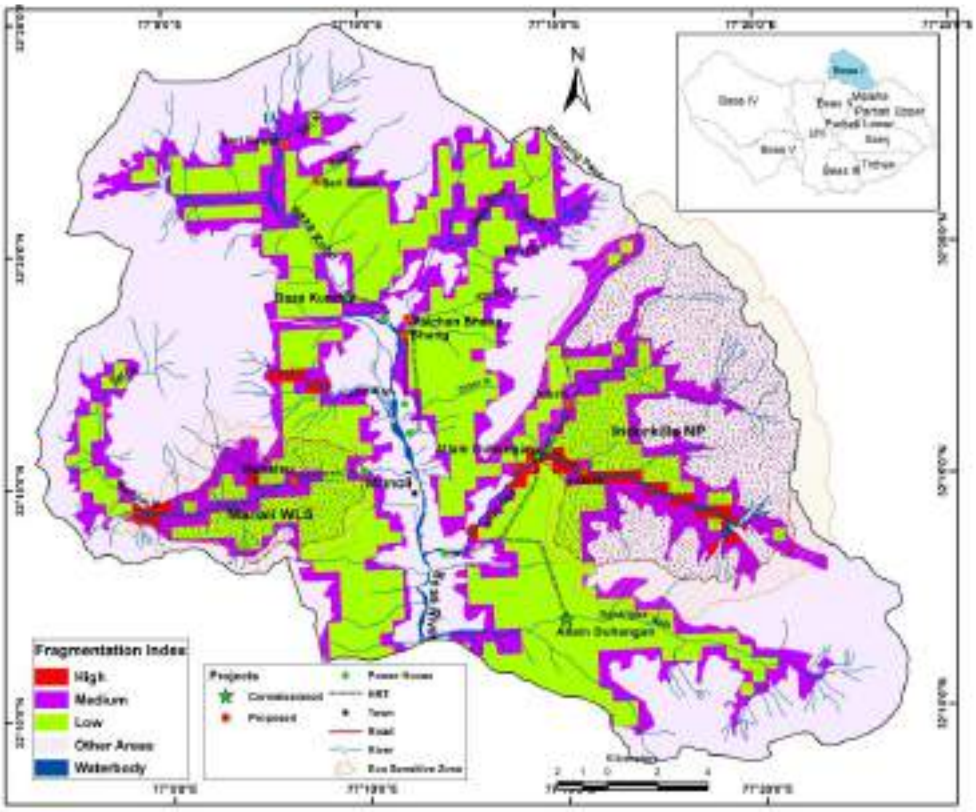


Figure 9.9: Fragmentation Index map of Beas-I sub-basin

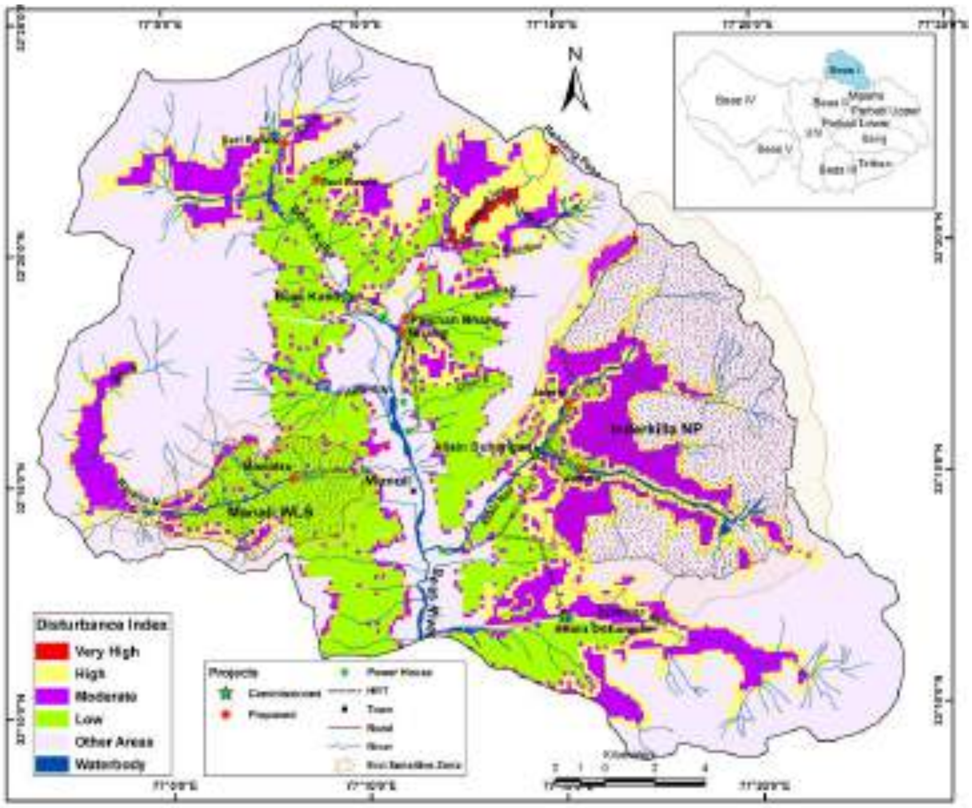


Figure 9.10: Disturbance Index map of Beas-I sub-basin

Table 9.5: Area under different Biological Richness Index categories in Beas I sub-basin

Biological Richness Index	Area (sq km)	(%)
Very High	132.77	21.47
High	148.12	23.95
Moderate	9.94	1.61
Low	1.73	0.28
Other Areas (Water, Barren land, Snow, Glaciers, etc.)	325.89	52.69
	618.45	

Table 9.6: Area under different categories of Fragmentation Index and Disturbance Index in Beas I sub-basin

Fragmentation Index	Area (sq km)	(%)	Disturbance Index	Area (sq km)	(%)
High	7.47	1.21	Very High	1.73	0.28
Moderate	115.57	18.69	High	91.43	14.78
Low	169.91	27.47	Moderate	84.87	13.72
Other Areas (Water, Barren land, Snow, Glaciers, etc.)	325.50	52.63	Low	114.78	18.56
			Other Areas (Water, Barren land, Snow, Glaciers, etc.)	325.64	52.65

9.4.1.2 Biodiversity Profile

During the present studies 96 species of flowering plants were recorded during field surveys conducted in the projects areas though according to cumulative list compiled from primary surveys and secondary sources 129 angiosperm species are reportedly found in the basin. According to Red Data Book of BSI, 4 RET species were encountered during sampling. i.e. *Allium stracheyi* in Vulnerable category was found in project area of Beas Kund HEP as well as Jobrie HEP and it has also been listed in Vulnerable category by FRLHT RET medicinal plants list. *Eremurus himalaicus* in Rare category and endemic to Western Himalaya was found in Jobrie HEP area where another RET species *Dioscorea deltoidea* in Vulnerable category was also found. *Acer caesium* in Vulnerable category were found in project areas of Bhang HEP. *Aconitum heterophyllum* an important medicinal plant listed as Endangered in IUCN Redlist also endemic to Western Himalaya was recorded from project areas of Bhang and Jobrie HEPs. *Sinopodophyllum hexandrum* listed as Endangered and *Roscoea alpina* as Vulnerable by FRLHT RET medicinal plants list were found in the project areas of Beas Kund and Jobrie HEPs. In Allain Duhangan HEP *Gentiana kurroo* an important medicinal plant listed as Critically Endangered in IUCN Redlist as well as in FRLHT RET medicinal plants list was found. *Zanthoxylum armatum* another important medicinal plant listed as Endangered in FRLHT RET list was found in project areas of Allain Duhangan, Palchan Bhang and Bhang project areas. *Berberis aristata* and *Berberis jaeschkeana* which are endemic to Western Himalaya were recorded from Allain Duhangan and Beas Kund HE project areas. Allain Duhangan and Beas Kund projects are already operational projects while Jobrie, Palchan Bhang and Bhang are is in proposal stage.

Thirty species of mammals are reported from this sub-basin out of which 9 are listed as RET in IUCN Redlist and 6 are Schedule-I species. Important species are Brown Bear (*Ursus arctos*), Otter (*Lutra lutra*), Blue Sheep (*Pseudois nayur*), Siberian Ibex (*Capra sibirica*), Himalayan

Tahr (*Hemitragus jemlahicus*), Serow (*Capricornis sumatraensis*), and Musk Deer (*Moschus chrysogaster*).

Avi-fauna of the sub-basin is comprised of 117 species which are reportedly found in this area with 7 Schedule-I species and 4 RET species in IUCN Redlist. White-backed Vulture is a Critically Endangered species while Cheer Pheasant and Western tragopan are in Vulnerable category and these two along with Monal pheasant are Schedule-I species as per WPA (1972).
Water quality in general in this sub-basin is in Good category at most of the project areas. Biological water quality in the form of BMWP was in Good to Very Good category. Only at few sites near upstream of Manali town in Beas river after the after of Beas Kund Nala with Beas river near Bhang village where Total coliform population was quite high.

Fish fauna of the sub-basin is comprised of 11 species comprised mainly of Snow trout (*Schizothorax richardsonii*), *Glyptothorax* spp., *Garra gotyla, Schistura rupecola* and introduced trout species like Brown trout (*Salmo trutta*) and Rainbow trout (*Oncorhynchus mykiss*). The Beas river and its tributary streams in this sub-basin are characterised by steep gradient and step pools and most of the tributary streams are narrow with dense vegetation cover characteristic of Type A1 streams where recovery potential from any disturbance is high (Rosgen, 1994) as according to Rosgen classification of streams wherever the river bed slope is higher than 2%, the restoration of river is faster i.e. it is able to restore over a shorter distance while in case of gentle bed slope it takes more time and distance to recover its natural state.

As already mentioned there are two operational projects with total capacity of 201 MW and 3 projects with total capacity of 30 MW have been proposed. In additional 2 more projects (Seri Rawla and Manalsu HEPs) with total capacity of 34.9 MW have recently been adverstised but are yet to be allotted.

There are two Protected Areas in the sub-basin i.e. Manali Wildlife Sanctuary and Inderlilla National Park (final notification yet not been issued). Jobrie HE project is located within Inderkilla NP of which notification of intent to establish only was issued in July, 2010. Recently advertised project Manalsu (21.9 MW) is located within Manali Wildlife Sanctuary.

No fisheries activities are seen in this sub-basin.

Impact Assessment

This sub-basin is characterized by high altitudes going up to 6600m. As already discussed above 6 projects are located in this sub-basin with a total installed capacity of 265.9 MW Beas Kund, Palchan Bhang, Bhang, Jobrie and Allain Duhangan in cluding 2 recently advertised projects (seri Rawla and Manlasu HEPs). Of these 6 projects Beas Kund and Allain Duhangan are 2 operational projects with installed capacity of 9 MW and 192 MW, respectively. Therefore, out of total 265.9 MW of potential 201MW has already been harnessed. Three proposed projects viz. Palchan Bhang (9 MW), Bhang (9 MW) and Jobrie (12 MW) have been proposed with a total potential of 30MW excluding 2 recently advertised projects. As seen from the forest cover change map not much change in forest cover has happened in last 10 years even as 2 projects Beas Kund (operational since 2012) while Allain Duhangan HE project is operational since 2010.

Beas Kund project on Beas Kund Nala is comprised of trench weir only with a dewatered stretch of about 1.991 km of the Beas Kund Nala. Majority of immediate impact area i.e. area within 500m radius of the project which is about 3.12 sq km is characterized by non-forest landuse with only small part of HRT passing below open forests. However, in these forests *Allium stracheyi* a plant species in Vulnerable category of BSI Red Data Book was found Beas Kund HEP area during field surveys. *Sinopodophyllum hexandrum* listed as Endangered and *Roscoea alpina* as Vulnerable by FRLHT RET medicinal plants list were also found in the Beas Kund direct impact area. It is therefore advised to conservation plan for these species.

Allain Duhangan project harnesses the potential of Allain and Duhangan Nalas with power house located near confluence of Allain Nala with Beas river. Most of the project components like diversion structure and power house are located in open forest or non-forest land use while the 2 HRTs traverse below open as well as moderately dense forest cover. In Allain Duhangan HEP direct impact area of about 11.36 sq km, *Gentiana kurroo* an important medicinal plant listed as Critically Endangered in IUCN Redlist as well as in FRLHT RET medicinal plants list was recorded. It is understood that as the project is operational since 2010, the conservation plan for these species are already been implemented.

Palchan Bhang HE project in envisaged on Beas river (also known as Kothi Nala) immediately upstream of confluence of Beas Kund nala with Beas river near Palchan village. According to the data provided by Department of Energy, GoHP the levels of this project are conflicting with those of downstream proposed Bhang HE project. The trench weir of Palchan Bhang project is located at 2246m (river bed level at intake) while tail water level is 2035m where powerhouse is proposed on left bank of Beas river. The river bed level of trench weir of Bhang HEP is 2240m immediately downstream of Beas Kund Nala with Beas river. The tail water in its case is at 2104m with powerhouse proposed near Bhang village. Therefore, tail water evel of the two projects conflict with each other. It is understood Palchan Bhang project is being shelved for this reason. Both the projects envisage installed capacity of 9 MW each. In this scenario only Bhang project seems feasible. As the disrturbance along NH-21 leading to Rohtang Pass is already quite high it is all more advisable to forego such projects which may cause further damage to the fragile forest cover in the direct impact area. The project components of Bhang HE project are located along the NH-21 which consist of open water conductor system all along Beas river, desilting chamber located mid-way up to proposed powerhouse location near Bhang village. Penstock too is more than 2 km long. As the project is located highly disturbed area it may not be feasible to go ahead with this project which can generate only 9MW of power. It can help in preservation of free flowing stretch of about 3.85 km of Beas river.

Two projects Jobrie and Manalsu (a recently adverstised project and yet to be allotted) are located within Protected Areas i.e. part of Jobrie project lies within Inderkilla National Park while Manalsu project is entirely located within Manali Wildlife Sanctuary.

In addition, another recently advertised Seri Rawla project is in high altitude area characterized by Moist aline scrub and is very rich in biodiversity.

In view of the above Palchan Bhang, Bhang, Jobrie, Manalsu and Seri Rawla projects may not be taken up for implementation to preserve the temperate and moist alpine scrub forest of this sub-basin. As already 201 MW of power has already been harnessed by two projects out of total potential of 231 MW (excluding two recently adverstised projects), it would be prudent to forego the above-mentioned projects to preserve the biodiversity of the sub-basin and causing further degradation of this area which is subjected to heavy tourist traffic.

9.4.2 Beas II Sub-basin

Beas Sub-basin-II is comprised of catchment area of Beas river between the confluence point of Duhangan nala with river Beas near Jagatsukh village and confluence Point of Parbati River with river Beas near Bhuntar in Kullu district. The elevation varies from 1160 m to about 4900m.

9.4.2.1 Forest Cover and Forest Types

Table 9.7 and **Figure 9.11** show that area of Very dense forest increased marginally by 0.29% in 2015 from 2005 and moderately dense forest, open forest and scrub has reduced by 0.21%, 0.32% and 0.01%, respectively.

Table 9.7: Temporal Forest cover change from 2005 to 2015 in Beas II sub-basin

Class	2005		2015		Change	
	(ha)	(%)	(ha)	(%)	(ha)	(%)
Very Dense Forest	9933.97	12.44	10164.93	12.73	230.96	+2.32
Moderately Dense Forest	21652.61	27.12	21493.43	26.92	-159.18	-0.74
Open Forest	13846.11	17.34	13595.81	17.03	-250.30	-1.81
Total Forest	**45432.69**	56.90	**45254.17**	56.68	-178.52	-0.39
Scrub	210.26	0.26	200.61	0.25	-9.65	-4.59
Non Forest	**34201.93**	**42.84**	**34390.10**	**43.07**	**188.17**	**+0.55**
Total Geographic Area (ha)	**79844.88**					

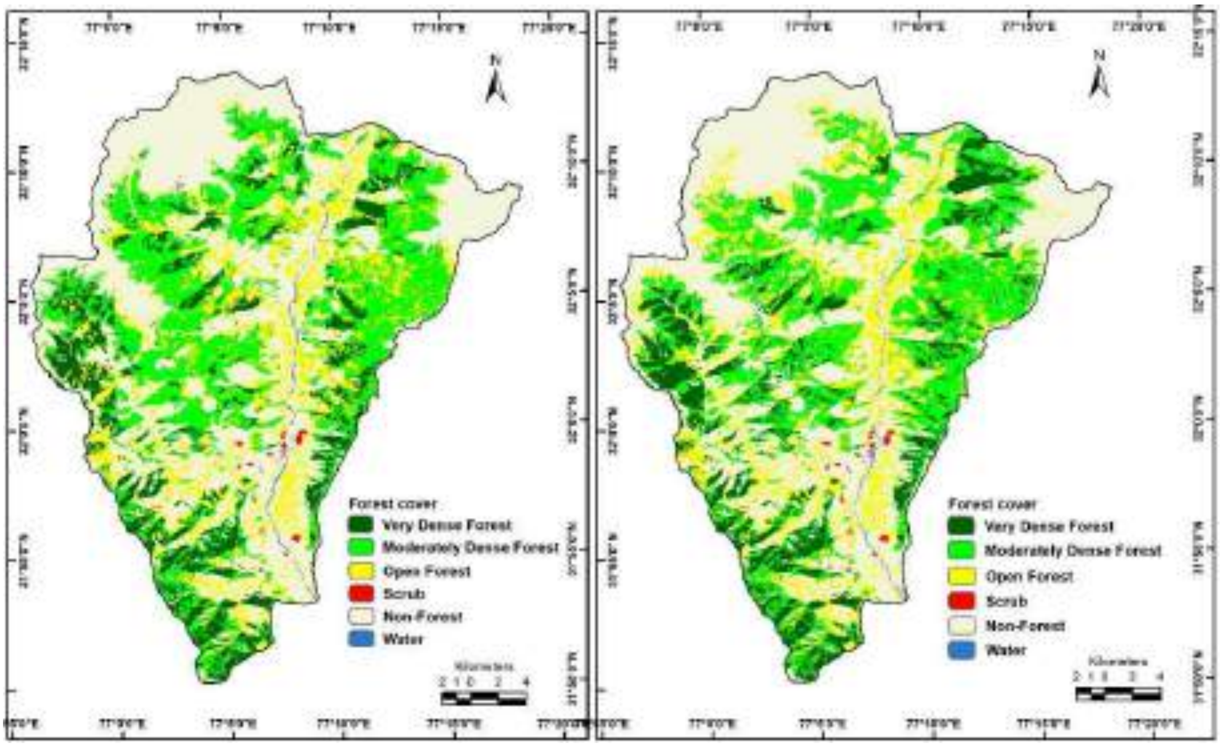


Figure 9.11: Forest cover map for the year 2005 and 2015 of Beas II Sub-basin

(*Source:* Indian State of Forest Report, 2005 and 2015, Forest Survey of India)

Forest type/ Vegetation map of the sub-basin (**see Figure 9.12**) shows that majority its area is under Semi-evergreen forests (more than 48%). The vegetation along the both the sides of Beas river valley are characterized by scrub forest which is about 22.81%. Next predominant vegetation type in the sub-basin is Moist alpine scrub.

The Semi-evergreen forests harbor rich biodiversity as indicated by 62.81% of sub-basin areas under Very High to High Biological Richness Index (**refer Figure 9.13 & Table 9.8**). Rest of the area is under snow and glaciers.

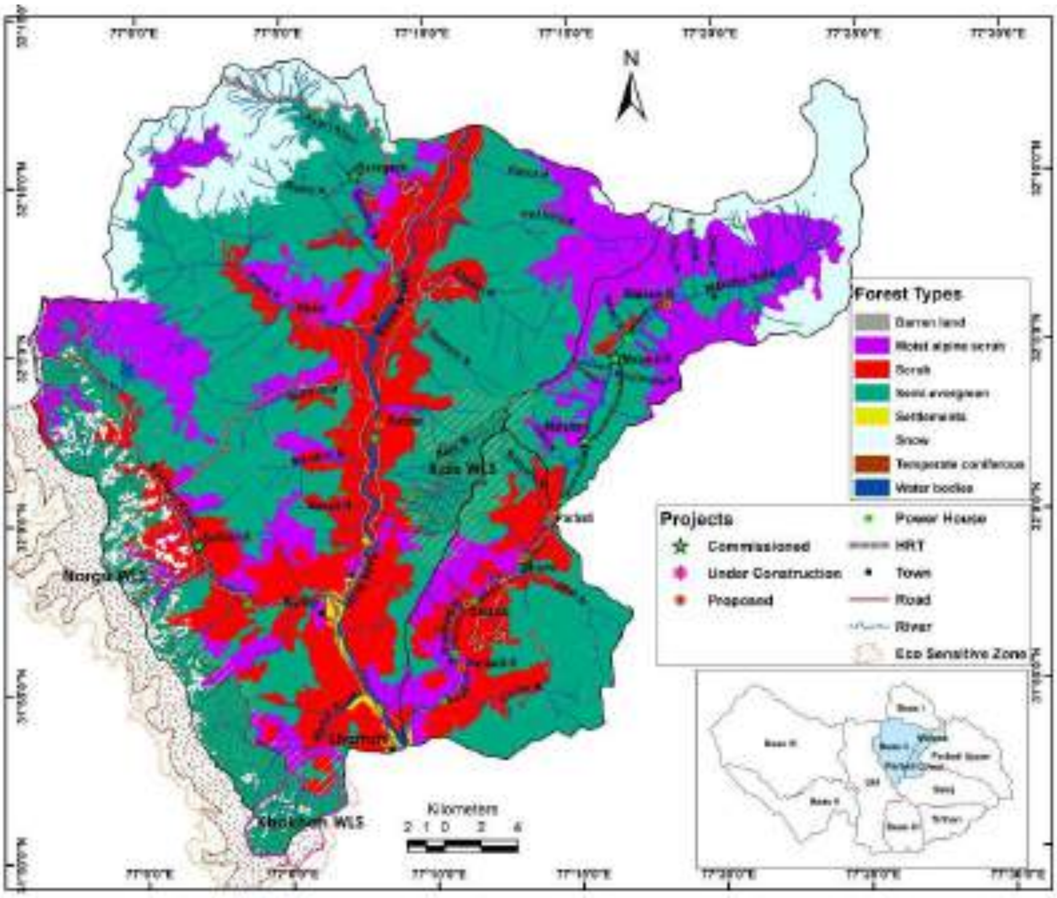


Figure 9.12: Forest type map of Beas-II, Malana and Parbati Lower sub-basins

Most of the forested landscape in the sub-basin is still in good condition as indicated by majority of its area is under low fragmentation index category (**see Figure 9.14 and Table 9.9**). This sub-basin also home to two wildlife sanctuaries i.e. Kais WLS on its eastern slopes and part of Nargu WLS comprised of mainly the catchment of Sarbari Khad.

In this sub-basin also NH-21 passes all through it along the Beas river. However the overall biotic disturbance is low to medrate as shown in **Figure 9.15 and Table 9.9**.

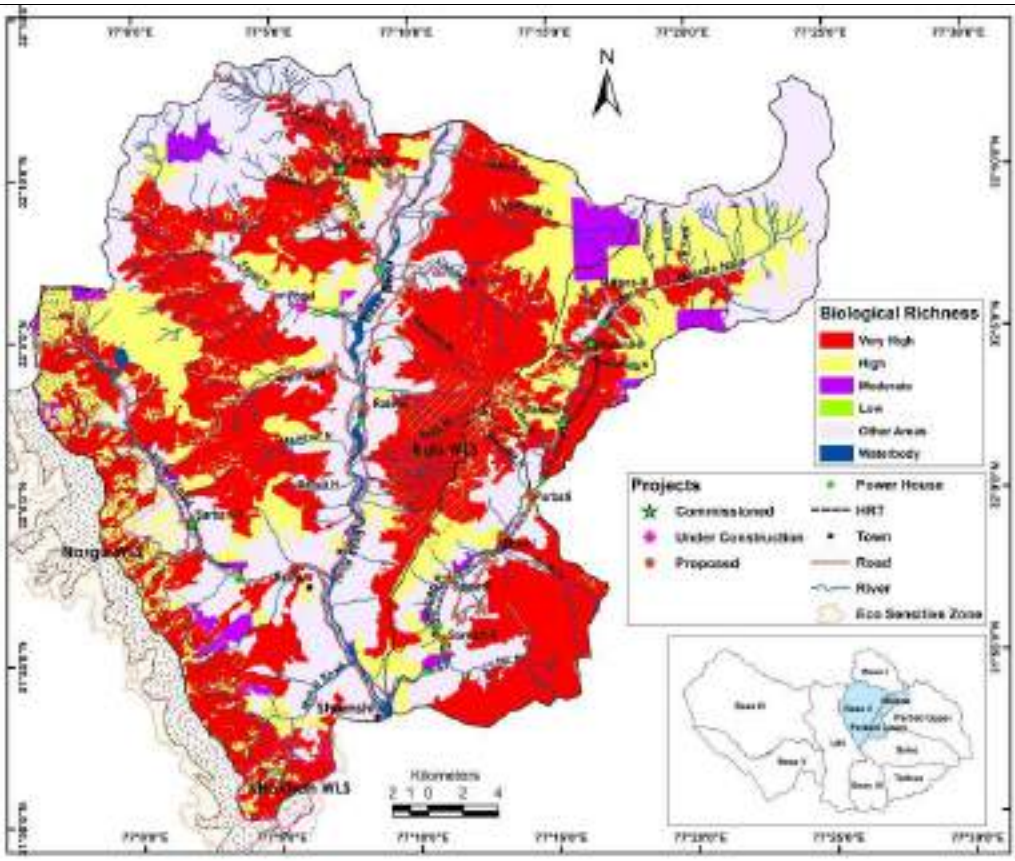


Figure 9.13: Biological Richness Index map of Beas-II, Malana and Parbati Lower sub-basins

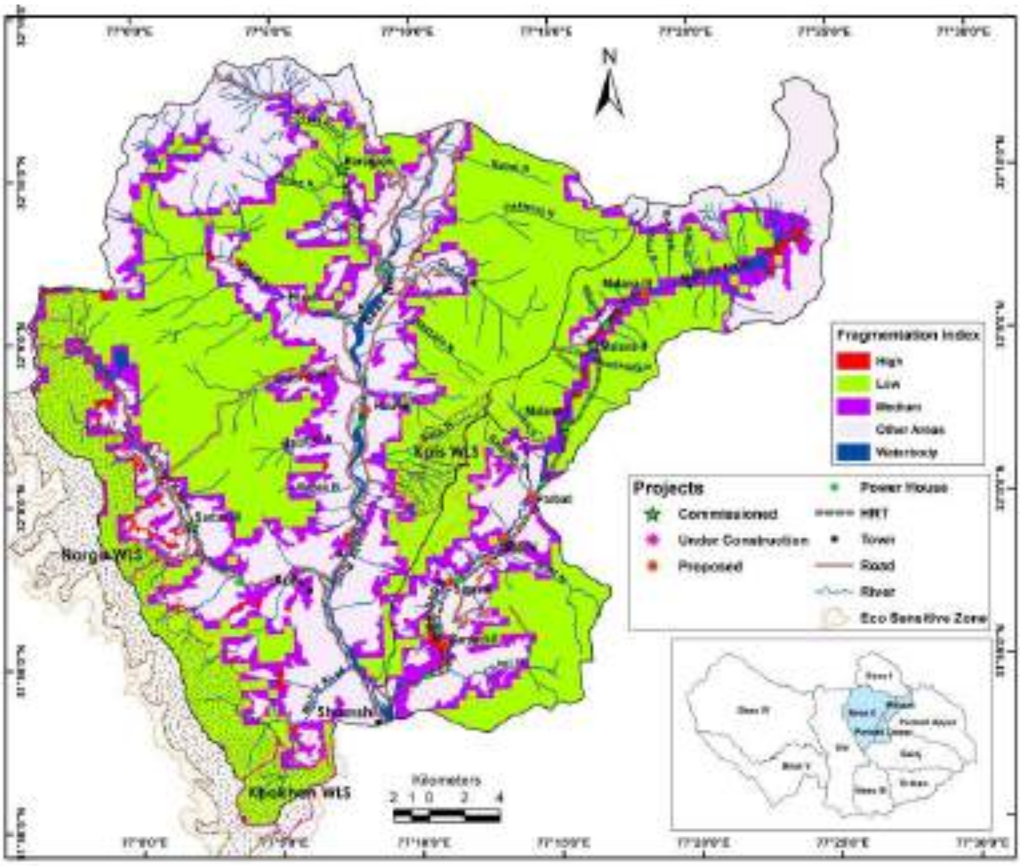


Figure 9.14: Fragmentation Index map of Beas-II, Malana and Parbati Lower sub-basins

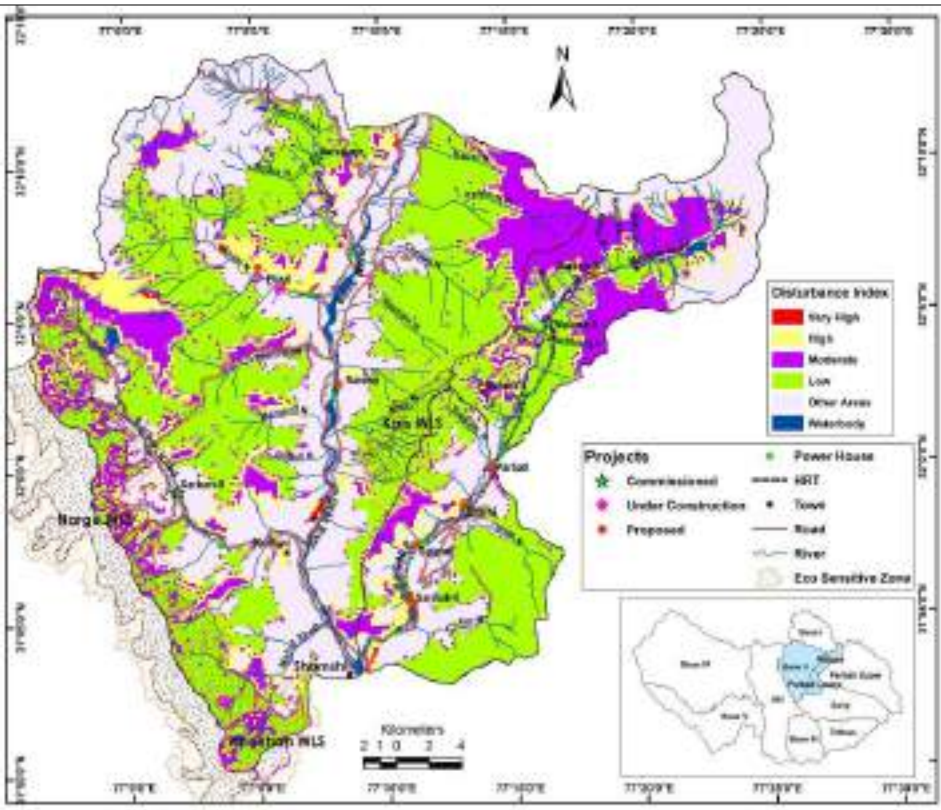


Figure 9.15: Disturbance Index map of Beas-II, Malana and Parbati Lower sub-basins

Table 9.8: Area under different Biological Richness Index categories in Beas II sub-basin

Biological Richness Index	Area (sq km)	(%)
Very High	348.42	43.64
High	153.05	19.17
Moderate	24.43	3.06
Low	1.81	0.23
Other Areas (Water, Barren land, Snow, Glaciers, etc.)	270.74	33.91
	798.45	

Table 9.9: Area under different categories of Fragmentation Index and Disturbance Index in Beas II sub-basin

Fragmentation Index	Area (sq km)	(%)	Disturbance Index	Area (sq km)	(%)
High	5.40	0.68	Very High	2.95	0.37
Moderate	119.19	14.93	High	85.39	10.69
Low	403.54	50.54	Moderate	116.97	14.65
Other Areas (Water, Barren land, Snow, Glaciers, etc.)	270.33	33.86	Low	322.55	40.40
			Other Areas (Water, Barren land, Snow, Glaciers, etc.)	270.59	33.89

9.4.2.2 Biodiversity Profile

During the present studies 83 species of flowering plants were recorded during field surveys conducted in the projects areas though according to cumulative list compiled from primary surveys and secondary sources 111 angiosperm species are reportedly found in the basin. No species according to Red Data Book of BSI was found during sampling. *Berberis aristata* listed as Endangered by FRLHT RET medicinal plants list was found in the project area of Sarbari-II HEP. *Berberis aristata, Berberis lycium, Celtis australis, Desmodium elegans, Rosa macrophylla* and *Spiraea canescens* which are endemic to Western Himalaya were recorded from Sarbari-II HE project area.

Thirty-three species of mammals are reported from this sub-basin out of which 7 are listed as RET in IUCN Redlist and 6 are Schedule-I species. Important species are Brown Bear (*Ursus arctos*), Otter (*Lutra lutra*), Blue Sheep (*Pseudois nayur*), Siberian Ibex (*Capra sibirica*), Himalayan Tahr (*Hemitragus jemlahicus*), Serow (*Capricornis sumatraensis*), and Musk Deer (*Moschus chrysogaster*).

Avi-fauna of the sub-basin is comprised of 123 species which are reportedly found in this sub-basin with 7 Schedule-I species as per WPA and 4 RET species in IUCN Redlist. White-backed Vulture is a Critically Endangered species while Cheer Pheasant and Western tragopan are in Vulnerable category and these two along with Monal pheasant are Schedule-I species as per WPA (1972).

The physico-chemical water quality in general in this sub-basin is in Good to Excellent category. Biological water quality in the form of BMWP was in Good category at all the project sites.

Fish fauna of the sub-basin is comprised of 22 species comprised mainly of Snow trout (*Schizothorax richardsonii, S. plagiostomus*), *Glyptothorax brevipinnis, G. gracilis, G. indicus* and *G. telchitta, Amblyceps mangois, Botia dario* and *Garra gotyla* and introduced trout species like Brown trout (*Salmo trutta*) and Rainbow trout (*Oncorhynchus mykiss*). The sub-basin is drained by tributaries of Beas river which are characterised by steep gradient and step pools and most of the tributary streams are narrow with dense vegetation cover characteristic of Type A1 streams where recovery potential from any disturbance is high (Rosgen, 1994).

There are two operational projects i.e. Baragaon and Sarbari-II HEPs with total capacity of 29.4 MW and 2 projects (Fozal and Raison HEPs) with total capacity of 27 MW have been proposed.

Sanjoin Nala and Fozal (Phozal) Nala are considered as important trout streams harboring good trout populations. Haripur Nala also known as Pakhanoj Nala is another tributary which harbours good trout population. Katrain in an important landing site for trouts.

Sanjoin Nala as well as Haripur Nala have been marked as streams for fish conservation and are in negative list for hydropower development by HP Fisheries Department.

Impact Assessment

Total hydropower potential of this sub-basin has been estimated as 56.9 MW of which 24 MW Baragaon HE project is already operational since 2016 while Sarbari-II project (5.4 MW) is operational since 2010. Fozal (9 MW) project is under construction while Raison (18 MW) is proposed project on Beas river.

The project area of Sarbari-II HEP is rich in floristic diversity as *Berberis aristata* listed as Endangered by FRLHT RET medicinal plants list was recorded from its project area. In addition, endemic species like *Berberis aristata, Berberis lycium, Celtis australis, Desmodium elegans, Rosa macrophylla* and *Spiraea canescens* were recorded from Sarbari-II HE project area. However, Sarbari-II HE project is already operational since 2010. This sub-basin is also rich in avi-fauna and mammalian wildlife and the entire left bank catchment of Sarbari Khad constitutes part of Nargu Wildlife Sanctuary. Baragaon HE project is located in the northern part of the sub-basin on Sanjoin and Bijara streams and became operational last year i.e. 2016. Fozal HEP is under construction and is the only project on Fozal Nala.

Fisheries activities are most prominent feature in this sub-basin. Sanjoin Nala and Haripur Nala (Pakhanoj Nala) have been put in negative list by HP Fisheries Department for fish conservation. Fozal, Sanjoin and Naggar areas are some of the most important trout fishing sites in the sub-basin. Therefore, no further hydropower project should be allowed in this sub-basin. Raison project which is proposed on the main Beas river should not be allowed to come up as main Bear river channel should be kept free flowing and no project be allowed on it.

Already more than 68% of hydropower potential has been harnessed therefore shelving of Raison project won't much affect the hydro potential in this sub-basin.

9.4.3 Malana Sub-basin

Malana sub-basin comprises of the catchment area of Malana nala, a right bank tributary of river Parbati. Malana nala is the largest tributary of Parbati river which originates from an unnamed glacier and travels a distance of about 25 km before joining river Parbati. The elevation varies from 1400 m to about 5700 m. Malana river is the right bank tributary of Parbati river, meets near village Jari.

9.4.3.1 Forest Cover

It can be seen from **Table 9.10** and **Figure 9.16** that Very Dense dense forest in the sub-basin has increased significantly by 55.59% in 2015 from 2005 which is resultant change from Moderately dense forest which reduced by 11.82%. However overall the forest cover has not changed very much in last one decade.

Table 9.10: Forest cover changes from 2005 to 2015

Class	2005		2015		Change	
	(ha)	(%)	(ha)	(%)	(ha)	(%)
Very Dense Forest	502.66	3.18	782.10	4.95	279.44	55.59
Moderately Dense Forest	2977.69	18.84	2625.78	16.61	-351.90	-11.82
Open Forest	1669.40	10.56	1671.39	10.57	1.99	0.12
Total Forest	**5149.74**	**32.57**	**5079.27**	**32.13**	**-70.47**	**-1.37**
Scrub	9.93	0.06	0.00	0.00	-9.93	-100.00
Non-Forest	**10649.24**	**67.36**	**10729.65**	**67.87**	**80.40**	**0.76**
Total Geographic Area (ha)	**15808.92**					

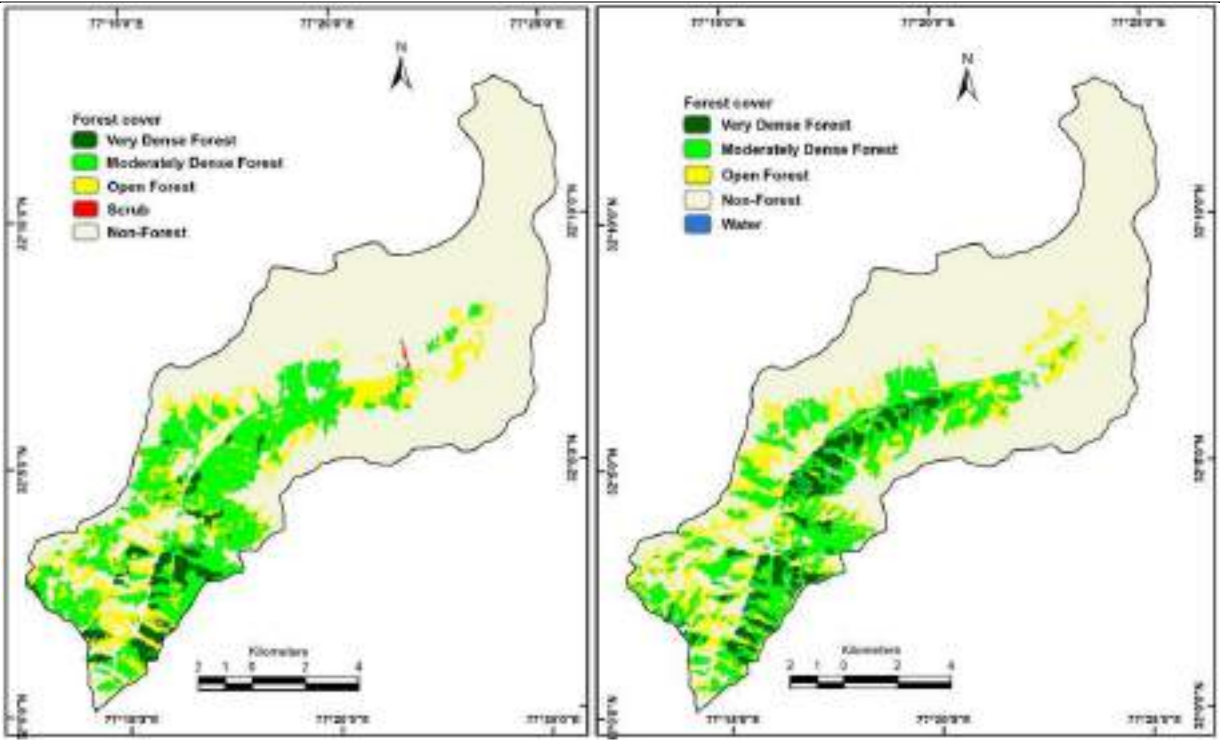


Figure 9.16: Forest cover map for the year 2005 and 2015 of Malana Sub-basin
(*Source:* Indian State of Forest Report, 2005 and 2015, Forest Survey of India)

As seen from the forest type map of the sub-basin (**refer Figure 9.12**) more than 27% of the sub-basin is covered under snow and glaciers. However, the lower levation are covered with Semi-evergreen forest (29.24%) while higher reaches are under Mosit alpine scrub (38.84%).

As large part of the sub-basin is under good forest cover, more than 63% of sub-basin area is under Very High or High Biological richness category (**see Table 9.11 and Figure 9.13**). Fragmentation of the landscape in this sub-basin also is low and most of its landscape is intact. Disturbance due to human interference however is little more as compared to adjacent sub-basins (refer **Figure 9.14** and **Table 9.12**).

Table 9.11: Area under different Biological Richness Index categories in Malana sub-basin

Biological Richness Index	Area (sq km)	(%)
Very High	39.90	25.24
High	60.13	38.04
Moderate	6.41	4.05
Low	0.34	0.22
Other Areas (Water, Barren land, Snow, Glaciers, etc.)	51.31	32.46
	158.09	**100.00**

Table 9.12: Area under different categories of Fragmentation Index and Disturbance Index in Malana sub-basin

Fragmentation Index	Area (sq km)	(%)	Disturbance Index	Area (sq km)	(%)
High	2.81	1.78	Very High	0.02	0.01
Moderate	24.20	15.31	High	24.22	15.32
Low	79.93	50.56	Moderate	48.56	30.72

Fragmentation Index	Area (sq km)	(%)	Disturbance Index	Area (sq km)	(%)
Other Areas (Water, Barren land, Snow, Glaciers, etc.)	51.14	32.35	Low	34.08	21.56
			Other Areas (Water, Barren land, Snow, Glaciers, etc.)	51.21	32.39

9.4.3.2 *Biodiversity Profile*

During the present studies 68 species of flowering plants were recorded during the field surveys conducted in the projects areas though according to cumulative list compiled from primary surveys and secondary sources 94 angiosperm species are reportedly found in the basin. According to Red Data Book of BSI, one RET species was encountered during sampling. i.e. *Acer caesium* in Vulnerable category was found in project areas of Malana II and Malana III HEPs. *Berberis aristata* and *Juniperus communis* listed in Endangered and Vulnerable categories, respectively by FRLHT RET medicinal plants list were recorded from project area of Malana II & Malana III. Six species endemic to Western Himalaya were found in the sub-basin. *Acer caesium, Salix denticulata* and *Aesculus indica* were recorded from project areas of Malana II & Malana III.

Mammals in this sub-basin are represented by 31 species and out of which 8 are listed as RET in IUCN Redlist and 7 are Schedule-I species. Important species are Brown Bear (*Ursus arctos*), Otter (*Lutra lutra*), Blue Sheep (*Pseudois nayur*), Siberian ibex (*Capra sibirica*), Himalayan tahr (*Hemitragus jemlahicus*), Serow (*Capricornis sumatraensis*), and Musk deer (*Moschus chrysogaster*).

Avi-fauna of the sub-basin is comprised of 121 species which are reportedly found in this area with 7 Schedule-I species and 4 RET species in IUCN Redlist. White-backed Vulture is a Critically Endangered species while Cheer Pheasant and Western tragopan are in Vulnerable category and these two along with Monal pheasant are Schedule-I species as per WPA (1972).

Water quality in general in this sub-basin is in Good to Excellent category at all locations. Biological water quality in the form of BMWP was in Good category.

Fish fauna of the sub-basin is comprised of 17 species comprised mainly of Snow trout (*Schizothorax richardsonii* and *S. plagiostomus*), *Amblyceps mangois* (Endangered), *Botia dario*, *Crossocheilus latius* and *Garra gotyla* (all Vulnerable).

Malana river is not much known for fisheries activities.

Impact Assessment

There are 3 projects in the sub-basin with total installed capacity of 216 MW. Malana-I (86 MW) is operational since 2001 and Malana-II (100 MW) is operational since 2012. Malana-III (30 MW) is a proposed project. All three are located on Malana nala. Higher reaches of Malana catchment where Malana-II and Malana-III are located are rich in biodiversity with number of endemic and RET species. As Malana-I & Malana-II have already been implemented with total capacity of 186 MW, there seems to be no need to develop Malana-III HE project located higher up in the catchment which is not only rich in biodiversity but also to keep upper stretch of Malana Nala free flowing.

9.4.4 Parbati Lower Sub-basin

Parbati Lower sub-basin comprises of the catchment area of Parbati river from its confluence with Malana nala till it meets river Beas near Bhuntar. The river flows for only about 18 km in the sub-basin. The river bed level varies from 1100 m to about 3700 m.

9.4.4.1 Forest Cover

Table 9.13 and Figure 9.17 show that the forest cover in this sub-basin has not change d since 2005. There has been a change of forest cover from Moderately dense category to Very Dense forest which increased by about 2.33% and an increase in Open forests category by 4.93%.

Table 9.13: Forest cover changes from 2005 to 2015

Class	2005		2015		Change	
	(ha)	(%)	(ha)	(%)	(ha)	(%)
Very Dense Forest	3110.35	22.70	3182.94	23.23	72.59	2.33
Moderately Dense Forest	2398.83	17.50	2225.92	16.24	-172.91	-7.21
Open Forest	2054.76	14.99	2156.02	15.73	101.26	4.93
Total Forest	**7563.94**	**55.19**	**7564.88**	**55.20**	0.94	0.01
Scrub	274.80	2.01	267.88	1.95	-6.92	-2.52
Non Forest	**5866.05**	**42.80**	**5872.03**	**42.85**	**5.98**	**0.10**
Total Geographic Area (ha)	**13704.79**					

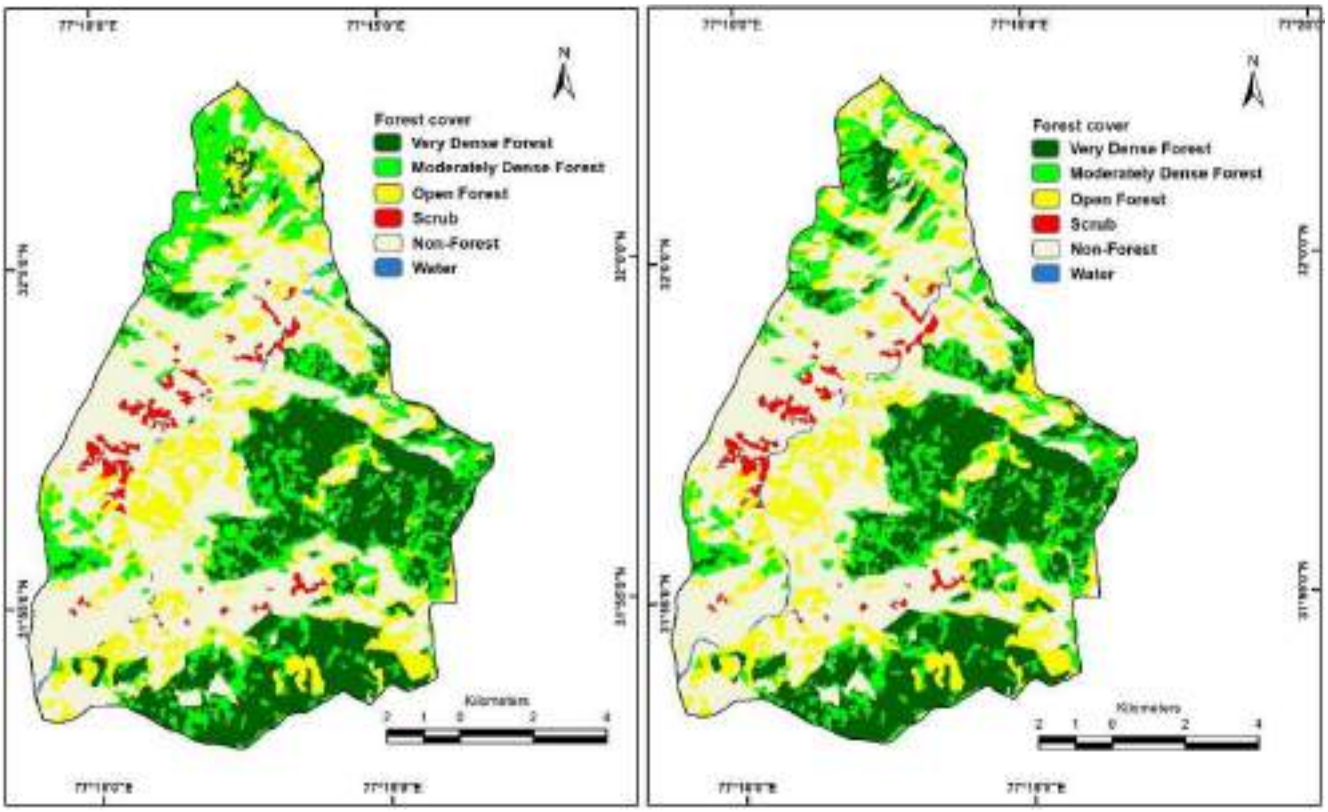


Figure 9.17: Forest cover map for the year 2005 and 2015 of Parbati Lower Sub-basin

(*Source*: Indian State of Forest Report, 2005 and 2015, Forest Survey of India)

More than half of the sub-basin area is under Semi-evergreen forests and nearly one third of its area is under scrub (refer **Figure 9.12**). Moist alpine scrub is found at higher elevations.

Area under Very High and High Biological Richness Index is more than 64%. Fragmentation of landscape is low to moderate while disturbance also in moderate category in general (**see Tables 9.14 and 9.15**).

Table 9.14: Area under different Biological Richness Index categories in Parbati Lower sub-basin

Biological Richness Index	Area (sq km)	(%)
Very High	69.46	50.68
High	19.04	13.89
Moderate	1.60	1.17
Low	0.45	0.33
Other Areas (Water, Barren land, Snow, Glaciers, etc.)	46.50	33.93
	137.05	**100.00**

Table 9.15: Area under different categories of Fragmentation Index and Disturbance Index in Parbati Lower sub-basin

Fragmentation Index	Area (sq km)	(%)	Disturbance Index	Area (sq km)	(%)
High	1.34	0.98	Very High	1.20	0.88
Moderate	28.33	20.67	High	13.40	9.78
Low	60.92	44.45	Moderate	11.59	8.46
Other Areas (Water, Barren land, Snow, Glaciers, etc.)	46.47	33.91	Low	64.39	46.98
			Other Areas (Water, Barren land, Snow, Glaciers, etc.)	46.47	33.91

9.4.4.2 Biodiversity Profile

During the present studies 121 species of flowering plants were recorded during field surveys conducted in the projects areas though according to cumulative list compiled from primary surveys and secondary sources 125 angiosperm species are reportedly found in the sub-basin. According to Red Data Book of BSI, one RET species were encountered during sampling. i.e. *Acer caesium* in Vulnerable category was found in project area of Parbati HEP. *Ulmus wallichiana* listed as Vulnerable in IUCN Redlist was recorded from project area of Parbati HEP. Even though as many as 30 species under FRLHT RET medicinal plants list are reportedly found in this sub-basin no species was recorded from any of the project sites. From the sub-basin 3 IUCN Redlisted species and 12 endemic species are reported.

Thirty-two (32) species of mammals are reported from this sub-basin out of which 8 are listed as RET in IUCN Redlist and 8 are Schedule-I species. Important RET species are Leopard (*Panthera pardus*), Brown bear (*Ursus arctos*), Himalayan black Bear (*Ursus thibetanus*), Serow (*Capricornis sumatraensis*) and Musk Deer (*Moschus chrysogaster*).

Avi-fauna of the sub-basin is comprised of 123 species which are reportedly found in this area with 6 Schedule-I species and 4 RET species in IUCN Redlist. White-backed Vulture is a Critically Endangered species while Cheer Pheasant and Western tragopan are in Vulnerable category and these two along with Monal pheasant are Schedule-I species as per WPA (1972).

Physico-chemical water quality in general in most part of this sub-basin is in Medium category while Biological water quality in the form of BMWP was in Good to Very Good category at most of the sites.

Fish fauna of the sub-basin is comprised of 20 species comprised mainly of *Amblyceps mangois, Sperata aor, Botia dario, Crossocheilus latius, Garra gotyla, Labeo pangusia, Puntius chola, Schizothorax richardsonii* and *Systomus sarana*. Parbati river in this sub-basin is rich in fishes.

There are 4 projects with total capacity of 36.6 MW have been proposed on Parbati river i.e. Parbati (12 MW), Sharni (9.6 MW), Sarsadi (9.6 MW) and Sarsadi-II (9 MW).

There is no Protected Area in this sub-basin.

Impact Assessment

Four projects viz. Parbati (12 MW), Sharni (9.6 MW), Sarsadi (9.6 MW) and Sarsadi-II (9 MW) with total capacity of 40.20 MW are proposed in this sub-basin. Al these projects are planned on Parbati river in cascade. Total length of Parbati river in this sub-basin is little more than 15 km and the proposed 4 projects would affect more than 13 km of the river and only 2 km of river will be flowing freely. Parbati river would be flowing mostly in tunnels or as open channels and river will have decreased flow at all times even after release of e-flows. Parbati river as described above is rich in fish fauna and trout is known to migrate upstream in Parbati river and Kasol is an important trout fishing site upstream of these projects. The proposed projects would hamper its movement leading to dwindling of populations of trout and other fishes in the sub-basin. Therefore, in order to preserve the important habitat of fish the proposed 4 projects are not desirable as addition of only 40.20 MW of power cannot justify the loss of important fish habitat.

9.4.5 Parbati Upper Sub-basin

Parbati Upper sub-basin comprises of the catchment area of Parbati river from its origin at Pin Parbati Pass up to its confluence with Malana nala. Parbati river is the largest tributary of Beas river. It meets Beas river at its left bank near Shamshi village. The river originates from Pin Parbati Pass at an elevation of around 5400m. The elevation varies from 1400 m to about 6600 m. Parbati river is left bank tributary of Beas river which is joined first with Tosh river near Tosh Village and then confluences with Beas river near Bhuntar. Upstream of the confluence, Khirganga hot water spring is main tourist attraction in the area. This area is well connected with road network, nearest airport is Bhuntar.

9.4.5.1 Forest Cover and Forest Types

Parbati Upper is one of the most important sub-basins in the area. The forest cover has decreased in this sub-basin by about 2.71% in last decade (**Table 9.16**). Area under Very

Dense and Moderately Dense forest has decreased by 7.03% and 6.17%, respectively. Area of open forest has increased by 6.24%.

Table 9.16: Forest cover change from 2005 to 2015

Class	2005		2015		Change	
	(ha)	(%)	(ha)	(%)	(ha)	(%)
Very Dense Forest	5961.78	4.15	5542.77	3.86	-419.01	-7.03
Moderately Dense Forest	7519.14	5.23	7055.57	4.91	-463.57	-6.17
Open Forest	5772.46	4.02	6132.54	4.27	360.08	6.24
Total Forest	**19253.38**	**13.39**	**18730.88**	**13.03**	**-522.50**	**-2.71**
Scrub	247.07	0.17	218.99	0.15	-28.08	-11.37
Non Forest	**124253.82**	**86.43**	**124804.40**	**86.82**	**550.58**	**0.44**
Total Geographic Area (ha)	**143754.27**					

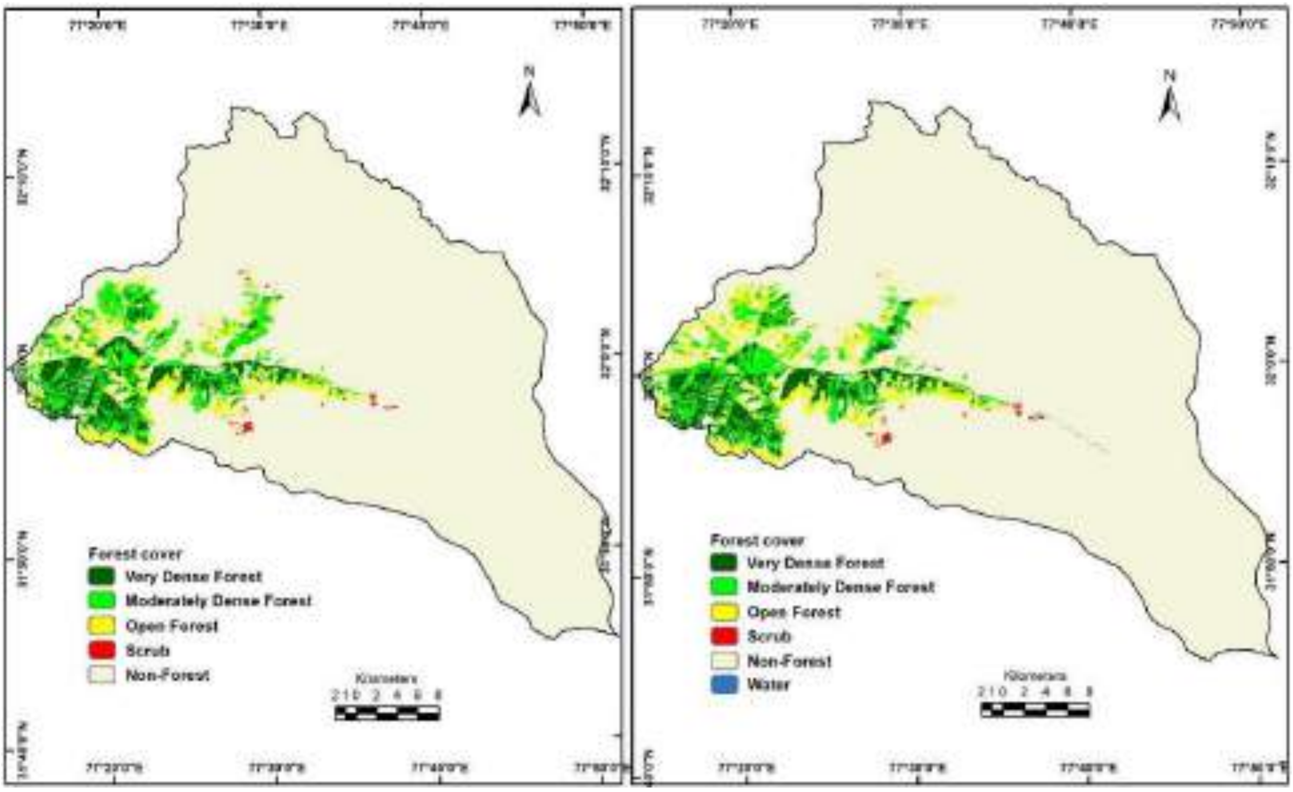


Figure 9.18: Forest cover map for the year 2005 and 2015 of Parbati Upper Sub-basin

(*Source:* Indian State of Forest Report, 2005 and 2015, Forest Survey of India)

As seen from the forest/vegetation types map of the sub-basin more than 61% of its area is either under snow or glaciers. More than 20% of its area is characterized by Mosit alpine scrub and lower areas are under Semi-evergreen forests (**see Figure 9.19**).

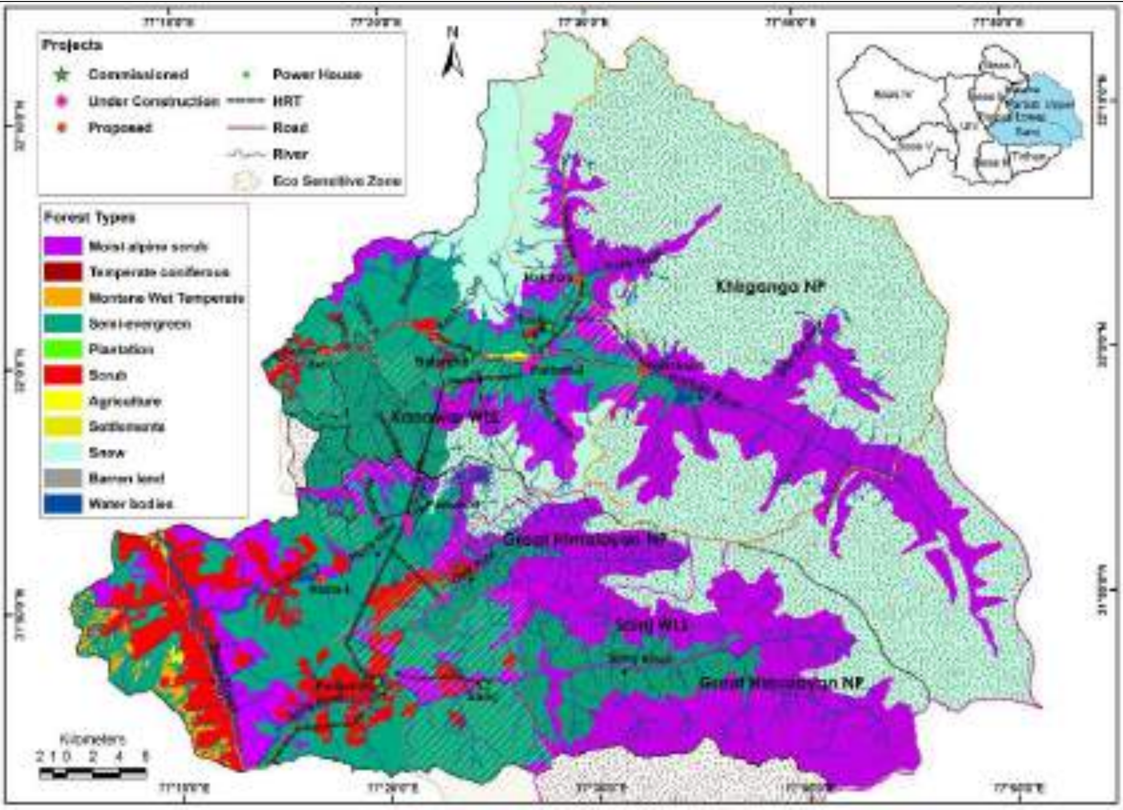


Figure 9.19: Forest type map of Parbati Upper and Sainj sub-basins

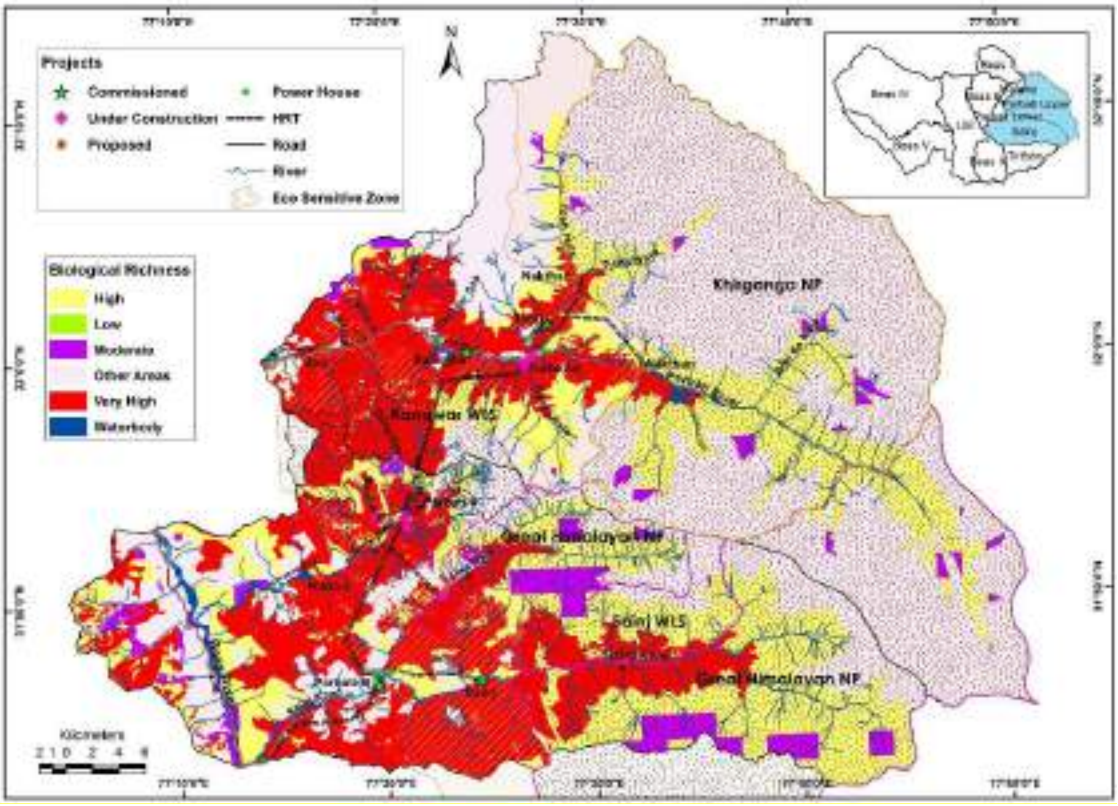


Figure 9.20: Biological Richness Index map of Parbati Upper and Sainj sub-basins

This sub-basin is one of the richest in biodiversity as most of its forested landscape is rich in Very High to High Biological Richness Index (**refer Figure 9.20 and Table 9.17**). However, some of its areas have been subjected to moderate landscape fragmentation as seen from

Figure 9.21 and Table 9.18. Nearly one third of its snow free landscape is under moderate human disturbance in the form of construction activities.

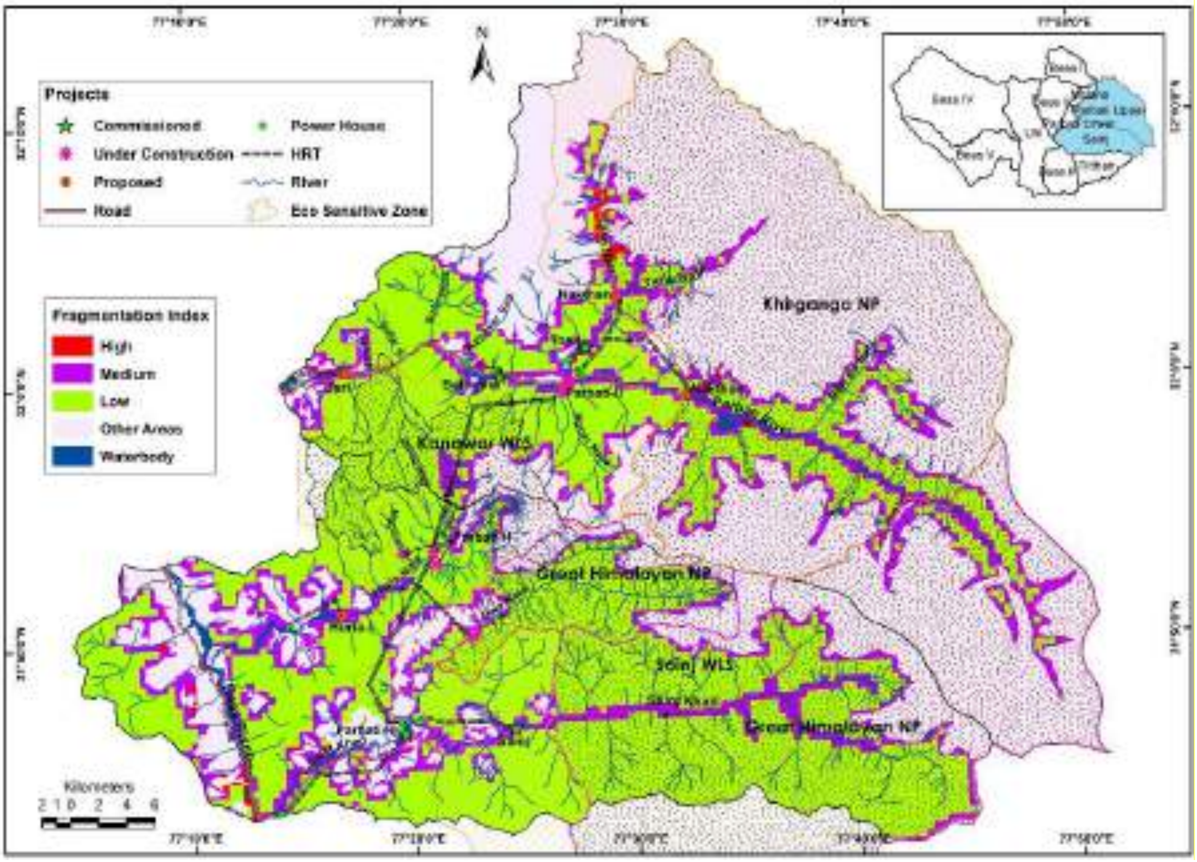


Figure 9.21: Fragmentation Index map of Parbati Upper and Sainj sub-basins

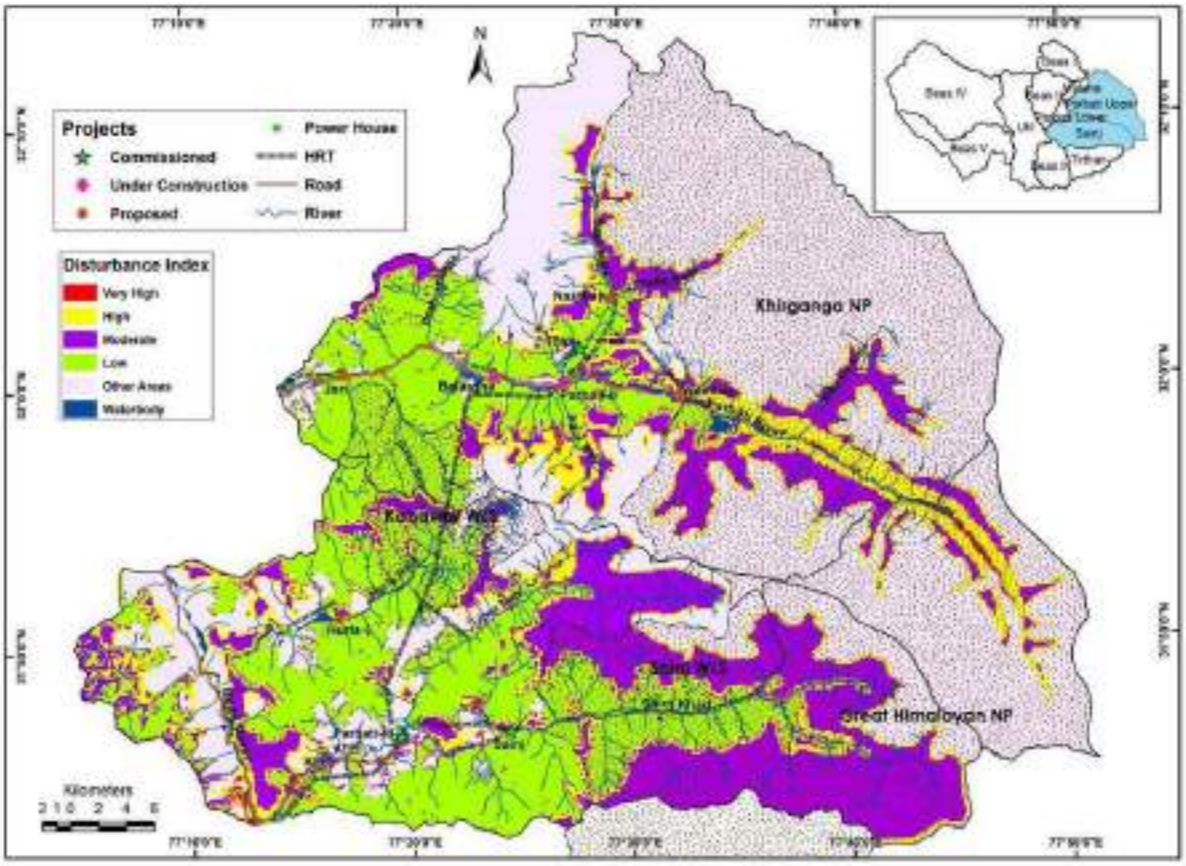


Figure 9.22: Disturbance Index map of Parbati Upper and Sainj sub-basins

Table 9.17: Area under different Biological Richness Index categories in Parbati Upper sub-basin

Biological Richness Index	Area (sq km)	(%)
Very High	219.07	15.24
High	285.06	19.83
Moderate	21.92	1.52
Low	2.20	0.15
Other Areas (Water, Barren land, Snow, Glaciers, etc.)	909.29	63.25
	1437.54	**100.00**

Table 9.18: Area under different categories of Fragmentation Index and Disturbance Index in Parbati Upper sub-basin

Fragmentation Index	Area (sq km)	(%)	Disturbance Index	Area (sq km)	(%)
High	5.03	0.35	Very High	6.21	0.43
Moderate	159.12	11.07	High	162.77	11.32
Low	364.36	25.35	Moderate	156.18	10.86
Other Areas (Water, Barren land, Snow, Glaciers, etc.)	909.03	63.24	Low	203.35	14.15
			Other Areas (Water, Barren land, Snow, Glaciers, etc.)	909.02	63.23

9.4.5.2 Biodiversity Profile

During the present studies 149 species of flowering plants were recorded during field surveys conducted in the projects areas though according to cumulative list compiled from primary surveys and secondary sources 171 angiosperm species are reportedly found in the basin. According to Red Data Book of BSI, 3 RET species were recorded during sampling. i.e. *Acer caesium* in Vulnerable category was found in project area of Parbati II and Nakthan HEPs. *Aconitum violaceum* and *Indigofera heterantha* both in IUCN Vulnerable category were recorded from Nakthan HE Project area. *Sinopodophyllum hexandrum*, *Polygonatum verticillatum*, *Dioscorea deltoidea* and *Zanthoxylum armatum* listed as Endangered and *Roscoea alpina* as Vulnerable by FRLHT RET medicinal plants list were found in the project area of Nakthan HEP. There are as many as 16 Western Himalayan endemics found in this sub-basin. *Taxus wallichiana* is of the most important medicinal plant found in this sub-basin.

Thirty-one (31) species of mammals are reported from this sub-basin out of which 9 are listed as RET in IUCN Redlist and 8 are Schedule-I species. Snow leopard (*Panthera uncia*) is found in this sub-basin only in the entire basin. Other important RET species are Leopard (*Panthera pardus*), Brown bear (*Ursus arctos*), Himalayan black Bear (*Ursus thibetanus*), Serow (*Capricornis sumatraensis*), Otter (*Lutra lutra*) and Musk Deer (*Moschus chrysogaster*)

Avi-fauna of the sub-basin is comprised of 120 species which are reportedly found in this area with 7 Schedule-I species and 4 RET species in IUCN Redlist. White-backed Vulture is a

Critically Endangered species while Cheer Pheasant and Western tragopan are in Vulnerable category and these two along with Monal pheasant are Schedule-I species as per WPA (1972).

Water quality in general in this sub-basin is in Medium to Good category. Biological water quality in the form of BMWP was in Very Good category at all locations.

Fish fauna of the sub-basin is comprised of 12 species. Important fish species are *Amblyceps mangois, Sperata aor, Botia dario, Crossocheilus latius, Garra gotyla, Labeo pangusia, Puntius chola, Schizothorax richardsonii* and *Systomus sarana*. Kasol in the sub-basin is one of most important fishery location in the sub-basin.

Most part of the sub-basin is under Protected Areas. While the entire upper catchment is under Khirganga national Park lower part is under Kanawar Wildlife Sanctuary. Both these Pas comprise a part of larger Great Himalayan Conservation Reserve.

Impact Assessment

In this sub-basin, there is one operational project i.e. Tosh HEP on Tosh Nala with a capacity of 10 MW. There are 2 under construction projects on Parbati river (Balarhga and Parbati II) with total capacity of 809 MW. Nakthan and Jari are the 2 projects proposed on Parbati river with a total capacity of 472 MW.

As described above this sub-basin is one of the richest in terms of biodiversity and large part of the sub-basin is under Protected Areas. Area immediately upstream of proposed Nakthan HEP comprised Khirganga National Park and Great Himalayan National Park. In addition, slopes on the left bank of Parbati river at lower elevations constitute part of Kanawar Wildlife Sanctuary. The sub-basin some of the importatnt RET plant species and *Taxus wallichiana* is an important medicinal plant found in the sub-basin.

Already the under-construction project like Parbati-II HEP has lead to fragmentation of landscape and degradation of forests. The proposed Nakthan HE project is located within a 100m of the boundary of Khirganga National Park. Its entire catchment constitutes Khirganga National Park and is home to important wildlife and number of RET plant species. The construction of the proposed Nakthan HE project would lead to fragmentation of dense temperate forests which contain valuable plant resources. The fragile ecosystem of the area already under stress due to under-construction Parbati-II HE project would be severely affected due to construction of new roads and other project related construction activities like blasting, mining for construction material, and construction of other infrastructure and influx of workers in the otherwise pristine area. It is therefore recommended no more project should be taken up in this sub-basin as Tosh HEP is already operational and Parbati-II and Balargha projects are under construction. Abandoning of proposed Nakthan HE project would help in preservation of already under stress ecosystem.

Jari is another project proposed on Parbati river. Jari along with other 4 projects in cascade on Parbati river in Parbati Lower sub-basin would affect more than 17 km of Parbati river out of total 30 km stretch of Parbati river from Jari to lowermost Sarsadi-II project on Parbati river.

9.4.6 Sainj Sub-basin

Sainj sub-basin comprises mainly of the catchment area of Sainj river up to its confluence with Beas river near dam site of Larji HEP (**Figure 9.19**). This sub-basin also includes the catchment of Beas river from the confluence of Parbati river up to the confluence of sainj river including the catchment of Hurla nala and Sainj khad. Hurla nala which meets Beas river on its left bank near Hurla village. The elevation varies from 1100 m to about 5700 m.

9.4.6.1 Forest Cover & Forest Types

It can be seen from **Figure 9.23 and Table 9.19** that the forest cover in the sub-basin has decreased by about 1% in 2015 from 2005 wherein Very Dense, Moderately Dense and Open forest has decreased by 0.71%, 1.30% and 1.52%, respectively.

Table 9.19: Forest cover changes from 2005 to 2015

Class	2005		2015		Change	
	(ha)	(%)	(ha)	(%)	(ha)	(%)
Very Dense Forest	16726.18	15.09	16607.40	14.98	-118.78	-0.71
Moderately Dense Forest	14212.93	12.82	14028.73	12.65	-184.20	-1.30
Open Forest	15030.97	13.56	14802.62	13.35	-228.35	-1.52
Total Forest	**45970.08**	41.46	**45438.75**	**40.98**	-531.33	-1.16
Scrub	753.02	0.68	754.80	0.68	1.78	0.24
Non-Forest	**64148.42**	**57.86**	**64677.97**	**58.34**	**529.55**	**0.83**
Total Geographic Area (ha)	**110871.52**					

As seen from the forest/vegetation types map the forest cover is mainly in the form of Semi-evergreen and Moist alpine scrubs. Areas near the roadsides and villages has been converted into scrub (refer **Table 9.19**).

Like other sub-basins it is characterized by Very High and High Biological Richness (refer **Table 9.20**). The fragmentation of the landscape too is on low side. However due to human activities disturbance is moderate as compared to adjacent sub-basins (**Table 9.21**).

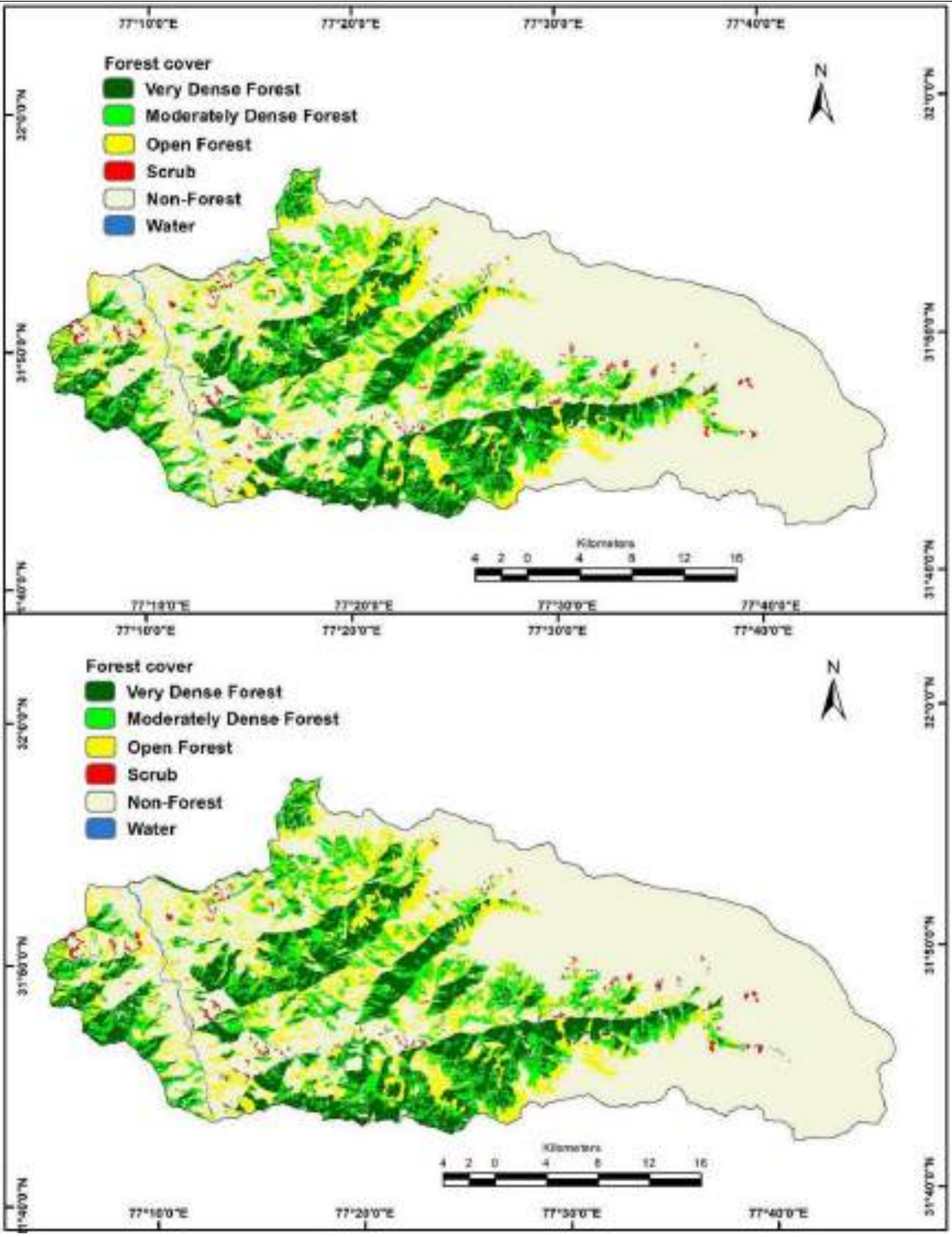


Figure 9.23: Forest cover map for the year 2005 and 2015 of Sainj sub-basin

(*Source:* Indian State of Forest Report, 2005 and 2015, Forest Survey of India)

Table 9.20: Area under different Biological Richness Index categories in Sainj sub-basin

Biological Richness Index	Area (sq km)	(%)
Very High	400.94	36.16
High	379.78	34.25
Moderate	69.63	6.28
Low	2.03	0.18
Other Areas (Water, Barren land, Snow, Glaciers, etc.)	256.33	23.12
	1108.71	**100.00**

Table 9.21: Area under different categories of Fragmentation Index and Disturbance Index in Sainj sub-basin

Fragmentation Index	Area (sq km)	(%)	Disturbance Index	Area (sq km)	(%)
High	4.10	0.37	Very High	4.97	0.45
Moderate	158.07	14.26	High	132.35	11.94
Low	690.55	62.28	Moderate	345.78	31.19
Other Areas (Water, Barren land, Snow, Glaciers, etc.)	255.98	23.09	Low	369.85	33.36
			Other Areas (Water, Barren land, Snow, Glaciers, etc.)	255.76	23.07

9.4.6.2 Biodiversity Profile

During the present studies 74 species of flowering plants were recorded during field surveys conducted in the projects areas though according to cumulative list compiled from primary surveys and secondary sources 101 angiosperm species are reportedly found in the sub-basin. No RET species according to BSI Red Data Book was found during field sampling in any of the project sites. *Zanthoxylum armatum* an important medicinal plant listed as Endangered in FRLHT RET list was found in project areas of Parbati III and Hurla-I HEPs. Three endemic species viz. *Aesculus indica, Berberis lycium* and *Celtis australis* are found in this sub-basin.

Thirty-three (33) species of mammals are reported from this sub-basin out of which 8 are listed as RET in IUCN Redlist and 8 more are Schedule-I species. Important species found in the sub-basin are Leopard (*Panthera pardus*), Black bear (*Ursus thibetanus*), Otter (*Lutra lutra*), Goral (*Naemorhedus goral*), Himalayan Tahr (*Hemitragus jemlahicus*), Serow (*Capricornis sumatraensis*), and Musk Deer (*Moschus chrysogaster*). All thses are listed in IUCN Redlist and are also listed as Schedule-I species as per WPA.

Avi-fauna of the sub-basin is comprised of 123 species which are reportedly found in this area with 7 Schedule-I species and 4 RET species in IUCN Redlist. White-backed Vulture (*Gyps bengalensis*) is a Critically Endangered species while Cheer Pheasant (*Catreus wallichii*) and Western tragopan (*Tragopan melanocephalus*) are in Vulnerable category and Himalayan griffon (*Gyps himalayaensis*) is in Near Threatened category. Cheer Pheasant (*Catreus wallichii*), Western tragopan (*Tragopan melanocephalus*), Monal pheasant (*Lophophorus impejanus*), Sparrow hawk (*Accipiter nisus*) and Indian peafowl (*Pavo cristatus*) are Schedule-I species as per WPA (1972).

Physico-chemical Water quality in general in this sub-basin is in Good category while at few sites it is in Medium category. Biological water quality in the form of macro-invertebrates was in poor condition.

Fish fauna of the sub-basin is comprised of 20 species. Important fishes found in the sub-basin are *Amblyceps mangois, Sperata aor, Botia dario, Crossocheilus latius, Garra gotyla, Labeo pangusia, Puntius chola, Schizothorax richardsonii* and *Systomus sarana*. Sainj river is one of the important trout fishing sites in the basin.

There are three Protected Areas in the sub-basin i.e. Sainj Wildlife Sanctuary, Great Himalayan National Park and Kanawar WLS.

Impact Assessment

In this sub-basin, there are 3 hydropower projects out of these 2 are already operational i.e. Parbati III (520 MW) and Sainj (100 MW). Only Hurla-I (9.40 MW) is proposed project on Hurla Nala.

Most of the sub-basin is under Protected Areas owing to rich biodiversity. With 2 projects already operational, it is not advisable to add another project in this sub-basin. Hurla Nla catchment is also known for frequent cloud bursts which can cause seriously damage the smaller projects like Hurla-I.

9.4.7 Tirthan Sub-basin

Tirthan sub-basin comprises of the catchment area of Tirthan river from its origin and up to its confluence with Sainj Khad near Larji village. It originates from unnamed glacier at an elevation of 4378m and travels a distance of about 50.7 km to join Sainj khad at its left bank. It is the biggest tributary of Sainj khad. The elevation varies from 1100 m to about 5200 m.

9.4.7.1 Forest Cover & Forest Types

It can be seen from **Figure 9.24** and **Table 9.22** area of very dense forest, moderately dense forest and open forest has increased by 0.16%, 0.04% and 0.02% respectivery in 2015 from 2005 and no change in scrub land area.

Table 9.22: Forest cover changes from 2005 to 2015

Class	2005		2015		Change	
	(ha)	(%)	(ha)	(%)	(ha)	(%)
Very Dense Forest	15996.97	23.34	15888.30	23.18	-108.66	-0.68
Moderately Dense Forest	14772.33	21.55	14743.00	21.51	-29.33	-0.20
Open Forest	7403.94	10.80	7389.31	10.78	-14.64	-0.20
Total Forest	**38173.24**	**55.69**	**38020.61**	**55.47**	-152.63	-0.40
Scrub	257.83	0.38	260.26	0.38	2.43	0.94
Non Forest	**30115.00**	**43.93**	**30265.20**	**44.15**	**150.20**	**0.50**
Total Geographic Area (ha)	**68546.07**					

More than half of Tirthan catchment is characterized by Semi-evergreen forest while higher at elevation Moist alpine scrub is predominant forest type (**see Figure 9.25**). However, scrub formation is found in Koti Gad catchment.

As seen from the Biological Richness map (**Figure 9.26**) and **Table 9.23** Tirthan sub-basin comprised of Tirthan river catchment is very rich in Biological diversity as neary 79% of its area is characterized by Very High and High Biological Richness Index (**Table 9.24**).

Fragmentation of the landscape is very low and disturbance due to anthropogenic activities also is quite low (**Figures 9.27 & 9.28**).

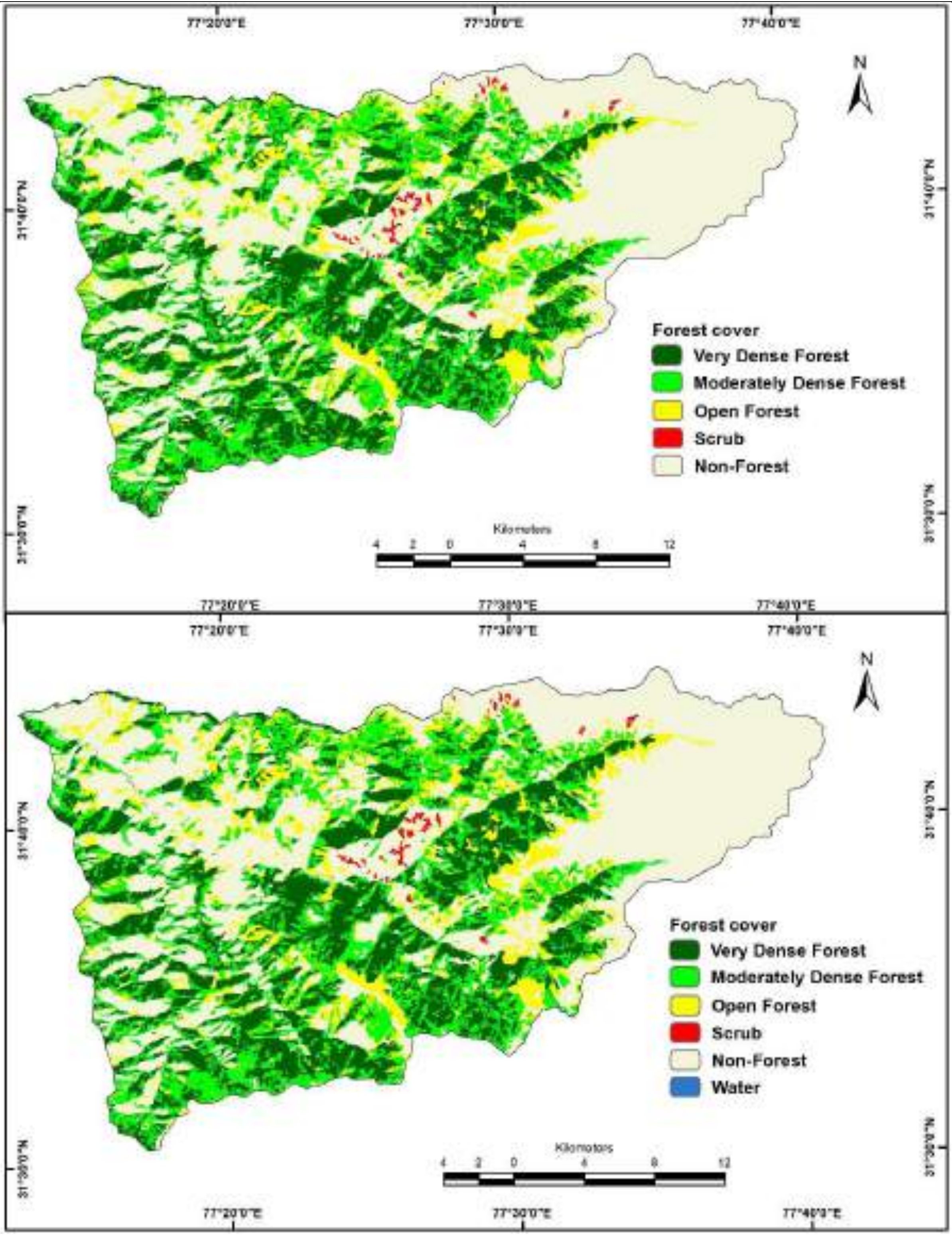


Figure 9.24: Forest cover map for the year 2005 and 2015 of Tirthan sub-basin

(*Source:* Indian State of Forest Report, 2005 and 2015, Forest Survey of India)

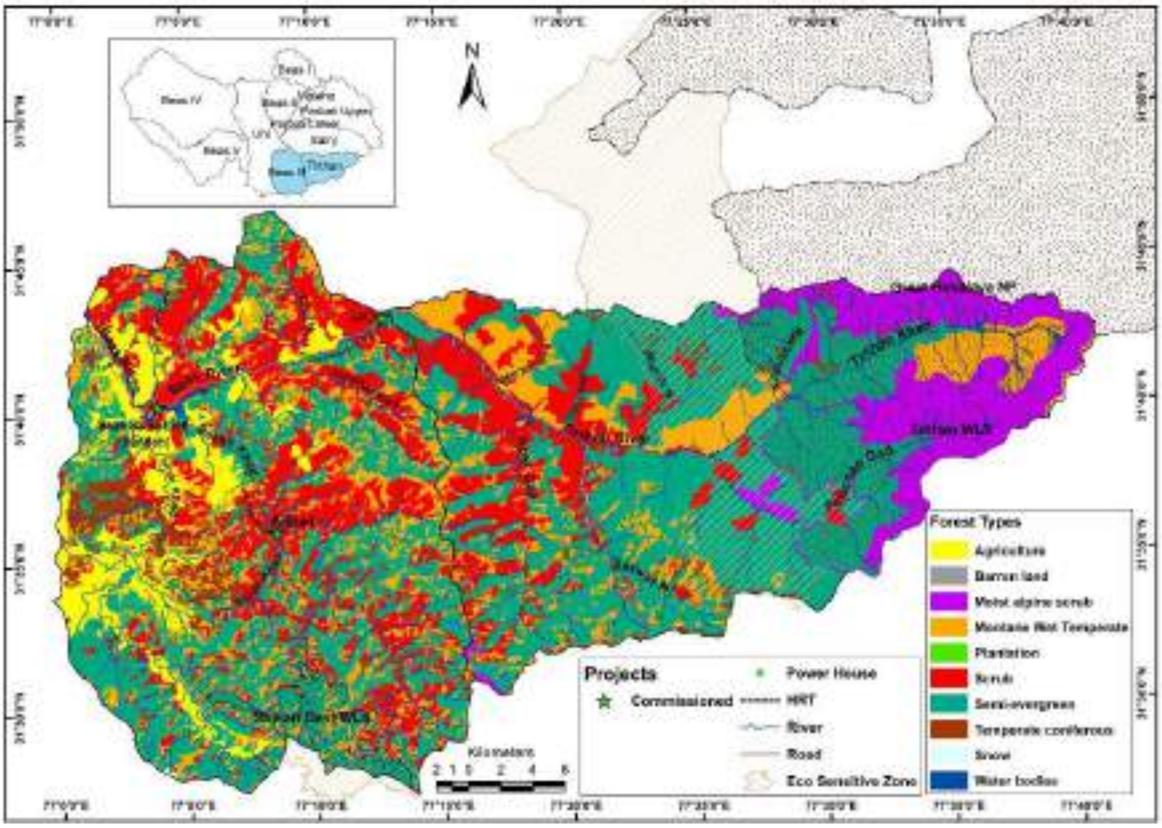


Figure 9.25: Forest type map of Tirthan and Beas III sub-basins

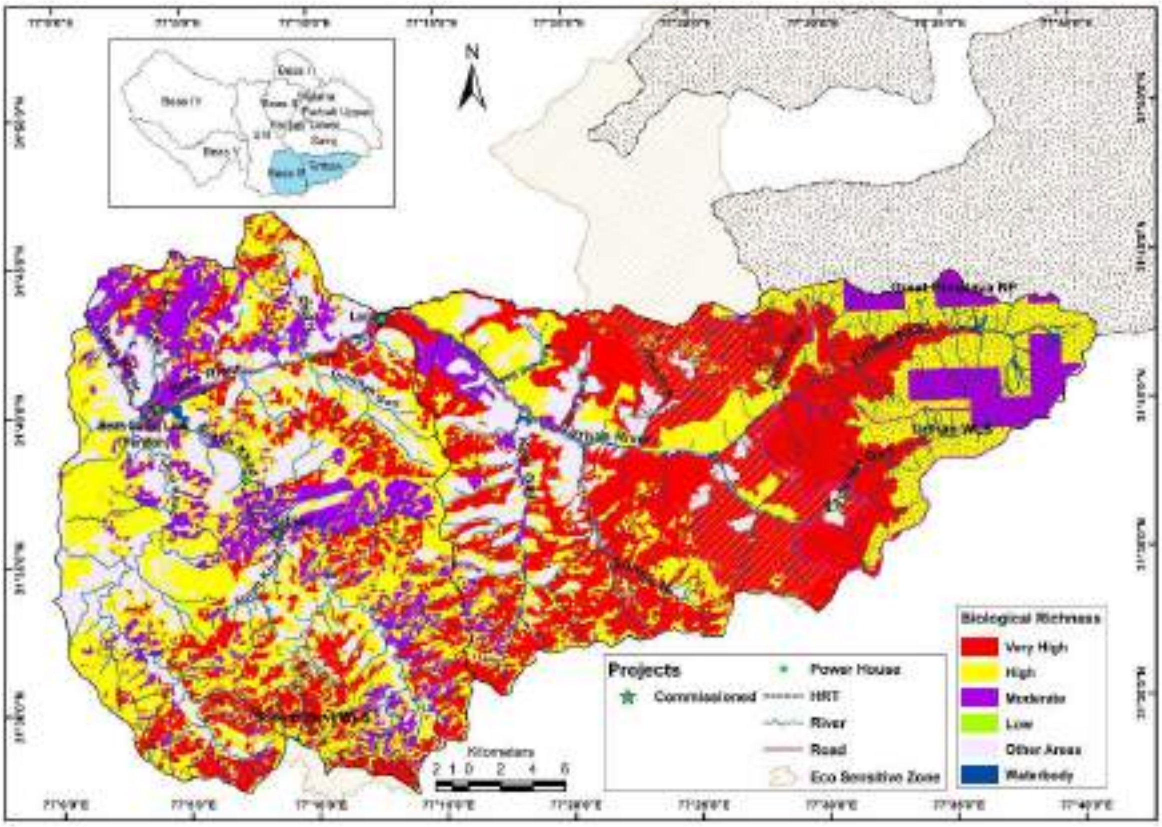


Figure 9.26: Biological Richness Index map of Tirthan and Beas III sub-basins

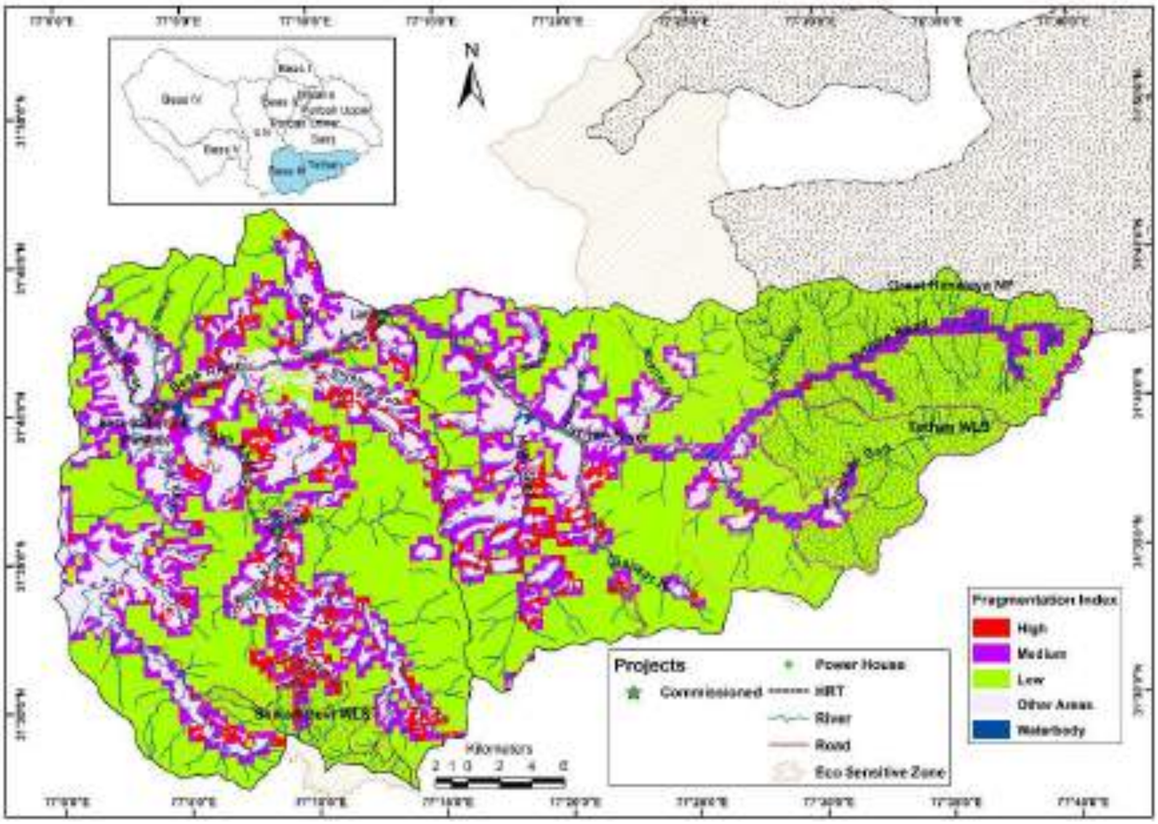


Figure 9.27: Fragmentation Index map of Tirthan and Beas III sub-basins

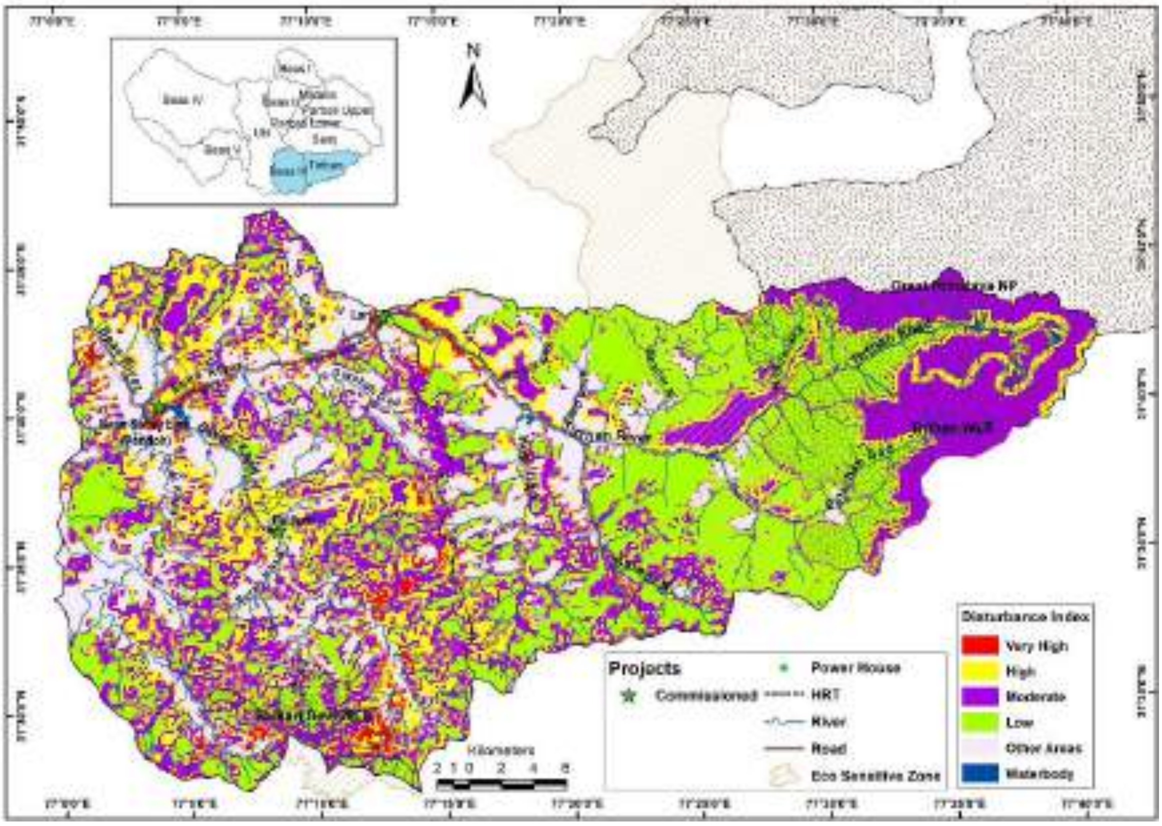


Figure 9.28: Disturbance Index map of Tirthan and Beas III sub-basins

Table 9.23: Area under different Biological Richness Index categories in Tirthan sub-basin

Biological Richness Index	Area (sq km)	(%)
Very High	338.66	49.41
High	201.90	29.45
Moderate	57.70	8.42
Low	2.03	0.30
Other Areas (Water, Barren land, Snow, Glaciers, etc.)	85.17	12.43
	685.46	**100.00**

Table 9.24: Area under different categories of Fragmentation Index and Disturbance Index in Tirthan sub-basin

Fragmentation Index	Area (sq km)	(%)	Disturbance Index	Area (sq km)	(%)
High	19.29	2.81	Very High	5.34	0.78
Moderate	107.83	15.73	High	92.30	13.47
Low	473.14	69.03	Moderate	203.26	29.65
Other Areas (Water, Barren land, Snow, Glaciers, etc.)	85.20	12.43	Low	299.38	43.68
			Other Areas (Water, Barren land, Snow, Glaciers, etc.)	85.19	12.43

9.4.7.2 Biodiversity Profile

In Tirthan sub-basin 108 species of flowering plants based upon a list compiled from different sources. According to Red Data Book of BSI, one RET species *Acer caesium* in Vulnerable category was found in the sub-basin. As many as 10 species listed in IUCN Redlist are reported from the sub-basin. *Aconitum violaceum* and *Indigofera heterantha* both in IUCN Vulnerable category reported from this area. *Sinopodophyllum hexandrum*, *Polygonatum verticillatum, Dioscorea deltoidea* and *Zanthoxylum armatum* listed as Endangered and *Roscoea alpina* as Vulnerable by FRLHT RET medicinal plants list were found in the sub-basin. There are as many as 33 FRLHT RET medicinal plant species found in this sub-basin. The sub-basin also harbours 7 Westerm Himalayan endemics.

Thirty-three (33) species of mammals are reported from this sub-basin out of which 8 are listed as RET in IUCN Redlist and 8 more are Schedule-I species. Important species found in the sub-basin are Leopard (*Panthera pardus*), Black bear (*Ursus thibetanus*), Otter (*Lutra lutra*), Goral (*Naemorhedus goral*), Himalayan Tahr (*Hemitragus jemlahicus*), Serow (*Capricornis sumatraensis*), and Musk Deer (*Moschus chrysogaster*). All thses are listed in IUCN Redlist and are also listed as Schedule-I species as per WPA.

Avi-fauna of the sub-basin is comprised of 123 species which are reportedly found in this area with 6 Schedule-I species and 4 RET species in IUCN Redlist. White-backed Vulture (*Gyps bengalensis*) is a Critically Endangered species while Cheer Pheasant (*Catreus wallichii*) and Western tragopan (*Tragopan melanocephalus*) are in Vulnerable category and Himalayan griffon (*Gyps himalayaensis*) is in Near Threatened category. Cheer pheasant (*Catreus wallichii*), Western tragopan (*Tragopan melanocephalus*), Monal pheasant (*Lophophorus* *impejanus*), Sparrow hawk (*Accipiter nisus*) and Indian peafowl (*Pavo cristatus*) are Schedule-I species as per WPA (1972).

Water quality in general in this sub-basin is in Good category. Similarly, Biological water quality was also in Good category.

Fish fauna of the sub-basin is comprised of 18 species comprised mainly of Snow trout (*Schizothorax richardsonii*), *Glyptothorax* spp., *Garra gotyla, Schistura rupecola*. Snow trout is predominant fish of Tirthan river and its tributaries. It is famous for trout fishing.

Tirthan river has been marked as No Go area for hydropower development by the state Fisheries Development for fish conservation and therefore no project has been planned in the sub-basin.

<u>**Impact Assessment**</u>

No project has been planned in this sub-basin on Tirthan river in order to preserve the pristine ecosystem as well the fish habitats. In future to projects should therefore be envisaged in this sub-basin.

9.4.8 Beas III Sub-basin

Beas Sub-basin-III is comprised of catchment area of Beas river between the confluence point of Tirthan River with river Beas and upstream of Uhl River near Ghamun village. The elevation varies from 800 m to about 3400 m.

9.4.8.1 Forest Cover & Forest Types

It is evident from Table below that area of Very dense forest, moderately dense forest and scrub has reduced by 0.15%, 0.13% and 0.03% respectivery in 2015 from 2005 and open forest has increased by 0.18% (**Table 9.25**).

Table 9.25: Forest cover changes from 2005 to 2015

Class	2005		2015		Change	
	(ha)	**(%)**	**(ha)**	**(%)**	**(ha)**	**(%)**
Very Dense Forest	13103.07	18.62	13205.75	18.77	102.67	0.78
Moderately Dense Forest	18691.74	26.56	18783.35	26.69	91.60	0.49
Open Forest	10430.90	14.82	10310.18	14.65	-120.73	-1.16
Total Forest	**42225.72**	60.01	**42299.27**	**60.11**	73.55	**0.17**
Scrub	6.32	0.01	26.75	0.04	20.43	323.17
Non-Forest	28132.62	39.98	28038.63	39.85	-93.98	-0.33
Total Geographic Area (ha)	**70364.66**					

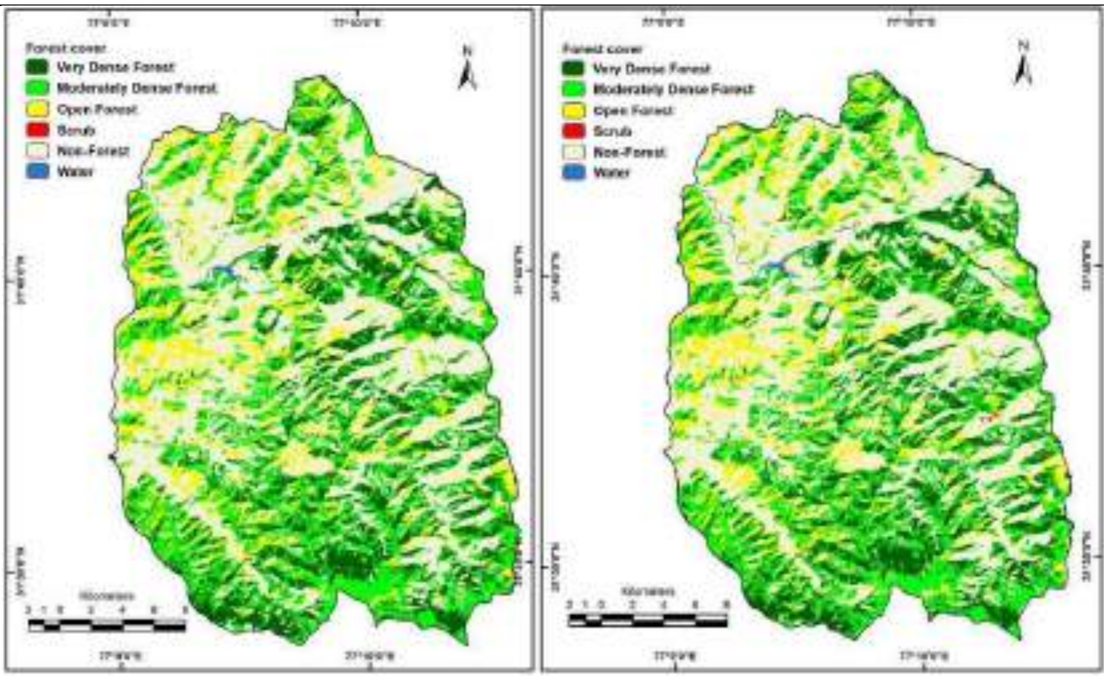


Figure 9.29: Forest cover map for the year 2005 and 2015 of Beas III Sub-basin
(*Source*: Indian State of Forest Report, 2005 and 2015, Forest Survey of India)

The predominant forest type in the sub-basin is Semi-evergreen. Montane wet temperate forest is next dominant forest iin the area. Agriculture is one of the main land use in the sub-basin covering about 13% of its area (**see Figure 9.25**).

More than 57.17% area is under Very High and High Biological Richness Index (**Figure 9.26 & Table 9.26**). There is moderate landscape fragmentation in the sub-basin due to agricultutural activities and disturbance too is Moderate to High (**Figures 9.27 & 9.28 and Table 9.26).**

Table 9.26: Area under different Biological Richness Index categories in Beas III sub-basin

Biological Richness Index	Area (sq km)	(%)
Very High	123.28	17.52
High	282.76	40.19
Moderate	118.58	16.85
Low	3.16	0.45
Other Areas (Water, Barren land, etc.)	175.86	24.99
	703.65	**100.00**

Table 9.27: Area under different categories of Fragmentation Index and Disturbance Index in Beas III sub-basin

Fragmentation Index	Area (sq km)	(%)	Disturbance Index	Area (sq km)	(%)
High	49.43	7.03	Very High	20.12	2.86
Moderate	142.15	20.20	High	164.80	23.42
Low	336.65	47.84	Moderate	211.87	30.11
Other Areas (Water, Barren land, etc.)	175.42	24.93	Low	130.76	18.58
			Other Areas (Water, Barren land, etc.)	176.10	25.03

9.4.8.2 *Biodiversity Profile*

During the present studies 104 species of flowering plants were recorded during field surveys conducted in the projects areas though according to cumulative list compiled from primary surveys and secondary sources 133 angiosperm species are reportedly found in the basin.

No RET species according to BSI Red Data Book was found during field sampling in any of the project sites. *Zanthoxylum armatum* an important medicinal plant listed as Endangered in FRLHT RET list was found in project areas of Patikari HEP. Three endemic species viz. *Alnus nitida, Desmodium elegans* and *Celtis australis* are found in this sub-basin.

Thirty-one (31) species of mammals are reported from this sub-basin out of which 8 are listed as RET in IUCN Redlist and 5 more are Schedule-I species. Important species found in the sub-basin are Leopard (*Panthera pardus*), Black bear (*Ursus thibetanus*), Otter (*Lutra lutra*), Goral (*Naemorhedus goral*), Himalayan tahr (*Hemitragus jemlahicus*), Serow (*Capricornis sumatraensis*), and Musk Deer (*Moschus chrysogaster*). All thses are listed in IUCN Redlist and are also listed as Schedule-I species as per WPA.

Avi-fauna of the sub-basin is comprised of 136 species which are reportedly found in this area with 7 Schedule-I species and 7 RET species in IUCN Redlist. White-backed Vulture (*Gyps bengalensis*) is a Critically Endangered species while Cheer Pheasant (*Catreus wallichii*) and Western tragopan (*Tragopan melanocephalus*) are in Vulnerable category and Himalayan griffon (*Gyps himalayaensis*) is in Near Threatened category. Cheer Pheasant (*Catreus wallichii*), Western tragopan (*Tragopan melanocephalus*), Monal pheasant (*Lophophorus impejanus*), Sparrow hawk (*Accipiter nisus*) and Indian peafowl (*Pavo cristatus*) are Schedule-I species as per WPA (1972).

Physico-chemical water quality in general in this sub-basin is in Good category. Biological water quality in the form of macro-invertebrates was in Good category with some sites in poor condition.

Fish fauna of the sub-basin is comprised of 22 species. Important fishes found in the sub-basin are *Amblyceps mangois, Sperata aor, Botia dario, Crossocheilus latius, Garra gotyla, Labeo pangusia, Puntius chola, Schizothorax richardsonii* and *Systomus sarana*. Sainj river is one of the important trout fishing sites in the basin.
Jeuni Khad and Bakhli Khad two streams in this sub-basin have been earmarked for fish conservation by HP Fisheries Department.

<u>**Impact Assessment**</u>
In this sub-basin, there are 3 hydropower projects all of which are operational i.e. Pandoh (990 MW), Larji (126 MW) and Patikari (16 MW). While Pandoh and Larji projects are located on main Beas river Patikari is located on Bakhli Khad.

The construction of Pandoh dam to divert water of Beas to Sutlej has already halted the migration of Mahseer upstream. Prior to these projects Mahseer used to migrate to Bakhli Khad however due to damning of Beas river has blocked the upstream migration of Mahseer and not much of Mahseer is found in Bakhli Khad. Larji project on Beas river also has affected the upstream movement of trout even though there is a fish ladder in the project to facilitate the movement of trout.

Bakhli Khad and Jeuni Khad in this sub-basin has been included in the negative list of streams by HP State Fisheries Department for fish conservation. Therefore, no new projects have been planned on Bakhli Khad or Jeuni Khad in this sub-basin.

9.4.9 Uhl Sub-basin

Uhl sub-basin comprises of the catchment area of tributaries of Beas river i.e. Uhl river and Rana Khad on its right bank and Suketi Khad and Arnodi Khad on its left bank. It also includes intermediate catchment of Beas river from downstream of Pandoh Dam up to its confluence with Rana Khad in Mandi district. The elevation varies from 650 m to about 5200 m. Uhl river is the right bank tributary of Beas river which meets near Mandi town.

9.4.9.1 Forest Cover & Forest Types

Forest cover change from 2005 to 2015 is given in **Figure 9.30** and **Table 9.28** shows there has been an increase in forest cover in the sub-basin from 2005 by about 2.94%. The decrease in Very Dense forest has lead to increase in area under Moderately dense forest cover. The scrub has decreased by 27% in 2015 from 2005.

Table 9.28: Forest cover changes from 2005 to 2015

Class	2005		2015		Change	
	(ha)	(%)	(ha)	(%)	(ha)	(%)
Very Dense Forest	16822.86	9.83	16335.01	9.54	-487.85	-2.90
Moderately Dense Forest	28778.78	16.81	30428.97	17.77	1650.19	5.73
Open Forest	23064.20	13.47	23743.04	13.87	678.84	2.94
Total Forest	**68665.85**	40.10	**70507.03**	**41.18**	1841.18	**2.68**
Scrub	247.98	0.14	180.98	0.11	-67.00	-27.02
Non-Forest	102309.52	59.75	100535.34	58.72	-1774.18	-1.73
Total Geographic Area (ha)	**171223.35**					

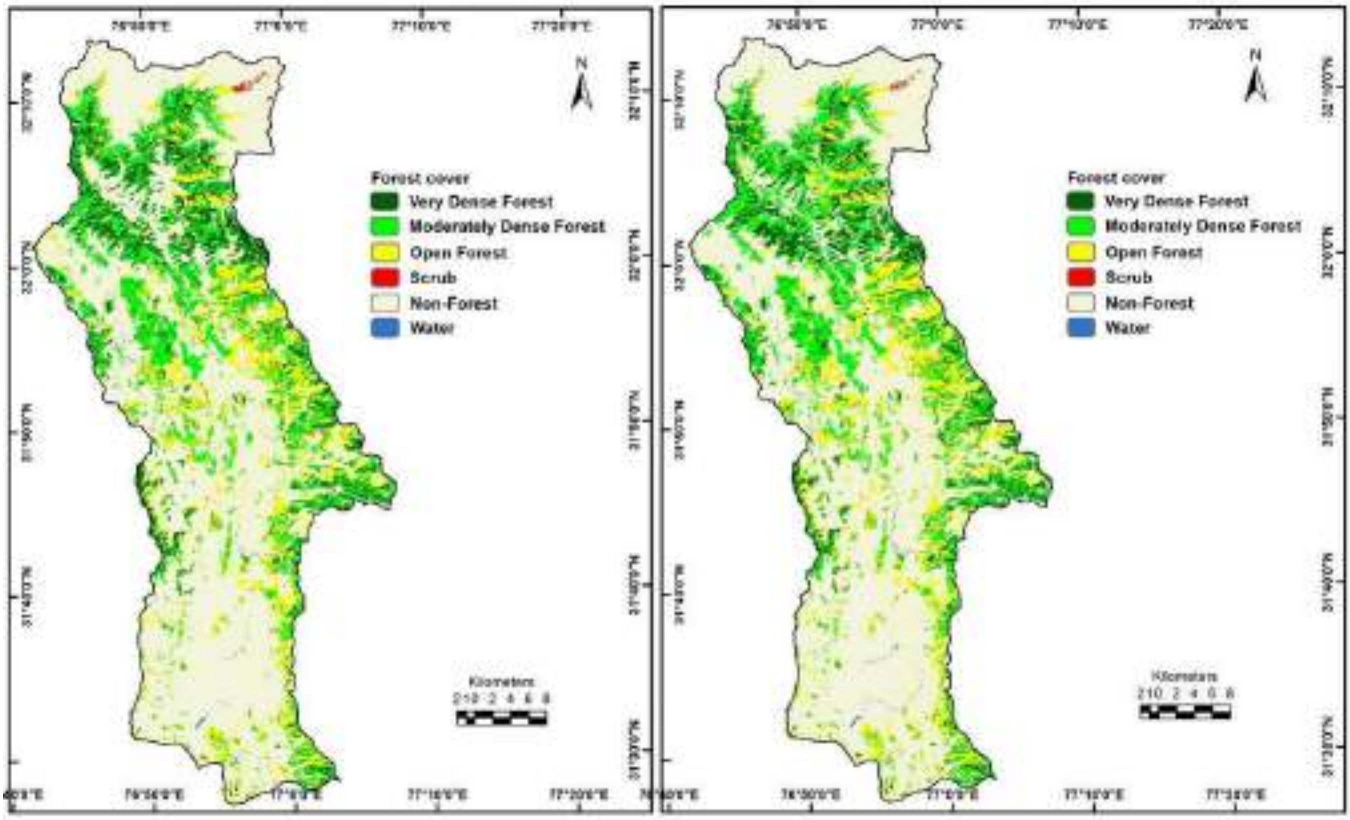


Figure 9.30: Forest cover map for the year 2005 and 2015 of Uhl Sub-basin
(*Source:* Indian State of Forest Report, 2005 and 2015, Forest Survey of India)

Agriculture is the major land use in this sub-basin (**Figure 9.31**) covering 32% of its area. Among forests Semi-evergreen forest is the main type followed by Montane wet temperate forest.

As compared to other Beas sub-basins area under Very High and High Biological Richness Index is less than 50% (**Figure 9.32** and **Table 9.29**) and disturbance also is low to moderate in this sub-basin (**Figure 9.32** & **8.34** and **Table 9.29**).

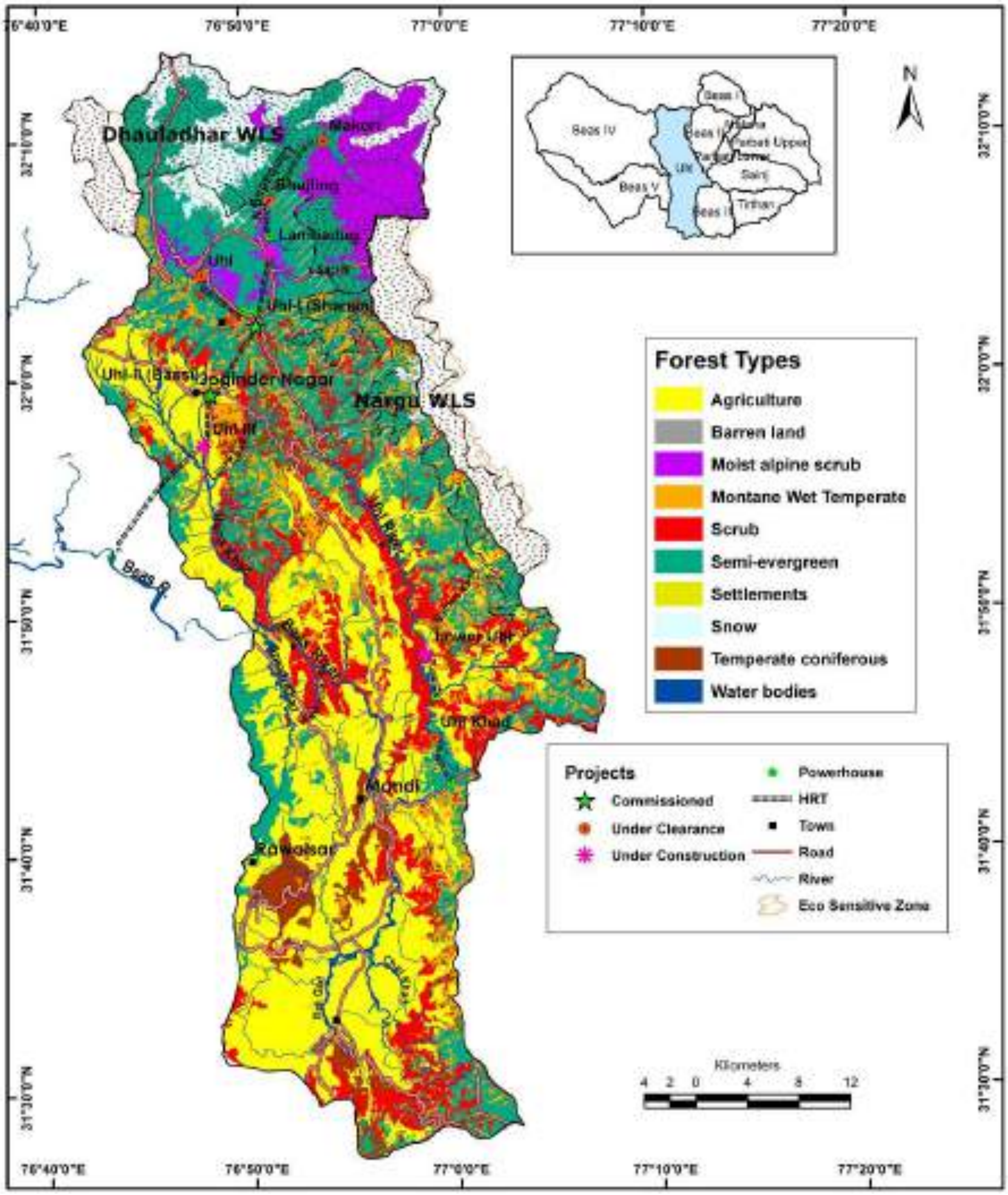


Figure 9.31: Forest type map of Uhl sub-basin

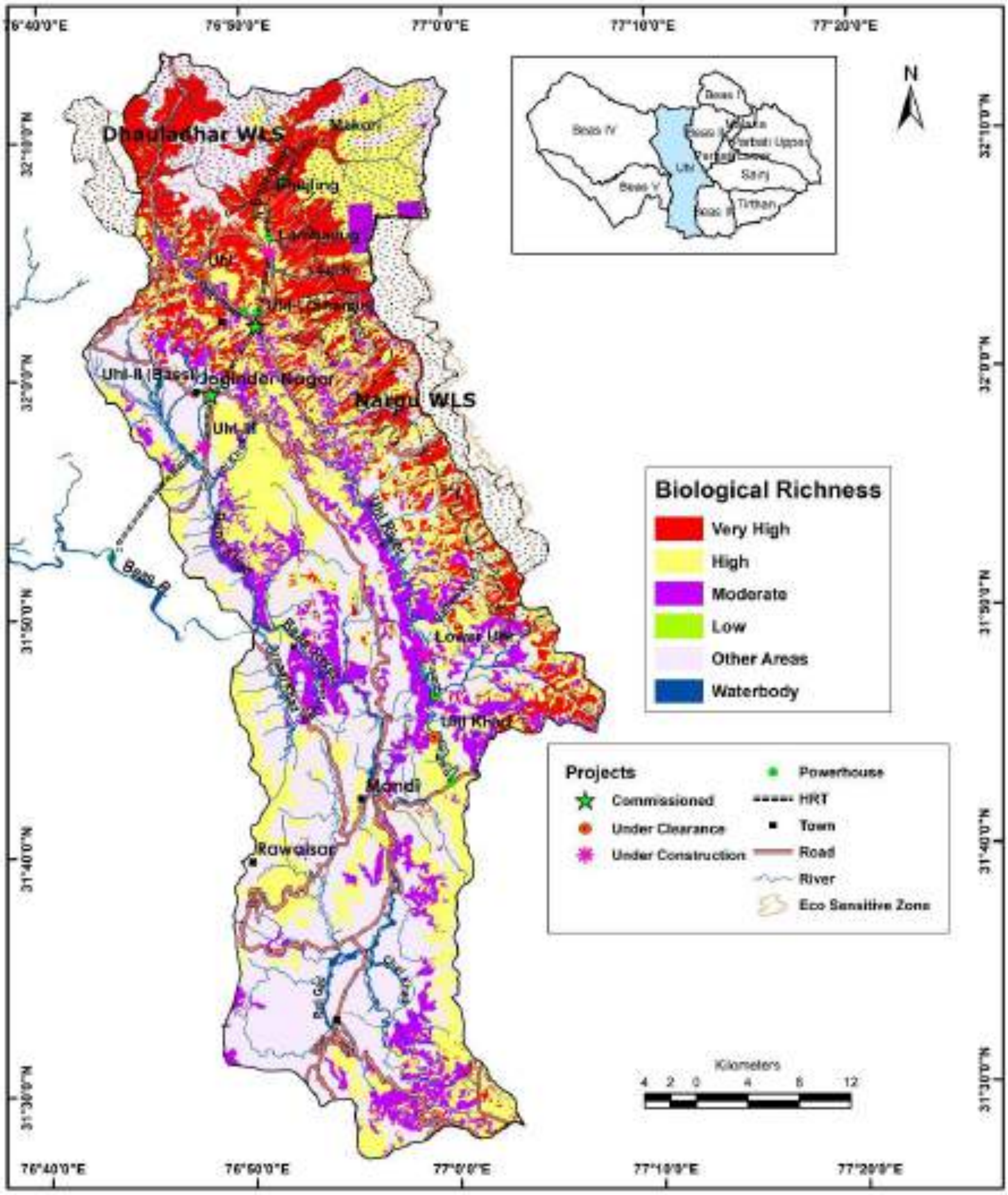


Figure 9.32: Biological Richness Index map of Uhl sub-basin

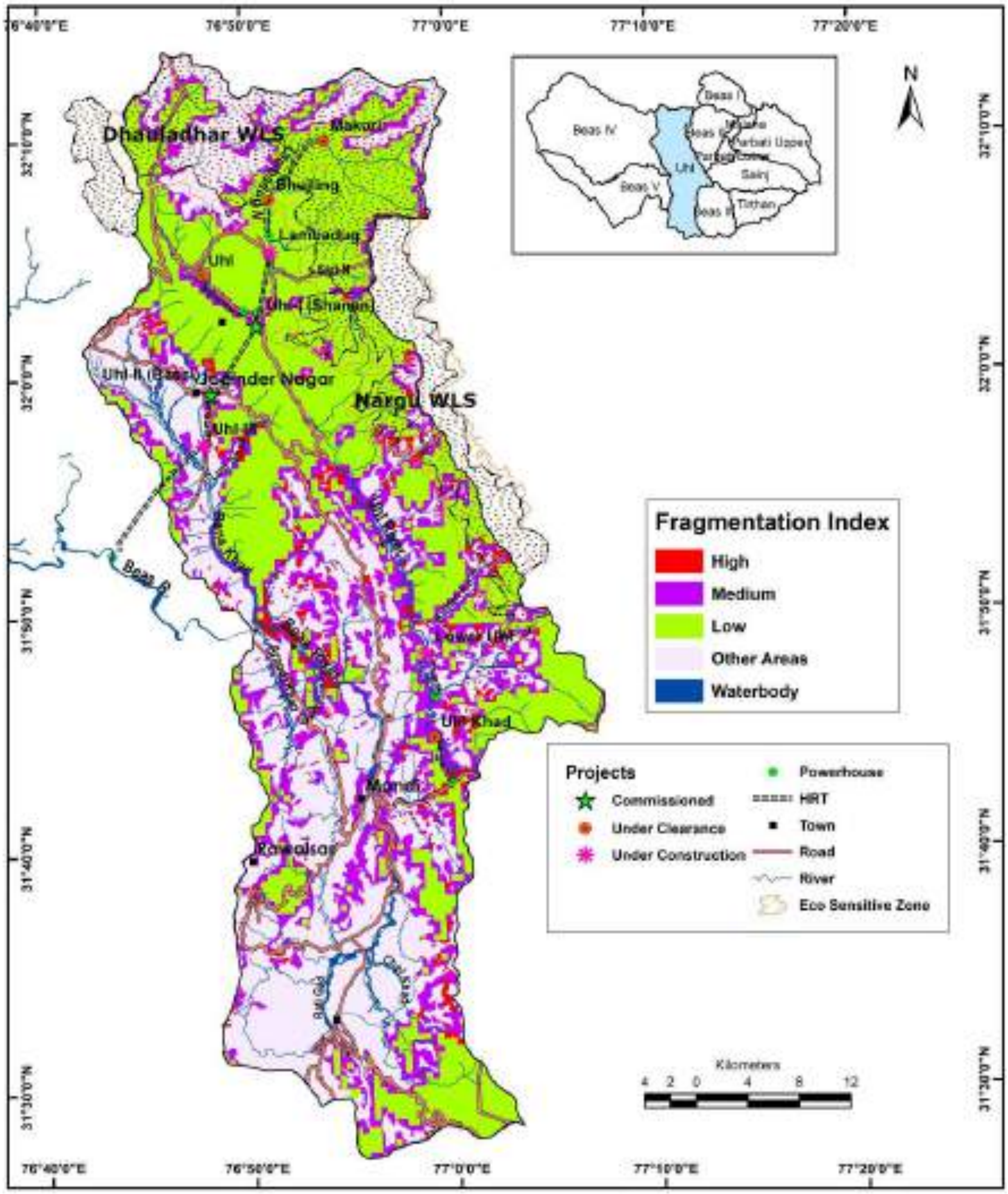


Figure 9.33: Fragmentation Index map of Uhl sub-basin

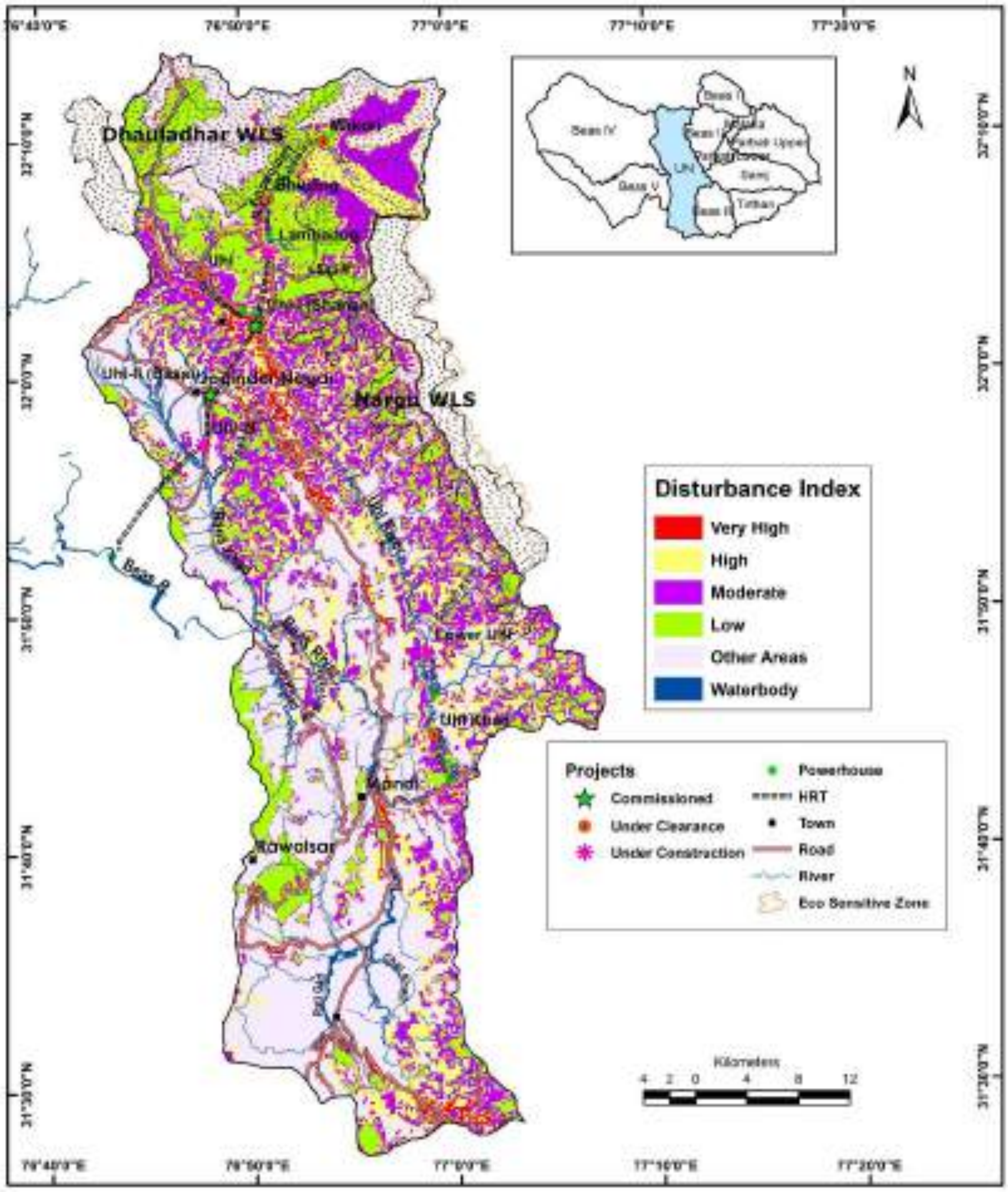


Figure 9.34: Disturbance Index map of Uhl sub-basin

Table 9.29: Area under different Biological Richness Index categories in Uhl sub-basin

Biological Richness Index	Area (sq km)	(%)
Very High	243.33	14.21
High	561.60	32.80
Moderate	223.94	13.08
Low	5.80	0.34
Other Areas (Water, Barren land, Snow, Glaciers, etc.)	677.56	39.57
	1712.23	**100.00**

Table 9.30: Area under different categories of Fragmentation Index and Disturbance Index in Uhl sub-basin

Fragmentation Index	Area (sq km)	(%)	Disturbance Index	Area (sq km)	(%)
High	47.20	2.76	Very High	35.89	2.10
Moderate	309.80	18.09	High	317.12	18.52
Low	678.78	39.64	Moderate	388.38	22.68

Fragmentation Index	Area (sq km)	(%)	Disturbance Index	Area (sq km)	(%)
Other Areas (Water, Barren land, Snow, Glaciers, etc.)	676.45	39.51	Low	293.52	17.14
	47.20	2.76	Other Areas (Water, Barren land, Snow, Glaciers, etc.)	677.32	39.56

9.4.9.2 Biodiversity Profile

During the present studies 107 species of flowering plants were recorded during field surveys conducted in the projects areas though according to cumulative list compiled from primary surveys and secondary sources 143 angiosperm species are reportedly found in the sub-basin.

No RET species according to BSI Red Data Book was found during field sampling in any of the project sites. *Zanthoxylum armatum* an important medicinal plant listed as Endangered in FRLHT RET list was found in project areas of Uhl I and Lower Uhl HEPs.

Thirty-five (35) species of mammals are reported from this sub-basin out of which 8 are listed as RET in IUCN Redlist and 8 more are Schedule-I species. Important species found in the sub-basin are Leopard (*Panthera pardus*), Black bear (*Ursus thibetanus*), Otter (*Lutra lutra*), Goral (*Naemorhedus goral*), Himalayan Tahr (*Hemitragus jemlahicus*), Serow (*Capricornis sumatraensis*), and Musk Deer (*Moschus chrysogaster*). All thses are listed in IUCN Redlist and are also listed as Schedule-I species as per WPA.

Avi-fauna of the sub-basin is comprised of 137 species which are reportedly found in this area with 7 Schedule-I species and 7 RET species in IUCN Redlist. White-backed Vulture (*Gyps bengalensis*) is a Critically Endangered species while Cheer Pheasant (*Catreus wallichii*) and Western tragopan (*Tragopan melanocephalus*) are in Vulnerable category and Himalayan griffon (*Gyps himalayaensis*) is in Near Threatened category. Cheer Pheasant (*Catreus wallichii*), Western tragopan (*Tragopan melanocephalus*), Monal pheasant (*Lophophorus impejanus*), Sparrow hawk (*Accipiter nisus*) and Indian peafowl (*Pavo cristatus*) are Schedule-I species as per WPA (1972).

Water quality in general in this sub-basin is in Good category while water quality in Excellent category was found in projects areas of Lambadug and Uhl-I HEPs. Biological water quality in the form of BMWP was in Good category.

Fish fauna of the sub-basin is comprised of 24 species. Fish composition is dominated by Snow trout (*Schizothorax richardsonii*) followed by *Glyptothorax* spp., *Garra gotyla, Schistura rupecola.*

Uhl sub-basin is most important sub-basin where trout fishing is undertaken extensively. The trout fishing sites near villages like Kamand and Tikkar on Uhl river in the lower reaches, Tikkan, Lachkhandi and Barot near the confluence of Lambadug and Uhl river are most suitable sites for trout fishing. There is Trout fish farm near the Barot reservoir. Rana Khad is one of potential mahseer breeding and fishing site while its tributary in upper reaches Sukhad khad is important trout breeding site. Arnodi Khad, a left bank tributary also is a potential trout breeding site.

Rana Khad, Arnodi Khad and Uhl river have been put in negative list for hydel projects for fish conservation by HP Fisheries Department.

There are 3 Wildlife Sanctuaries parts of which are located in the sub-basin viz. Dhauladhar Wildlife Sanctuary, Nargu WLS and Khokan WLS. These sanctuaries cover most part of upper regions of Uhl sub-basin.

Impact Assessment

In all there are 9 hydropower projects in Uhl sub-basin. Two of them have been operational for very long time i.e. Uhl-I (Shanon) 110 MW, Uhl-II (Bassi) 66 MW. Uhl-III (100 MW), Lower Uhl (13 MW) and Lambadug (25 MW) are the 3 under construction projects. Uhl (14 MW) and Uhl Khad (14 MW) are the 2 proposed projects while recently 2 more projects Bhujling (20 MW) and Makori (20.80 MW) have been advertised and allotted by the government.

More than 95% (314 MW) of the total power potential (328 MW) of Uhl river sub-basin has already been harnessed through 5 projects. Uhl Khad has also been proposed and in addition two more projects have recently been advertised for allotment. Uhl Khad will divert water of Uhl river and drain into Beas river instead of Uhl river which will result in decreased flow in 6.40 km stretch of Uhl river up to its confluence with Beas river.

Entire Uhl river has been included in negative list for hydropower projects to conserve fish by HP State Fisheries Department. Even after the implementation of 5 projects it offers habitat for trout fisheries, breeding and spawning. Kamand, Tikkar, Tikkan, Lachkhandi and Barot on Uhl have been identified as trout fisheries sites. Tikkan one one of potential breeding site of trout on Uhl river. There is a fish farm on Barot reservoir before the confluence of Lambadug with Uhl river.

On Rana Khad another tributary in the sub-basin there potential breeding sites of mahseer and trout at Rana Khad and Sukhad Khad, respectively. Rana Khad is already a mahseer fisheries site. Arnodi Khad another left bank tributary has potential trout breeding site at Kotli and entire stream like Uhl river has been included in negative list of streams for hydropower development for the conservation of fish.

In view of the further development of more hydropower projects might affect the important trout and mahseer habitats.

Recently allotted 2 projects viz. Bhujling and Makori are located within Dhauladhar Wildlife Sanctuary, therefore these may not be allowed.

9.4.10 Beas IV Sub-basin

Beas IV sub-basin comprises of the right bank catchment area of Beas river from the confluence of Rana Khad and Arnodi Khad with river Beas up to Pong Dam. The elevation varies from 400 m to about 4900 m.

9.4.10.1 Forest Cover & Forest Types

The forest cover in this sub-basin increased by 2.54% in 2015 estimate (**Figure 9.35 and Table 9.31**). However Open forest cover too has increased by 8%. The scrub has decreased significantly by about 93% in the sub-basin.

Table 9.31: Forest cover changes from 2005 to 2015

Class	2005		2015		Change	
	(ha)	(%)	(ha)	(%)	(ha)	(%)
Very Dense Forest	28237.75	7.75	29650.14	8.13	1412.39	5.00
Moderately Dense Forest	90891.40	24.93	91263.25	25.04	371.85	0.41
Open Forest	22449.18	6.16	24263.77	6.66	1814.59	8.08
Total Forest	**141578.33**	38.84	**145177.15**	**39.83**	**3598.83**	**2.54**
Scrub	493.71	0.14	34.47	0.01	-459.23	-93.02
Non Forest	222447.92	61.02	219308.32	60.16	-3139.59	-1.41
Total Geographic Area (ha)	**364519.95**					

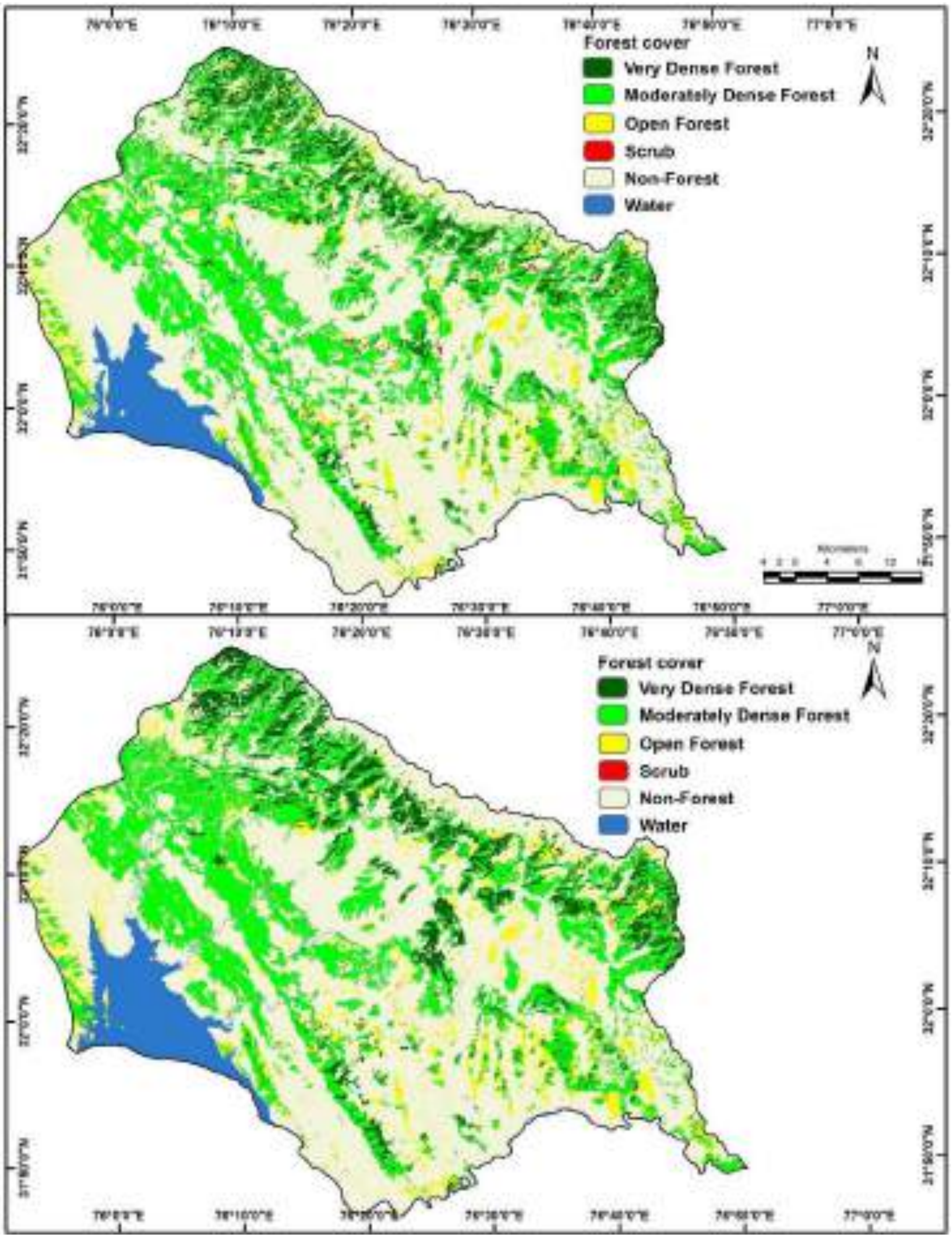


Figure 9.35: Forest cover map for the year 2005 and 2015 of Beas IV Sub-basin

(*Source:* Indian State of Forest Report, 2005 and 2015, Forest Survey of India)

In this sub-basin too agriculture is the predominant land use which is about 32% of sub-basin area (**Figure 9.36**). Semi-evergreen forest in the main forest type and scrub forest is next major land use.

Biological Richness is under High category along with Moderate category (**Figure 9.37 & Table 9.32**). Fragmentation of landscape too is moderate while disturbance is moderate to high (**Figures 9.38** & **8.39** and **Table 9.32**).

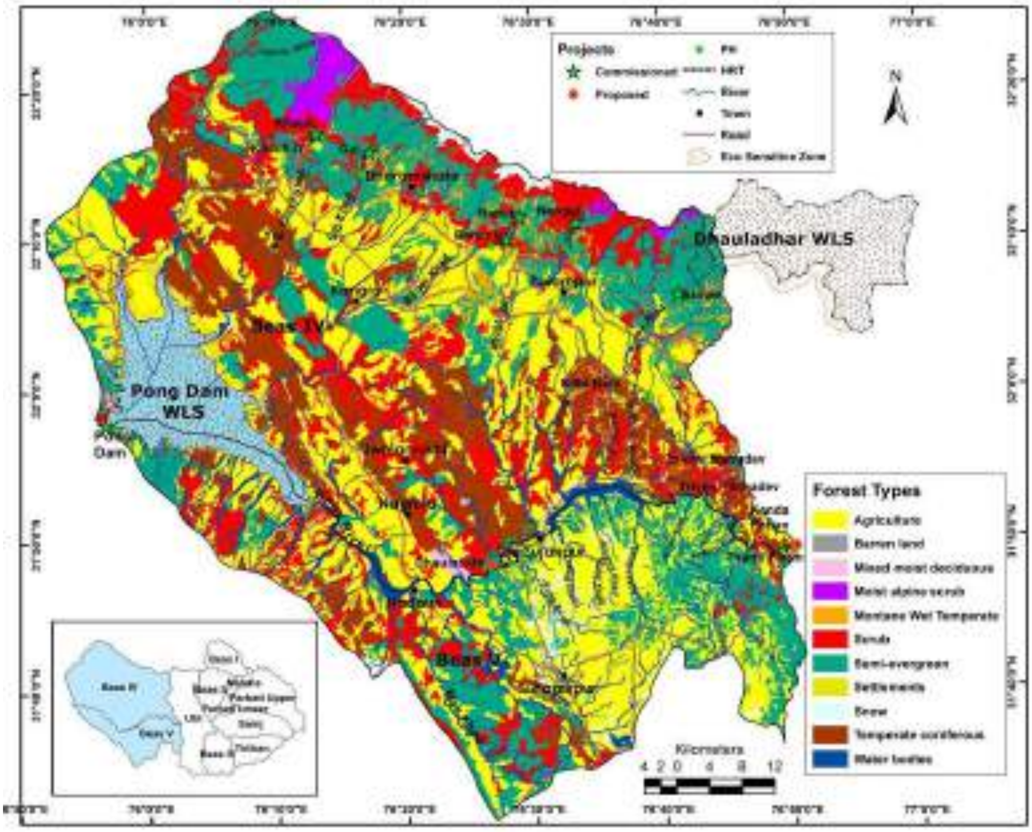


Figure 9.36: Forest type map of Beas IV and Beas V sub-basins

Table 9.32: Area under different Biological Richness Index categories in Beas IV sub-basin

Biological Richness Index	Area (sq km)	(%)
Very High	123.28	17.52
High	282.76	40.19
Moderate	118.58	16.85
Low	3.16	0.45
Other Areas (Water, Barren land, Snow, Glaciers, etc.)	175.86	24.99
	703.65	**100.00**

Table 9.33: Area under different categories of Fragmentation Index and Disturbance Index in Beas IV sub-basin

Fragmentation Index	Area (sq km)	(%)	Disturbance Index	Area (sq km)	(%)
High	49.43	7.03	Very High	20.12	2.86
Moderate	142.15	20.20	High	164.80	23.42
Low	336.65	47.84	Moderate	211.87	30.11
Other Areas (Water, Barren	175.42	24.93	Low	130.76	18.58

Fragmentation Index	Area (sq km)	(%)	Disturbance Index	Area (sq km)	(%)
land, etc.)					
			Other Areas (Water, Barren land, etc.)	176.10	25.03

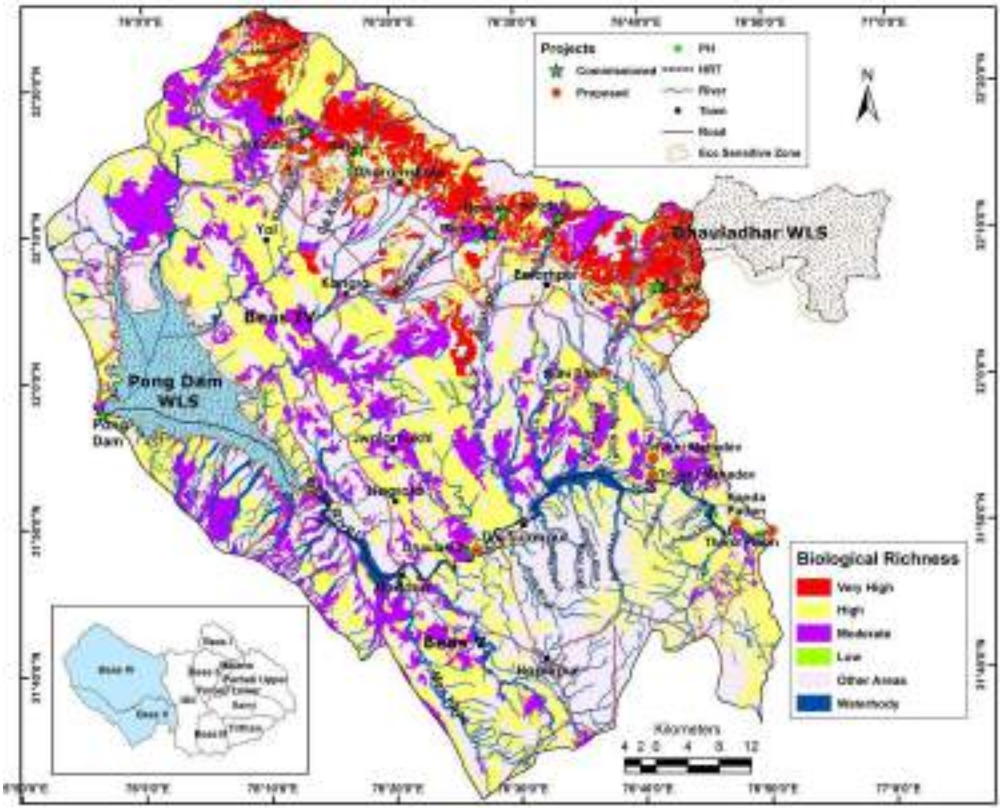


Figure 9.37: Biological Richness Index map of Beas IV and Beas V sub-basins

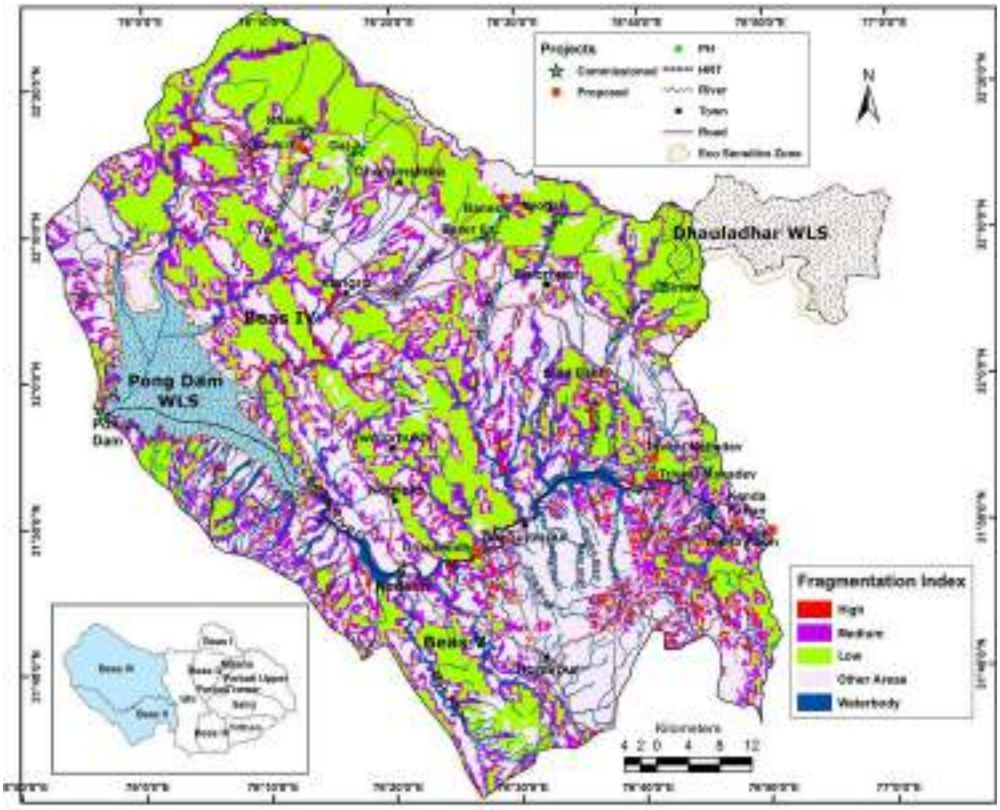


Figure 9.38: Fragmentation Index map of Beas IV and Beas V sub-basins

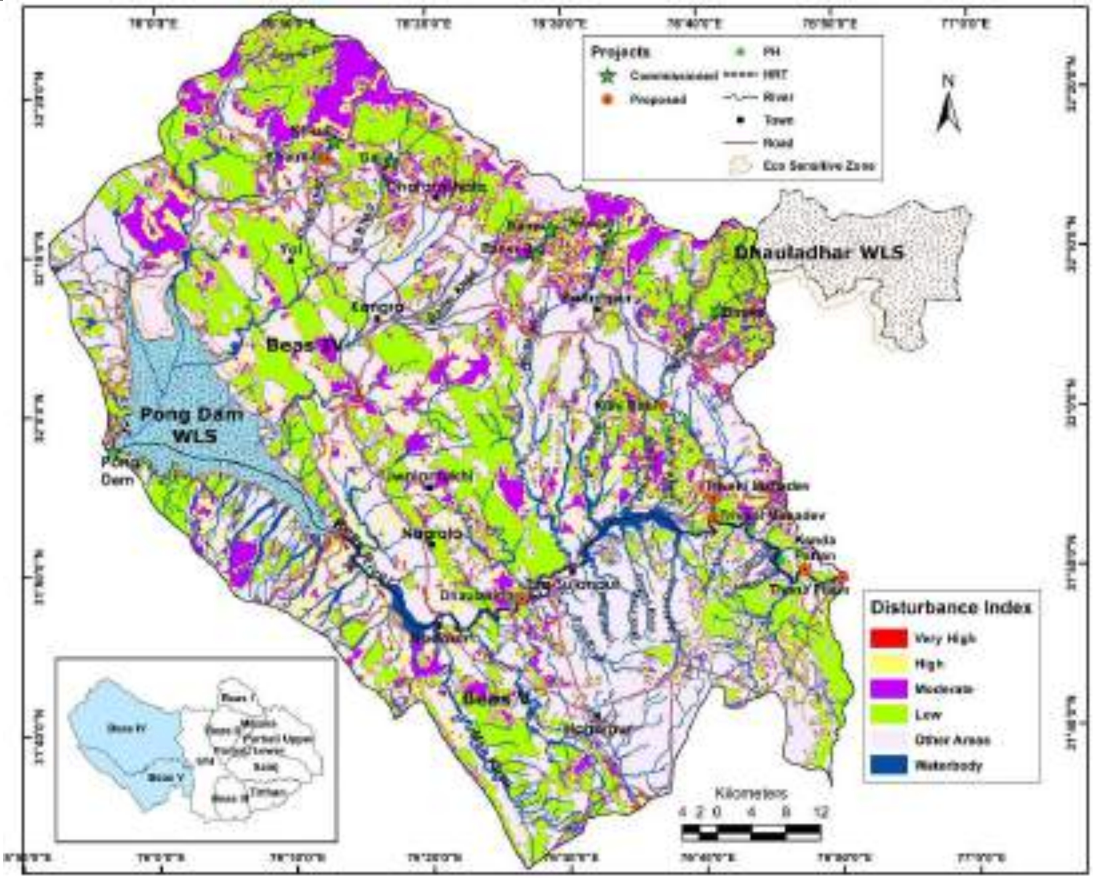


Figure 9.39: Disturbance Index map of Beas IV and Beas V sub-basins

9.4.10.2 Biodiversity Profile

During the present studies 146 species of flowering plants were recorded during field surveys conducted in the projects areas though according to cumulative list compiled from primary surveys and secondary sources 154 angiosperm species are reportedly found in the basin.

No RET species according to BSI Red Data Book was found during field sampling in any of the project sites. *Indigofera heterantha* a Vulnerable as per IUCN Redlist was found in the project area of Neugal HEP.

Berberis aristata (EN) and *Zathoxylum armatum* (EN) the two important FRLHT RET medicinal plants list were found in project areas of Neugal Khad, Baner and Binwa HE projects.

Thirty-six (36) species of mammals are reported from this sub-basin out of which 8 are listed as RET in IUCN Redlist and 7 are Schedule-I species. Important species are Leopard (*Panthera pardus*), Otter (*Lutra lutra*), Goral (*Naemorhedus goral*), Striped hyaena (*Hyaena hyaena*), and Royle's vole (*Alticola roylei*). All these are listed in IUCN Redlist and are also listed as Schedule-I species as per WPA

Avi-fauna of the sub-basin is comprised of 418 species which are reportedly found in this area with 5 Schedule-I species and 21 RET species in IUCN Redlist. These are listed in **Table 9.34**). Pong dam lake is the most important birding site in the basin. It receives large populations of winter fowls for wintering.

Table 9.34: RET bird species reported from Beas IV sub-basin

Name	*Species name*	IUCN Status	WPA Schedule-I
Cinereous vulture	*Aegypius monachus*	NT	
Imperial Eagle	*Aquila heliaca*	VU	
Steppe Eagle	*Aquila nipalensis*	EN	
Common Pochard	*Aythya ferina*	VU	
Ferruginous Pochard	*Aythya nyroca*	NT	
Curlew Sandpiper	*Calidris ferruginea*	NT	
Cheer Pheasant	*Catreus wallichii*	VU	I
Pallid Harrier	*Circus macrourus*	NT	
White-backed Vulture	*Gyps bengalensis*	CR	
Himalayan Griffon	*Gyps himalayensis*	NT	
Long-billed Griffon	*Gyps indicus*	CR	
Black tailed Godwit	*Limosa limosa*	NT	
Monal Pheasant	*Lophophorus impejanus*		I
Painted Stork	*Mycteria leucocephala*	NT	
Egyptian Vulture	*Neophron percnopterus*	EN	
Eurasian Curlew	*Numenius arquata*	NT	
Osprey	*Pandion haliaetus*		I
Alexandrine Parakeet	*Psittacula eupatria*	NT	
Red-headed vulture	*Sarcogyps calvus*	CR	
Indian Tern	*Sterna aurantia*	NT	
Western Tragopan	*Tragopan melanocephalus*	VU	I
River Lapwing	*Vanellus duvaucelii*	NT	
Northern Lapwing	*Vanellus venellus*	NT	

Water quality in general in this sub-basin is in Good category. Biological water quality in the form of BMWP also is in Good category.

Fish fauna of the sub-basin is comprised of 57 species. Mahseer, catla, carps, mrigal, rohu, and Singhara are main fish species found in the reservoir of Pong dam and its tributaries and is dominated by catfishes.

Beas IV sub-basin is the most important sub-basin in terms of fisheries which is mainly due to Pong dam lake. Most of its tributary streams like Dehar Khad, Gaj Khad, Baner Khad, Neugal Khad and Binwa Khad are in negative list of streams for hydropower development for fish conservation by HP Fisheries Department.

There are three fish farms in the sub-basin i.e. in Pong Dam, Kangra and Chobbu at Palampur. Important mahseer fishing sites are located at Dehar Khad confluence with Pong reservoir, Kuru, Neugal Khad, Binwa Khad and Sari Marog. Binwa Khad is one of the potential mahseer breeding site. Khauli and Poon Nala are the potential trout breeding sites in the sub-basin.

Impact Assessment

There is one big project Pong Dam (396 MW) in the sub-basin which is operational since 1978. In addition, there are 6 more operational projects which are on the tributaries draining into Pong dam reservoir or Beas river. These are Gaj, Khauli, Baner, Baner-II, Neugal, and Binwa projects with combined capacity of 61.50 MW and are since 2012, 2007, 1996, 2015, 2013 and 1984, respectively.

Kilhi Bahl (7.50 MW) is a proposed project while recently Khauli-II (6 MW) has been recently advertised for allotment.

It may be noted that since 2005 the forest cover in th sub-basin has incread by 2.54%. There has not been much degradation of the landscape also. After the commissioning of Pong Dam, the population of migratory birds has increased manifold due to the formation large water body i.e. Pong Dam reservoir and due to these reasons only it has been declared as Pong Dam Wildlife Sanctuary and listed as Ramsar site. It is most preferable habitat for water fowl for wintering.

Not only it has lead to increase in bird populations it has also given a boost to fisheries and source of income for locals. As discussed above even tributaries of Beas draining into the reservoir provide suitable habitat not only for mahseer fisheries but for trout fisheries also. There are 3 mahseer fish farms in this sub-basin. One is located near the confluence of Dehar Khad with Pong reservoir, second one is in Kangra and the third one is at Chobbu near Palampur. Kuru, Harsi Patan- Nadaun, Neugal Khad, Sari Marog, Binwa Khad and Rana Khad are the imporatant identified mahseer fishing sites. Binwa Khad and Rana Khad are potential breeding sites of mahseer. Khauli Nala, upper reaches of Binwa Khad near Poon Nala confluence and Sukhad Khad in upper catchment of Rana Khad are the potential trout breeding sites.

Owing its rich fisheries Dehar Khad, Gaj Khad, Baner Khad, Neugal Khad and Binwa Khad have been included in the negative list of streams for hydropower development for fish conservation by HP Fisheries Department.

Even as 6 projects are already operational on these tributaries, no more projects should be taken up for implementation to preserve the important trout and mahseer habitats. Kilhi Bahl is one such project proposed on Binwa Khad and another recently advertised Khauli-II project may not be alloted. It is therefore recommended to maintain the status quo and no more projects in this sub-basin.

9.4.11 Beas V Sub-basin

Beas V sub-basin comprises of the left bank catchment area of Beas river from the confluence of Rana Khad and Arnodi Khad with river Beas up to Pong Dam. The elevation varies from 380 m to about 2040 m.

9.4.11.1 Forest Cover & Forest Types

In this sub-basin also the forest cover has increased slightly by 1.64%. Very Dense and Moderately Dense forest have registered an increase of 2.76 and 2.59%, respectively (**Figure 9.40** and **Table 9.35**).

Table 9.35: Forest cover changes from 2005 to 2015

Class	2005		2015		Change	
	(ha)	(%)	(ha)	(%)	(ha)	(%)
Very Dense Forest	3908.22	2.46	4015.95	2.53	107.72	2.76
Moderately Dense Forest	12922.63	8.13	13256.80	8.34	334.17	2.59
Open Forest	16676.15	10.49	16783.65	10.56	107.50	0.64
Total Forest	**33506.99**	21.08	**34056.39**	**21.42**	549.40	**1.64**
Scrub	23.62	0.01	66.97	0.04	43.35	183.52
Non-Forest	125436.40	78.91	124843.65	78.53	-592.75	-0.47
Total Geographic Area (ha)	**158967.02**					

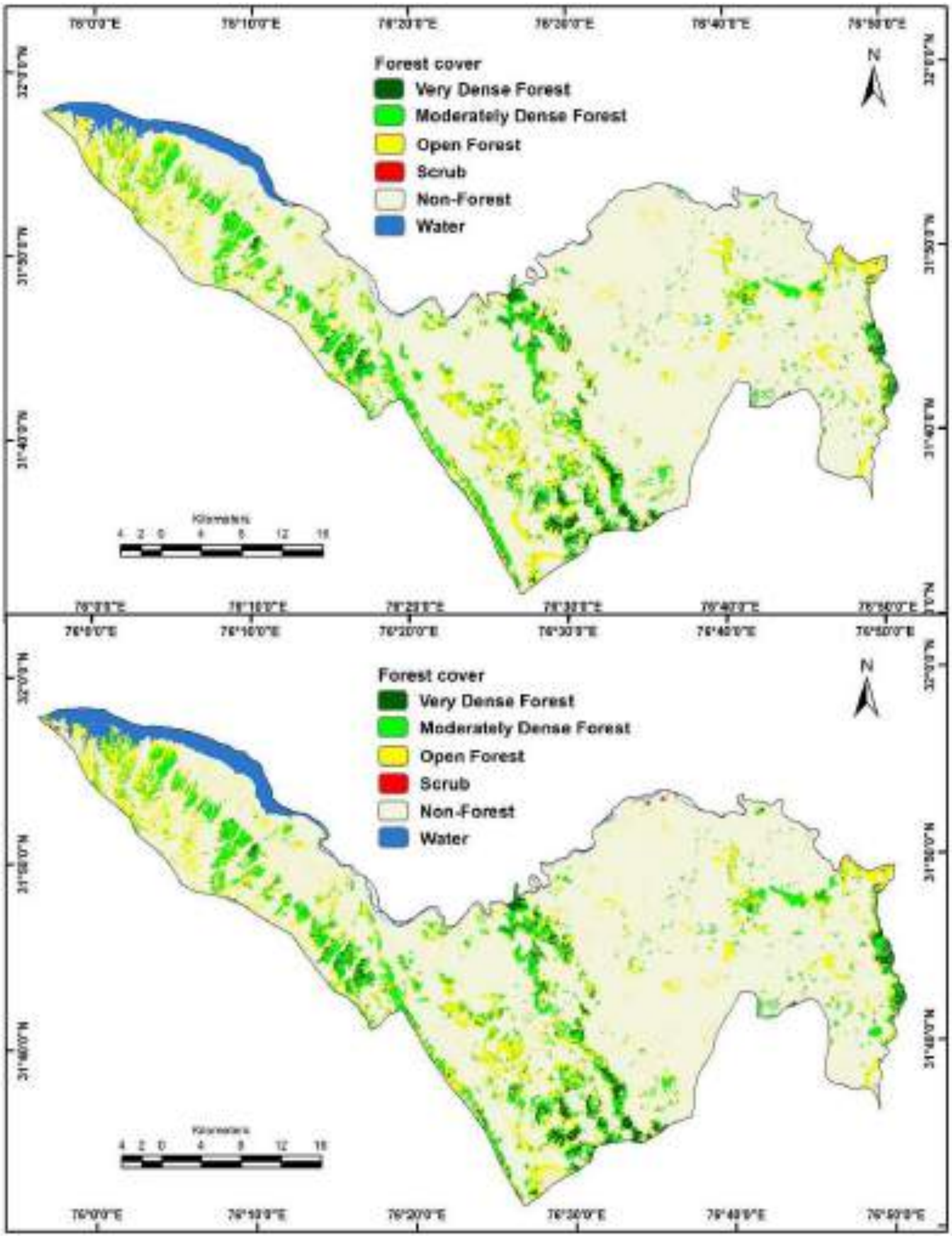


Figure 9.40: Forest cover map for the year 2005 and 2015 of Beas V Sub-basin
(*Source:* Indian State of Forest Report, 2005 and 2015, Forest Survey of India)

As seen from the forest/vegetation types map agriculture is main land use in the sub-absin comprising nearly 45% of its area (**Figure 9.36**).

The forest cover is mainly comprised of Semi-evergreen forest covering 27.46% of the sub-basin and as much as 12.27% is under scrub.

Biological Richness Index map indicates that 4019% of its area is under High richness category (refer **Table 9.36**). The fragmentation of landscape is in Moderate category (**Table 9.37**).

Table 9.36: Area under different Biological Richness Index categories in Beas V sub-basin

Biological Richness Index	Area (sq km)	(%)
Very High	123.28	17.52
High	282.76	40.19
Moderate	118.58	16.85
Low	3.16	0.45
Other Areas (Water, Barren land, etc.)	175.86	24.99
	703.65	**100.00**

Table 9.37: Area under different categories of Fragmentation Index and Disturbance Index in Beas V sub-basin

Fragmentation Index	Area (sq km)	(%)	Disturbance Index	Area (sq km)	(%)
High	49.43	7.03	Very High	20.12	2.86
Moderate	142.15	20.20	High	164.80	23.42
Low	336.65	47.84	Moderate	211.87	30.11
Other Areas (Water, Barren land, etc.)	175.42	24.93	Low	130.76	18.58
			Other Areas (Water, Barren land etc.)	176.10	25.03

9.4.11.2 *Biodiversity Profile*

During the present studies 101 species of flowering plants were recorded during field surveys conducted in the projects areas though according to cumulative list compiled from primary surveys and secondary sources 105 angiosperm species are reportedly found in the basin.

No RET species according to BSI Red Data Book was found during field sampling in any of the project sites. Only one species under IUCN Redlist is found in this sub-basin.

Thirty-three (33) species of mammals are reported from this sub-basin out of which 5 are listed as RET in IUCN Redlist and 4 are Schedule-I species. Important species are Leopard (*Panthera pardus*), Otter (*Lutra lutra*), Goral (*Naemorhedus goral*), Striped hyaena (*Hyaena hyaena*), and Royle's vole (*Alticola roylei*). All these are listed in IUCN Redlist and are also listed as Schedule-I species as per WPA.

Avi-fauna of the sub-basin is comprised of 145 species which are reportedly found in this area with one Schedule-I species and 3 RET species in IUCN Redlist.

Water quality in general in this sub-basin is in Good category. Biological water quality in the form of BMWP was in Good category.

Fish fauna of the sub-basin is comprised of 41 species Mahseer, catla, carps, mrigal, rohu, and Singhara are main fish species found.

Impact Assessment

There is no operational project in this sub-basin however 3 projects are proposed on Beas river with total capacity of 353 MW. These are Triveni Mahadev (96 MW), Thana Plaun (191 MW) and Dhaulasidh (66 MW).

Beas river in the sub-basin in general is quite wide with its width varying between 250m and 1000m at different places. Beas river flows with a gentle gradient in the sub-basin traversing about 120 km from El. 510m to El. 410m. People living in this area/ stretch are dependent upon Beas river for drinking and irrigation.

This part of the river constitutes important mahseer habitat as mahseer breeds and spawns in its tributaries on the left bank as well as right bank. Right bank tributaries are Man Khad and Gasoti Khad along with Kunah Khad. Both these tributaries are in the negative list of HP Fisheries Department for hydropower project owing to their fisheries potential.

The proposed 3 projects would affect about 52 km of Beas river mainly due to formation of reservoirs. Dhaulasidh HEP alone would affect about 20 km of Beas river with total submergence area of about 320 ha and reservoir would also enter tributaries like Neugal Khad (2 km) and Pung Khad (4 km). The project has already been granted Environmental Clearance by MoEF&CC. Triveni Mahadev and Thana Plaun HEPs would have reservoirs of about 10 and 16 km. There will be a free-flowing stretch of Beas river varying from 12 to 25 km between these proposed projects. While Dhaulasidh HEP has obtained Environmental Clearance in 2013 as well as Stage-I Forest Clearance recommended in 2012, Thana Plaun and Triveni Mahadev HEPs till date have obtained Scoping Clearance only.

The proposed projects will have to make arrangement for movement of mahseer in Beas river and into its tributaries for breeding and spawning as these would restrict the free movement of mahseer which will affect fisheries potential of Beas river in this stretch and fisheries is one of the income generating activity for the local population even though the proposed reservoir would help in fish production which however mainly would comprise mainly of commercial carps and exotic fish species.

9.5 IMPACT OF CASCADE DEVELOPMENT

When hydropower projects were planned in different river basins during last 10-15 years, the focus of planners were on maximum utilization of available hydropower potential in each river basin. This resulted in projects being conceived in cascade with Full Reservoir Level (FRL) of downstream projects almost matching with that of Tail Water Level (TWL) of upstream projects in several cases. Expert Appraisal Committee (EAC) for River Valley and Hydropower Projects has always been insisting on the importance of free-flowing river stretches between adjacent projects with a view to provide natural conditions to river for recovery.

To review the present status of availability of free-flowing river stretches in Beas basin, critical stretches have been identified where projects have been planned in cascade and longitudinal profiles prepared. These are:

1. Main Beas River (10 Projects)
2. Parbati River (8 projects)
3. Malana Nala (3 projects)
4. Uhl River (4 Projects)

In addition, there are projects in cascade on Baner Khad (2 projects) and projects on tributaries.

9.5.1 Longitudinal Profile of Beas River

Main Beas River has nine planned hydropower projects, viz.;

- Beas Kund SHEP (9 MW)
- Bhang HEP (9 MW)
- Raison SHEP (18 MW)
- Larji HEP (126 MW)
- Beas Satluj Link HEP (990 MW)
- Thana Plaun HEP (191 MW)
- Kanda Pattan (40 MW)
- Triveni Mahadev HEP (96 MW)
- Dhaulasidh HEP (66 MW)
- Pong Dam HEP (396 MW)

Total length of Beas river in Himachal Pradesh is about 274 Km from origin. It flows free for 8.77 Km in upper reaches up to the tip of reservoir of upper most project i.e. Beas Kund SHEP. There are ten projects viz. Beas Kund, Bhang, Raison, Larji, Beas Satluj Link, Thana Plaun, Kanda Pattan, Triveni Mahadev, Dhaulasidh and Pong Dam together will affect about 260.06 Km of the river stretch. Out of this about 86.06 Km will be in reservoirs, 36.96 Km in tunnels and 137.04 km free flowing stretch that can be seen from L-section given at **Figure 9.41**.

9.5.2 Longitudinal Profile of Parbati River

Parbati river is a left bank tributary of Beas River and has eight planned hydropower projects viz.

1. Nakhtan HEP (460 MW)
2. Parbati II HEP (800 MW)
3. Balargha SHEP (9 MW)
4. Jari SHEP (12 MW)
5. Parbati SHEP (12 MW)
6. Sharni SHEP (9.60 MW)

7. Sarsadi SHEP (9.60 MW)
8. Sarsadi II SHEP (9 MW)

Total length of Parbati river is 77.90 Km from origin to its confluence with Beas river. It flows free for 27.50 Km in upper reaches up to the tip of reservoir of upper most project i.e. Nakhtan HEP. There are eight projects viz. Nakhtan, Parabti II, Balargha, Jari, Parbati, Sharni, Sarsadi and Sarsadi II together will affect about 46.58 Km of the river stretch. Out of this 3.64 Km will be in reservoirs, 24.38 Km in tunnels and 18.56 km free flowing stretch that can be seen from L-section given at **Figure 9.42**.

9.5.3 Longitudinal Profile of Malana Nala

Malana Nala is a tributary of Parbati River and has three planned hydropower projects on main river viz.

1. Malana III HEP (30 MW)
2. Malana II HEP (100 MW)
3. Malana I HEP (86 MW)

Out of about 25.52 Km long river stretch of Malana nala from origin to its confluence with Parbati river, these projects will use about 11.86 Km of river stretch. It flows free for 11.16 Km in upper reaches up to the tip of reservoir of upper most proposed project i.e. Malana III HEP. Free flowing river stretch in adjacent projects can be seen from L-section of Malana Nala given at **Figure 9.43**.

9.5.4 Longitudinal Profile of Uhl River

Uhl River is a tributary of Beas River and has four planned hydropower projects viz.

1. Uhl SHEP (14 MW)
2. Uhl I (Shanon) HEP (110 MW)
3. Lower Uhl SHEP (13 MW)
4. Uhl Khad SHEP (14 MW)

Total length of Uhl river is 82.50 Km from origin to its confluence with Beas river. It flows free for 20.50 Km in upper reaches up to the tip of reservoir of upper most project i.e. Uhl SHEP. From FRL tip of upper most project i.e. Uhl SHEP on Uhl River upto the tip of the reservoir of Uhl Khad SHEP, these projects will use about 55.60 Km of river stretch. Major free stretch of 38.84 Km is between Uhl I and Lower Uhl HEPs. L-section of Uhl River is given at **Figure 9.44**.

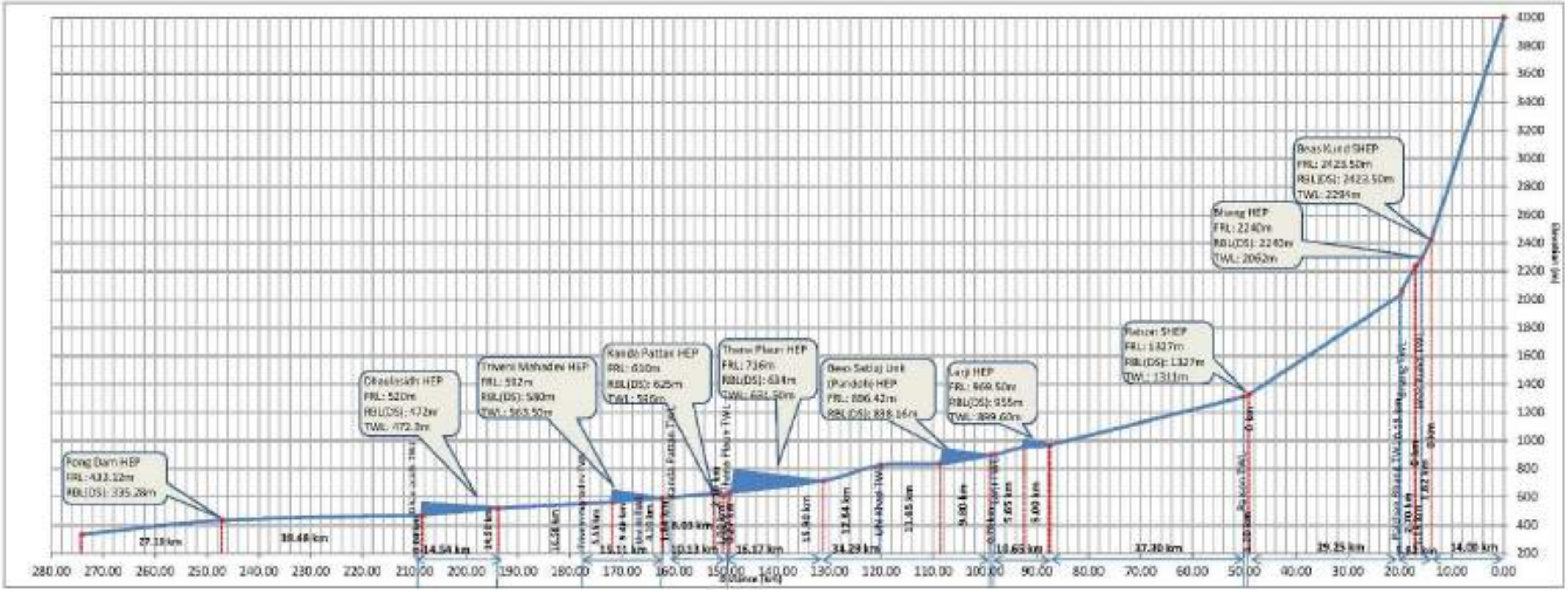


Figure 9.41: Longitudinal Profile of Beas River

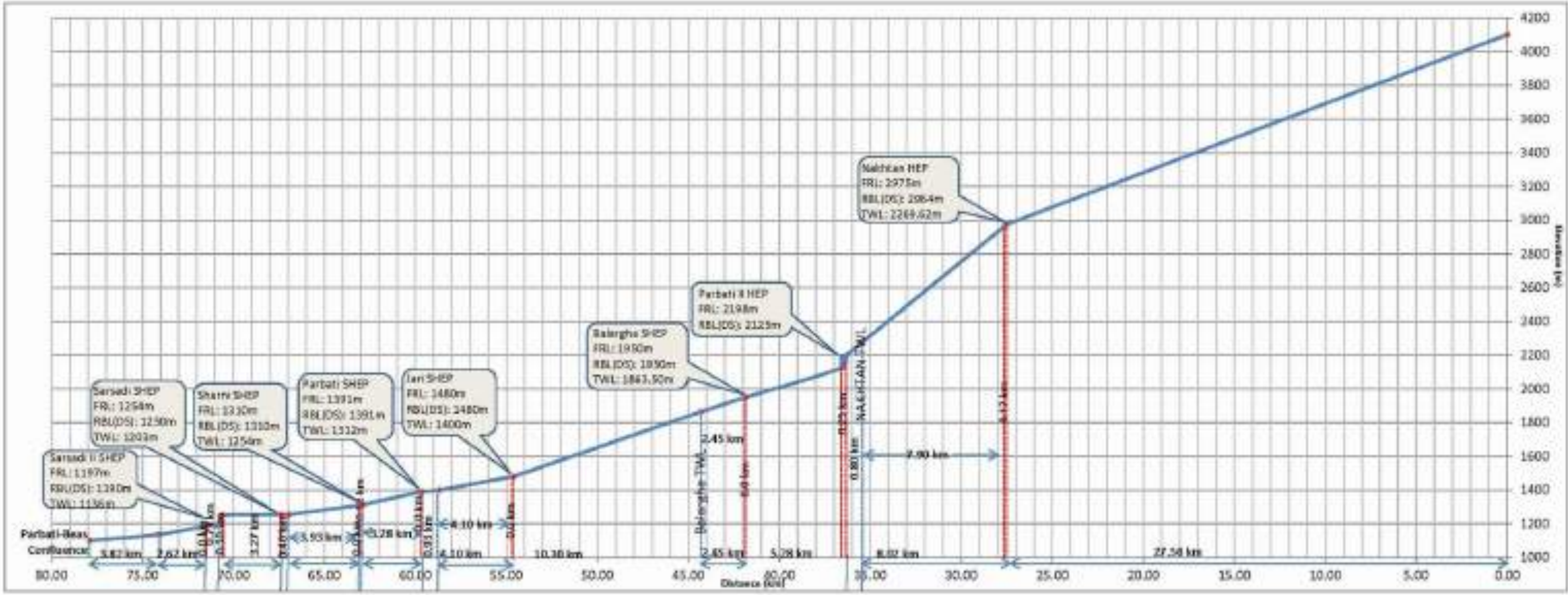


Figure 9.42: Longitudinal Profile of Parbati River

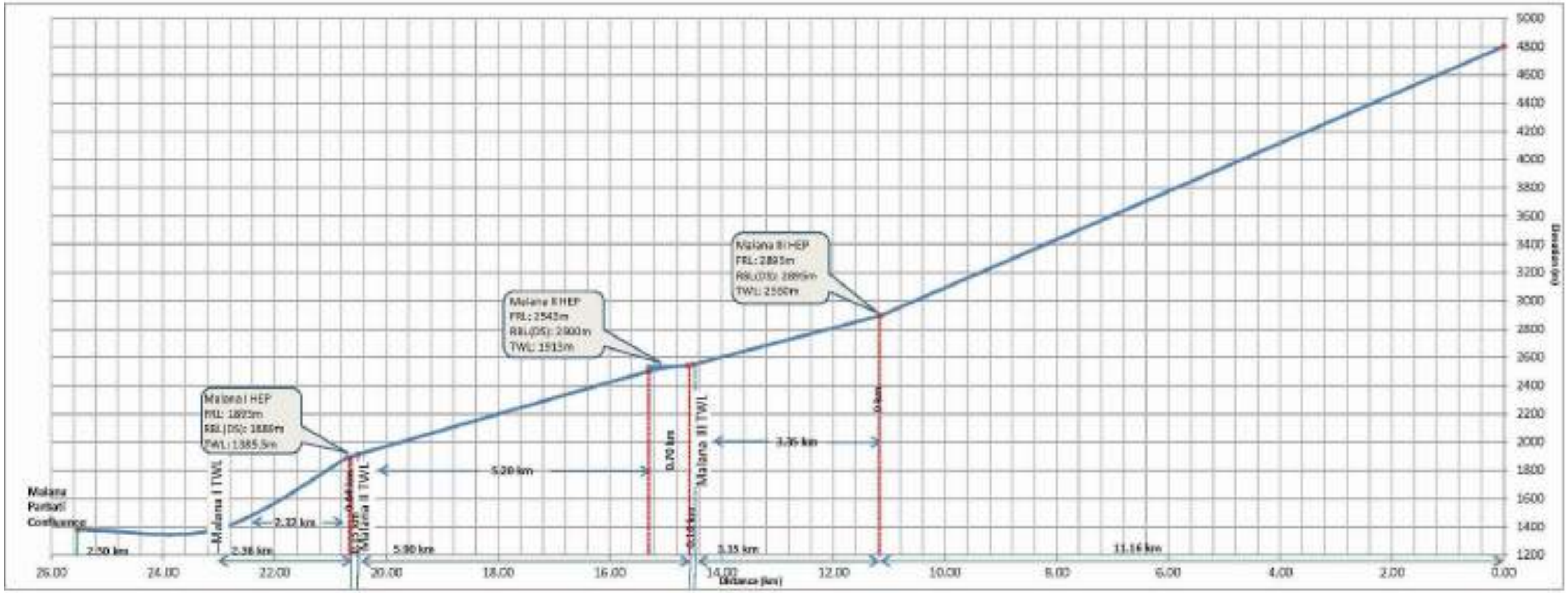


Figure 9.43: Longitudinal Profile of Malana Nala

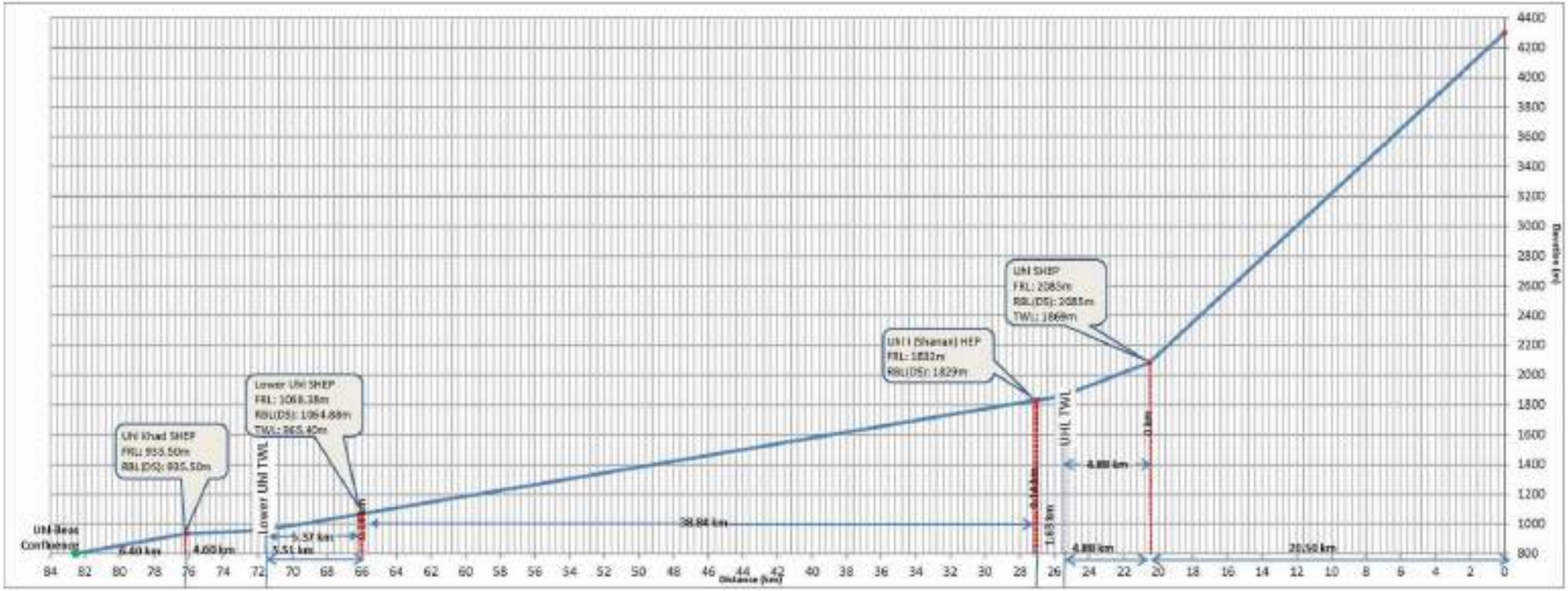


Figure 9.44: Longitudinal Profile of Uhl River

It can be seen from the data on free-flowing stretch and affected river stretch downstream of diversion structure given in **Table 9.38** that Parbati river is most affected by the cascade of projects where at places there is hardly any free flowing stetch between two projects. Moreover, large part of flow of Parbati is being diverted to other basin due to construction of Parbati II HE project where all the diverted water does not come back to Parbati river rather it gets added to the fow of Sainj river, a different basin.

Table 9.38: Summary of length of affected river stretch and free-flowing between cascade of two projects on Beas river and its tributaries

S. No.	Name of Project	Capacity (MW)	River Length Affected (km)			Present free stretch between TWL of u/s project and FRL of the d/s project in km	River Length likely to be affected (m)/MW
			Reservoir reach	Intermediate reach	Total		
BEAS RIVER							
1	Beas Kund	9	0	1.82	1.82	14.00 (Length from source to upstream of Beas Kund)	202.22
2	Bhang	9	0	2.70	2.70	1.15	300.00
3	Raison	18	0	1.10	1.10	29.25	61.11
4	Larji	126	5	5.65	10.65	37.30	84.52
5	Beas Sutlej Link (Pandoh)	990	9.80	-	9.80	0.70	9.90
6	Thana Plaun	191	18.00	0.27	18.27	10.74	95.65
7	Kanda Pattan	40	2.10	8.03	10.13	1.00	253.25
8	Triveni Mahadev	96	9.56	5.55	15.11	1.84	157.40
9	Dhaulasidh	66	14.50	0.04	14.54	16.58	220.30
10	Pong Dam	396	27.10	-	27.10	38.48	68.43
	TOTAL	**1941**	**86.06**	**25.16**	**111.22**	**Total River Length = 151.04**	
PARBATI RIVER							
	Nakhtan	460	0.12	7.90	8.02	27.50 (Length from source to upstream of Nakthan FRL)	17.43
	Parbati-II	800	0.25	0	0.25	0.8	Inter basin transfer
	Balargha	9	0	2.45	2.45	5.28	272.22
	Jari	12	0	4.10	4.10	10.30	341.67
	Parbati	12	0	3.28	3.28	0.93	273.33
	Sharni	9.6	0	3.93	3.93	0.12	409.38
	Sarsadi	9.6	3.27	0.10	3.37	0.40	351.04
	Sarsadi-II	9	0	2.62	2.62	0.73	291.11
						3.82 (From TWL of Sarsadi-II up to confluence with Beas river)	
	TOTAL	**1321.2**	**3.64**	**24.38**	**28.02**	**77.90**	
UHL RIVER							
	Uhl	14	0	4.88	4.88	**20.50** (Length from source to upstream of Uhl)	348.57
	Uhl-I (Shanan)	110	0.14	0	0.14	1.63	1.27
	Lower Uhl	13	0.14	5.37	5.51	38.84	423.85
	Uhl Khad	14	0	6.40	6.40	4.60	457.14
	TOTAL	**151**	**0.28**	**10.25**	**10.53**	**82.5**	
MALANA							

S. No.	Name of Project	Capacity (MW)	River Length Affected (km)			Present free stretch between TWL of u/s project and FRL of the d/s project in km	River Length likely to be affected (m)/MW
			Reservoir reach	Intermediate reach	Total		
NALA							
	Malana-III	30	0	3.35	3.35	**11.16** (Length from source to upstream of Malana-III FRL)	111.67
	Malana-II	100	0.7	5.2	5.90	0.10	59.00
	Malana-I	86	0.04	2.32	2.36	0.15	27.44
						2.5 (From TWL of Malana-I up to confluence with Parbati river)	
	TOTAL	**216**	**0.74**	**10.87**	**11.61**	**25.52**	

CHAPTER-10

CONCLUSIONS & RECOMMENDATIONS

10.1 INTRODUCTION

Previous chapter has discussed the cumulative impacts in Beas basin keeping in view the baseline setting in the region. This chapter deals with specific recommendations for sustainable and optimal ways for hydropower development in the basin. Recommendations are based upon the impacts evaluated and probable scenarios on biodiversity values, riverine ecosystem, riparian habitats, and environmental flow requirements.

Beas Basin in Himachal Pradesh has 4877.70 MW of power potential (for > 5 MW projects), distributed among 51 hydropower projects spread throughout the basin. Out of these 51 projects, 22 projects are commissioned (total installed capacity 2820.90 MW), 5 are under construction (total installed capacity 947 MW), 20 are at various stages of investigations (total installed capacity 1028.90 MW) and 4 are yet to be allotted. Out of proposed 24 projects, many of which are under different stages of survey and investigation, only 4 projects have installed capacity of more than 50 MW i.e. requiring environment clearance as category “A” projects; two are with installed capacity greater than 25 MW but less than 50 MW i.e. environment clearance is applicable under category “B” and remaining 18 projects are less than 25 MW of installed capacity i.e. environment clearance is not applicable.

As can be seen from above text, large part of basin’s hydropower potential has already been exploited and more than 50 percent projects are commissioned/under construction. No modification of such projects is suggested; however, environment flow assessment is carried out uniformly for all the projects, irrespective of their status of implementation, and therefore to ensure continuity of flow in the river, recommendations are made for all the projects. For remaining 24 projects, which are under survey & investigations/yet to be allotted critical assessment is made for their impacts keeping in view the sensitivity of their location and cumulative impacts, and recommendations are made accordingly.

10.2 SUSTAINABLE AND OPTIMAL WAYS OF HYDROPOWER DEVELOPMENT

10.2.1 Preclusion of projects

Following Projects were recommended for dropping in the draft report:

S. No.	Name of Project	Capacity (MW)	Developer	Status
1	Jobrie	12	Green Infra Limited	Under S&I
2	Manalsu	21.9		Yet to be allotted
3	Bujling	20	Sai Engineering Foundation	Recently Allotted
4	Makori	20.8	Sai Engineering Foundation	Recently Allotted
5	Palchan Bhang	9	Palchan Bhang Power Pvt. Ltd.	Under S&I
6	Bhang	9	Bhang Hydel Power L.L.P.	Under S&I
7	Seri Rawla	7		Yet to be allotted
8	Raison	18	Himachal Pradesh State Electricity Board	Under S&I

S. No.	Name of Project	Capacity (MW)	Developer	Status
9	Parbati	12	Manimahesh Power Private Ltd.	Under S&I
10	Sarsadi	9.6	Himshakti Power Pvt. Ltd.	Under S&I
11	Sharni	9.6	Sharni Hydro Power Pvt. Ltd.	Under S&I
12	Sarsadi-II	9	Aroma Colonisers Pvt. Ltd.	Under S&I
Total		**157.9**		

Jobrie (12 MW), Manalsu (21.9 MW), Bhujling (20 MW) and Makori (20.8 MW) HEPs

These four projects are located within the protected areas. Jobrie lies within Inderkilla National Park, Manalsu in Manali Wildlife Sanctuary, Buijang and Makori are located within Dhauladhar Wildlife Sanctuary.

Palchan Bhang (9 MW) and Bhang (9 MW) HEPs

Trench weir Palchan Bhang HE project, is located at 2246m (river bed level at intake on Beas River) while tail water level is 2035m and the trench weir of immediate downstream project on Beas River Bhang HEP is 2240m with tail water at 2104m. Due to conflicts in level only one project is possible. However, both are recommended for dropping keeping in view the disturbance along NH-21 leading to Rohtang Pass, which is already quite high. Any construction on that stretch will further damage the fragile forest cover in the direct impact area as the project components of Bhang HE project are located along the NH-21. The project is located highly disturbed area and dropping will avoid further damage and help in preservation of free flowing stretch of about 3.85 km of Beas river.

Seri Rawla (7 MW) HEP

Project is located in high altitude area at an elevation of about 3000m characterized by Moist alpine scrub and the area is very rich in biodiversity.

Raison HEP (18 MW)

Raison project which is proposed on the main Beas river, upstream of Kullu, should be dropped as the construction along the already crowded National Highway between Kullu and Manali is not desirable. Projects are already operational on tributaries and one project is under construction on Fozal Nalla. The stretch along with tributaries has several trout fisihing sites. Dropping this stretch will keep the main Beas river free for tourism and further degradation of already crowded stretch.

Parbati (12 MW), Sharni (9.6 MW), Sarsadi (9.6 MW) and Sarsadi-II (9 MW)

Four projects viz. Parbati (12 MW), Sharni (9.6 MW), Sarsadi (9.6 MW) and Sarsadi-II (9 MW) with total capacity of 40.20 MW are proposed on Parbati river in cascade. Total length of Parbati river from confluence of Malana Nala to confluence with Beas is little more than 15 km, out which 13 Km will be affected by these four projects. Parbati river is rich in fish fauna and trout is known to migrate upstream in Parbati river; Kasol is an important trout fishing site upstream of these projects. Development of this stretch would hamper trout's movement leading to dwindling of populations of trout and other fishes. Further these projects are located along already stressed narrow Manikaran road. Construction phase will severely affect this stretch.

10.2.2 Recommendations made for Nakhtan HEP (460 MW) in draft report

The proposed Nakthan HE project is located on the boundary of Khirganga National Park. Draft notification declaring ESZ of Great Himalayan National Park Conservation Area (Khirganga National Park is a part) was issued on 25th July 2016; the matter was discussed in Expert Committee Meeting held on 27th February 2017 where it was recommended for finalization subject to certain corrections in coordinates. The project certainly falls within the ESZ as it is just touching the boundary of the National Park, ESZ is about 1.8 Km wide on this part of the park. Entire catchment of Nakthan constitutes Khirganga National Park and is home to important wildlife and number of RET plant species. The construction of the proposed Nakthan HE project would lead to fragmentation of dense temperate forests which contain valuable plant resources. The fragile ecosystem of the area already under stress due to under-construction Parbati-II HE project would be severely affected due to construction of new roads and other project related construction activities like blasting, mining for construction material, and construction of other infrastructure and influx of workers in the otherwise pristine area.

At present the matter related to diversion of Tosh Nalla for Nakthan is sub-judice and EAC has taken a note of it during the discussion in 91st meeting held on 8-9th February 2016. EAC deferred the appraisal till the time the matter is settled in court.

It is therefore recommended, that whenever, the project is considered by EAC for appraisal after court order; it is to ensure that all the project components and pondage, up to the tip of submergence should be well outside the ESZ of Great Himalayan National Park Conservation Area (Khirganga is a part of this). A wildlife management plan should be prepared and approved by Chief Wildlife Warden for the construction of the project ensuring enough safeguard to protect the wildlife in the region.

10.3 ENVIRONMENTAL FLOW RELEASE RECOMMENDATIONS

There are 51 hydro projects in the Beas river basin; for carrying out hydro-dynamic simulation modelling, projects with 25 MW or more installed capacity have been considered, which are 19 projects in number. Out of these 19 projects, 10 are already commissioned, 3 are under construction, 5 are under different stages of survey & investigations, one is yet to be allotted. Recommendations for 19 projects is given at **Table 10.1** below.

Table 10.1: Environment Flow Release Recommendations for Projects with Installed Capacity ≥ 25 MW

Sl No.	Project	River (Affected Stretch)	Recommended E-flow as % of average discharge in 90% DY			Recommended E-flow cumec		
			Lean Season	Peak Season	Other Months	Lean Season	Peak Season	Other Months
1	Beas Satluj Link	Beas River (25 km)	20	15	15	18.99	64.72	25.74
2	Parbati-III	Sainj River (13.7 Km)	20	15	15	1.51	8.46	2.83
3	Allain Duhangan	Allain (9.2 Km)	20	15	15	0.42	2.43	0.85
		Duhangan (5 Km)	20	15	20	0.15	0.96	0.4
4	Larji	Beas River (5.65 Km)	20	15	15	11.42	64.06	21.45
5	Uhl-I	Uhl River (40 Km)	20	15	15	0.44	2.37	1.11
6	Malana-II	Malana Nalla (5.2 Km)	20	15	15	0.52	2.56	1.2
7	Sainj	Sainj River (9 Km)	20	15	15	0.71	3.34	1.61
8	Malana-I	Malana Nalla (2.32 Km)	20	15	15	0.49	3.32	1.24
9	Uhl II	Tailrace of Uhl I	-	-	-	-	-	-
10	Pong Dam	Beas	-	-	-	-	-	-
11	Parbati-II	Parbati River (5.28 Km)	20	15	15	2.99	16.3	3.79
		Jigrai Nalla (0.8 Km)	20	30	25	0.2	1.16	0.54
		Jiva Nalla (8.2 Km)	20	30	25	1.19	6.2	2.53
		Hurla Nalla (12 Km)	20	30	25	0.57	3.12	1.28
12	Lambadug	Lambadug (6.3 Km)	20	15	15	0.25	1.28	0.6
13	Uhl III*	Rana Khad	20	30	25			
		Neri Khad	20	30	25			
14	Nakhtan	Toss (4.4 Km)	25	20	20	0.93	5.24	1.99
		Parbati (8.9 Km)	25	20	20	1.42	7.84	2.94
15	Thana Plaun	Beas River (12.7 Km)	20	15	15	5.05	46.62	11.64
16	Triveni Mahadev	Beas River (5.5 Km)	20	15	15	5.62	54.05	14.49
		Binwa Khad (3.2 Km)	20	15	15	0.93	4.6	1.5
17	Malana-III	Malana Nalla (3.35 Km)	20	15	15	0.31	2.02	0.94
18	Dhaulasidh	Beas River (37 Km)	20	30	20	6.24	90.79	8.1
19	Kanda Pattan	Beas River (8 Km)	20	30	25			

For the remaining 32 projects, i.e. projects with less than 25 MW installed capacity, irrespective of their stage of implementation environment flow release recommendations shall be 20% in lean season, 30% in peak season and 25% in other months.

Calculations for environment flow release in lean season should be based on average of 4-6 leanest months discharge in 90% dependable year. Calculations for environment flow release in peak season should be based on average peak season discharge for 4 months in 90% dependable year i.e. June to September. Calculations for environment flow release remaining 2-4 months (non peak and non lean period) should be based on average discharge in 90% dependable year in remaining months.

10.4 REVIEW OF DRAFT REPORT AND FINALIZATION OF RECOMMENDATIONS BY EAC

After reviewing the draft report, as discussed in 4th EAC meeting held on April 12, 2017, sub-committee of EAC made a visit to Beas basin during April 12-14, 2018. Sub-committee visited Parbati valley, Beas river up to Solang valley including Allain and Duhangan tributaries, Sainj valley and Tirthan valley. Detailed discussions were held during the visit based on the observations made by the Sub-committee members and following major issues were flagged:

1) Protected areas in the basin with status of declaration of ESZ along with marking on the map
2) Environment flow assessment for all the projects
3) Justification for projects recommended to be dropped

10.4.1 Outcome of 13th EAC meeting

Post visit, the basin study report was discussed in detail during the 13th EAC meeting held on April 27, 2018. Outcome of the meeting as recorded in the minutes of meeting is summarized below. Copy of the MoM is enclosed as **Annexure X** of **Volume II** of the report.

1. EAC accepted the recommendation of dropping four projects falling in protected areas viz. Jobrie, Manalsu, Bujiling and Makori.

2. Regarding the level conflicts between two proposed projects, viz. Palchan Bhang and Bhang HEPs, and recommendation dropping of both the projects, EAC suggested that as due to conflicts in level only one project is possible. therefore, state government may take a decision on which project to proceed with and sort out the matter with private developers.

3. EAC accepted the recommendation of dropping of Seri Rawala.

4. Regarding dropping of Raison HEP (18 MW), EAC flagged the matter for discussion with State Government.

5. Regarding dropping of four projects, namely, Parbati (12 MW), Sharni (9.6 MW), Sarsadi (9.6 MW) and Sarsadi-II (9 MW) with total capacity of 40.20 MW proposed on Parbati river in cascade, EAC deliberated the issue in detail and flagged it for further discussion.

6. EAC agreed to recommendations made on Nakhtan HEP regarding its consideration only after the legal issues are settled for diversion of Tosh Nalla and also to keep the project components outside the Eco-sensitive Zone.

7. EAC concluded that MoEF&CC will discuss the report with state government of Himachal Pradesh and thereafter the final report will be discussed in EAC again for final appraisal and recommendation.

10.4.2 Outcome of 15th EAC meeting

After receiving the output of Beas basin study and minutes of 13th EAC meeting, Directorate of Energy, Government of Himachal Pradesh had requested to attend the EAC meeting for submissions of their comments on the recommendations of Beas River Basin Study on behalf of state of Himachal Pradesh. Officials of the Directorate of Energy, Govt. of H.P attended the 15th EAC meeting and inter-alia, made a detailed presentation on the recommendation of the study report. EAC deliberated on all the issues in detail. Outcome of the meeting as recorded in the minutes of meeting is summarized below. Copy of the MoM is enclosed as **Annexure XI** of **Volume II** of the report.

1. Dropping of Jobrie HEP (12 MW) as it falls in Protected Area – GoHP requested not to drop the project on the ground that some of project components falls in Inderkilla Wildlife Sanctuary. Govt. of H.P. requested time to redefine the project so that no component would fall within the protected area. EAC asked the H.P. Govt. representative to revise the project proposal so that it would completely fall outside the protected area and also the ESZ boundary and bring a certificate from Chief Wildlife Warden that all the components of the revised project are located outside the protected area and ESZ.

2. Dropping of Manalsu HEP (21.9 MW) as it falls in Protected area – Govt. of H.P. confirmed that the project shall not be allotted.

3. Dropping of Bujling HEP (20 MW) as it falls in Protected Area – GoHP requested not to drop the project on the ground that some of project components fall in Dhauladhar Wildlife Sanctuary. Govt. of H.P. requested time to redefine the project so that no component would fall within the protected area. EAC asked the H.P. Govt. representative to revise the project proposal so that it would completely fall outside the protected area and also the ESZ boundary and bring a certificate from Chief Wildlife Warden that all components of the revised project are located outside the protected area and ESZ.

4. Dropping of Makori HEP (20.8 MW) as it falls in Protected Area - GoHP confirmed that the project shall be cancelled.

5. Dropping of Palchan Bhang HEP (9 MW) and Bhang HEP (9 MW) due to level conflicts – Govt. of H.P clarified that these two are parallel schemes, one on Kothi Khad, a tributary of river Beas and another on Beas river and there are no level conflicts between these two schemes. EAC recommended that both the schemes can be developed, as they are independent schemes. Govt. of H.P was requested to submit a location map showing the layouts of both the projects components and levels.

6. Dropping of Seri Rawla (7 MW) due to high altitude and biodiversity richness – Govt. of H.P submitted that the project may be allowed with stringent conditions to conserve the Biodiversity, and ensured that all the necessary measures shall be adopted in designing of the project, during construction of the project and also after commissioning. EAC deliberated the concerns in detail and concluded that as the project is in vicinity of Rohtang tunnel portal, Small HEP can be taken up, with adequate precautions to minimize adverse impacts on biodiversity.

7. Dropping of Raison HEP (18 MW) due to richness of trout fish and proximity to fishing sites – Govt. of H.P. submitted that this project is proposed to be developed as a model project by using the head attained by the meandering of Beas river stretch at Raison. The technology to be adopted for the construction of this HEP with flexible weir option will have the least impacts in comparison to what has been anticipated in the report. The concept and proposal of the project have already been appreciated by the experts. EAC deliberated on the issue in detail and considering the new technology, recommended this project for development.

8. Dropping of four projects on Parbati River viz. Parbati HEP (12 MW), Sharni HEP (9.6 MW), Sarasadi HEP (9.60 MW) & Sarasadi-II HEP (9 MW) in cascade to ensure free flowing Parbati river stretch, which is rich in fish fauna and trout is known to migrate upstream in Parbati river along this stretch from Beas. Govt. of H.P. has submitted that they will redefine the projects to ensure the minimum free flowing river stretch is maintained between projects in cascade and shall also ensure fish movement by provisions of well-designed fish ladders. Further Sharni HEP (9.6 MW) and Sarasadi HEP (9.6 MW) are proposed to be dropped. It was also submitted that project construction will be taken up in phased manner. EAC recommended that Govt. of H.P. may redefine these projects by ensuring minimum 1 km of free flowing river stretch between FRL and TWL of projects in cascade. E-flows have to be provided as per the norms and the impact on the river should be minimum.

9. Flagging of Nakhtan HEP (460 MW as the proposed project falls within the ESZ boundary of Great Himalayan National Park Conservation Area (Khirganga National Park is a part) and also the matter related to diversion of Tosh Nalla for Nakthan HEP is sub-judice. Govt. of H.P., requested that the recommendations on above two aspects may be left for the stage of individual EC of this project. EAC noted the concerns raised and concluded that it is a legal requirement to keep the project components outside the ESZ. Further, the court order with respect to diversion of Tosh Nalla will be binding on project developer. Therefore, once the matters are resolved, a fresh look will be taken at the project at that point of time.

10. Environment Flow Release Recommendations – With respect to environment flow release recommendations of all the projects viz., operational, under construction and proposed as made in Beas river basin study report; GoHP has submitted that project specific e-flow release with respect to 8 operational projects and 3 under construction projects should not be considered. These Hydro Electric Projects are bound by GoHP Notification dated 09.09.2005 regarding release of e-flow which states that “threshold value of not less than 15% of the minimum inflow observed in lean season to the main river water body whose water is being harnessed by the project” shall be the quantum of minimum flow of water to be

released and maintained immediately downstream of the diversion structure of existing and upcoming hydel projects. The same has also been incorporated in the respective agreements executed for these HEPs and accordingly the e-flow is being maintained and monitored through Himachal Pradesh State Pollution Control Board.

However, few developers like Bhakra Beas Management Board, Punjab State Power Corp. Ltd., etc. were not following the notification and have moved the Hon'ble NGT. Now as per 9th August, 2017 orders of Hon'ble NGT, all theses HEPs have been directed to maintain e-flow @ 15-20% of the average lean seasons flow of a particular river. GoHP requested that let the e-flow release be as per NGT order rather than as per the basin study report because implementation of recommendation of basin study report on operational and under construction project would be a challenge for the state and developers can again take the legal recourse.

EAC noted the issue and asked Govt. of H.P. to make a comparative statement within 2 months for all under construction and operational projects about the e-flow and energy generation under all the three scenarios viz. present release, release as per NGT order and release as per basin study report. The matter will be again deliberated in EAC on receipt of this information.

11. E-flow release recommendation of 3 proposed projects viz. Thana Plaun (191 MW), Triveni Mahadev (96 MW) and Malana-III (30 MW) HEPs has been accepted by the state government.

12. E-flow release recommendation with respect to Dhaulasidh HEP (66 MW), may require revision as the 90% dependable year as per the approved DPR and as taken in Beas river basin study appears to be different. EAC opined that the results be re-examined and submitted.

13. GoHP also requested that e-flow release requirement with respect to Nakhtan HEP should not be fixed at this stage because based on court order and ESZ boundary resolution, project components will undergo certain changes. Based on final project components, a fresh e-flow requirement study will be undertaken and presented along with the EIA report at the time of environment clearance. EAC agreed with the submission.

14. EAC concluded that the Beas RBS shall be deliberated after receiving the requisite information from Govt. of H.P. after two months.

10.4.3 Outcome of 19th EAC meeting

Further to the discussion in 15th meeting, the Directorate of Energy, Government of Himachal Pradesh responded vide their letter dated 23.10.2018 and made presentation in 19th EAC meeting. Outcome of the meeting as recorded in the minutes of meeting is summarized below. Copy of the MoM is enclosed as **Annexure XII** of **Volume II** of the report.

1. Revision of layout of Jobrie HEP (12 MW) to ensure all components are outside the ESZ of Inderkilla WLS - GoHP submitted that Jobri Nalla is falling within the wildlife sanctuary and therefore they are not diverting the water of Jobri Nalla, whereas another diversion of the project in on Allan Nalla, which is outside the protected area and therefore, they should be

allowed to utilize the water of Allan Nalla for developing an HEP with reduced capacity of 6 MW. As up to 2 MW projects are permitted in the Eco-Sensitive Zone, GoHP may be allowed to develop an HEP of 2 MW in ESZ of Inderkilla WLS on Jobrie Nalla. EAC accepted the GoHP request with regard to Jobrie HEP.

2. Dropping of Manalsu HEP (21.9 MW) as it falls in Manali WLS – The project was dropped as it falls in Manali WLS; and the recommendation was accepted by EAC as well as GoHP. However, a prospective developer has represented that the major project features viz., the powerhouse, forebay, penstock, switchyard and transmission lines will be located outside the sanctuary area. It involves an intake in a deep gorge and an underground tunnel of 2.5 km which will be excavated from one end that is out of the WLS boundary. No adit is proposed in between the tunneling excavation, ensuring no interference with the Sanctuary. However, the representation is silent on the locations of the dam/ barrage/diversion structure and the intake structure to HRT. EAC noted that as per the basin study report, the diversion structure, intake structure, etc. were falling within the Manali Wildlife Sanctuary. After detailed deliberation, it has been decided that let the State Govt. shall submit the details of the locations of the project features of the Manalsu HEP vis-a-vis the boundary of the Manali WLS for further consideration of the EAC.

3. Revision of layout of Bujling HEP (20 MW) to ensure all components are outside the ESZ of Dhualadhar WLS - GoHP was asked to re-plan the project to ensure that revised project should be completely outside the protected area as well as proposed eco-sensitive zone. GoHP has requested more time, as the ESZ of Dhauladhar Wildlife Sanctuary has not been finalized as yet. EAC accepted the request and observed that basin study should record that all the components of revised Bujling project should be outside the protected area as well as ESZ.

4. Dropping of Makori HEP (20.8 MW) - GoHP confirmed that the allotment of project will be cancelled.

5. Submission of a clear layout of Palchan Bhang HEP (9 MW) and Bhang HEP (9 MW) by GoHP - GoHP presented a map, however, it was not very clear and therefore EAC asked the GoHP to submit a clear location map produced by GIS showing contours in the region for inclusion in the basin study report.

6. Revision of configuration of four projects on Parbati River viz. Parbati HEP (12 MW), Sharni HEP (9.6 MW), Sarsadi HEP (9.60 MW) & Sarsadi-II HEP (9 MW) to ensure free flowing river stretch in trout rich river stretch - GoHP presented that they have revised the project configurations and now only two projects are being planned on this stretch to ensure adequate free stretch between these two projects.

7. Flagging of Nakhtan HEP (460 MW as the proposed project falls within the ESZ boundary of Great Himalayan National Park Conservation Area (Khirganga National Park is a part) and also the matter related to diversion of Tosh Nalla for Nakthan HEP is sub-judice – GoHP submitted that an out of court settlement is being done with the developer of Tosh project under which Nakhtan HEPs Tosh diversion will be dropped altogether. Instead, capacity of the existing projects on Tosh will be increased as follows: Tosh I HEP from 10 MW to 20 MW Tosh II HEP

from 5 MW to 25 MW Tosh III HEP from 5 MW to 25 MW EAC asked the GoHP to provide the details of revised capacities of projects along with agreement on Tosh projects so that they can be included in the basin study report.

8. Kanda Pattan HEP - GoHP submitted that a new project has been conceived in Beas basin and it was earlier not covered in the study. This falls between Thana Plaun HEP and Triveni Mahadev HEP and will have an installed capacity of about 40 MW. EAC asked the GoHP to provide the details so that they can be appropriately included in the basin study report.

9. Environment Flow Release Recommendations - EAC noted that regarding environment flow recommendations, GoHP was asked to submit the energy calculation and tariff loss for existing/under construction projects where environment flow has been recommended to be increased from the present releases. GoHP has submitted calculations for 4 operational projects only and remaining data is yet to be submitted. EAC noted that data submitted is not legible and incomplete and therefore asked GoHP to provide full detail as requested for all the projects which are under construction and under operation.

10. Recommendations of e-flows release of Dhaulasidh HEP – As directed by EAC, revised e-flow assessment for Dhaulasidh HEP was carried out. The recommendation made earlier was reviewed and 90% DY is not found to be different in basin study from that of EIA study/DPR of Dhaulasidh HEP. Difference was in seasons, how they were considered in EIA study and in basin study; therefore, data was re-examined to re-represent the seasons as

    Monsoon – June to September
    Lean Season – November to April
    Other Months – May and October

    This has resulted in slight change in the recommendation and the revised e-flows recommendation for Dhaulasidh HEP are:
    Monsoon (June to September) – 30% (90.80 cumec)
    Lean Season (November to April) – 20% (6.24 cumec)
    Other Months (May and October) – 20% (8.30 cumec)

    Being a dam toe powerhouse based project, e-flows can be released from the turbines as long as continuity of release can be maintained. EAC accepted the revised e-flow recommendation for Dhaulasidh HEP.

10.4.4 Outcome of 20th EAC meeting

Further to discussion in 19th EAC meeting, GoHP made another presentation in 20th EAC meeting on the pending issues. Outcome of the meeting as recorded in the minutes of meeting is summarized below. Copy of the MoM is enclosed as **Annexure XIII** of **Volume II** of the report.

1. Revision of layout of Jobrie HEP (12 MW) to ensure all components are outside the ESZ of Inderkilla WLS – Govt. of Himachal Pradesh (GoHP) again confirmed that as recommended by EAC, the HEPs will be developed as per the applicable norms and restrictions of project development in protected areas and Eco-sensitive Zones.

2. Dropping of Manalsu HEP (21.9 MW) as it falls in Manali WLS - Government of Himachal Pradesh submitted that diversion structure as well as part of tunnel falls within the Manali WLS while the rest of the components including powerhouse is outside the WLS. The project envisages a drop type trench weir structure in the protected area, thus involves minimum construction in the protected area. GoHP further submitted that it will be ensured that while executing the construction of intake structure, utmost care will be exercised to avoid any infringement to wildlife, etc. under any circumstances.

   EAC deliberated that generally during the basin studies, consideration of overall impact of development of HEPs in the entire basin is taken and, projects falling in protected areas are out rightly dropped and therefore, Manalsu HEP was also recommended to be dropped and the recommendation was accepted by EAC & Govt. of H.P. It was further discussed that while the project is considered on the request of the state government, the project will also require wildlife clearance. It has been opined that let the matter be discussed in the State Board of Wildlife whether the portion of the project coming in the WLS be permissible activities and accordingly Wildlife Clearance be obtained from the Standing Committee on National Board of Wildlife. Accordingly, it has been opined that let the project be placed before the NBWL for its viability.

3. Revision of layout of Bujling HEP (20 MW) – GoHP has submitted that they have accepted the recommendation that all the components of revised Bujling project should be outside the protected area as well as ESZ and it will be finalized after the final notification of ESZ of Dhauladhar WLS is notified.

4. Dropping of Makori HEP (20.8 MW) - GoHP agreed with the recommendation of the report and confirmed that the allotment of project will be cancelled.

5. Submission of a clear layout of Palchan Bhang HEP (9 MW) and Bhang HEP (9 MW) by GoHP - GoHP has submitted the map as required for inclusion in the basin study report.

6. Revision of configuration of four projects on Parbati River viz. Parbati HEP (12 MW), Sharni HEP (9.6 MW), Sarsadi HEP (9.60 MW) & Sarsadi-II HEP (9 MW) to ensure free flowing river stretch in trout rich river stretch – GoHP presented that they have revised the project configurations and now only two projects are being planned on this stretch to ensure adequate free stretch between these two projects. As per the revised schemes, HEP I is 15 MW with a trench weir across Parbati river at around 600 m downstream of confluence of Baladi Nallah with Parbati river at Elevation of 1365 m and powerhouse on right bank at elevation of 1273 m. HEP II will be 20 MW with a diversion barrage across Parbati river downstream of HPPWD RCC bridge at elevation of 1245 m where the good rock is available on right bank. Powerhouse at elevation of 1135 m on right bank opposite to the village Jachani. This arrangement will ensure a minimum of 1 km of free flowing river stretch between FRL and TWL of projects in cascade. Once, all the information is provided for both the projects, the e-flow, etc. will be recalculated again and included in the River Basin Study.

7. Revision of project configurations on Tosh Nalla and revision of Nakhtan HEP (460 MW) – GoHP submitted that Tosh Nalla will have independent schemes as: 3 Tosh I HEP (20 MW), presently

10 MW from 2280 m to 2480 m. Tosh II HEP (25 MW), new project from 2490 m to 2690 m. Tosh III HEP (32 MW), new project from 2700 m to 2960 m. EAC discussed the matter and concluded that there is no objection to development of such schemes as long as at least 1 km free flow river stretch is available between FRL and TWL of projects in cascade and the projects on Tosh as well as on Parbati remain outside the ESZ of Khirganga National Park.

8. Kanda Pattan HEP - GoHP submitted that a new project, Kanda Patan HEP has been conceived in Beas basin which was not included in the study. The scheme will maintain the required riparian distance of about 1 to 1.5 km from TWL of upstream project and FRL of downstream project. The diversion site is proposed at around 600 m upstream of Neri bridge on Dharampur-Jogindernagar Road and powerhouse on the right bank at around 11 km downstream of the diversion site. EAC discussed the matter and concluded that the scheme can be considered in the basin study as long as the minimum of 1 km distance of free flow stretch is ensured from FRL of downstream project and TWL of upstream project.

9. Environment Flow Release Recommendations - Based on the observation of EAC, GoHP has now worked out energy loss calculations due to implementation of environment flow recommendations by existing and under construction projects. GoHP has also submitted that some of the older projects do not comply even to the state government norms and are also not complying with NGT's order applicable to all rivers in the country for release of minimum environment flow by HEPs. GoHP requested EAC not to recommend environment flow as assessed in the basin study report for existing and under construction projects and they should be allowed to continue to follow the state government/NGT guidelines, which are comparable.

   EAC deliberated the matter in detailed and concluded that environment flow in basin study has been worked out taking basin as a whole and irrespective of the fact whether there exists a project or a project is under construction or a project is proposed in future. It is based on scientific study and such recommendation should remain independent of the legal issues involved in implementation. Therefore, environment flow recommendation as per basin study should be applicable to all projects irrespective of their status of implementation. If GoHP finds it difficult to implement, GoHP can approach NGT or central government and deal with the matter separately.

10. EAC finally concluded all the discussions on Beas River Basin study and directed the Consultant to update/finalize the basin study report, keeping in view the matter discussed and recorded in various EAC meetings.

10.5 CONCLUSIONS

Beas basin study has been updated, incorporating all the discussions and recommendations made by EAC and the additional data submitted by Government of Himachal Pradesh. The final set of recommendations are:

1. Jobrie HEP (12 MW) will be developed as two independent projects – one with diversion on Allan Nalla, and will be of 6 MW installed capacity and another with diversion on Jobrie nalla and will be of 2 MW installed capacity. All the components including pondage for both the

projects will be outside the boundary of Inderkilla WLS and its Eco-sensitive Zone (ESZ) with the exception of 2 MW project on Jobrie Nalla, which can be developed in ESZ only if permitted by the ESZ notification.

2. Manalsu HEP (21.9 MW) falling within Manali WLS will undergo Wildlife Clearance as per Wildlife Protection Act. Based on the assessment by the State Board of Wildlife that whether the portion of the project coming in the WLS is a permissible activities and accordingly, Wildlife Clearance should be obtained from the Standing Committee on National Board of Wildlife.

3. Bujling HEP (20 MW) – Location of Bujiling HEP will be changed/project component revised to ensure that all the components including pondage will be outside the boundary of Dhauladhar WLS as well as ESZ of Dhauladhar WLS as and when it is notified.

4. Makori HEP (20.8 MW) – Project is recommended for dropping and therefore the allotment of project will be cancelled.

5. Palchan Bhang HEP (9 MW), Bhang HEP (9 MW), Seri Rawla (7 MW), Raison (18 MW) will be developed as planned.

6. Four projects on Parbati River viz. Parbati HEP (12 MW), Sharni HEP (9.6 MW), Sarsadi HEP (9.60 MW) & Sarsadi-II HEP (9 MW) are dropped. The stretch of Parbati river from the confluence of Malana Nalla with Parbati up to confluence of Parbati river with Beas river, will have only two projects – HEP I (15 MW) and HEP II (20 MW). These projects will be so located to ensure that a minimum of 1 Km of river stretch will flow free between FRL and TWL of projects in cascade. As the both the projects are less than 25 MW installed capacity, environment flow release will be maintained as 20% in lean season, 30% in peak season and 25% in remaining months. Percentage calculations will be made based on the 90% dependable year discharge data used for the project design/power potential calculation in DPR.

7. Nakhtan HEP (460 MW) will be re-designed with diversion on Parbati river only. Tip of the submergence of revised Nakhtan HEP will be outside the Eco-Sensitive Zone of Khirganga National Park.

8. Installed capacity of present Tosh HEP will be increased from 10 MW to 20 MW and it will be termed as Tosh I HEP. Upstream of Tosh I HEP, Tosh II HEP and Tosh III HEP can be developed, however, it is to be ensured that:
   a. TWL of Tosh II HEP will be at least 1 Km upstream of FRL of Tosh I HEP and
   b. TWL of Tosh III HEP will be at least 1 Km upstream of FRL of Tosh II HEP and
   c. FRL of Tosh III HEP will be outside the ESZ of Khirganga National Park and
   d. All three projects will follow environment flow release norms i.e. 20% in lean season, 30% in peak season and 25% in remaining months. Percentage calculations will be made based on the 90% dependable year discharge data used for the project design/power potential calculation in DPR.

9. Kanda Pattan HEP will be developed on Beas river between Thana Plaun HEP and Triveni Mahadev HEP, however it is to be ensured that:
   a. FRL of Kanda Pattan on Beas river will be at least 1 Km downstream of TWL of Thana Plaun HEP and
   b. TWL of Kanda Pattan on Beas Rvier will be at least 1 Km upstream of FRL of Triveni Mahadev HEP and
   c. the project will follow environment flow release norms i.e. 20% in lean season, 30% in peak season and 25% in remaining months. Percentage calculations will be made based on the 90% dependable year discharge data used for the project design/power potential calculation in DPR.

10. Environment Flow Release Recommendations

    Environment flow release recommendations will be implemented for all the projects i.e. operational projects, under construction projects and projects being planned/designed or are under survey & investigation stage.

    E-flow is recommended for 19 projects in **Table 10.1** and shall be adopted. For remaining projects, i.e. projects with less than 25 MW installed capacity, irrespective of their stage of implementation environment flow release recommendations shall be 20% in lean season, 30% in peak season and 25% in other months.

    Calculations for environment flow release in lean season should be based on average of 4-6 leanest months discharge in 90% dependable year. Calculations for environment flow release in peak season should be based on average peak season discharge for 4 months in 90% dependable year i.e. June to September. Calculations for environment flow release remaining 2-4 months (non-peak and non-lean period) should be based on average discharge in 90% dependable year in remaining months.

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ANNEXURES

List of Angiosperms

S. No.	Group	Family	Name of Species
1	Dicots	Acanthaceae	*Aeschmanthera tomentosa*
2	Dicots	Acanthaceae	*Andrographis paniculata*
3	Dicots	Acanthaceae	*Barleria cristata*
4	Dicots	Acanthaceae	*Barleria prionitis*
5	Dicots	Acanthaceae	*Blepharis maderaspatensis*
6	Dicots	Acanthaceae	*Dicliptera bupleuroides*
7	Dicots	Acanthaceae	*Dicliptera roxburghiana*
8	Dicots	Acanthaceae	*Eranthemum pulchellum*
9	Dicots	Acanthaceae	*Hygrophila auriculata*
10	Dicots	Acanthaceae	*Hygrophylla polysperma*
11	Dicots	Acanthaceae	*Justicia adhatoda*
12	Dicots	Acanthaceae	*Justicia japonica*
13	Dicots	Acanthaceae	*Justicia mollisima*
14	Dicots	Acanthaceae	*Lepidagathis cuspidata*
15	Dicots	Acanthaceae	*Lepidagathis incurva*
16	Dicots	Acanthaceae	*Peristrophe bicalyculata*
17	Dicots	Acanthaceae	*Peristrophe paniculata*
18	Dicots	Acanthaceae	*Phlogacanthus thyrsiflorus*
19	Dicots	Acanthaceae	*Ruellia patula*
20	Dicots	Acanthaceae	*Rungia pectinata*
21	Dicots	Acanthaceae	*Strobilanthes alatus*
22	Dicots	Acanthaceae	*Strobilanthes angustifrona*
23	Dicots	Acanthaceae	*Strobilanthes atropurpureus*
24	Dicots	Acanthaceae	*Strobilanthes auriculata*
25	Dicots	Acanthaceae	*Strobilanthes dalhousianus*
26	Dicots	Acanthaceae	*Strobilanthes extensa*
27	Dicots	Acanthaceae	*Strobilanthes wallichii*
28	Dicots	Asteraceae	*Achillea millefolium*
29	Dicots	Asteraceae	*Adenocaulon himalaicum*
30	Dicots	Asteraceae	*Adenostemma parviflorum*
31	Dicots	Asteraceae	*Ageratina adenophora*
32	Dicots	Asteraceae	*Ageratum conyzoides*
33	Dicots	Asteraceae	*Ainsliaea aptera*
34	Dicots	Asteraceae	*Ainsliaea latifolia*
35	Dicots	Asteraceae	*Anaphalis busua*
36	Dicots	Asteraceae	*Anaphalis contorta*
37	Dicots	Asteraceae	*Anaphalis cuneifolia*
38	Dicots	Asteraceae	*Anaphalis margaritacea*
39	Dicots	Asteraceae	*Anaphalis nepalensis*
40	Dicots	Asteraceae	*Anaphalis triplinervis*
41	Dicots	Asteraceae	*Anaphalis triplinervis var. intermedia*
42	Dicots	Asteraceae	*Anthemis cotula*
43	Dicots	Asteraceae	*Arctium lappa*
44	Dicots	Asteraceae	*Artemisia absinthium*

45	Dicots	Asteraceae	*Artemisia indica*
46	Dicots	Asteraceae	*Artemisia scoparia*
47	Dicots	Asteraceae	*Artemisia vestita*
48	Dicots	Asteraceae	*Aster falconeri*
49	Dicots	Asteraceae	*Aster himalaicus*
50	Dicots	Asteraceae	*Aster molliusculus*
51	Dicots	Asteraceae	*Aster peduncularis*
52	Dicots	Asteraceae	*Bidens bipinnata*
53	Dicots	Asteraceae	*Bidens biternata*
54	Dicots	Asteraceae	*Bidens pilosa*
55	Dicots	Asteraceae	*Bidens tripartita*
56	Dicots	Asteraceae	*Blumea hieracifolia*
57	Dicots	Asteraceae	*Blumea mollis*
58	Dicots	Asteraceae	*Calendula arvensis*
59	Dicots	Asteraceae	*Carpesium abortanoides*
60	Dicots	Asteraceae	*Carpesium pedunculosum*
61	Dicots	Asteraceae	*Chrysanthemum leucanthemum*
62	Dicots	Asteraceae	*Cirsium vertum*
63	Dicots	Asteraceae	*Cirsium wallichii*
64	Dicots	Asteraceae	*Conyza aegyptiaca*
65	Dicots	Asteraceae	*Conyza japonica*
66	Dicots	Asteraceae	*Conyza stricta*
67	Dicots	Asteraceae	*Coreopsis lanceolata*
68	Dicots	Asteraceae	*Cotula anthemoides*
69	Dicots	Asteraceae	*Cousinia thomsoni*
70	Dicots	Asteraceae	*Cremanthodium arnicoides*
71	Dicots	Asteraceae	*Crepis flexuosa*
72	Dicots	Asteraceae	*Dichrocephala integrifolia*
73	Dicots	Asteraceae	*Dubayaea hispida*
74	Dicots	Asteraceae	*Echinops cornigerus*
75	Dicots	Asteraceae	*Eclipta prostrata*
76	Dicots	Asteraceae	*Emilia sonchifolia*
77	Dicots	Asteraceae	*Erigeron alpinus*
78	Dicots	Asteraceae	*Erigeron bellidioides*
79	Dicots	Asteraceae	*Erigeron bonariensis*
80	Dicots	Asteraceae	*Erigeron candensis*
81	Dicots	Asteraceae	*Erigeron multicaulis*
82	Dicots	Asteraceae	*Erigeron multiradiatus*
83	Dicots	Asteraceae	*Filago pyramidata*
84	Dicots	Asteraceae	*Galinsoga parvifolia*
85	Dicots	Asteraceae	*Gerbera gossypina*
86	Dicots	Asteraceae	*Gnaphalium affine*
87	Dicots	Asteraceae	*Gnaphalium hypoleuccum*
88	Dicots	Asteraceae	*Gynura cusimbua*
89	Dicots	Asteraceae	*Hieracium vulgatum*
90	Dicots	Asteraceae	*Hypochoeris glabra*
91	Dicots	Asteraceae	*Inula cappa*
92	Dicots	Asteraceae	*Inula cuspidata*
93	Dicots	Asteraceae	*Inula grandiflora*
94	Dicots	Asteraceae	*Jurinea macrocephala*

95	Dicots	Asteraceae	*Lactuca brunoniana*
96	Dicots	Asteraceae	*Lactuca dissecta*
97	Dicots	Asteraceae	*Lactuca hastata*
98	Dicots	Asteraceae	*Lactuca lessertiana*
99	Dicots	Asteraceae	*Lactuca longifolia*
100	Dicots	Asteraceae	*Lactuca macrorhiza*
101	Dicots	Asteraceae	*Lactuca serriola*
102	Dicots	Asteraceae	*Launea obtusatus*
103	Dicots	Asteraceae	*Launea secunda*
104	Dicots	Asteraceae	*Leontopodium himalayanum*
105	Dicots	Asteraceae	*Ligularia amplexicaulis*
106	Dicots	Asteraceae	*Ligularia fischeri*
107	Dicots	Asteraceae	*Myriactis nepalensis*
108	Dicots	Asteraceae	*Onopordum acanthium*
109	Dicots	Asteraceae	*Parthenium hysterophorus*
110	Dicots	Asteraceae	*Phagnalon niveum*
111	Dicots	Asteraceae	*Picris hieracioides*
112	Dicots	Asteraceae	*Prenanthes brunoniana*
113	Dicots	Asteraceae	*Prenanthes violaefolia*
114	Dicots	Asteraceae	*Psychrogeton andryaloides*
115	Dicots	Asteraceae	*Pterotheca falconeri*
116	Dicots	Asteraceae	*Saussurea costus*
117	Dicots	Asteraceae	*Saussurea gossypiphora*
118	Dicots	Asteraceae	*Saussurea heteromalla*
119	Dicots	Asteraceae	*Saussurea hypoleuca*
120	Dicots	Asteraceae	*Saussurea obvallata*
121	Dicots	Asteraceae	*Saussurea piptanthera*
122	Dicots	Asteraceae	*Saussurea roylei*
123	Dicots	Asteraceae	*Senecio alatus*
124	Dicots	Asteraceae	*Senecio chenopodifolius*
125	Dicots	Asteraceae	*Senecio chrysanthemoides*
126	Dicots	Asteraceae	*Senecio graciliflorus*
127	Dicots	Asteraceae	*Senecio kunthianus*
128	Dicots	Asteraceae	*Senecio nudicaulis*
129	Dicots	Asteraceae	*Senecio rufinervis*
130	Dicots	Asteraceae	*Sigesbeckia orientalis*
131	Dicots	Asteraceae	*Silybum marianum*
132	Dicots	Asteraceae	*Solidago virga-aurea*
133	Dicots	Asteraceae	*Sonchus asper*
134	Dicots	Asteraceae	*Sonchus brachyotus*
135	Dicots	Asteraceae	*Sonchus oleraceus*
136	Dicots	Asteraceae	*Sonchus wightianus*
137	Dicots	Asteraceae	*Tagetes minuta*
138	Dicots	Asteraceae	*Tagetes patula*
139	Dicots	Asteraceae	*Tanacetum dolichophyllum*
140	Dicots	Asteraceae	*Taraxacum officinale*
141	Dicots	Asteraceae	*Taraxacum watii*
142	Dicots	Asteraceae	*Tragopogon dubius*
143	Dicots	Asteraceae	*Tricholepis elongata*
144	Dicots	Asteraceae	*Tridex procumbens*

145	Dicots	Asteraceae	*Vernonia anthelmintica*
146	Dicots	Asteraceae	*Vernonia cinerea*
147	Dicots	Asteraceae	*Vicoa indica*
148	Dicots	Asteraceae	*Xanthium strumarium*
149	Dicots	Asteraceae	*Youngia japonica*
150	Dicots	Balsaminaceae	*Impatiens bicornuta*
151	Dicots	Balsaminaceae	*Impatiens chinensis*
152	Dicots	Balsaminaceae	*Impatiens cristata*
153	Dicots	Balsaminaceae	*Impatiens glandulifera*
154	Dicots	Balsaminaceae	*Impatiens laxiflora*
155	Dicots	Balsaminaceae	*Impatiens racemosa*
156	Dicots	Balsaminaceae	*Impatiens scabrida*
157	Dicots	Balsaminaceae	*Impatiens sulcata*
158	Dicots	Balsaminaceae	*Impatiens thomsonii*
159	Dicots	Basellaceae	*Basella rubra*
160	Dicots	Begoniaceae	*Begonia picta*
161	Dicots	Berberidaceae	*Berberis aristata*
162	Dicots	Berberidaceae	*Berberis asiatica*
163	Dicots	Berberidaceae	*Berberis chitria*
164	Dicots	Berberidaceae	*Berberis glaucocarpa*
165	Dicots	Berberidaceae	*Berberis jaeeschkeana*
166	Dicots	Berberidaceae	*Berberis lycium*
167	Dicots	Berberidaceae	*Berberis pseudoumbellata*
168	Dicots	Berberidaceae	*Berberis umbellata*
169	Dicots	Berberidaceae	*Sinopodophyllum hexandrum*
170	Dicots	Betulaceae	*Alnus nepalensis*
171	Dicots	Betulaceae	*Alnus nitida*
172	Dicots	Betulaceae	*Betula alnoides*
173	Dicots	Betulaceae	*Betula utilis*
174	Dicots	Betulaceae	*Carpinus viminea*
175	Dicots	Betulaceae	*Corylus colurna*
176	Dicots	Betulaceae	*Corylus jacquemontii*
177	Dicots	Betulaceae	*Corylus jacquemontii*
178	Dicots	Bignoniaceae	*Jacaranda mimosifolia*
179	Dicots	Bignoniaceae	*Stereospermum chelonoides*
180	Dicots	Bignoniaceae	*Tecoma stans*
181	Dicots	Bignonicaeae	*Incarvillea arguta*
182	Dicots	Bignonicaeae	*Incarvillea emodi*
183	Dicots	Bignonicaeae	*Oroxylum indicum*
184	Dicots	Bignonicaeae	*Tecomaria capensis*
185	Dicots	Bixaceae	*Cochlospermum religiosum*
186	Dicots	Bombacaceae	*Bombax ceiba*
187	Dicots	Boraginaceae	*Arnebia benthami*
188	Dicots	Boraginaceae	*Arnebia euchroma*
189	Dicots	Boraginaceae	*Asperugo procumbens*
190	Dicots	Boraginaceae	*Cordia vestita*
191	Dicots	Boraginaceae	*Cynoglossum lanceolatum*
192	Dicots	Boraginaceae	*Cynoglossum nervosum*
193	Dicots	Boraginaceae	*Cynoglossum wallichii* var. *glochidiatum*
194	Dicots	Boraginaceae	*Cynoglossum zeylanicum*

195	Dicots	Boraginaceae	*Ehretia acuminata*
196	Dicots	Boraginaceae	*Ehretia laevis*
197	Dicots	Boraginaceae	*Eritrichium canum*
198	Dicots	Boraginaceae	*Hackelia uncinata*
199	Dicots	Boraginaceae	*Heliotropium indicum*
200	Dicots	Boraginaceae	*Heliotropium strigosum*
201	Dicots	Boraginaceae	*Lappula barbata*
202	Dicots	Boraginaceae	*Lasiocaryum diffusum*
203	Dicots	Boraginaceae	*Lindelofia longiflora*
204	Dicots	Boraginaceae	*Lindelofia stylosa*
205	Dicots	Boraginaceae	*Lithospermum arvense*
206	Dicots	Boraginaceae	*Lithospermum tenuiflorum*
207	Dicots	Boraginaceae	*Mertensia racemosa*
208	Dicots	Boraginaceae	*Myosotis alpestris*
209	Dicots	Boraginaceae	*Myosotis sylvatica*
210	Dicots	Boraginaceae	*Trichodesma indicum*
211	Dicots	Brassicaceae	*Alliaria petiolata*
212	Dicots	Brassicaceae	*Arabidopsis himalaica*
213	Dicots	Brassicaceae	*Arabidopsis mollissima*
214	Dicots	Brassicaceae	*Arabidopsis thaliana*
215	Dicots	Brassicaceae	*Arabidopsis wallichii*
216	Dicots	Brassicaceae	*Arabis amplexicaulis*
217	Dicots	Brassicaceae	*Arabis bijuga*
218	Dicots	Brassicaceae	*Arabis pterosperma*
219	Dicots	Brassicaceae	*Arabis tenuirostris*
220	Dicots	Brassicaceae	*Barbarea vulgaris*
221	Dicots	Brassicaceae	*Brassica napus*
222	Dicots	Brassicaceae	*Brassica nigra*
223	Dicots	Brassicaceae	*Brassica rapa* (Syn. *Brassica campestris*)
224	Dicots	Brassicaceae	*Capsella bursa-pastoris*
225	Dicots	Brassicaceae	*Cardamine flexuosa*
226	Dicots	Brassicaceae	*Cardamine hirsuta*
227	Dicots	Brassicaceae	*Cardamine impatiens*
228	Dicots	Brassicaceae	*Cardamine macrophylla*
229	Dicots	Brassicaceae	*Christolea himalayensis*
230	Dicots	Brassicaceae	*Descurainia sophia*
231	Dicots	Brassicaceae	*Dontostemon glandulosus*
232	Dicots	Brassicaceae	*Draba altaica*
233	Dicots	Brassicaceae	*Eruca vesicaria* (Syn. *Eruca sativa*)
234	Dicots	Brassicaceae	*Erysimum hieraciifolium*
235	Dicots	Brassicaceae	*Erysimum thomsonii*
236	Dicots	Brassicaceae	*Lepidium apetalum*
237	Dicots	Brassicaceae	*Lepidium didymum* (Syn. *Coronopus didymus*)
238	Dicots	Brassicaceae	*Lepidium latifolium*
239	Dicots	Brassicaceae	*Lepidium pinnatifidum*
240	Dicots	Brassicaceae	*Lepidium sativum*
241	Dicots	Brassicaceae	*Lepidium virginicum*
242	Dicots	Brassicaceae	*Megacarpaea polyandra*
243	Dicots	Brassicaceae	*Nasturtium officinale*
244	Dicots	Brassicaceae	*Raphanus raphanistrum* subsp. *sativus* (Syn. *Raphanus*

			sativus)
245	Dicots	Brassicaceae	*Rorippa indica*
246	Dicots	Brassicaceae	*Rorippa montana*
247	Dicots	Brassicaceae	*Sisymbrium irio*
248	Dicots	Brassicaceae	*Sisymbrium loeselii*
249	Dicots	Brassicaceae	*Sisymbrium officinale*
250	Dicots	Brassicaceae	*Thlaspi andersonii*
251	Dicots	Brassicaceae	*Thlaspi arvense*
252	Dicots	Brassicaceae	*Thlaspi cochleariforme*
253	Dicots	Brassicaceae	*Thlaspi cochlearioides*
254	Dicots	Brassicaceae	*Turrtis glabra*
255	Dicots	Buxaceae	*Buxus wallichiana*
256	Dicots	Buxaceae	*Sarcococca pruniformis* (Syn. *Sarcococca saligna*)
257	Dicots	Cactaceae	*Opuntia elatior*
258	Dicots	Cactaceae	*Opuntia monacantha*
259	Dicots	Cactaceae	*Opuntia vulgaris*
260	Dicots	Caesalpiniaceae	*Cassia occidentalis*
261	Dicots	Calophyllaceae	*Mesua ferrea*
262	Dicots	Campanulaceae	*Campanula benthamii*
263	Dicots	Campanulaceae	*Campanula cashmeriana*
264	Dicots	Campanulaceae	*Campanula colorata*
265	Dicots	Campanulaceae	*Campanula wattiana*
266	Dicots	Campanulaceae	*Codonopsis clematidea*
267	Dicots	Campanulaceae	*Codonopsis rotundifolia*
268	Dicots	Campanulaceae	*Cyananthus lobatus*
269	Dicots	Cannabaceae	*Cannabis sativa*
270	Dicots	Cannabaceae	*Celtis australis*
271	Dicots	Cannabaceae	*Celtis tetrandra*
272	Dicots	Capparaceae	*Capparis sepiaria*
273	Dicots	Capparaceae	*Capparis zeylanica*
274	Dicots	Capparaceae	*Crataeva magna*
275	Dicots	Capparaceae	*Crateva religiosa*
276	Dicots	Capparidaceae	*Capparis spinosa*
277	Dicots	Caprifoliaceae	*Leycesteria formosa*
278	Dicots	Caprifoliaceae	*Lonicera angustifolia*
279	Dicots	Caprifoliaceae	*Lonicera asperifolia*
280	Dicots	Caprifoliaceae	*Lonicera hypoleuca*
281	Dicots	Caprifoliaceae	*Lonicera obovata*
282	Dicots	Caprifoliaceae	*Lonicera purpurascens*
283	Dicots	Caprifoliaceae	*Lonicera quinquelocularis*
284	Dicots	Caprifoliaceae	*Morina longifolia*
285	Dicots	Caprifoliaceae	*Nardostachys jatamansi* (Syn. *Nardostachys grandiflora*)
286	Dicots	Caprifoliaceae	*Viburnum cotnifolium*
287	Dicots	Caprifoliaceae	*Viburnum cylindricum*
288	Dicots	Caprifoliaceae	*Viburnum foetens*
289	Dicots	Caprifoliaceae	*Viburnum mullaha*
290	Dicots	Caryophyllaceae	*Arenaria balansae*
291	Dicots	Caryophyllaceae	*Arenaria festucoides*
292	Dicots	Caryophyllaceae	*Arenaria neelgherrensis*
293	Dicots	Caryophyllaceae	*Arenaria serpyllifolia*

294	Dicots	Caryophyllaceae	*Cerastium cerastoides*
295	Dicots	Caryophyllaceae	*Cerastium fontanum*
296	Dicots	Caryophyllaceae	*Drymaria cordata*
297	Dicots	Caryophyllaceae	*Drymaria diandra*
298	Dicots	Caryophyllaceae	*Gypsophila cerastioides*
299	Dicots	Caryophyllaceae	*Lapyrodiclis holosteoides*
300	Dicots	Caryophyllaceae	*Lychnis indica*
301	Dicots	Caryophyllaceae	*Minuartia kashmirica*
302	Dicots	Caryophyllaceae	*Myosoton aquaticum*
303	Dicots	Caryophyllaceae	*Polycarpa corymbosa*
304	Dicots	Caryophyllaceae	*Sagina saginoides*
305	Dicots	Caryophyllaceae	*Silene conoidea*
306	Dicots	Caryophyllaceae	*Silene edgeworthii*
307	Dicots	Caryophyllaceae	*Silene vulgaris*
308	Dicots	Caryophyllaceae	*Stellaria decumbens*
309	Dicots	Caryophyllaceae	*Stellaria himalayensis*
310	Dicots	Caryophyllaceae	*Stellaria media*
311	Dicots	Caryophyllaceae	*Stellaria monosperma*
312	Dicots	Caryophyllaceae	*Vaccaria pyramidata*
313	Dicots	Celastraceae	*Cassine glauca*
314	Dicots	Celastraceae	*Celastrus paniculatus*
315	Dicots	Celastraceae	*Elaeodendron glaucum*
316	Dicots	Celastraceae	*Euonymus echinatus*
317	Dicots	Celastraceae	*Euonymus fimbriatus*
318	Dicots	Celastraceae	*Euonymus hamiltonianus*
319	Dicots	Celastraceae	*Euonymus lucidus* (Syn. *Euonymus pendulus*)
320	Dicots	Celastraceae	*Euonymus tingens*
321	Dicots	Celastraceae	*Gymnosporia senegalensis* (Syn. *Maytenus senegalensis*)
322	Dicots	Chenopodiaceae	*Acroglochin persicarioides*
323	Dicots	Chenopodiaceae	*Chenopodium album*
324	Dicots	Chenopodiaceae	*Chenopodium ambrosioides*
325	Dicots	Chenopodiaceae	*Chenopodium botrys*
326	Dicots	Chenopodiaceae	*Chenopodium opulifolium*
327	Dicots	Chenopodiaceae	*Kochia prostata*
328	Dicots	Clavicipitaceae	*Claviceps purpurea*
329	Dicots	Cleomaceae	*Cleome viscosa*
330	Dicots	Combretaceae	*Anogeissus latifolia*
331	Dicots	Combretaceae	*Terminalia alata*
332	Dicots	Combretaceae	*Terminalia arjuna*
333	Dicots	Combretaceae	*Terminalia bellirica*
334	Dicots	Combretaceae	*Terminalia chebula*
335	Dicots	Convolvulaceae	*Convolvulus arvensis*
336	Dicots	Convolvulaceae	*Cuscuta chinensis*
337	Dicots	Convolvulaceae	*Cuscuta europaea*
338	Dicots	Convolvulaceae	*Cuscuta reflexa*
339	Dicots	Convolvulaceae	*Evolvulus alsinoides*
340	Dicots	Convolvulaceae	*Ipomoea alba*
341	Dicots	Convolvulaceae	*Ipomoea cairica*
342	Dicots	Convolvulaceae	*Ipomoea carnea*

343	Dicots	Convolvulaceae	*Ipomoea dumosa* (Syn. *Exogonium purga*)
344	Dicots	Convolvulaceae	*Ipomoea eriocarpa*
345	Dicots	Convolvulaceae	*Ipomoea fistulosa*
346	Dicots	Convolvulaceae	*Ipomoea nil*
347	Dicots	Convolvulaceae	*Ipomoea purpurea*
348	Dicots	Convolvulaceae	*Ipomoea quamoclit*
349	Dicots	Coriariaceae	*Coriaria nepalensis*
350	Dicots	Cornaceae	*Cornus capitata*
351	Dicots	Cornaceae	*Cornus macrophylla*
352	Dicots	Crassulaceae	*Bryophyllum pinnatum*
353	Dicots	Crassulaceae	*Kalanchoe integra*
354	Dicots	Crassulaceae	*Kalanchoe spathulata*
355	Dicots	Crassulaceae	*Rhodiola heterodonta*
356	Dicots	Crassulaceae	*Rhodiola quadrifida*
357	Dicots	Crassulaceae	*Rhodiola sinuata* (Syn. *Sedum linearifolium*)
358	Dicots	Crassulaceae	*Rhodiola tibetica*
359	Dicots	Crassulaceae	*Rosularia adenotricha*
360	Dicots	Crassulaceae	*Sedum ewersii*
361	Dicots	Crassulaceae	*Sedum glaucophyllum*
362	Dicots	Crassulaceae	*Sedum indicum*
363	Dicots	Crassulaceae	*Sedum multicaule*
364	Dicots	Crassulaceae	*Sedum rosulatum*
365	Dicots	Crassulaceae	*Sedum trullipetalum*
366	Dicots	Crassulaceae	*Sedum wallichianum*
367	Dicots	Crassulaceae	*Tillaea pentsandra*
368	Dicots	Cucurbitaceae	*Cayaponia laciniosa* (Syn. *Bryonopsis laciniosa*)
369	Dicots	Cucurbitaceae	*Citrullus colocynthis*
370	Dicots	Cucurbitaceae	*Coccinia grandis*
371	Dicots	Cucurbitaceae	*Diplocyclos palmatus*
372	Dicots	Cucurbitaceae	*Herpetospermum pedunculosum*
373	Dicots	Cucurbitaceae	*Melothria heterophylla*
374	Dicots	Cucurbitaceae	*Solena amplexicaulis* (Syn. *Melothria heterophylla*)
375	Dicots	Cucurbitaceae	*Trichosanthes cucumerina*
376	Dicots	Cucurbitaceae	*Trichosanthes dioica*
377	Dicots	Cucurbitaceae	*Trichosanthes tricuspidata*
378	Dicots	Daphniphyllaceae	*Daphniphyllum himalayense*
379	Dicots	Dipsacaceae	*Dipsacus inermis*
380	Dicots	Dipterocarpaceae	*Shorea robusta*
381	Dicots	Ebenaceae	*Diospyros montana(Syn Diospyros cordifolia)*
382	Dicots	Ehretiaceae	*Cordia dichotoma*
383	Dicots	Elaeagnaceae	*Elaeagnus conferta*
384	Dicots	Elaeagnaceae	*Elaeagnus laltifolia*
385	Dicots	Elaeagnaceae	*Elaeagnus parvifolia*
386	Dicots	Elaeagnaceae	*Hippophae salicifolia*
387	Dicots	Elatinaceae	*Elatine gracilis*
388	Dicots	Ericaceae	*Cassiope fastigata*
389	Dicots	Ericaceae	*Gaultheria nummularioides*
390	Dicots	Ericaceae	*Gaultheria trichophylla*
391	Dicots	Ericaceae	*Lyonia ovalifolia*

392	Dicots	Ericaceae	*Rhododendron anthopogon*
393	Dicots	Ericaceae	*Rhododendron arboreum*
394	Dicots	Ericaceae	*Rhododendron campanulatum*
395	Dicots	Ericaceae	*Rhododendron lepidotum*
396	Dicots	Erythroxylaceae	*Erythroxylum coca*
397	Dicots	Euphorbiaceae	*Acalypha brachystachya*
398	Dicots	Euphorbiaceae	*Andrachne cordifolia*
399	Dicots	Euphorbiaceae	*Baliospermum solanifolium* (Syn. *Baliospermum montanum*)
400	Dicots	Euphorbiaceae	*Bridelia verrucosa*
401	Dicots	Euphorbiaceae	*Croton tiglium*
402	Dicots	Euphorbiaceae	*Euphorbia antiquorum*
403	Dicots	Euphorbiaceae	*Euphorbia helioscopia*
404	Dicots	Euphorbiaceae	*Euphorbia heterophylla* (Syn. *Euphorbia geniculata*)
405	Dicots	Euphorbiaceae	*Euphorbia hirta*
406	Dicots	Euphorbiaceae	*Euphorbia indica*
407	Dicots	Euphorbiaceae	*Euphorbia kanaorica*
408	Dicots	Euphorbiaceae	*Euphorbia prostrata*
409	Dicots	Euphorbiaceae	*Euphorbia purpurea* (Syn. *Euphorbia pilosa*)
410	Dicots	Euphorbiaceae	*Euphorbia royleana*
411	Dicots	Euphorbiaceae	*Euphorbia stracheyi*
412	Dicots	Euphorbiaceae	*Euphorbia thymifolia*
413	Dicots	Euphorbiaceae	*Euphorbia wallichii*
414	Dicots	Euphorbiaceae	*Falconeria insignis* (Syn. *Sapium insigne*)
415	Dicots	Euphorbiaceae	*Jatropha curcas*
416	Dicots	Euphorbiaceae	*Mallotus philippensis*
417	Dicots	Euphorbiaceae	*Ricinus communis*
418	Dicots	Euphorbiaceae	*Sapium sebiferum*
419	Dicots	Euphorbiaceae	*Tragia involucrata*
420	Dicots	Fabaceae	*Abrus precatorius*
421	Dicots	Fabaceae	*Acacia catechu*
422	Dicots	Fabaceae	*Acacia farnesiana*
423	Dicots	Fabaceae	*Acacia leucophloea*
424	Dicots	Fabaceae	*Acacia modesta*
425	Dicots	Fabaceae	*Acacia nilotica*
426	Dicots	Fabaceae	*Aeschynomene indica*
427	Dicots	Fabaceae	*Albizia chinensis*
428	Dicots	Fabaceae	*Albizia julibrissin*
429	Dicots	Fabaceae	*Albizia lebbeck*
430	Dicots	Fabaceae	*Albizia odoratissima*
431	Dicots	Fabaceae	*Albizia stipulata*
432	Dicots	Fabaceae	*Alysicarpus rugosus*
433	Dicots	Fabaceae	*Argyrolobium flaccidum*
434	Dicots	Fabaceae	*Argyrolobium roseum*
435	Dicots	Fabaceae	*Astragalus candolleanus*
436	Dicots	Fabaceae	*Astragalus chlorostachys*
437	Dicots	Fabaceae	*Astragalus graveolens*
438	Dicots	Fabaceae	*Astragalus leucocephalus*
439	Dicots	Fabaceae	*Astragalus rhizanthus*
440	Dicots	Fabaceae	*Bauhinia divaricata* (Syn. *Bauhinia retusa*)

441	Dicots	Fabaceae	*Bauhinia malabarica*
442	Dicots	Fabaceae	*Bauhinia purpurea*
443	Dicots	Fabaceae	*Bauhinia vahlii*
444	Dicots	Fabaceae	*Bauhinia vahlii* (Syn. *Bauhinia racemosa*)
445	Dicots	Fabaceae	*Bauhinia variegata*
446	Dicots	Fabaceae	*Butea monosperma*
447	Dicots	Fabaceae	*Caesalpinia bonduc*
448	Dicots	Fabaceae	*Caesalpinia decapetala*
449	Dicots	Fabaceae	*Cajanus crassus* (Syn. *Atylosia mollis*)
450	Dicots	Fabaceae	*Campylotropis eriocarpa*
451	Dicots	Fabaceae	*Campylotropis stenocarpa*
452	Dicots	Fabaceae	*Caragana gerardiana*
453	Dicots	Fabaceae	*Cassia absus*
454	Dicots	Fabaceae	*Cassia fistula*
455	Dicots	Fabaceae	*Cassia mimosoides*
456	Dicots	Fabaceae	*Cassia obtusifolia*
457	Dicots	Fabaceae	*Chamaecrista mimosoides* (Syn. *Cassia mimosoides*)
458	Dicots	Fabaceae	*Chesnea cuneata*
459	Dicots	Fabaceae	*Clitoria ternata*
460	Dicots	Fabaceae	*Crotalaria albida*
461	Dicots	Fabaceae	*Crotalaria calycina*
462	Dicots	Fabaceae	*Crotolaria albida*
463	Dicots	Fabaceae	*Dalbergia sissoo*
464	Dicots	Fabaceae	*Delonix regia*
465	Dicots	Fabaceae	*Desmodium caudatum*
466	Dicots	Fabaceae	*Desmodium concinnum*
467	Dicots	Fabaceae	*Desmodium elegans*
468	Dicots	Fabaceae	*Desmodium gangeticum*
469	Dicots	Fabaceae	*Desmodium laxiflorum*
470	Dicots	Fabaceae	*Desmodium microphyllum*
471	Dicots	Fabaceae	*Desmodium motorium*
472	Dicots	Fabaceae	*Desmodium multiflorum*
473	Dicots	Fabaceae	*Desmodium oojeinense* (Syn. *Ougeinia oojeinensis*)
474	Dicots	Fabaceae	*Desmodium podocarpum*
475	Dicots	Fabaceae	*Desmodium tiliaefolium*
476	Dicots	Fabaceae	*Desmodium triflorum*
477	Dicots	Fabaceae	*Desmodium triquetrum*
478	Dicots	Fabaceae	*Desmodium velutinum*
479	Dicots	Fabaceae	*Entada rheedii* (Syn. *Entada pursaetha*)
480	Dicots	Fabaceae	*Flemingia fruticulosa*
481	Dicots	Fabaceae	*Hedysarum astragaloides*
482	Dicots	Fabaceae	*Hedysarum cachemiriana*
483	Dicots	Fabaceae	*Hedysarum microcalyx*
484	Dicots	Fabaceae	*Indigofera astragalina*
485	Dicots	Fabaceae	*Indigofera atropurpurea*
486	Dicots	Fabaceae	*Indigofera cassioides* (Syn. *Indigofera pulchella*)
487	Dicots	Fabaceae	*Indigofera elegans*
488	Dicots	Fabaceae	*Indigofera hebepetala*
489	Dicots	Fabaceae	*Indigofera heterantha* (Syn. *Indigofera gerardiana*)
490	Dicots	Fabaceae	*Lathyrus aphaca*

491	Dicots	Fabaceae	*Lathyrus emodi*
492	Dicots	Fabaceae	*Lathyrus erectus*
493	Dicots	Fabaceae	*Lathyrus gerardiana*
494	Dicots	Fabaceae	*Lathyrus pratensis*
495	Dicots	Fabaceae	*Lathyrus sphaericus*
496	Dicots	Fabaceae	*Lespedeza juncea*
497	Dicots	Fabaceae	*Lotus corniculatus*
498	Dicots	Fabaceae	*Medicago lupulina*
499	Dicots	Fabaceae	*Medicago polymorpha*
500	Dicots	Fabaceae	*Melilotus alba*
501	Dicots	Fabaceae	*Melilotus indica*
502	Dicots	Fabaceae	*Mimosa himalayana*
503	Dicots	Fabaceae	*Mimosa pudica*
504	Dicots	Fabaceae	*Mucuna pruriens*
505	Dicots	Fabaceae	*Oxytropis cachemirica*
506	Dicots	Fabaceae	*Oxytropis mollis*
507	Dicots	Fabaceae	*Parochetus communis*
508	Dicots	Fabaceae	*Piptanthus nepalensis*
509	Dicots	Fabaceae	*Pongamia pinnata*
510	Dicots	Fabaceae	*Pueraria phaseoloides*
511	Dicots	Fabaceae	*Pueraria tuberosa*
512	Dicots	Fabaceae	*Robinia pseudo-acacia*
513	Dicots	Fabaceae	*Saraca asoca*
514	Dicots	Fabaceae	*Saraca indica*
515	Dicots	Fabaceae	*Senna occidentalis* (Syn. *Cassia occidentalis*)
516	Dicots	Fabaceae	*Senna tora* (Syn. *Cassia tora*)
517	Dicots	Fabaceae	*Shuteria involucrata*
518	Dicots	Fabaceae	*Tamarindus indica*
519	Dicots	Fabaceae	*Tephrosia angustissima* (Syn. *Tephrosia purpurea*)
520	Dicots	Fabaceae	*Thermopsis barbata*
521	Dicots	Fabaceae	*Trifolium clusii*
522	Dicots	Fabaceae	*Trifolium dubium*
523	Dicots	Fabaceae	*Trifolium pratense*
524	Dicots	Fabaceae	*Trifolium repens*
525	Dicots	Fabaceae	*Trifolium resupinatum*
526	Dicots	Fabaceae	*Trigonella corniculata*
527	Dicots	Fabaceae	*Trigonella emodi* (Syn. *Trigonella fimbriata*)
528	Dicots	Fabaceae	*Trigonella foenum-graecum*
529	Dicots	Fabaceae	*Trigonella incisa*
530	Dicots	Fabaceae	*Uraria lagopoides*
531	Dicots	Fabaceae	*Vicia bakeri*
532	Dicots	Fabaceae	*Vicia hirsuta*
533	Dicots	Fabaceae	*Vicia sativa*
534	Dicots	Fabaceae	*Vigna aconitifolia*
535	Dicots	Fabaceae	*Vigna vexillata*
536	Dicots	Fabaceae	*Albizia modesta*
537	Dicots	Fabaceae	*Albizia nilotica*
538	Dicots	Fabaceae	*Glycyrrhiza glabra*
539	Dicots	Fagaceae	*Castanea sativa*
540	Dicots	Fagaceae	*Quercus dilatata*

541	Dicots	Fagaceae	*Quercus floribunda*
542	Dicots	Fagaceae	*Quercus glauca*
543	Dicots	Fagaceae	*Quercus infectoria*
544	Dicots	Fagaceae	*Quercus leucotrichophora*
545	Dicots	Fagaceae	*Quercus semecarpifolia*
546	Dicots	Flacourtiaceae	*Flacourtia jangomas*
547	Dicots	Flacourtiaceae	*Flacourtia ramontchi*
548	Dicots	Flacourtiaceae	*Xylosoma longifolium*
549	Dicots	Gentianaceae	*Canscora diffusa*
550	Dicots	Gentianaceae	*Comastoma tenellum* (Syn.*Gentianella tenella*)
551	Dicots	Gentianaceae	*Gentiana aprica*
552	Dicots	Gentianaceae	*Gentiana argentea*
553	Dicots	Gentianaceae	*Gentiana cachemirica*
554	Dicots	Gentianaceae	*Gentiana carinata*
555	Dicots	Gentianaceae	*Gentiana kurroo*
556	Dicots	Gentianaceae	*Gentiana moorcroftiana*
557	Dicots	Gentianaceae	*Gentiana pedicillata*
558	Dicots	Gentianaceae	*Gentiana venusta*
559	Dicots	Gentianaceae	*Gentianella moorcroftiana*
560	Dicots	Gentianaceae	*Halenia elliptica*
561	Dicots	Gentianaceae	*Jaeschkea oligosperma*
562	Dicots	Gentianaceae	*Swertia alata*
563	Dicots	Gentianaceae	*Swertia alternifolia*
564	Dicots	Gentianaceae	*Swertia angustifolia*
565	Dicots	Gentianaceae	*Swertia chirayita*
566	Dicots	Gentianaceae	*Swertia ciliata*
567	Dicots	Gentianaceae	*Swertia cordata*
568	Dicots	Gentianaceae	*Swertia paniculata*
569	Dicots	Gentianaceae	*Swertia petiolata*
570	Dicots	Gentianaceae	*Swertia speciosa*
571	Dicots	Gentianaceae	*Swertia tetragona*
572	Dicots	Geraniaceae	*Erodium cicutarium*
573	Dicots	Geraniaceae	*Geranium lucidum*
574	Dicots	Geraniaceae	*Geranium maculatum*
575	Dicots	Geraniaceae	*Geranium mascatense*
576	Dicots	Geraniaceae	*Geranium nepalense*
577	Dicots	Geraniaceae	*Geranium ocellatum*
578	Dicots	Geraniaceae	*Geranium polyanthes*
579	Dicots	Geraniaceae	*Geranium pratense*
580	Dicots	Geraniaceae	*Geranium rotundifolium*
581	Dicots	Geraniaceae	*Geranium wallichianum*
582	Dicots	Gesneriaceae	*Chirita bifolia*
583	Dicots	Gesneriaceae	*Didymocarpus pedicellatus*
584	Dicots	Gleicheniaceae	*Dicranopteris linearis*
585	Dicots	Grossulariaceae	*Ribes alpestre*
586	Dicots	Grossulariaceae	*Ribes glaciale*
587	Dicots	Hamamelidaceae	*Parrotiopsis jacquemontiana*
588	Dicots	Hydrangeaceae	*Deutzia corymbosa*
589	Dicots	Hydrangeaceae	*Deutzia staminea*
590	Dicots	Hydrangeaceae	*Hydrangea anomala*

591	Dicots	Hydrangeaceae	*Hydrangea robusta*
592	Dicots	Hydrangeaceae	*Philadelphus tomentosus*
593	Dicots	Hypericaceae	*Hypericum patalum*
594	Dicots	Hypericaceae	*Hypericum perforatum*
595	Dicots	Hypericaeae	*Hypericum elodeoides*
596	Dicots	Hypericaeae	*Hypericum oblongifolium*
597	Dicots	Hypericaeae	*Hypericum uralum*
598	Dicots	Juglandaceae	*Juglans regia*
599	Dicots	Lamiaceae	*Ajuga brachystemon*
600	Dicots	Lamiaceae	*Ajuga integrifolia* (Syn. *Ajuga bracteosa*)
601	Dicots	Lamiaceae	*Ajuga parviflora*
602	Dicots	Lamiaceae	*Caryopteris odorata*
603	Dicots	Lamiaceae	*Clerodendrum divaricatum*
604	Dicots	Lamiaceae	*Clerodendrum indicum*
605	Dicots	Lamiaceae	*Clerodendrum philippinum*
606	Dicots	Lamiaceae	*Clerodendrum phlomidis*
607	Dicots	Lamiaceae	*Clinopodium umbrosum*
608	Dicots	Lamiaceae	*Clinopodium vulgare*
609	Dicots	Lamiaceae	*Colebrookea oppositifolia*
610	Dicots	Lamiaceae	*Colquhounia coccinea*
611	Dicots	Lamiaceae	*Cranitome furcata*
612	Dicots	Lamiaceae	*Elsholtzia ciliata*
613	Dicots	Lamiaceae	*Elsholtzia flava*
614	Dicots	Lamiaceae	*Elsholtzia fruticosa*
615	Dicots	Lamiaceae	*Elsholtzia strobilifera*
616	Dicots	Lamiaceae	*Eramostachys superba*
617	Dicots	Lamiaceae	*Gmelina arborea*
618	Dicots	Lamiaceae	*Isodon rugosus* (Syn. *Plectranthus rugosus*)
619	Dicots	Lamiaceae	*Lamium album*
620	Dicots	Lamiaceae	*Lamium amplexicaule*
621	Dicots	Lamiaceae	*Leonurus cardiaca*
622	Dicots	Lamiaceae	*Leucas cephalotes*
623	Dicots	Lamiaceae	*Leucas lanata*
624	Dicots	Lamiaceae	*Leucosceptrum canum*
625	Dicots	Lamiaceae	*Lycopus europaeus*
626	Dicots	Lamiaceae	*Mentha arvensis*
627	Dicots	Lamiaceae	*Mentha longifolia*
628	Dicots	Lamiaceae	*Mentha spicata*
629	Dicots	Lamiaceae	*Meriandra strobilifera*
630	Dicots	Lamiaceae	*Micromeria biflora*
631	Dicots	Lamiaceae	*Mosla dianthera*
632	Dicots	Lamiaceae	*Nepeta campestris*
633	Dicots	Lamiaceae	*Nepeta ciliaris*
634	Dicots	Lamiaceae	*Nepeta erecta*
635	Dicots	Lamiaceae	*Nepeta eriostachya*
636	Dicots	Lamiaceae	*Nepeta govaniana*
637	Dicots	Lamiaceae	*Nepeta hindostana*
638	Dicots	Lamiaceae	*Nepeta laevigata*
639	Dicots	Lamiaceae	*Nepeta leucophylla*

640	Dicots	Lamiaceae	*Nepeta podostachys*
641	Dicots	Lamiaceae	*Nepeta raphanorhiza*
642	Dicots	Lamiaceae	*Nepeta royleana*
643	Dicots	Lamiaceae	*Ocimum americanum*
644	Dicots	Lamiaceae	*Ocimum basilicum*
645	Dicots	Lamiaceae	*Ocimum sanctum*
646	Dicots	Lamiaceae	*Ocimum tenuiflorum*
647	Dicots	Lamiaceae	*Origanum vulgare*
648	Dicots	Lamiaceae	*Perilla frutescens*
649	Dicots	Lamiaceae	*Phlomoides bracteosa*
650	Dicots	Lamiaceae	*Plectranthes lophanthoides*
651	Dicots	Lamiaceae	*Plectranthes mollis*
652	Dicots	Lamiaceae	*Plectranthus japonicus*
653	Dicots	Lamiaceae	*Pogostemon benghalensis*
654	Dicots	Lamiaceae	*Pogostemon plectrantoides*
655	Dicots	Lamiaceae	*Premna barbata*
656	Dicots	Lamiaceae	*Premna serratifolia* (Syn. *Premna obtusifolia*)
657	Dicots	Lamiaceae	*Prunella vulgaris*
658	Dicots	Lamiaceae	*Pseudocaryopteris bicolor* (Syn.*Caryopteris wallichiana*)
659	Dicots	Lamiaceae	*Rabdosia rugosa*
660	Dicots	Lamiaceae	*Rolea cinerea*
661	Dicots	Lamiaceae	*Salvia aethiopis* (Syn. *Salvia lanata*)
662	Dicots	Lamiaceae	*Salvia hians*
663	Dicots	Lamiaceae	*Salvia leucantha*
664	Dicots	Lamiaceae	*Salvia moorcroftiana*
665	Dicots	Lamiaceae	*Salvia nubicola*
666	Dicots	Lamiaceae	*Salvia plebia*
667	Dicots	Lamiaceae	*Scutellaria repens*
668	Dicots	Lamiaceae	*Scutellaria scandens*
669	Dicots	Lamiaceae	*Stachys floccosa*
670	Dicots	Lamiaceae	*Stachys sericea*
671	Dicots	Lamiaceae	*Tectona grandis*
672	Dicots	Lamiaceae	*Teucrium quadrifarium*
673	Dicots	Lamiaceae	*Teucrium royleanum*
674	Dicots	Lamiaceae	*Thymus linearis*
675	Dicots	Lamiaceae	*Thymus serpyllum*
676	Dicots	Lamiaceae	*Thymus vulgaris*
677	Dicots	Lamiaceae	*Mentha piperita*
678	Dicots	Lauraceae	*Cinnamomum camphora*
679	Dicots	Lauraceae	*Cinnamomum tamala*
680	Dicots	Lauraceae	*Cinnamomum verum*
681	Dicots	Lauraceae	*Neolitsea pallens*
682	Dicots	Lauraceae	*Neolitsea umbrosa*
683	Dicots	Lauraceae	*Persea odoratissima*
684	Dicots	Lauraceae	*Phoebe lanceolata*
685	Dicots	Lecythidaceae	*Careya arborea*
686	Dicots	Leeaceae	*Leea crispa*
687	Dicots	Lentibulariaceae	*Utricularia brachiata*
688	Dicots	Linaceae	*Linum usitatissimum*
689	Dicots	Linaceae	*Reinwardtia indica*

690	Dicots	Linderniaceae	*Lindernia anagallis*
691	Dicots	Linderniaceae	*Lindernia ciliata*
692	Dicots	Linderniaceae	*Lindernia numularifolia*
693	Dicots	Linderniaceae	*Torenia cordifolia*
694	Dicots	Loganiaceae	*Strychnos nux-vomica*
695	Dicots	Loranthaceae	*Dendrophthoe falcata*
696	Dicots	Loranthaceae	*Scurrula pulverulenta*
697	Dicots	Loranthaceae	*Taxillus vestitus*
698	Dicots	Lythraceae	*Lawsonia inermis*
699	Dicots	Lythraceae	*Leucas aspera*
700	Dicots	Lythraceae	*Lythrum salicaria*
701	Dicots	Lythraceae	*Punica granatum*
702	Dicots	Lythraceae	*Rotala densiflora*
703	Dicots	Lythraceae	*Rotala rotundifolia*
704	Dicots	Lythraceae	*Woodfordia fruticosa*
705	Dicots	Malpighiaceae	*Aspidopterys wallichii*
706	Dicots	Malpighiaceae	*Hiptage benghalensis*
707	Dicots	Malvaceae	*Abelmoschus crinitus*
708	Dicots	Malvaceae	*Abelmoschus manihot*
709	Dicots	Malvaceae	*Abutilon indicum*
710	Dicots	Malvaceae	*Gossypium arboreum*
711	Dicots	Malvaceae	*Gossypium herbaceum*
712	Dicots	Malvaceae	*Grewia serrulata* (Syn. *Grewia disperma*)
713	Dicots	Malvaceae	*Helicteres isora*
714	Dicots	Malvaceae	*Hibiscus rosa-sinensis*
715	Dicots	Malvaceae	*Kydia calycina*
716	Dicots	Malvaceae	*Malva neglecta*
717	Dicots	Malvaceae	*Malva parviflora*
718	Dicots	Malvaceae	*Malva verticillata*
719	Dicots	Malvaceae	*Malvastrum coromandelianum*
720	Dicots	Malvaceae	*Sida acuta*
721	Dicots	Malvaceae	*Sida cordata*
722	Dicots	Malvaceae	*Sida rhombifolia*
723	Dicots	Malvaceae	*Triumfetta rhomboidea*
724	Dicots	Malvaceae	*Urena lobata*
725	Dicots	Melanthiaceae	*Trillium govanianum*
726	Dicots	Melastomaceae	*Osbeckia stellata*
727	Dicots	Melastomataceae	*Melastoma malabathricum*
728	Dicots	Melastomataceae	*Oxyspora paniculata*
729	Dicots	Meliaceae	*Azadirachta indica*
730	Dicots	Meliaceae	*Melia azedarach*
731	Dicots	Meliaceae	*Soymida febrifuga*
732	Dicots	Meliaceae	*Toona ciliata*
733	Dicots	Meliaceae	*Toona hexandra*
734	Dicots	Meliaceae	*Toona sinensis* (Syn. *Toona serrata*)
735	Dicots	Menispermaceae	*Cissampelos pareira*
736	Dicots	Menispermaceae	*Stephania elegans*
737	Dicots	Menispermaceae	*Stephania glabra*
738	Dicots	Menispermaceae	*Tinospora cordifolia*
739	Dicots	Molluginaceae	*Glinus lotoides*

740	Dicots	Molluginaceae	*Mollugo pentaphylla*
741	Dicots	Moraceae	*Broussonetia papyrifera*
742	Dicots	Moraceae	*Ficus auriculata*
743	Dicots	Moraceae	*Ficus bengalensis*
744	Dicots	Moraceae	*Ficus glomerata*
745	Dicots	Moraceae	*Ficus hispida*
746	Dicots	Moraceae	*Ficus nerifolia*
747	Dicots	Moraceae	*Ficus oligodon*
748	Dicots	Moraceae	*Ficus palmata*
749	Dicots	Moraceae	*Ficus racemosa*
750	Dicots	Moraceae	*Ficus religiosa*
751	Dicots	Moraceae	*Ficus roxburghii*
752	Dicots	Moraceae	*Ficus rumphii*
753	Dicots	Moraceae	*Ficus sarmentosa*
754	Dicots	Moraceae	*Ficus semicordata*
755	Dicots	Moraceae	*Ficus virens*
756	Dicots	Moraceae	*Morus alba*
757	Dicots	Moraceae	*Morus australis*
758	Dicots	Moraceae	*Morus serrata*
759	Dicots	Moraceae	*Streblus asper*
760	Dicots	Moringaceae	*Moringa oleifera*
761	Dicots	Musaceae	*Musa paradisiaca*
762	Dicots	Myricaceae	*Myrica esculenta*
763	Dicots	Myristicaceae	*Myristica fragrans*
764	Dicots	Myrsinaceae	*Ardisia solanacea*
765	Dicots	Myrsinaceae	*Embelia tesjeriam-cottam*
766	Dicots	Myrsinaceae	*Myrisine affricana*
767	Dicots	Myrtaceae	*Callistemon viminalis*
768	Dicots	Myrtaceae	*Corymbia citriodora* (Syn. *Eucalyptus citriodora*)
769	Dicots	Myrtaceae	*Eucalyptus camaldulensis*
770	Dicots	Myrtaceae	*Eucalyptus crebra*
771	Dicots	Myrtaceae	*Eucalyptus globulus*
772	Dicots	Myrtaceae	*Eucalyptus melanophloia*
773	Dicots	Myrtaceae	*Psidium guajava*
774	Dicots	Myrtaceae	*Syzygium aromaticum*
775	Dicots	Myrtaceae	*Syzygium cumini*
776	Dicots	Nyctaginaceae	*Boerhavia diffusa*
777	Dicots	Nyctaginaceae	*Bougainvillea glabra*
778	Dicots	Nyctaginaceae	*Mirabilis jalapa*
779	Dicots	Oleaceae	*Fraxinus excelsior*
780	Dicots	Oleaceae	*Fraxinus floribunda*
781	Dicots	Oleaceae	*Fraxinus micrantha*
782	Dicots	Oleaceae	*Fraxinus xanthoxyloides*
783	Dicots	Oleaceae	*Jasminum dispermum*
784	Dicots	Oleaceae	*Jasminum grandiflorum*
785	Dicots	Oleaceae	*Jasminum humile*
786	Dicots	Oleaceae	*Jasminum multiflorum*
787	Dicots	Oleaceae	*Jasminum officinale*
788	Dicots	Oleaceae	*Nyctanthes arbor-tristis*
789	Dicots	Oleaceae	*Olea ferruginea*

790	Dicots	Oleaceae	*Olea glandulifera*
791	Dicots	Oleaceae	*Syringa emodi*
792	Dicots	Onagraceae	*Circaea alpina* subsp. *imaicola*
793	Dicots	Onagraceae	*Circaea repens*
794	Dicots	Onagraceae	*Epilobium angustifolium*
795	Dicots	Onagraceae	*Epilobium cylindricum*
796	Dicots	Onagraceae	*Epilobium hirsutum*
797	Dicots	Onagraceae	*Epilobium latifolium*
798	Dicots	Onagraceae	*Epilobium laxum*
799	Dicots	Onagraceae	*Epilobium leiophyllum*
800	Dicots	Onagraceae	*Epilobium royleanum*
801	Dicots	Onagraceae	*Epilobium wallichianum*
802	Dicots	Onagraceae	*Ludwigia octovalvis*
803	Dicots	Onagraceae	*Oenothera affinis*
804	Dicots	Onagraceae	*Oenothera glazioviana*
805	Dicots	Onagraceae	*Oenothera rosea*
806	Dicots	Orobanchaceae	*Euphrasia simplex*
807	Dicots	Orobanchaceae	*Leptorhabdos parviflora*
808	Dicots	Orobanchaceae	*Orobanche alba*
809	Dicots	Orobanchaceae	*Pedicularis albida*
810	Dicots	Orobanchaceae	*Pedicularis bicornuta*
811	Dicots	Orobanchaceae	*Pedicularis bifida*
812	Dicots	Orobanchaceae	*Pedicularis gracilis*
813	Dicots	Orobanchaceae	*Pedicularis hoffmeisteri*
814	Dicots	Orobanchaceae	*Pedicularis mollis*
815	Dicots	Orobanchaceae	*Pedicularis oederi*
816	Dicots	Orobanchaceae	*Pedicularis pectinata*
817	Dicots	Orobanchaceae	*Pedicularis punctata*
818	Dicots	Orobanchaceae	*Pedicularis pyramidata*
819	Dicots	Oxalidaceae	*Oxalis acetosella*
820	Dicots	Oxalidaceae	*Oxalis corniculata*
821	Dicots	Oxalidaceae	*Oxalis corymbosa*
822	Dicots	Oxalidaceae	*Oxalis latifolia*
823	Dicots	Paeoniaceae	*Paeonia emodi*
824	Dicots	Papaveraceae	*Argemone mexicana*
825	Dicots	Papaveraceae	*Corydalis cashmeriana*
826	Dicots	Papaveraceae	*Corydalis cornuta*
827	Dicots	Papaveraceae	*Corydalis crassifolia*
828	Dicots	Papaveraceae	*Corydalis diphylla*
829	Dicots	Papaveraceae	*Corydalis govaniana*
830	Dicots	Papaveraceae	*Corydalis govaniana*
831	Dicots	Papaveraceae	*Corydalis meifolia*
832	Dicots	Papaveraceae	*Corydalis thyrsiflora*
833	Dicots	Papaveraceae	*Corydalis vaginans* (Syn. *Corydalis ramosa*)
834	Dicots	Papaveraceae	*Dicentra scandens*
835	Dicots	Papaveraceae	*Fumaria indica*
836	Dicots	Papaveraceae	*Meconopsis aculeata*
837	Dicots	Papaveraceae	*Papaver dubium*
838	Dicots	Papaveraceae	*Papaver somniferum*
839	Dicots	Parnassaceae	*Parnassia nubicola*

840	Dicots	Pasiifloraceae	*Passiflora coerulea*
841	Dicots	Pedaliaceae	*Sesamum indicum* (Syn. *Sesamum orientale*)
842	Dicots	Phrymaceae	*Mazus pumilus*
843	Dicots	Phrymaceae	*Mazus surculosus*
844	Dicots	Phrymaceae	*Phryma leptostachya*
845	Dicots	Phyllanthaceae	*Bischofia javanica*
846	Dicots	Phyllanthaceae	*Bridelia retusa* (Syn. *Bridelia squamosa*)
847	Dicots	Phyllanthaceae	*Glochidion heyneanum* (Syn. *Glochidion velutinum*)
848	Dicots	Phyllanthaceae	*Phyllanthus amarus*
849	Dicots	Phyllanthaceae	*Phyllanthus emblica*
850	Dicots	Phyllanthaceae	*Phyllanthus fraternus*
851	Dicots	Phyllanthaceae	*Phyllanthus niruri*
852	Dicots	Phyllanthaceae	*Phyllanthus parvifolius*
853	Dicots	Phyllanthaceae	*Phyllanthus urinaria*
854	Dicots	Phytolaccaceae	*Phytolacca acinosa*
855	Dicots	Piperaceae	*Pepromia tetraphylla*
856	Dicots	Piperaceae	*Piper cubeba*
857	Dicots	Piperaceae	*Piper nepalense*
858	Dicots	Plantaginaceae	*Digitalis purpurea*
859	Dicots	Plantaginaceae	*Hemiphragma heterophyllum*
860	Dicots	Plantaginaceae	*Lagotis cashmeriana*
861	Dicots	Plantaginaceae	*Lagotis minor*
862	Dicots	Plantaginaceae	*Limnophila indica*
863	Dicots	Plantaginaceae	*Lindenbergia grandiflora*
864	Dicots	Plantaginaceae	*Lindenbergia indica*
865	Dicots	Plantaginaceae	*Lindenbergia macrostachya*
866	Dicots	Plantaginaceae	*Nanorrhinum ramosissimum* (Syn. *Kickxia ramosissima*)
867	Dicots	Plantaginaceae	*Picrorhiza kurrooa*
868	Dicots	Plantaginaceae	*Plantago depressa*
869	Dicots	Plantaginaceae	*Plantago erosa*
870	Dicots	Plantaginaceae	*Plantago gentianoides*
871	Dicots	Plantaginaceae	*Plantago himalaica*
872	Dicots	Plantaginaceae	*Plantago lanceolata*
873	Dicots	Plantaginaceae	*Plantago major*
874	Dicots	Plantaginaceae	*Plantago ovata*
875	Dicots	Plantaginaceae	*Veronica agrestis*
876	Dicots	Plantaginaceae	*Veronica anagalis-aquatica*
877	Dicots	Plantaginaceae	*Veronica beccabunga*
878	Dicots	Plantaginaceae	*Veronica biloba*
879	Dicots	Plantaginaceae	*Veronica persica*
880	Dicots	Plantaginaceae	*Veronica serpyllifolia*
881	Dicots	Plantaginaceae	*Veronica verna*
882	Dicots	Plantaginaceae	*Wulfenia amherstiana*
883	Dicots	Platanaceae	*Platinus orientalis*
884	Dicots	Plumbaginaceae	*Plumbago zeylanica*
885	Dicots	Polygalaceae	*Polygala abyssinica*
886	Dicots	Polygalaceae	*Polygala arvensis*
887	Dicots	Polygalaceae	*Polygala sibirica*
888	Dicots	Polygonaceae	*Aconogonum alpinum*
889	Dicots	Polygonaceae	*Aconogonum molle*

890	Dicots	Polygonaceae	*Aconogonum rumicifolium*
891	Dicots	Polygonaceae	*Bilderdykia convolvulus*
892	Dicots	Polygonaceae	*Bilderdykia pterocarpa*
893	Dicots	Polygonaceae	*Bistorta affinis*
894	Dicots	Polygonaceae	*Bistorta amplexicaulis*
895	Dicots	Polygonaceae	*Bistorta macrophylla*
896	Dicots	Polygonaceae	*Bistorta vaccinifolia*
897	Dicots	Polygonaceae	*Bistorta vivipara*
898	Dicots	Polygonaceae	*Fagopyrum dibotrys*
899	Dicots	Polygonaceae	*Fagopyrum esculentum*
900	Dicots	Polygonaceae	*Fagopyrum tataricum*
901	Dicots	Polygonaceae	*Koenigia delicatula*
902	Dicots	Polygonaceae	*Oxyria digyna*
903	Dicots	Polygonaceae	*Persicaria amplexicaulis* (Syn. *Polygonum amplexicaule*)
904	Dicots	Polygonaceae	*Persicaria barbata*
905	Dicots	Polygonaceae	*Persicaria capitata*
906	Dicots	Polygonaceae	*Persicaria chinensis*
907	Dicots	Polygonaceae	*Persicaria hydropiper* (Syn. *Polygonum hydropiper*)
908	Dicots	Polygonaceae	*Persicaria microcephala*
909	Dicots	Polygonaceae	*Persicaria nepalensis*
910	Dicots	Polygonaceae	*Persicaria polystachya*
911	Dicots	Polygonaceae	*Persicaria pubescens*
912	Dicots	Polygonaceae	*Persicaria sagittata*
913	Dicots	Polygonaceae	*Persicaria vivipara* (Syn. *Polygonum viviparum*)
914	Dicots	Polygonaceae	*Persicaria wallichii* (Syn. *Polygonum polystachyum*)
915	Dicots	Polygonaceae	*Polygonum aviculare*
916	Dicots	Polygonaceae	*Polygonum bistorta*
917	Dicots	Polygonaceae	*Polygonum humile*
918	Dicots	Polygonaceae	*Polygonum paronychioides*
919	Dicots	Polygonaceae	*Polygonum plebieum*
920	Dicots	Polygonaceae	*Polygonum recumbens*
921	Dicots	Polygonaceae	*Polygonum rottboellioides*
922	Dicots	Polygonaceae	*Polygonum sinuatum*
923	Dicots	Polygonaceae	*Polygonum verticillatum*
924	Dicots	Polygonaceae	*Rheum australe*
925	Dicots	Polygonaceae	*Rheum australe*
926	Dicots	Polygonaceae	*Rheum moorcroftiana*
927	Dicots	Polygonaceae	*Rheum spiciforme*
928	Dicots	Polygonaceae	*Rheum webbianum*
929	Dicots	Polygonaceae	*Rumex acetosa*
930	Dicots	Polygonaceae	*Rumex hastatus*
931	Dicots	Polygonaceae	*Rumex nepalensis*
932	Dicots	Portulacaceae	*Portulaca oleracea*
933	Dicots	Portulacaceae	*Portulaca pilosa*
934	Dicots	Primulaceae	*Anagalis arvensis*
935	Dicots	Primulaceae	*Andrasace delavayi*
936	Dicots	Primulaceae	*Androsace globifera*
937	Dicots	Primulaceae	*Androsace rotundifolia*
938	Dicots	Primulaceae	*Androsace sarmentosa*
939	Dicots	Primulaceae	*Androsace semipervivoides*

940	Dicots	Primulaceae	*Androsace umbellata*
941	Dicots	Primulaceae	*Ardisia khasiana*
942	Dicots	Primulaceae	*Embelia ribes*
943	Dicots	Primulaceae	*Lysimachia chenopodioides*
944	Dicots	Primulaceae	*Lysimachia ferruginea*
945	Dicots	Primulaceae	*Lysimachia prolifera*
946	Dicots	Primulaceae	*Maesa chisia*
947	Dicots	Primulaceae	*Primula denticulata*
948	Dicots	Primulaceae	*Primula floribunda*
949	Dicots	Primulaceae	*Primula glomerata*
950	Dicots	Primulaceae	*Primula involucrata*
951	Dicots	Primulaceae	*Primula minutissima*
952	Dicots	Primulaceae	*Primula petiolaris*
953	Dicots	Primulaceae	*Primula rosea*
954	Dicots	Primulaceae	*Primula stuartii*
955	Dicots	Proteaceae	*Grevillea robusta*
956	Dicots	Putranjivaceae	*Putranjiva roxburghii*
957	Dicots	Ranunculaceae	*Aconitum chasmanthum*
958	Dicots	Ranunculaceae	*Aconitum ferox*
959	Dicots	Ranunculaceae	*Aconitum heterophyllum*
960	Dicots	Ranunculaceae	*Aconitum laeve*
961	Dicots	Ranunculaceae	*Aconitum lethale* (Syn. *Aconitum balfourii*)
962	Dicots	Ranunculaceae	*Aconitum violaceum*
963	Dicots	Ranunculaceae	*Actaea acuminata*
964	Dicots	Ranunculaceae	*Actaea spicata*
965	Dicots	Ranunculaceae	*Adonis aestivalis*
966	Dicots	Ranunculaceae	*Anemone obtusiloba*
967	Dicots	Ranunculaceae	*Anemone polyanthes*
968	Dicots	Ranunculaceae	*Anemone pubiflora*
969	Dicots	Ranunculaceae	*Anemone rivularis*
970	Dicots	Ranunculaceae	*Anemone rupicola*
971	Dicots	Ranunculaceae	*Anemone tetrasepala*
972	Dicots	Ranunculaceae	*Anemone vitifolia*
973	Dicots	Ranunculaceae	*Caltha palustris*
974	Dicots	Ranunculaceae	*Clematis barbellata*
975	Dicots	Ranunculaceae	*Clematis buchananiana*
976	Dicots	Ranunculaceae	*Clematis connata*
977	Dicots	Ranunculaceae	*Clematis graveolens*
978	Dicots	Ranunculaceae	*Clematis montana*
979	Dicots	Ranunculaceae	*Clematis vestitum*
980	Dicots	Ranunculaceae	*Delphinium brunonianum*
981	Dicots	Ranunculaceae	*Delphinium cashmirianum*
982	Dicots	Ranunculaceae	*Delphinium denudatum*
983	Dicots	Ranunculaceae	*Delphinium elatum*
984	Dicots	Ranunculaceae	*Delphinium kolzii*
985	Dicots	Ranunculaceae	*Delphinium pyramidale*
986	Dicots	Ranunculaceae	*Delphnium vestitum*
987	Dicots	Ranunculaceae	*Nigella sativa*
988	Dicots	Ranunculaceae	*Oxygraphis polypetala*
989	Dicots	Ranunculaceae	*Ranunculus arvensis*

990	Dicots	Ranunculaceae	*Ranunculus diffusus*
991	Dicots	Ranunculaceae	*Ranunculus hirtellus*
992	Dicots	Ranunculaceae	*Ranunculus laetus*
993	Dicots	Ranunculaceae	*Ranunculus lingua*
994	Dicots	Ranunculaceae	*Ranunculus pulchellus*
995	Dicots	Ranunculaceae	*Ranunculus sceleratus*
996	Dicots	Ranunculaceae	*Thalictrum alpinum*
997	Dicots	Ranunculaceae	*Thalictrum cultratum*
998	Dicots	Ranunculaceae	*Thalictrum elegans*
999	Dicots	Ranunculaceae	*Thalictrum foetidum*
1000	Dicots	Ranunculaceae	*Thalictrum foliolosum*
1001	Dicots	Ranunculaceae	*Thalictrum javanicum*
1002	Dicots	Ranunculaceae	*Thalictrum reniforme*
1003	Dicots	Ranunculaceae	*Thalictrum rostellatum*
1004	Dicots	Ranunculaceae	*Thalictrum secundum*
1005	Dicots	Ranunculaceae	*Trollius acaulis*
1006	Dicots	Rhamnaceae	*Helinus lanceolatus*
1007	Dicots	Rhamnaceae	*Rhamnus purpureus*
1008	Dicots	Rhamnaceae	*Rhamnus triquetra*
1009	Dicots	Rhamnaceae	*Rhamnus virgatus*
1010	Dicots	Rhamnaceae	*Sageretia thea*
1011	Dicots	Rhamnaceae	*Ziziphus jujuba*
1012	Dicots	Rhamnaceae	*Ziziphus mauritiana*
1013	Dicots	Rhamnaceae	*Ziziphus nummularia*
1014	Dicots	Rhamnaceae	*Ziziphus oxyphylla*
1015	Dicots	Rosaceae	*Agrimonia pilosa*
1016	Dicots	Rosaceae	*Aruncus dioicus*
1017	Dicots	Rosaceae	*Cotoneaster acuminatus*
1018	Dicots	Rosaceae	*Cotoneaster affinis*
1019	Dicots	Rosaceae	*Cotoneaster bacillaris*
1020	Dicots	Rosaceae	*Cotoneaster microphyllus*
1021	Dicots	Rosaceae	*Cotoneaster obtusus*
1022	Dicots	Rosaceae	*Cotoneaster roseus*
1023	Dicots	Rosaceae	*Duchesnea indica*
1024	Dicots	Rosaceae	*Eriobotrya japonica*
1025	Dicots	Rosaceae	*Filipendula vestita*
1026	Dicots	Rosaceae	*Fragaria indica*
1027	Dicots	Rosaceae	*Fragaria nubicola*
1028	Dicots	Rosaceae	*Fragaria vesca*
1029	Dicots	Rosaceae	*Geum elatum*
1030	Dicots	Rosaceae	*Geum roylei*
1031	Dicots	Rosaceae	*Malus baccata*
1032	Dicots	Rosaceae	*Potentilla arbuscula*
1033	Dicots	Rosaceae	*Potentilla argyrophylla*
1034	Dicots	Rosaceae	*Potentilla atrosanguinea*
1035	Dicots	Rosaceae	*Potentilla eriocarpa*
1036	Dicots	Rosaceae	*Potentilla fruticosa*
1037	Dicots	Rosaceae	*Potentilla fulgens*
1038	Dicots	Rosaceae	*Potentilla gerardiana*
1039	Dicots	Rosaceae	*Potentilla indica*

1040	Dicots	Rosaceae	*Potentilla nepalensis*
1041	Dicots	Rosaceae	*Potentilla supina*
1042	Dicots	Rosaceae	*Prinsepia utilis*
1043	Dicots	Rosaceae	*Prunus armeniaca*
1044	Dicots	Rosaceae	*Prunus avium*
1045	Dicots	Rosaceae	*Prunus cerasoides*
1046	Dicots	Rosaceae	*Prunus cornuta*
1047	Dicots	Rosaceae	*Prunus domestica*
1048	Dicots	Rosaceae	*Prunus padus*
1049	Dicots	Rosaceae	*Prunus persica*
1050	Dicots	Rosaceae	*Pyracantha crenulata*
1051	Dicots	Rosaceae	*Pyrus communis*
1052	Dicots	Rosaceae	*Pyrus pashia*
1053	Dicots	Rosaceae	*Rosa brunonii*
1054	Dicots	Rosaceae	*Rosa macrophylla*
1055	Dicots	Rosaceae	*Rosa sericea*
1056	Dicots	Rosaceae	*Rosa webbiana*
1057	Dicots	Rosaceae	*Rubus biflorus*
1058	Dicots	Rosaceae	*Rubus burkillii*
1059	Dicots	Rosaceae	*Rubus ellipticus*
1060	Dicots	Rosaceae	*Rubus foliolatus*
1061	Dicots	Rosaceae	*Rubus lasiocarpus*
1062	Dicots	Rosaceae	*Rubus macilentus*
1063	Dicots	Rosaceae	*Rubus nepalensis*
1064	Dicots	Rosaceae	*Rubus niveus*
1065	Dicots	Rosaceae	*Rubus paniculatus*
1066	Dicots	Rosaceae	*Sibbaldia cuneata*
1067	Dicots	Rosaceae	*Sibbaldia purpurea*
1068	Dicots	Rosaceae	*Sorbaria tomentosa*
1069	Dicots	Rosaceae	*Sorbus foliolosa*
1070	Dicots	Rosaceae	*Sorbus lanata*
1071	Dicots	Rosaceae	*Spiraea bella*
1072	Dicots	Rosaceae	*Spiraea canescens*
1073	Dicots	Rosaceae	*Spiraea sorbifolia*
1074	Dicots	Rosaceae	*Spiraea vaccinifolia*
1075	Dicots	Rosaceae	*Rosa moschata*
1076	Dicots	Rubiaceae	*Agrostemma verticillata*
1077	Dicots	Rubiaceae	*Borreria articularis*
1078	Dicots	Rubiaceae	*Catunaregam spinosa*
1079	Dicots	Rubiaceae	*Galium acutum*
1080	Dicots	Rubiaceae	*Galium aparine*
1081	Dicots	Rubiaceae	*Galium asperifolium*
1082	Dicots	Rubiaceae	*Galium asperuloides*
1083	Dicots	Rubiaceae	*Galium elegans*
1084	Dicots	Rubiaceae	*Galium rotundifolium*
1085	Dicots	Rubiaceae	*Haldina cordifolia*
1086	Dicots	Rubiaceae	*Hedyotis diffusa*
1087	Dicots	Rubiaceae	*Hedyotis pruinosa* (Syn. *Hedyotis corymbosa*)
1088	Dicots	Rubiaceae	*Hedyotis verticillata*
1089	Dicots	Rubiaceae	*Hymenodictyon excelsum*

1090	Dicots	Rubiaceae	*Hymenodictyon orixense*
1091	Dicots	Rubiaceae	*Leptodermis lanceolata*
1092	Dicots	Rubiaceae	*Leptodermis virgata*
1093	Dicots	Rubiaceae	*Luculia pinceana*
1094	Dicots	Rubiaceae	*Mitragyna parvifolia*
1095	Dicots	Rubiaceae	*Oldenlandia corymbosa*
1096	Dicots	Rubiaceae	*Randia dumetorum*
1097	Dicots	Rubiaceae	*Randia tetrasperma*
1098	Dicots	Rubiaceae	*Rubia cordifolia*
1099	Dicots	Rubiaceae	*Rubia manjith*
1100	Dicots	Rubiaceae	*Spermadictyon suaveolens*
1101	Dicots	Rubiaceae	*Wendlandia puberula*
1102	Dicots	Rutaceae	*Aegle marmelos*
1103	Dicots	Rutaceae	*Boenninghausenia albiflora*
1104	Dicots	Rutaceae	*Citrus aurantiifolia*
1105	Dicots	Rutaceae	*Citrus aurantium*
1106	Dicots	Rutaceae	*Citrus media*
1107	Dicots	Rutaceae	*Glycosmis mauritiana*
1108	Dicots	Rutaceae	*Glycosmis pentaphylla* (Syn.*Glycosmis arborea*)
1109	Dicots	Rutaceae	*Murraya koenigii*
1110	Dicots	Rutaceae	*Murraya paniculata*
1111	Dicots	Rutaceae	*Naringi crenulata*
1112	Dicots	Rutaceae	*Skimmia laureola*
1113	Dicots	Rutaceae	*Zanthoxylum armatum*
1114	Dicots	Sabiaceae	*Meliosma dilleniifolia*
1115	Dicots	Sabiaceae	*Sabia campanulata*
1116	Dicots	Salicaceae	*Flacourtia indica*
1117	Dicots	Salicaceae	*Populus ciliata*
1118	Dicots	Salicaceae	*Populus deltoides*
1119	Dicots	Salicaceae	*Populus nigra*
1120	Dicots	Salicaceae	*Salix acutifolia*
1121	Dicots	Salicaceae	*Salix alba*
1122	Dicots	Salicaceae	*Salix denticulata*
1123	Dicots	Salicaceae	*Salix disperma* (Syn. *Salix wallichiana*)
1124	Dicots	Salicaceae	*Salix flabellaris*
1125	Dicots	Salicaceae	*Salix fragilis*
1126	Dicots	Salicaceae	*Salix hastata*
1127	Dicots	Salicaceae	*Salix lindleyana*
1128	Dicots	Salicaceae	*Salix oxycarpa*
1129	Dicots	Salicaceae	*Salix tetrasperma*
1130	Dicots	Salicaceae	*Salix wallichiana*
1131	Dicots	Sambucaceae	*Sambucus wightiana*
1132	Dicots	Santalaceae	*Korthalsella opuntia*
1133	Dicots	Santalaceae	*Osyris quadripartita*
1134	Dicots	Santalaceae	*Viscum album*
1135	Dicots	Sapindaceae	*Acer acuminata*
1136	Dicots	Sapindaceae	*Acer acuminatum*
1137	Dicots	Sapindaceae	*Acer caesium*
1138	Dicots	Sapindaceae	*Acer cappadocicum*
1139	Dicots	Sapindaceae	*Acer pictum*

1140	Dicots	Sapindaceae	*Acer villosum*
1141	Dicots	Sapindaceae	*Aesculus indica*
1142	Dicots	Sapindaceae	*Cardiospermum helicacabum*
1143	Dicots	Sapindaceae	*Dodonaea viscosa*
1144	Dicots	Sapindaceae	*Litchi chinensis*
1145	Dicots	Sapindaceae	*Litsea elongata*
1146	Dicots	Sapindaceae	*Litsea glutinosa*
1147	Dicots	Sapindaceae	*Litsea salicifolia*
1148	Dicots	Sapindaceae	*Litsea umbrosa*
1149	Dicots	Sapindaceae	*Sapindus mukorossi*
1150	Dicots	Saururaceae	*Houttuynia cordata*
1151	Dicots	Saxifragaceae	*Astilbe rivularis*
1152	Dicots	Saxifragaceae	*Bergenia ciliata*
1153	Dicots	Saxifragaceae	*Bergenia pacumbis* (Syn. *Bergenia ligulata*)
1154	Dicots	Saxifragaceae	*Bergenia stracheyi*
1155	Dicots	Saxifragaceae	*Saxifraga brunonis*
1156	Dicots	Saxifragaceae	*Saxifraga diversifolia*
1157	Dicots	Saxifragaceae	*Saxifraga moorcroftiana*
1158	Dicots	Saxifragaceae	*Saxifraga odontophylla*
1159	Dicots	Saxifragaceae	*Saxifraga parnassifolia*
1160	Dicots	Saxifragaceae	*Saxifraga sibirica*
1161	Dicots	Schisandraceae	*Illicium verum*
1162	Dicots	Schisandraceae	*Schisandra grandiflora*
1163	Dicots	Scrophulariaceae	*Antirrhinum orontium*
1164	Dicots	Scrophulariaceae	*Buchneria hispida*
1165	Dicots	Scrophulariaceae	*Buddleja asiatica*
1166	Dicots	Scrophulariaceae	*Buddleja crispa*
1167	Dicots	Scrophulariaceae	*Buddleja madagascariensis*
1168	Dicots	Scrophulariaceae	*Euphrasia himalaica*
1169	Dicots	Scrophulariaceae	*Scrophularia decomposita*
1170	Dicots	Scrophulariaceae	*Scrophularia himalensis*
1171	Dicots	Scrophulariaceae	*Scrophularia scabiosaefolia*
1172	Dicots	Scrophulariaceae	*Verbascum chinense*
1173	Dicots	Scrophulariaceae	*Verbascum thapsus*
1174	Dicots	Simaroubaceae	*Ailanthus altissima*
1175	Dicots	Simaroubaceae	*Brucea javanica* (Syn. *Rhus javanica*)
1176	Dicots	Simaroubaceae	*Brucea mollis*
1177	Dicots	Simaroubaceae	*Picrasma quassioides*
1178	Dicots	Solanaceae	*Atropa acuminata*
1179	Dicots	Solanaceae	*Atropa belladonna*
1180	Dicots	Solanaceae	*Brugmansia suaveolens*
1181	Dicots	Solanaceae	*Datura innoxia*
1182	Dicots	Solanaceae	*Datura metel*
1183	Dicots	Solanaceae	*Datura stramonium*
1184	Dicots	Solanaceae	*Datura stramonium*
1185	Dicots	Solanaceae	*Hyocyamus niger*
1186	Dicots	Solanaceae	*Lycopersicum esculentum*
1187	Dicots	Solanaceae	*Nicandra physaloides*
1188	Dicots	Solanaceae	*Nicotiana tabacum*
1189	Dicots	Solanaceae	*Physalis micrantha*

1190	Dicots	Solanaceae	*Physalis peruviana*
1191	Dicots	Solanaceae	*Physochlaina praealta*
1192	Dicots	Solanaceae	*Solanum erianthum*
1193	Dicots	Solanaceae	*Solanum indicum*
1194	Dicots	Solanaceae	*Solanum nigrum*
1195	Dicots	Solanaceae	*Solanum pseudo-capsicum*
1196	Dicots	Solanaceae	*Solanum surettense*
1197	Dicots	Solanaceae	*Solanum viarum*
1198	Dicots	Solanaceae	*Withania somnifera*
1199	Dicots	Staphyleaceae	*Staphylea emodi*
1200	Dicots	Symplocaceae	*Symplocos paniculata*
1201	Dicots	Tamaricaceae	*Myricaria germanica*
1202	Dicots	Tamaricaceae	*Tamarix indica* (Syn. *Tamarix troupii*)
1203	Dicots	Theaceae	*Camellia sinensis*
1204	Dicots	Thymelaeaceae	*Daphne cannabina*
1205	Dicots	Thymelaeaceae	*Daphne papyracea*
1206	Dicots	Thymelaeaceae	*Wikrostroemia canescens*
1207	Dicots	Tiliaceae	*Corchorus aestuans*
1208	Dicots	Tiliaceae	*Grewia eriocarpa*
1209	Dicots	Tiliaceae	*Grewia glabra*
1210	Dicots	Tiliaceae	*Grewia optiva*
1211	Dicots	Tiliaceae	*Tilia cordata*
1212	Dicots	Ulmaceae	*Holoptelea integrifolia*
1213	Dicots	Ulmaceae	*Trema cannabina*
1214	Dicots	Ulmaceae	*Ulmus villosa*
1215	Dicots	Ulmaceae	*Ulmus wallichiana*
1216	Dicots	Urticaceae	*Boehmeria macrophylla* (Syn. *Boehmeria platyphylla*)
1217	Dicots	Urticaceae	*Boehmeria rugulosa*
1218	Dicots	Urticaceae	*Debregeasia longifolia*
1219	Dicots	Urticaceae	*Debregeasia salicifolia*
1220	Dicots	Urticaceae	*Elatostema aquifolium*
1221	Dicots	Urticaceae	*Elatostema lineolatum*
1222	Dicots	Urticaceae	*Elatostema platyphyllum*
1223	Dicots	Urticaceae	*Elatostemma sessile*
1224	Dicots	Urticaceae	*Geradiana diversifolia*
1225	Dicots	Urticaceae	*Lecanthus peduncularis*
1226	Dicots	Urticaceae	*Parietaria micranthera*
1227	Dicots	Urticaceae	*Pilea racemosa*
1228	Dicots	Urticaceae	*Pilea scripta*
1229	Dicots	Urticaceae	*Pilea umbrosa*
1230	Dicots	Urticaceae	*Pouzolzia petendra*
1231	Dicots	Urticaceae	*Pouzolzia zeylanica*
1232	Dicots	Urticaceae	*Urtica dioica*
1233	Dicots	Urticaceae	*Urtica hyperborea*
1234	Dicots	Urticaceae	*Urtica mairei*
1235	Dicots	Urticaceae	*Urtica parviflora*
1236	Dicots	Valerianaceae	*Valeriana hardwickii*
1237	Dicots	Valerianaceae	*Valeriana jatamansii*
1238	Dicots	Valerianaceae	*Valeriana pyrolifolias*

1239	Dicots	Verbenaceae	*Callicarpa macrophylla*
1240	Dicots	Verbenaceae	*Caryopteris bicolor*
1241	Dicots	Verbenaceae	*Duranta erecta*
1242	Dicots	Verbenaceae	*Duranta repens*
1243	Dicots	Verbenaceae	*Homskioldia sanguinea*
1244	Dicots	Verbenaceae	*Lantana camara*
1245	Dicots	Verbenaceae	*Phyla nodiflora*
1246	Dicots	Verbenaceae	*Verbena bonnariensis*
1247	Dicots	Verbenaceae	*Verbena officinalis*
1248	Dicots	Verbenaceae	*Vitex negundo*
1249	Dicots	Violaceae	*Viola betonicifolia*
1250	Dicots	Violaceae	*Viola biflora*
1251	Dicots	Violaceae	*Viola canescens*
1252	Dicots	Violaceae	*Viola odorata*
1253	Dicots	Violaceae	*Viola pilosa*
1254	Dicots	Vitaceae	*Ampelocissus divaricata*
1255	Dicots	Vitaceae	*Ampelocissus latifolia*
1256	Dicots	Vitaceae	*Cayratia trifolia*
1257	Dicots	Vitaceae	*Cissus himalayana*
1258	Dicots	Vitaceae	*Cissus quadrangularis*
1259	Dicots	Vitaceae	*Cissus repanda*
1260	Dicots	Vitaceae	*Leea asiatica*
1261	Dicots	Vitaceae	*Parthenocissus semicordata*
1262	Dicots	Vitaceae	*Tetrastigma serrulatum*
1263	Dicots	Zygophyllaceae	*Tribulus terrestris*
1264	Monocots	Acoraceae	*Acorus calamaus*
1265	Monocots	Agavaceae	*Agave wightii*
1266	Monocots	Alismataceae	*Alisma plantago-aquatica*
1267	Monocots	Alismataceae	*Sagittaria guyanensis*
1268	Monocots	Amaryllidaceae	*Allium cepa*
1269	Monocots	Amaryllidaceae	*Allium humile*
1270	Monocots	Amaryllidaceae	*Allium rubellum*
1271	Monocots	Amaryllidaceae	*Allium stracheyi*
1272	Monocots	Amaryllidaceae	*Allium victorialis*
1273	Monocots	Amaryllidaceae	*Allium wallichii*
1274	Monocots	Araceae	*Amorphophallus paeoniifolius*
1275	Monocots	Araceae	*Arisaema costatum*
1276	Monocots	Araceae	*Arisaema flavum*
1277	Monocots	Araceae	*Arisaema intermedium*
1278	Monocots	Araceae	*Arisaema jacquemontii*
1279	Monocots	Araceae	*Arisaema tortuosum*
1280	Monocots	Araceae	*Arisaema wallichianum*
1281	Monocots	Araceae	*Colocasia affinis*
1282	Monocots	Araceae	*Colocasia esculenta*
1283	Monocots	Araceae	*Remusatia hookeriana*
1284	Monocots	Araceae	*Sauromatum venosum*
1285	Monocots	Araceae	*Scindapsus officinalis*
1286	Monocots	Araliaceae	*Aralia cachemirica*
1287	Monocots	Araliaceae	*Hedera helix*

1288	Monocots	Arecaceae	*Arenga saccharifera*
1289	Monocots	Arecaceae	*Phoenix acaulis*
1290	Monocots	Arecaceae	*Phoenix humilis*
1291	Monocots	Arecaceae	*Phoenix sylvestris*
1292	Monocots	Asparagaceae	*Agave americana*
1293	Monocots	Asparagaceae	*Asparagus adscendens*
1294	Monocots	Asparagaceae	*Asparagus filicinus*
1295	Monocots	Asparagaceae	*Asparagus racemosus*
1296	Monocots	Asparagaceae	*Drimia indica*
1297	Monocots	Asparagaceae	*Elephantopus mollis* (Syn. *Elephantopus scaber*)
1298	Monocots	Asparagaceae	*Ophiopogon intermedius*
1299	Monocots	Asparagaceae	*Polygonatum cirrhifolium*
1300	Monocots	Asparagaceae	*Polygonatum multiflorum*
1301	Monocots	Asparagaceae	*Polygonatum verticillatum*
1302	Monocots	Asparagaceae	*Yucca aloifolia*
1303	Monocots	Asparagaceae	*Yucca gloriosa* (Syn. *Yucca superba*)
1304	Monocots	Colchicaceae	*Gloriosa superba*
1305	Monocots	Commelinaceae	*Commelina benghalensis*
1306	Monocots	Commelinaceae	*Commelina paludosa*
1307	Monocots	Commelinaceae	*Cyanotis cristata*
1308	Monocots	Commelinaceae	*Cyanotis vaga*
1309	Monocots	Commelinaceae	*Pollia subumbellata*
1310	Monocots	Cyperaceae	*Bulbostylis barbata*
1311	Monocots	Cyperaceae	*Bulbostylis densa*
1312	Monocots	Cyperaceae	*Carex breviculmis*
1313	Monocots	Cyperaceae	*Carex cruciata*
1314	Monocots	Cyperaceae	*Carex infuscata*
1315	Monocots	Cyperaceae	*Carex longipes*
1316	Monocots	Cyperaceae	*Carex munroi*
1317	Monocots	Cyperaceae	*Carex nubigena*
1318	Monocots	Cyperaceae	*Carex obscura*
1319	Monocots	Cyperaceae	*Carex sempervirens* (Syn. *Carex alpina*)
1320	Monocots	Cyperaceae	*Carex setosa*
1321	Monocots	Cyperaceae	*Carex stramentitia* (Syn. *Carex filicina*)
1322	Monocots	Cyperaceae	*Cyperus alulatus*
1323	Monocots	Cyperaceae	*Cyperus breviculmis*
1324	Monocots	Cyperaceae	*Cyperus cardiolepis*
1325	Monocots	Cyperaceae	*Cyperus compressus*
1326	Monocots	Cyperaceae	*Cyperus cuspidatus*
1327	Monocots	Cyperaceae	*Cyperus cyperoides*
1328	Monocots	Cyperaceae	*Cyperus diaphanus*
1329	Monocots	Cyperaceae	*Cyperus filicina*
1330	Monocots	Cyperaceae	*Cyperus foliosa*
1331	Monocots	Cyperaceae	*Cyperus ligulata*
1332	Monocots	Cyperaceae	*Cyperus melanatha*
1333	Monocots	Cyperaceae	*Cyperus niveus*
1334	Monocots	Cyperaceae	*Cyperus nubigena*
1335	Monocots	Cyperaceae	*Cyperus rotundus*

1336	Monocots	Cyperaceae	*Cyperus setigera*
1337	Monocots	Cyperaceae	*Cyperus squarrosus*
1338	Monocots	Cyperaceae	*Eleocharis congesta*
1339	Monocots	Cyperaceae	*Eriophorum comosum*
1340	Monocots	Cyperaceae	*Eriophorum microstachyum*
1341	Monocots	Cyperaceae	*Eriophorum palustris*
1342	Monocots	Cyperaceae	*Fimbristylis bisumbellata*
1343	Monocots	Cyperaceae	*Fimbristylis dichotoma*
1344	Monocots	Cyperaceae	*Kobresia royleana*
1345	Monocots	Cyperaceae	*Kyllinga brevifolia*
1346	Monocots	Cyperaceae	*Scirpus juncoides*
1347	Monocots	Cyperaceae	*Scirpus littoralis*
1348	Monocots	Cyperaceae	*Scirpus mucronatus*
1349	Monocots	Cyperaceae	*Scirpus squarrosus*
1350	Monocots	Dioscoreaceae	*Dioscorea bulbifera*
1351	Monocots	Dioscoreaceae	*Dioscorea deltoidea*
1352	Monocots	Dioscoreaceae	*Dioscorea glabra*
1353	Monocots	Dioscoreaceae	*Dioscorea melanophyma*
1354	Monocots	Dioscoreaceae	*Dioscorea pentaphylla*
1355	Monocots	Eriocaulaceae	*Eriocaulon nepalense*
1356	Monocots	Haemodoraceae	*Aletris pauciflora*
1357	Monocots	Hydrocharitaceae	*Hydrilla verticillata*
1358	Monocots	Hypoxidaceae	*Curculigo orchoides*
1359	Monocots	Hypoxidaceae	*Hypoxis aurea*
1360	Monocots	Hypoxidaceae	*Molineria capitulata*
1361	Monocots	Iridaceae	*Belamcanda chinensis*
1362	Monocots	Iridaceae	*Iris hookeriana*
1363	Monocots	Iridaceae	*Iris kemaonensis*
1364	Monocots	Iridaceae	*Iris milesii*
1365	Monocots	Juncaceae	*Juncus articulatus*
1366	Monocots	Juncaceae	*Juncus bufonius*
1367	Monocots	Juncaceae	*Juncus concinnus*
1368	Monocots	Juncaceae	*Juncus leucomelas*
1369	Monocots	Juncaceae	*Juncus membranaceus*
1370	Monocots	Juncaceae	*Juncus sphacelatus*
1371	Monocots	Juncaceae	*Juncus thomsonii*
1372	Monocots	Juncaceae	*Luzula multiflora*
1373	Monocots	Lemnaceae	*Lemna purpusilla*
1374	Monocots	Liliaceae	*Cardiocrinum giganteum*
1375	Monocots	Liliaceae	*Clintonia udensis*
1376	Monocots	Liliaceae	*Fritillaria cirrhosa* (Syn. *Fritillaria roylei*)
1377	Monocots	Liliaceae	*Gagea elegans*
1378	Monocots	Liliaceae	*Lilium giganteum*
1379	Monocots	Liliaceae	*Lilium polyphyllum*
1380	Monocots	Liliaceae	*Lilium thomsonianum*
1381	Monocots	Liliaceae	*Lloydia serotina*
1382	Monocots	Liliaceae	*Smilacina purpurea*

1383	Monocots	Liliaceae	*Tulipa stellata*
1384	Monocots	Orchidaceae	*Aerides multiflora*
1385	Monocots	Orchidaceae	*Brassiopsis mitis*
1386	Monocots	Orchidaceae	*Calanthe tricarinata*
1387	Monocots	Orchidaceae	*Cephalanthera ensifolia*
1388	Monocots	Orchidaceae	*Cypripedium cordigerum*
1389	Monocots	Orchidaceae	*Cypripedium himalaicum*
1390	Monocots	Orchidaceae	*Dactylorhiza hatagirea*
1391	Monocots	Orchidaceae	*Epipactis gigantea*
1392	Monocots	Orchidaceae	*Eulophia dabia* (Syn. *Eulophia campestris*)
1393	Monocots	Orchidaceae	*Gastrodia orobanchoides*
1394	Monocots	Orchidaceae	*Goodyera repens*
1395	Monocots	Orchidaceae	*Habenaria acuminata*
1396	Monocots	Orchidaceae	*Habenaria latilibris*
1397	Monocots	Orchidaceae	*Habenaria monorchis*
1398	Monocots	Orchidaceae	*Habenaria puginiforme*
1399	Monocots	Orchidaceae	*Herminium lanceum*
1400	Monocots	Orchidaceae	*Malaxis mucifera*
1401	Monocots	Orchidaceae	*Neottia listeroides*
1402	Monocots	Orchidaceae	*Platanthera edgeworthii* (Syn. *Habenaria edgeworthii*)
1403	Monocots	Orchidaceae	*Rhynchostylis retusa*
1404	Monocots	Orchidaceae	*Spiranthes sinensis*
1405	Monocots	Orchidaceae	*Vanda testacea*
1406	Monocots	Orobanchaceae	*Boschniakia himalaica*
1407	Monocots	Poaceae	*Agrostis micrantha*
1408	Monocots	Poaceae	*Agrostis munroana*
1409	Monocots	Poaceae	*Agrostis pilosula*
1410	Monocots	Poaceae	*Agrostis stolonifera*
1411	Monocots	Poaceae	*Alopecurus arundinaceus*
1412	Monocots	Poaceae	*Andropogon contortus*
1413	Monocots	Poaceae	*Andropogon halepensis*
1414	Monocots	Poaceae	*Andropogon ischaemum*
1415	Monocots	Poaceae	*Andropogon munroi*
1416	Monocots	Poaceae	*Anthoxanthum odoratum*
1417	Monocots	Poaceae	*Apluda aristata*
1418	Monocots	Poaceae	*Apluda mutica*
1419	Monocots	Poaceae	*Aristida adscensionis*
1420	Monocots	Poaceae	*Aristida cyanantha*
1421	Monocots	Poaceae	*Aristida setacea*
1422	Monocots	Poaceae	*Arthraxon hispidus*
1423	Monocots	Poaceae	*Arthraxon lanceolatus*
1424	Monocots	Poaceae	*Arthraxon lancifolius*
1425	Monocots	Poaceae	*Arundinaria falconeri*
1426	Monocots	Poaceae	*Arundinella bengalensis*
1427	Monocots	Poaceae	*Arundinella fatua*
1428	Monocots	Poaceae	*Arundinella nepalensis*
1429	Monocots	Poaceae	*Arundinella setosa*

1430	Monocots	Poaceae	*Arundo donax*
1431	Monocots	Poaceae	*Avena sativa*
1432	Monocots	Poaceae	*Avena volgensis*
1433	Monocots	Poaceae	*Bambusa arundinacea*
1434	Monocots	Poaceae	*Bambusa bambos*
1435	Monocots	Poaceae	*Bambusa nutans*
1436	Monocots	Poaceae	*Bothriochloa bladhii*
1437	Monocots	Poaceae	*Bothriochloa ischaemum*
1438	Monocots	Poaceae	*Bothriochloa pertusa*
1439	Monocots	Poaceae	*Brachiaria ramosa*
1440	Monocots	Poaceae	*Brachiaria reptans*
1441	Monocots	Poaceae	*Brachypodium sylvaticum*
1442	Monocots	Poaceae	*Briza minor*
1443	Monocots	Poaceae	*Bromus gracillimus*
1444	Monocots	Poaceae	*Bromus japonicus*
1445	Monocots	Poaceae	*Calamagrostis emodensis*
1446	Monocots	Poaceae	*Calamagrostis lahulensis*
1447	Monocots	Poaceae	*Calamagrostis parviflorum*
1448	Monocots	Poaceae	*Calamagrostis pseudophragmites*
1449	Monocots	Poaceae	*Calamagrostis scabrescens*
1450	Monocots	Poaceae	*Calamagrostis serrulatus*
1451	Monocots	Poaceae	*Capillipedium assimile*
1452	Monocots	Poaceae	*Cenchrus ciliaris*
1453	Monocots	Poaceae	*Chloris dolichostachya*
1454	Monocots	Poaceae	*Chrysopgon fulvus*
1455	Monocots	Poaceae	*Chrysopogon aciculatus*
1456	Monocots	Poaceae	*Chrysopogon gryllus*
1457	Monocots	Poaceae	*Coix lacryma-jobi*
1458	Monocots	Poaceae	*Cymbopogon martinii*
1459	Monocots	Poaceae	*Cynodon dactylon*
1460	Monocots	Poaceae	*Dactylis glomerata*
1461	Monocots	Poaceae	*Dactyloctenium aegyptium*
1462	Monocots	Poaceae	*Danthonia cachymyriana*
1463	Monocots	Poaceae	*Danthonia jacquemontii*
1464	Monocots	Poaceae	*Danthonia schneideri*
1465	Monocots	Poaceae	*Dendrocalamus hamiltonii*
1466	Monocots	Poaceae	*Dendrocalamus strictus*
1467	Monocots	Poaceae	*Deschampsia caespitosa*
1468	Monocots	Poaceae	*Dichanthium annulatum*
1469	Monocots	Poaceae	*Digitaria ciliaris*
1470	Monocots	Poaceae	*Digitaria cruciata*
1471	Monocots	Poaceae	*Digitaria stricta* (Syn. *Agrostis pilosa*)
1472	Monocots	Poaceae	*Drepanostachyum falcatum* (Syn. *Sinarundinaria falcata*)
1473	Monocots	Poaceae	*Echinochloa colona*
1474	Monocots	Poaceae	*Eleusine coracana*
1475	Monocots	Poaceae	*Elymus nutans*
1476	Monocots	Poaceae	*Eragrostis amabilis* (Syn. *Eragrostis tenella*)

1477	Monocots	Poaceae	*Eragrostis atrovirens*
1478	Monocots	Poaceae	*Eragrostis ciliaris*
1479	Monocots	Poaceae	*Eragrostis crusgalli*
1480	Monocots	Poaceae	*Eragrostis indica*
1481	Monocots	Poaceae	*Eragrostis minor*
1482	Monocots	Poaceae	*Eragrostis nigra*
1483	Monocots	Poaceae	*Eragrostis pilosa*
1484	Monocots	Poaceae	*Eragrostis unioloides*
1485	Monocots	Poaceae	*Eulalia mollis*
1486	Monocots	Poaceae	*Eulaliopsis binata*
1487	Monocots	Poaceae	*Festuca kashmiriana*
1488	Monocots	Poaceae	*Festuca rubra*
1489	Monocots	Poaceae	*Festuca valesiaca*
1490	Monocots	Poaceae	*Heteropogon contortus*
1491	Monocots	Poaceae	*Imperata cylindrica*
1492	Monocots	Poaceae	*Isachaemum rugosum*
1493	Monocots	Poaceae	*Isachne albens*
1494	Monocots	Poaceae	*Isachne himalaica*
1495	Monocots	Poaceae	*Koeleria macrantha*
1496	Monocots	Poaceae	*Leersia haxandra*
1497	Monocots	Poaceae	*Lolium temulentum*
1498	Monocots	Poaceae	*Melica scaberrima*
1499	Monocots	Poaceae	*Melocalamus compactiflorus*
1500	Monocots	Poaceae	*Miscanthus nudipes*
1501	Monocots	Poaceae	*Muhlenbergia himalayensis*
1502	Monocots	Poaceae	*Neyraudia arundinacea*
1503	Monocots	Poaceae	*Oplismenus burmannii*
1504	Monocots	Poaceae	*Oplismenus compositus*
1505	Monocots	Poaceae	*Oplismenus munroi*
1506	Monocots	Poaceae	*Oplismenus undulatifolius*
1507	Monocots	Poaceae	*Oryza sativa*
1508	Monocots	Poaceae	*Oryzopsis lateralis*
1509	Monocots	Poaceae	*Panicum paludosum*
1510	Monocots	Poaceae	*Panicum psilopodium*
1511	Monocots	Poaceae	*Paspalidium flavidum*
1512	Monocots	Poaceae	*Paspalum dilatatum*
1513	Monocots	Poaceae	*Paspalum distichum*
1514	Monocots	Poaceae	*Paspalum scrobiculatum*
1515	Monocots	Poaceae	*Pennisetum flaccidum*
1516	Monocots	Poaceae	*Pennisetum orientale*
1517	Monocots	Poaceae	*Phacelurus speciosus*
1518	Monocots	Poaceae	*Phalaris minor*
1519	Monocots	Poaceae	*Phleum alpinum*
1520	Monocots	Poaceae	*Phragmites austarlis*
1521	Monocots	Poaceae	*Poa alpina*
1522	Monocots	Poaceae	*Poa annua*
1523	Monocots	Poaceae	*Poa falconeri*

1524	Monocots	Poaceae	*Poa himalaicum*
1525	Monocots	Poaceae	*Poa himlayana*
1526	Monocots	Poaceae	*Poa lahulensis*
1527	Monocots	Poaceae	*Poa pagophylla*
1528	Monocots	Poaceae	*Poa pratensis*
1529	Monocots	Poaceae	*Poa sikkimensis*
1530	Monocots	Poaceae	*Poa staphiana*
1531	Monocots	Poaceae	*Poa supina*
1532	Monocots	Poaceae	*Pogonatherum paniceum*
1533	Monocots	Poaceae	*Polypogon fugax*
1534	Monocots	Poaceae	*Polypogon monspeliensis*
1535	Monocots	Poaceae	*Saccharum bengalense*
1536	Monocots	Poaceae	*Saccharum filifolium*
1537	Monocots	Poaceae	*Saccharum rufipilum* (Syn. *Erianthus rufipilus*)
1538	Monocots	Poaceae	*Saccharum spontaneum*
1539	Monocots	Poaceae	*Setaria glauca*
1540	Monocots	Poaceae	*Setaria homonyma*
1541	Monocots	Poaceae	*Setaria palmifolia*
1542	Monocots	Poaceae	*Setaria rufipilum*
1543	Monocots	Poaceae	*Setaria viridis*
1544	Monocots	Poaceae	*Sinarundinaria falcata*
1545	Monocots	Poaceae	*Sorghum miliaceum*
1546	Monocots	Poaceae	*Sorghum nitidum*
1547	Monocots	Poaceae	*Sorghum vulgare*
1548	Monocots	Poaceae	*Sporobolus piliferus*
1549	Monocots	Poaceae	*Stipa sibirica*
1550	Monocots	Poaceae	*Tenaxia cachemyriana* (Syn. *Danthonia cachemyriana*)
1551	Monocots	Poaceae	*Thamnocalamus falconeri*
1552	Monocots	Poaceae	*Thamnocalamus spathiflorus*
1553	Monocots	Poaceae	*Themeda anathera*
1554	Monocots	Poaceae	*Themeda arundinacea*
1555	Monocots	Poaceae	*Themeda purpurescens*
1556	Monocots	Poaceae	*Thysanolaena latifolia*
1557	Monocots	Poaceae	*Thysanolaena maxima*
1558	Monocots	Poaceae	*Tripogon filiformis*
1559	Monocots	Poaceae	*Trisetum aeneum*
1560	Monocots	Pontederiaceae	*Monochoria hastata*
1561	Monocots	Potamogetonaceae	*Potamogeton octandrus*
1562	Monocots	Potamogetonaceae	*Potamogeton perfoliatus*
1563	Monocots	Smilacaceae	*Smilax aspera*
1564	Monocots	Smilacaceae	*Smilax glaucophylla*
1565	Monocots	Smilacaceae	*Smilax menispermoidea*
1566	Monocots	Smilacaceae	*Smilax zeylanica*
1567	Monocots	Typhaceae	*Typha angustata*
1568	Monocots	Xanthorrhoeaceae	*Aloe vera*
1569	Monocots	Xanthorrhoeaceae	*Eremurus himalaicus*
1570	Monocots	Zingiberaceae	*Alpinia galanga*

1571	Monocots	Zingiberaceae	*Costus speciosus*
1572	Monocots	Zingiberaceae	*Curcuma amada*
1573	Monocots	Zingiberaceae	*Curcuma angustifolia*
1574	Monocots	Zingiberaceae	*Curcuma aromatica*
1575	Monocots	Zingiberaceae	*Curcuma longa* (Syn. *Curcuma domestica*)
1576	Monocots	Zingiberaceae	*Elettaria cardamomum*
1577	Monocots	Zingiberaceae	*Hedychium spicatum*
1578	Monocots	Zingiberaceae	*Roscoea alpina*
1579	Monocots	Zingiberaceae	*Roscoea purpurea*
1580	Monocots	Zingiberaceae	*Zingiber officinale*
1581	Monocots	Zingiberaceae	*Zingiber zerumbet*

Annexure II

List of Medicinal Plants reported from the Beas Basin

S. No.	Family	Scientific Name	Local Name	Habitat	Part Used
1	Solanaceae	*Atropa acuminata* (=*Atropa belladona*)		H	
2	Orchidaceae	*Dactylorhiza hatagirea* (=*Orchis latifolia*)		H	
3	Gentianaceae	*Gentiana kurroo*		H	
4	Asteraceae	*Jurinea dolomiaea* (=*J. macrocephala*)		H	
5	Liliaceae	*Lilium polyphyllum*		H	
6	Orchidaceae	*Malaxis muscifera*		H	
7	Plantaginaceae	*Picrorhiza kurroa*		H	
8	Gentianaceae	*Swertia chirayita* (= *S. chirata*)		H	
9	Apiaceae	*Angelica glauca*	Chora	H	Rt
10	Boraginaceae	*Arnebia benthamii*		H	
11	Berberidaceae	*Berberis aristata*		S	
12	Betulaceae	*Betula utilis*		T	
13	Dioscoreaceae	*Dioscorea deltoidea*	Shingli-Mingli	H	Tu
14	Liliaceae	*Fritillaria roylei*		H	
15	Caprifoliaceae	*Nardostachys grandiflora* (=*N. jatamansi*)		H	
16	Asparagaceae	*Polygonatum cirrhifolium*		H	
17	Asparagaceae	*Polygonatum multiflorum*		H	
18	Asparagaceae	*Polygonatum verticillatum*	Salam Mishri	H	Tu
19	Polygonaceae	*Rheum moorcroftianum*		H	
20	Asteraceae	*Saussurea obvallata*		H	
21	Berberidaceae	*Senopodophyllum hexandrum*		H	
22	Pinaceae	*Taxus wallichiana* (= *T. baccata*)		T	
23	Rutaceae	*Zanthoxylum armatum*	Tirmir	Sh	Fr, Sd
24	Ranunculaceae	*Aconitum laeve*		H	
25	Fabaceae	*Desmodium gangeticum*		H	
26	Bignoniaceae	*Oroxylum indicum*		T	
27	Solanaceae	*Hyoscyamus niger*		H	
28	Polygonaceae	*Rheum speciforme*		H	
29	Ranunculaceae	*Aconitum violaceum*		H	
30	Amaryllidaceae	*Allium stracheyi*		H	
31	Lauraceae	*Cinnamomum tamala*	Tejpatta	T	Bk, Lf
32	Ephederaceae	*Ephedra gerardiana*			
33	Hypericaceae	*Hypericum peforatum*		H	
34	Cupressaceae	*Juniperus communis*		S	
35	Lauraceae	*Litsea glutinosa*	Gwanyu	T	Bk, Lf
36	Polygonaceae	*Rheum webbianum*		H	
37	Zingiberaceae	*Roscoea alpina*		H	
38	Apiaceae	*Selinum connifolium* (*S. tenuifolium*)		H	
39	Apiaceae	*Selinum vaginatum*		H	
40	Rutaceae	*Skimmia laureola*		S	
41	Symplocaceae	*Symplocos paniculata*		T	
42	Malvaceae	*Abelmoschus crinitus*	Basuti	Sh	Rt, Fl, Fr. Lf., Wp
43	Fabaceae	*Abrus precatorius*	Rati	Sh	Rt, lf, Sd
44	Fabaceae	*Acacia catechu*	Khair	T	Bk, Wd
45	Fabaceae	*Acacia gageana*	Bagharne	Sh	Lf, Fl, Sd
46	Asteraceae	*Achillea millefolium*	Gandan	H	Lf, Fl
47	Amaranthaceae	*Achyranthes aspera*	Puthkanda	H	Wp
48	Amaranthaceae	*Achyranthes bidentata*	Puthkanda	H	Wp
49	Acoraceae	*Acorus calamus*	Bare/Bauch	H	Rh, St, Lf

S. No.	Family	Scientific Name	Local Name	Habitat	Part Used
50	Acanthaceae	*Adhatoda vasica*	Basuti		Lf
51	Rutaceae	*Aegle marmelos*	Bel	T	Fr
52	Asparagaceae	*Agave americana*	Ramban	H	Wp
53	Asteraceae	*Ageratum conyzoides*	Okalbuti	H	Lf, Rt, Sd, Fr, Fl
54	Asteraceae	*Ageratum houstonianum*	Okalbuti	H	Wp
55	Rosaceae	*Agrimonia pilosa*	Kuri	H	Ap, Rt
56	Asteraceae	*Ainsliaea aptera*	Sath jalari	H	Rt
57	Lamiaceae	*Ajuga integrifolia* (Syn. *Ajuga bracteosa*)	Neelkanthi	H	Lf, Rt
58	Fabaceae	*Albizia chinensis*	Srinh	T	Wd, Lf
59	Mimosaceae	*Albizia julibrissin*		T	Wd, Lf
60	Fabaceae	*Albizia lebbeck*	Chuli	T	Fl, Sd
61	Amaranthaceae	*Amaranthus cruentus* (Syn. *Amaranthus paniculatus*)	Saryara	H	Sd
62	Vitaceae	*Ampelocissus latifolia*		H	Lf, Fl
63	Araceae	*Arisaema flavum*	Kira aloo	H	Bb
64	Araceae	*Arisaema tortuosum*	Biskaphar	H	Wp
65	Asteraceae	*Artemisia absinthium*	Kachumebera	Sh	Lf
66	Asteraceae	*Artemisia japonica*	Chamber	H	Lf
67	Asteraceae	*Artemisia nilagirica*		H	Wp
68	Asteraceae	*Artemisia parviflora*	Jhau	H	Lf, Rt, Sd
69	Asteraceae	*Artemisia scoparia*	Jandrodhi	H	Lf, Rt, Sd
70	Apocynaceae	*Asclepias curassavica*		Sh	Lf, Rt
71	Asparagaceae	*Asparagus adscendens*	Sansarpali	H	Wp
72	Asparagaceae	*Asparagus filicinus*	Shatavari	Sh	Tu
73	Aspleniaceae	*Asplenium dalhousiae*	Kajeri	H	Wp
74	Meliaceae	*Azadirachta indica*	Darek	T	Lf, Bk, Fr
75	Plantaginaceae	*Bacopa monnieri*		H	Wp
76	Acanthaceae	*Barleria cristata*	Morani	H	Wp
77	Fabaceae	*Bauhinia divaricata* (Syn. *Bauhinia retusa*)		T	Sd, Fr
78	Fabaceae	*Bauhinia vahlii* (Syn. *Bauhinia racemosa*)	Tour	T	Lf, Bk, Sd, Fr
79	Fabaceae	*Bauhinia variegata*	Karyalae	T	Lf, Fr, Fl
80	Saxifragaceae	*Bergenia ciliata*	Bhander Pocha	H	Rh
81	Saxifragaceae	*Bergenia pacumbis* (Syn. *Bergenia ligulata*)	Pashanbhed	H	Lf, Rh
82	Asteraceae	*Bidens bipinnata*	Badigumbri	H	Fr, Lf, Fl, Rt
83	Asteraceae	*Bidens pilosa*		H	Wp
84	Asteraceae	*Blumea laciniata*		H	Lf
85	Rutaceae	*Boenninghausenia albiflora*	Chitri, Pissumar	H	Lf
86	Nyctaginaceae	*Boerhavia diffusa*	Itsit		Rt, Lf
87	Bombacaceae	*Bombax ceiba*	Simbal	T	Tr, Bk, Lf
88	Solanaceae	*Brugmansia suaveolens*	Datura	S	Fl
89	Scrophulariaceae	*Buddleja asiatica*		Sh	Lf
90	Scrophulariaceae	*Buddleja crispa*	Sfed saryu	Sh	Lf, Wd
91	Apiaceae	*Bupleurum hamiltonii*		H	Ap, Rt
92	Apiaceae	*Bupleurum tenuissimum* (Syn. *Bupleurum tenue*)		H	Wp
93	Fabaceae	*Butea monosperma*	Palah	T	Wp
94	Fabaceae	*Caesalpinia bonduc*		Sh	Rt, Bk, Sd
95	Fabaceae	*Cajanus crassus* (Syn. *Atylosia mollis*)		H	Wp
96	Verbenaceae	*Callicarpa macrophylla*	Nagdhava	Sh	Lf, Rt
97	Apocynaceae	*Calotropis procera*		Fl	
98	Cannabaceae	*Cannabis sativa*	Bhang	H	Lf, Bk, Sd,

S. No.	Family	Scientific Name	Local Name	Habitat	Part Used
					Fr, Fl, St
99	Capparaceae	*Capparis zeylanica*		Sh	Wp
100	Brassicaceae	*Cardamine impatiens*			H
101	Cyperaceae	*Carex breviculmis*		H	Ap
102	Cyperaceae	*Carex cruciata*		H	Wp
103	Apocynaceae	*Carissa spinarum* (Syn. *Carissa opaca*)	Garnoni	Sh	Lf, Fr
104	Verbenaceae	*Caryopteris foetida*	Rumri	Sh	Lf
105	Fabaceae	*Cassia fistula*	Amaltas	T	Rt, Lf, Fr, Bk
106	Apocynaceae	*Catharanthus roseus*		Sh	Wp, Rt, Lf
107	Apocynaceae	*Catharanthus roseus* (Syn. *Vinca rosea*)	Sadabahar	H	Rh, St, Lf
108	Cucurbitaceae	*Cayaponia laciniosa* (Syn. *Bryonopsis laciniosa*)	Shivlingi		Sd
109	Celastraceae	*Celastrus paniculatus*	Sankhiran		Sd
110	Ulmaceae	*Celtis australis*	Kharik	T	Lf, Rt, Bk
111	Apiaceae	*Centella asiatica*	Brahmi	H	Wp
112	Solanaceae	*Cestrum nocturnum*	Ratrani	Sh	Lf
113	Apiaceae	*Chaerophyllum reflexum*		H	Rt
114	Fabaceae	*Chamaecrista mimosoides* (Syn. *Cassia mimosoides*)		H	Rt, Lf
115	Amaranthaceae	*Chenopodium album*	Bathua	H	Sd, Lf
116	Amaranthaceae	*Chenopodium botrys*	Sokana	H	Wp
117	Menispermaceae	*Cissampelos pareira*	Bhatindru, Patindu	H	Wp
118	Lamiaceae	*Clinopodium vulgare*	Kusuma	Sh	Lf, Fl
119	Cucurbitaceae	*Coccinia grandis*		H	Rt, Lf, Fr
120	Lamiaceae	*Colebrookea oppositifolia*	Gaddoos	Sh	Lf, Wp
121	Araceae	*Colocasia antiquorum*		H	
122	Commelinaceae	*Commelina benghalensis*		H	Lf Rt
123	Commelinaceae	*Commelina paludosa*	Chura	H	Wp
124	Convolvulaceae	*Convolvulus arvensis*		H	Wp
125	Asteraceae	*Conyza japonica*	Gaadi	H	Wp
126	Ehretiaceae	*Cordia dichotoma*	Lasura		Lf
127	Coriariaceae	*Coriaria nepalensis*	Fanai	Sh	St, Lf, Fr
128	Myrtaceae	*Corymbia citriodora* (Syn. *Eucalyptus citriodora*)		T	
129	Asteraceae	*Cosmos caudatus*		H	lf
130	Anacardiaceae	*Cotinus coggygria*		Sh	Fr, Fl
131	Fabaceae	*Crotalaria albida*		H	Sd, Rt
132	Apocynaceae	*Cryptolepis dubia* (Syn. *Cryptolepis buchananii*)	Taern	Sh	Wp
133	Zingiberaceae	*Curcuma angustifolia*	Chudidar Haldi	H	Rh
134	Zingiberaceae	*Curcuma longa* (Syn. *Curcuma domestica*)	Haldi	H	Rh
135	Convolvulaceae	*Cuscuta reflexa*		H	Wp
136	Commelinaceae	*Cyanotis cristata*		H	Lf
137	Commelinaceae	*Cyanotis vaga*		H	Ap
138	Amaranthaceae	*Cyathula capitata*	Litra	H	Lf, Sd
139	Amaranthaceae	*Cyathula tomentosa*	Kutha	H	Ap, Rt, Lf
140	Apiaceae	*Cyclospermum leptophyllum* (Syn.		H	Fr

S. No.	Family	Scientific Name	Local Name	Habitat	Part Used
		Apium leptophyllum)			
141	Poaceae	*Cymbopogon martini*	Makora Ghas		Lf
142	Boraginaceae	*Cynoglossum zeylanicum*		H	Lf, Rt
143	Cyperaceae	*Cyperus compressus*		H	Wp
144	Cyperaceae	*Cyperus rotundus*	Dhabai	H	Rh
145	Cyperaceae	*Cyperus squarrosus*		H	
146	Fabaceae	*Dalbergia sissoo*	Shisam, ayointi	T	Lf, Wd
147	Thymelaeaceae	*Daphne papyracea*	Kania/ Patrori	Sh	Rt, Lf
148	Solanaceae	*Datura innoxia*	Datura	H	Lf, Sd, Fr
149	Solanaceae	*Datura stramonium*	Datura	H	Lf, Sd, Fr
150	Urticaceae	*Debregeasia longifolia*	Shyaru	Sh	Bk, Lf
151	Urticaceae	*Debregeasia salicifolia*		Sh	Bk, Lf
152	Amaranthaceae	*Deeringia amaranthoides*		Sh	Lf, Fr
153	Ranunculaceae	*Delphinium denudatum*	Nirbisi	S	Lf, Fl
154	Fabaceae	*Desmodium concinnum*		Sh	Wp
155	Fabaceae	*Desmodium oojeinense* (Syn. *Ougeinia oojeinensis*)		T	St, Lf
156	Fabaceae	*Desmodium sequax*		Sh	Lf, Rt
157	Fabaceae	*Desmodium triquetrum*		Sh	Wp
158	Asteraceae	*Dichrocephala bicolor* (Syn. *Dichrocephala integrifolia*)		H	Rt
159	Acanthaceae	*Dicliptera chinensis* (Syn. *Dicliptera roxburghiana*)	Saundi	H	Wp
160	Dioscoreaceae	*Dioscorea bulbifera*		H	Tu
161	Ebenaceae	*Diospyros montana*		T	Wd
162	Sapindaceae	*Dodonaea viscosa*	Mehndu	Sh	Lf, Fr
163	Caryophyllaceae	*Drymaria cordata*		H	Wp
164	Lythraceae	*Duabanga grandiflora* (*Duabanga sonneratioides*)		T	Wd, Bk
165	Asteraceae	*Eclipta prostrata* (Syn. *Eclipta alba*)	Bringraj	H	Wp
166	Ehretiaceae	*Ehretia acuminata*	Bakli/Bakaar/ Banchaula	T	Bk, Fr, Wd
167	Boraginaceae	*Ehretia laevis*		T	Lf, Bk, Fr
168	Elaeagnaceae	*Elaeagnus conferta*	Ghayai	Sh	Fl, Fr
169	Elaeagnaceae	*Elaeagnus parvifolia*	Ghayai	Sh	Fr, Lf
170	Asparagaceae	*Elephantopus mollis* (Syn. *Elephantopus scaber*)		H	Lf, Rt
171	Ateraceae	*Erigeron bonariensis*		H	Lf
172	Asteraceae	*Erigeron canadensis*		H	Wp
173	Asteraceae	*Erigeron trilobus* (Syn. *Conyza stricta*)		H	Wp
174	Myrtaceae	*Eucalyptus globulus*		T	
175	Celastraceae	*Euonymus lucidus* (Syn. *Euonymus pendulus*)		T	Rt, Bk, Lf
176	Euphorbiaceae	*Euphorbia helioscopia*		H	Wp
177	Euphorbiaceae	*Euphorbia hirta*	Dhudhi	H	Wp
178	Euphorbiaceae	*Euphorbia prolifera*		H	Wp
179	Euphorbiaceae	*Euphorbia royleana*	Choi	Sh	Bk
180	Convolvulaceae	*Evolvulus alsinoides*		H	Wp
181	Euphorbiaceae	*Falconeria insignis* (Syn. *Sapium insigne*)		T	
182	Moraceae	*Ficus benghalensis*	Bad	T	La, Lf, Fr
183	Moraceae	*Ficus hederacea*		Sh	Wd, Lf
184	Moraceae	*Ficus nemoralis*		T	Fr, Lf, Wd
185	Moraceae	*Ficus palmata*	Phaegda	T	Fr, Lf
186	Moraceae	*Ficus racemosa*		T	Wp

S. No.	Family	Scientific Name	Local Name	Habitat	Part Used
187	Moraceae	*Ficus religiosa*	Pipal	T	Wp
188	Moraceae	*Ficus roxburghii*	Traymbalu	T	Lf, Rt, Wd
189	Moraceae	*Ficus rumphii*		T	Fr
190	Salicaceae	*Flacourtia indica*	Kangu	T	Lf, Bk, Fr, Rt
191	Rosaceae	*Fragaria nubicola*	Bumbra	H	Fr
192	Rosaceae	*Fragaria vesca*		H	Fr
193	Papaveraceae	*Fumaria indica*		H	Wp
194	Rubiaceae	*Galium aparine*		H	Wp
195	Rubiaceae	*Galium rotundifolium*		H	Ap
196	Geraniaceae	*Geranium maculatum*	Dandupoocha	H	Lf, Fl
197	Geraniaceae	*Geranium nepalense*	Tirahni	H	Rt
198	Asteraceae	*Gerbera gossypina*	Bach	H	Rt
199	Urticaceae	*Girardinia diversifolia* (Syn. *Girardinia heterophylla*)	Jatahan	H	Bk, St
200	Colchicaceae	*Gloriosa superba*	Kalihari	H	Rh
201	Apocynaceae	*Gymnema sylvestre*		H	Lf, Rt
202	Caryophyllacea e	*Gypsophila cerastioides*		H	Wp
203	Araliaceae	*Hedera helix*	Kermayi	C	St, Lf
204	Araliaceae	*Hedera nepalensis*	Katari	Sh	Fr, Lf
205	Zingiberaceae	*Hedychium spicatum*	Ban Haldi	H	Rh, Lf
206	Malvaceae	*Helicteres isora*		Sh	Ap, St
207	Rubiaceae	*Himalrandia tetrasperma* (Syn. *randia tetrasperma*)	Kharnadu	Sh	Fr, Lf, Bk
208	Araliaceae	*Hydrocotyle javanica*		H	Lf
209	Rubiaceae	*Hymenodictyon excelsum*		T	Rt, Bk, Lf
210	Hypericaceae	*Hypericum oblongifolium* (Syn. *Hypericum cernuum*)	Kharau, Kalalber	Sh	Lf, Fl
211	Hypericaceae	*Hypericum uralum*	Bani Wakra	Sh	Sd, Lf
212	Lamiaceae	*Hyssopus officinalis*	Jufah		Wp
213	Fabaceae	*Indigofera atropurpurea*	Kathi	Sh	Lf, Wd
214	Asteraceae	*Indigofera heterantha* (Syn. *Indigofera gerardiana*)	Kali Kathi	Sh	Lf, Wd
215	Fabaceae	*Indigofera linifolia*		H	Wp
216	Asteraceae	*Inula cappa*		Sh	Lf
217	Asteraceae	*Inula cuspidata*		Sh	Lf
218	Convolvulacea e	*Ipomoea nil*	Ghaudan	H	Wp
219	Convolvulacea e	*Ipomoea purpurea*		H	Ap, Sd
220	Lamiaceae	*Isodon coetsa* (*Plectranthus coesta*)		H	Lf
221	Euphorbiaceae	*Jatropha curcas*	Jatropha	T	Sd, La
222	Juglandaceae	*Juglans regia*	Akhrot, Khod	T	Fr, Wd, lf
223	Acanthaceae	*Justicia adhatoda*	Adasthodalam	Sh	H
224	Acanthaceae	*Justicia japonica* (Syn. *Justicia simplex*)		H	H
225	Crassulaceae	*Kalanchoe integra* (*Kalanchoe spathulata*)	Patharchat	H	Lf
226	Anacardiaceae	*Lannea coromandelica*		T	Bk, Lf
227	Verbenaceae	*Lantana camara*		Sh	Lf, fr
228	Fabaceae	*Lathyrus aphaca*	Janglimattar	H	Sd
229	Lythraceae	*Lawsonia inermis*	Mehandi	Sh	Lf, Rt, Fl, Sd
230	Vitaceae	*Leea asiatica* (*Leea aspera*)		H	Rt
231	Acanthaceae	*Lepidagathis cuspidata*	Bralu	H	Wp
232	Acanthaceae	*Lepidagathis incurva*		H	Lf
233	Brassicaceae	*Lepidium virginicum*		H	Wp
234	Rubiaceae	*Leptodermis lanceolata*		Sh	Bk, Lf
235	Fabaceae	*Lespedeza gerardianan*		H	Lf
236	Lamiaceae	*Leucas lanata*		H	Wp
237	Rutaceae	*Limonia acidissima*		T	Rt, Bk

S. No.	Family	Scientific Name	Local Name	Habitat	Part Used
238	Boraginaceae	*Lindelofia longiflora*		H	Lf
239	Scrophulariaceae	*Lindenbergia indica*		H	Lf
240	Ericaceae	*Lyonia ovalifolia*	Ehran	T	Wp
241	Euphorbiaceae	*Mallotus philippensis*	Kambla	T	Sd, Fr
242	Malvaceae	*Malva neglecta*	Such	Sh	Lf
243	Malvaceae	*Malvastrum coromandelianum*		H	Lf
244	Anacardiaceae	*Mangifera indica*	Aam	T	Lf, Fr, Sd
245	Asclepiadaceae	*Marsdenia roylei*		H	Wp
246	Lamiaceae	*Mentha longifolia*	Pudina	H	Lf, Wp
247	Lamiaceae	*Mentha piperita*	Piperment	H	Wp
248	Lamiaceae	*Mentha spicata* (Syn. *Mentha viridis*)	Hungli Pudina	H	Lf
249	Fabaceae	*Millettia extensa* (*Millettia auriculata*)		Sh	Wp
250	Fabaceae	*Mimosa rubicaulis*		Sh	Wp
251	Moraceae	*Morus alba*	Sehtoot	T	Lf Fr
252	Fabaceae	*Mucuna pruriens*	Daryagal	Sh	Sd
253	Rutaceae	*Murraya koenigii*	Gandaela	Sh	Rt, Lf, Fr, Bk
254	Rutaceae	*Murraya paniculata*		Sh	Rt, Bk, Lf
255	Lamiaceae	*Nepeta hindostana*		H	Lf,Fl, Wp
256	Solanaceae	*Nicotiana tabacum*	Tambakhoo	H	Wp
257	Lamiaceae	*Ocimum basilicum*	Bhabri	H	Lf, Rt, Wp
258	Rubiaceae	*Oldenlandia corymbosa*		H	Wp
259	Cactaceae	*Opuntia monacantha*		Sh	Lf, Wd
260	Lamiaceae	*Origanum vulgare*	Van Tulsi	H	Lf, Rt, Wp
261	Melastomataceae	*Osbeckia stellata*		Sh	Rt, Lf
262	Santalaceae	*Osyris lanceolata*		Sh	Wp
263	Urticaceae	*Parietaria debilis*		H	Rt
264	Asteraceae	*Parthenium hysterophorus*	Chikadu	H	Wp
265	Vitaceae	*Parthenocissus himalayana*		H	Lf, Fl
266	Vitaceae	*Parthenocissus semicordata* var. *roylei*	Karmai	Sh	Fr, Lf
267	Acanthaceae	*Peristrophe bicalyculata*		H	Wp
268	Arecaceae	*Phoenix sylvestris*		Sh	Lf, Fr
269	Phyllanthaceae	*Phyllanthus emblica*	Amala	T	Fr, Br
270	Phyllanthaceae	*Phyllanthus fraternus*		H	Wp
271	Phyllanthaceae	*Phyllanthus parvifolius*		H	Lf
272	Solanaceae	*Physalis minima*		H	Wp
273	Urticaceae	*Pilea scripta*		H	Ap
274	Apiaceae	*Pimpinella diversifolia*		H	Rt, Wp
275	Anacardiaceae	*Pistacia integerrima*	Kakarsinghi	T	Fr
276	Lamiaceae	*Pogostemon benghalensis*	Bhaerda	H	Lf, Fl
277	Rosaceae	*Prinsepia utilis*	Bhekhal	Sh	Sd, Fr
278	Rosaceae	*Prunus persica*	Aadu	T	Fr, Fl, Lf
279	Rosaceae	*Pyrus pashia*	Shegal	T	Lf, Fr, Wd
280	Fagaceae	*Quercus glauca*	Bani	T	Wd, Lf
281	Fagaceae	*Quercus leucotrichophora*	Ban	T	Wd, Lf
282	Lamiaceae	*Rabdosia rugosa*		Sh	Lf, Wp
283	Linaceae	*Reinwardtia indica*	Matkhena	Sh	Ap
284	Rhamnaceae	*Rhamnus purpureus*	Chaunsha	Sh	Fr, Wd, Lf
285	Rhamnaceae	*Rhamnus triquetra*		T	Bk
286	Ericaceae	*Rhododendron arboreum*	Braah	T	Fl, Lf
287	Euphorbiaceae	*Ricinus communis*	Arndi	Sh	Sd, Rt, Lf, Fr
288	Fabaceae	*Robinia pseudoacacia*	Ravinia	T	St, Bk, Wd
289	Rosaceae	*Rosa brunonii*	Kunja	Sh	Rt
290	Lamiaceae	*Roylea cinerea*	Kadaku	Sh	Lf, Rt
291	Rubiaceae	*Rubia cordifolia*	Majeet, Pagalpathi	C	Lf, Rt, St
292	Rosaceae	*Rubus biflorus*	Aachhe	Sh	Fr, Rt
293	Rosaceae	*Rubus ellipticus*	Aachhe	Sh	Fr, Rt

S. No.	Family	Scientific Name	Local Name	Habitat	Part Used
294	Rosaceae	*Rubus foliolatus*		Sh	Fr, Rt
295	Polygonaceae	*Rumex hastatus*	Malori	H	St, Fl
296	Acanthaceae	*Rungia pectinata*		H	Wp
297	Salicaceae	*Salix denticulata*		Sh	Wd, Lf
298	Salicaceae	*Salix tetrasperma*	Biunsh	T	Lf, Wd
299	Lamiaceae	*Salvia aethiopis* (Syn. *Salvia lanata*)	Gawandru	H	Rt, Lf, Fl
300	Lamiaceae	*Salvia nubicola*		H	Lf, Rt
301	Sapindaceae	*Sapindus mukorossi*	Reetha, Doda	T	Fr, Fd, Fu
302	Araceae	*Sauromatum venosum*	Kidachali	H	Tu
303	Scrophulariaceae	*Scrophularia himalensis*		H	Lf
304	Lamiaceae	*Scutellaria angulosa*		H	Lf
305	Crassulaceae	*Sedum glaucophyllum*	Mochu-gha	H	Wp
306	Asteraceae	*Senecio graciliflorus*		H	Ap
307	Asteraceae	*Senecio nudicaulis*		H	Rt
308	Fabaceae	*Senna occidentalis* (Syn. *Cassia occidentalis*)		Sh	Rt, Lf, Fl, Sd
309	Fabaceae	*Senna tora* (Syn. *Cassia tora*)		H	Sd, Lf
310	Fabaceae	*Sesbania bispinosa*		H	Rt, Sd
311	Fabaceae	*Sesbania grandiflora*	Gach Munga	T	Lf
312	Malvaceae	*Sida cordata*		H	Wp
313	Asteraceae	*Sigesbeckia orientalis*	-	H	Wp
314	Smilacaceae	*Smilax aspera*		Sh	Rt, Lf, St
315	Solanaceae	*Solanum indicum*		H	Fr
316	Solanaceae	*Solanum nigrum*	Makoi, Bara lianchu	H	Fr, Lf, Fl, Sd
317	Cucurbitaceae	*Solena amplexicaulis* (Syn. *Melothria heterophylla*)	Bankakadi	H	Rt, Lf, Fr
318	Asteraceae	*Sonchus asper*		H	Lf
319	Asteraceae	*Sonchus oleraceus*		h	Lf, La
320	Rosaceae	*Sorbaria tomentosa*	Chhattayee	Sh	Wd
321	Symplocaceae	*Symplocos paniculata* (Syn. *Symplocos chinensis*)	Lojj	T	Bk, Lf
322	Asteraceae	*Tagetes minuta*		H	Lf, La
323	Asteraceae	*Taraxacum officinale*	Kanphul	H	Wp
324	Bignoniaceae	*Tecoma stans*		T	Wp
325	Combretaceae	*Terminalia bellirica*	Baheda	T	Bk, Fr
326	Combretaceae	*Terminalia chebula*	Harad	T	Bk, Fr
327	Lamiaceae	*Thymus linearis*	Ban ajwain	H	Wp
328	Menispermaceae	*Tinospora cordifolia*	Galoy/Gujya	Sh	Rt, St
329	Meliaceae	*Toona ciliata*	Daral	T	Bk, Fr, Lf
330	Meliaceae	*Toona sinensis* (Syn. *Toona serrata*)	Darlein	T	St
331	Apiaceae	*Trachydium roylei*		H	Ap
332	Cucurbitaceae	*Trichosanthes tricuspidata*		H	Lf, Rt, Sd, Fr
333	Asteraceae	*Tridax procumbens*		H	Wp
334	Fabaceae	*Trifolium repens*	Malori	H	Wp
335	Melanthiaceae	*Trillium govanianum* (Syn. *Trillidium govanianum*)	Nag Chhatri	H	Rh
336	Ulmaceae	*Ulmus villosa*	Chor	T	Lf, Rt, Bk
337	Malvaceae	*Urena lobata*		Sh	Rt, Lf
338	Urticaceae	*Urtica dioica*	Aan/ Bichubuti	Sh	Wp
339	Caprifoliaceae	*Valeriana jatamansi*	Mushkbala	H	Wp
340	Scrophulariaceae	*Verbascum thapsus*	Jungli Tambakhoo	H	Sd
341	Adoxaceae	*Viburnum cotinifolium*	Jungli dhak	Sh	Lf, Fr, Bk
342	Fabaceae	*Vicia rigidula*		H	Wp
343	Fabaceae	*Vigna vexillata*		H	Rt, Sd
344	Violaceae	*Viola canescens*	Banafsha,	H	Lf, Fl

S. No.	Family	Scientific Name	Local Name	Habitat	Part Used
			Guguluphul		
345	Violaceae	*Viola pilosa* (Syn. *Viola serpens*)	Banafsha	H	Lf, Fl
346	Santalaceae	*Viscum album*	Rhini, Banda	Sh	Wp
347	Verbenaceae	*Vitex negundo*	Banna	Sh	Wp
348	Vitaceae	*Vitis parviflora*		Sh	St
349	Rubiaceae	*Wendlandia heynei*		T	St
350	Solanaceae	*Withania somnifera*	Ashwagandha	Sh	Rt, Lf, Wp
351	Lythraceae	*Woodfordia fruticosa*		Sh	St, Fl, Rt
352	Salicaceae	*Xylosma longifolia*		T	Bk, Lf
353	Asparagaceae	*Yucca gloriosa* (Syn. *Yucca superba*)		H	Bb
354	Rhamnaceae	*Ziziphus mauritiana*	Ber	Sh	Ap, Fr, Rt, Bk
355	Rhamnaceae	*Ziziphus rugosa*		Sh	Bk, Fl

COMMUNITY STRUCTURE

Site V1: Upstream Beas Kund Diversion Weir – Beas River

Table 6.1: Community structure -Site-V1 (Trees)

S.No.	Scientific Name	Frequency (%)	Density (ind./ha)	Basal Cover (sq m/ha)	IVI
1	*Acer caesium*	20	20	17.96	25
2	*Alnus nitida*	20	40	6.08	26
3	*Cedrus deodara*	30	100	122.29	100
4	*Corylus colurna*	20	30	4.92	23
5	*Picea smithiana*	20	20	6.58	21
6	*Pinus wallichiana*	30	70	69.05	68
	Populus ciliata	10	20	3.40	13
8	*Salix fragilis*	20	30	1.90	23
			330		

Table 6.2: Community structure -Site-V1 (Shrubs)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	IVI
1	*Berberis jaeschkeana*	30	1200	47
2	*Cotoneaster bacillaris*	20	200	12
3	*Ephedra vulgaris*	20	400	21
4	*Indigofera pulchella*	30	800	32
5	*Juniperus communis*	30	1000	37
6	*Rabdosia rugosa*	30	500	30
7	*Rhododendron anthopogon*	40	1800	78
8	*Rosa webbiana*	40	1400	43
			7300	

Table 6.3: Community structure -Site-V1 (Herbs)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	IVI
	Pre-Monsoon			
1	*Aconitum violaceum*	17	4167	9
2	*Bromus japonicus*	17	14167	18
3	*Dactylis glomerata*	33	10000	19
4	*Eremurus himalaicus*	25	8333	15
5	*Fragaria nubicola*	33	6667	16
6	*Gentiana kurroo*	25	16667	23
7	*Iris kemaonesis*	17	8333	13
8	*Isodon rugosus*	33	9167	18
9	*Jurinea macrocephala*	25	2500	10
10	*Poa alpina*	17	12500	16
11	*Podophyllum hexandrum*	33	3333	13
12	*Thymus serpyllum*	33	9167	18
13	*Oxytropis mollis*	17	6667	11
			111667	
	Monsoon			
1	*Aconitum violaceum*	20	3333	7
2	*Bromus japonicus*	13	4000	7
3	*Carum copticum*	13	4667	7
4	*Cynodon dactylon*	33	6000	13
5	*Delphinium elatum*	20	6667	11
6	*Eremurus himalaicus*	20	6000	10
7	*Fragaria nubicola*	27	7333	13
8	*Gentiana kurroo*	33	6667	14
9	*Impatiens balsamina*	13	7333	10
10	*Iris kemaonesis*	33	8667	15

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	IVI
11	*Jurinea macrocephala*	27	9333	15
12	*Lilium giganteum*	20	8000	12
13	*Mentha longifolia*	53	4000	15
14	*Oxytropis mollis*	20	4667	9
15	*Poa alpina*	27	5333	11
16	*Podophyllum hexandrum*	33	6000	13
17	*Potentilla nepalensis*	27	4667	10
18	*Thymus serpyllum*	20	5333	9
			108000	
	Winter			
1	*Bromus japonicus*	17	5000	15.59
2	*Dactylis glomerata*	25	6667	21.98
3	*Eremurus himalaicus*	17	7500	19.82
4	*Gentiana kurroo*	17	6667	18.41
5	*Iris kemaonesis*	33	5000	22.74
6	*Jurinea macrocephala*	42	7500	30.53
7	*Oxytropis mollis*	17	6667	18.41
8	*Poa alpina*	42	5833	27.72
9	*Thymus serpyllum*	25	8333	24.80
			59167	

Site V2: Near Power House site of Proposed Palchan Bhang HE Project -Beas River

Table 6.4: Community structure -Site-V2 (Trees)

S. No.	Scientific Name	Frequency (%)	Density (ind./ha)	Basal Cover (sq m/ha)	IVI
1	*Alnus nitida*	20	50	2.21	29
2	*Cedrus deodara*	30	100	102.29	101
3	*Celtis australis*	20	30	3.74	24
4	*Fraxinus floribunda*	30	30	4.22	30
5	*Juglans regia*	30	70	19.05	50
6	*Pinus wallichiana*	20	20	68.58	53
7	*Populus ciliata*	10	20	2.40	14
			320		

Table 6.5: Community structure -Site-V2 (Shrubs)

S. No.	Scientific Name	Frequency (%)	Density (ind. /ha)	IVI
1	*Artemisia nilagirica*	40	1200	52
2	*Cotoneaster bacillaris*	20	200	13
3	*Ephedra vulgaris*	20	400	23
4	*Juniperus communis*	30	500	32
5	*Lonicera quinquelocularis*	40	800	69
6	*Rosa webbiana*	40	400	30
7	*Spiraea sorbifolia*	40	900	51
8	*Viburnum cotinifolium*	30	600	29
			5000	

Table 6.6: Community structure -Site V2 (Herbs)

S. No.	Scientific Name	Frequency (%)	Density (ind. /ha)	IVI
	Pre-Monsoon			
1	*Anaphalis triplinervis*	8	3333	6
2	*Bromus japonicus*	42	8333	22
3	*Cirsium falconeri*	25	4167	12
4	*Cousinia thomsonii*	25	6667	15

S. No.	Scientific Name	Frequency (%)	Density (ind. /ha)	IVI
5	*Dactylis glomerata*	33	8333	20
6	*Fragaria nubicola*	33	8333	20
7	*Gentiana kurroo*	25	18333	27
8	*Iris kemaonesis*	33	8333	20
9	*Oxytropis mollis*	25	5833	14
10	*Poa alpina*	25	8333	17
11	*Thymus serpyllum*	17	11667	18
12	*Girardinia heterophylla*	17	3333	9
			95000	
	Monsoon			
1	*Achyranthes asper*	20	4667	9
2	*Anaphalis triplinervis*	27	6667	13
3	*Andropogon ischaemum*	13	4667	8
4	*Bistorta macrophylla*	20	7333	12
5	*Bromus japonicus*	27	6667	13
6	*Cousinia thomsonii*	27	4667	11
7	*Cyperus niveus*	13	4000	7
8	*Fragaria nubicola*	20	3333	8
9	*Gentiana kurroo*	13	4667	8
10	*Impatiens bicolor*	27	7333	13
11	*Inula obtusifolia*	27	6000	12
12	*Iris kemaonesis*	20	6667	11
13	*Mentha longifolia*	33	4667	12
14	*Oxytropis mollis*	27	4000	10
15	*Pilea scripta*	20	4667	9
16	*Poa alpina*	33	6667	14
17	*Rumex nepalensis*	27	5333	11
18	*Thymus serpyllum*	20	6000	10
19	*Trifolium repens*	20	6667	11
			104667	
	Winter			
1	*Anaphalis triplinervis*	17	4167	18
2	*Cousinia thomsonii*	17	6667	23
3	*Dactylis glomerata*	25	4167	23
4	*Gentiana kurroo*	25	7500	29
5	*Iris kemaonesis*	17	5833	21
6	*Oxytropis mollis*	25	6667	28
7	*Poa alpina*	25	9167	32
8	*Thymus serpyllum*	17	8333	26
			52500	

Site V3: Near Bhang HE Project area- Beas River

Table 6.7: Community structure –Site-V3 (Trees and Shrubs)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	TBC (m^2ha^{-1})	IVI
1	*Acer caesium*	40	70	12.84	44.0
2	*Cedrus deodara*	50	80	89.13	78.9
3	*Corylus colurna*	10	20	3.50	11.8
4	*Juglans regia*	20	30	11.31	22.4
5	*Picea smithiana*	30	50	72.91	54.8
6	*Pinus wallichiana*	20	40	86.98	52.1
7	*Salix fragilis*	30	70	4.42	36.0
			360		

Table 6.8: Community structure –Site-V3 (Shurbs)

S.No.	Scientific Name	Frequency (%)	Density (ind./ha)	IVI

S.No.	Scientific Name	Frequency (%)	Density (ind./ha)	IVI
1	*Artemisia nilagirica*	40	1200	40
2	*Berberis aristata*	30	800	36
3	*Cotoneaster bacillaris*	20	200	10
4	*Ephedra vulgaris*	20	400	18
5	*Indigofera pulchella*	30	800	28
6	*Lonicera quinquelocularis*	40	800	54
7	*Parrotiopsis jacquemontiana*	30	500	25
8	*Rosa webbiana*	40	400	24
9	*Spiraea sorbifolia*	40	900	40
10	*Viburnum cotinifolium*	30	600	23
			6600	

Table 6.9: Community structure -Site-V3 (Herbs)

S.No.	Scientific Name	Frequency (%)	Density (ind./ha)	IVI
	Pre-Monsoon			
1	*Aconitum heterophyllum*	17	5000	10
2	*Allium stracheyi*	17	4167	9
3	*Cyperus squarrosus*	8	4167	7
4	*Dactylis glomerata*	25	10000	17
5	*Deutzia corymbosa*	33	14167	24
6	*Fragaria nubicola*	17	8333	13
7	*Gentiana kurroo*	25	15000	22
8	*Inula obtusifolia*	25	4167	12
9	*Isodon rugosus*	17	6667	12
10	*Poa alpina*	33	16667	26
11	*Polygonum bistorta*	33	8333	19
12	*Primula glomerata*	17	2500	8
13	*Saussurea lappa*	25	3333	11
14	*Trifolium repens*	17	4167	9
			106667	
	Monsoon			
1	*Aconitum heterophyllum*	33	6000	14
2	*Adiantum lunulatum*	20	8000	12
3	*Allium stracheyi*	27	6667	13
4	*Androsace rotundifolia*	20	6000	10
5	*Circium wallichii*	7	5333	6
6	*Cyperus squarrosus*	20	6667	11
7	*Deutzia corymbosa*	27	6000	12
8	*Fragaria nubicola*	20	8667	13
9	*Gentiana kurroo*	13	6000	9
10	*Gnaphalium hypoleucum*	27	6000	12
11	*Inula obtusifolia*	27	6667	13
12	*Isodon rugosus*	20	4667	9
13	*Onychium contiguum*	20	7333	11
14	*Poa alpina*	20	8667	13
15	*Primula glomerata*	20	7333	11
16	*Senecio chrysanthemoides*	27	5333	11
17	*Trifolium repens*	13	6000	9
18	*Viburnum nervosum*	27	6667	13
			118000	
	Winter			
1	*Allium stracheyi*	17	6667	20
2	*Cyperus squarrosus*	33	5000	25
3	*Dactylis glomerata*	42	7500	33
4	*Gentiana kurroo*	17	6667	20
5	*Isodon rugosus*	25	4167	19
6	*Poa alpina*	25	7500	25
7	*Primula glomerata*	25	9167	28

S.No.	Scientific Name	Frequency (%)	Density (ind./ha)	IVI
8	*Oxytropis mollis*	8	4167	11
9	*Trifolium repens*	17	6667	20
			57500	

Site V4: Near Proposed Jobrie HE Project area- Allain Nala

Table 6.10: Community structure -Site V4 (Trees)

S.No.	Scientific Name	Frequency (%)	Density (ind./ha)	TBC (m^2ha^{-1})	IVI
1	*Cedrus deodara*	20	40	62.682	123
2	*Celtis australis*	10	10	1.791	20
3	*Fraxinus floribunda*	30	30	3.899	59
4	*Picea smithiana*	20	20	18.291	59
5	*Pinus wallichiana*	20	20	4.011	41
			120		

Table 6.11: Community structure -Site V4 (Shrubs)

S.No.	Scientific Name	Frequency (%)	Density (ind./ha)	IVI
1	*Artemisia nilagirica*	50	900	85
2	*Indigofera pulchella*	40	1200	56
3	*Berberis aristata*	30	300	43
4	*Cotoneaster bacillaris*	40	700	38
5	*Daphne cannabina*	10	100	17
6	*Lonicera quinquelocularis*	30	300	28
7	*Rosa webbiana*	10	100	17
8	*Viburnum cotinifolium*	10	300	17
			3900	

Table 6.12: Community structure -Site V4 (Herbs)

S.No.	Scientific Name	Frequency (%)	Density (ind./ha)	IVI
	Pre-Monsoon			
1	*Aconitum heterophyllum*	17	2500	9
2	*Allium stracheyi*	17	3333	10
3	*Cyperus squarrosus*	8	2500	6
4	*Dactylis glomerata*	33	12500	27
5	*Deutzia corymbosa*	33	11667	26
6	*Gentiana kurroo*	25	13333	25
7	*Inula obtusifolia*	25	9167	20
8	*Isodon rugosus*	25	4167	14
9	*Poa alpina*	33	11667	26
10	*Podophyllum hexandrum*	25	3333	13
11	*Trifolium repens*	33	8333	22
			82500	
	Monsoon			
1	*Aconitum heterophyllum*	27	6667	14
2	*Ainsliaea latifolia*	20	5333	11
3	*Allium stracheyi*	27	7333	14
4	*Carex filicina*	27	8667	16
5	*Cyperus squarrosus*	20	10000	15
6	*Dactylis glomerata*	13	6667	10
7	*Deutzia corymbosa*	33	8000	17
8	*Fragaria nubicola*	33	4667	13
9	*Gentiana kurroo*	27	4000	11
10	*Inula obtusifolia*	20	6000	11
11	*Origanum vulgare*	20	3333	9
12	*Oxytropis mollis*	27	6000	13
13	*Poa alpina*	20	7333	13
14	*Roscoea alpina*	27	8000	15
15	*Salvia moorcroftiana*	20	2667	8

S.No.	Scientific Name	Frequency (%)	Density (ind./ha)	IVI
16	*Viola canescens*	27	5333	12
			100000	
	Winter			
1	*Allium stracheyi*	8	4167	14
2	*Cyperus squarrosus*	17	5833	24
3	*Dactylis glomerata*	17	5000	22
4	*Deutzia corymbosa*	33	9167	42
5	*Gentiana kurroo*	33	6667	37
6	*Poa alpina*	25	8333	35
7	*Trifolium repens*	17	7500	27
			46667	

Site V5: Near Power House area of Allain Duhangan HE Project area – Allain Nala

Table 6.13: Community structure –Site V5 (Trees)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	TBC (m^2ha^{-1})	IVI
1	*Abies pindrow*	30	80	14.16	51
2	*Aesculus indica*	10	20	10.01	19
3	*Cedrus deodara*	30	50	42.41	66
4	*Ilex dipyrena*	10	10	8.702	16
5	*Picea smithiana*	30	120	17.98	65
6	*Pinus wallichiana*	20	40	12.28	33
7	*Pyrus pashia*	10	10	0.774	9
8	*Quercus semecarpifolia*	20	20	13.63	28
9	*Ulmus villosa*	10	20	3.4	14
			370		

Table 6.14: Community structure –Site V5 (Shrubs)

S. No.	Scientific Name	Frequency (%)	Density (ind./ha)	IVI
1	*Berberis aristata*	20	200	22
2	*Cotoneaster bacillaris*	30	400	36
3	*Daphne cannabina*	40	700	62
4	*Indigofera pulchella*	30	300	28
5	*Juniperus communis*	30	300	29
6	*Lonicera quinquelocularis*	30	400	39
7	*Rosa webbiana*	40	500	53
8	*Viburnum cotinifolium*	20	300	29
			3100	

Table 6.15: Community structure –Site V5 (Herbs)

S. No.	Scientific Name	Frequency (%)	Density (ind./ha)	IVI
	Pre-Monsoon			
1	*Artemisia nilagirica*	25	7500	13
2	*Bromus japonicus*	33	10000	18
3	*Cirsium falconeri*	33	4167	12
4	*Cousinia thomsonii*	25	3333	10
5	*Cyperus squarrosus*	25	4167	10
6	*Dactylis glomerata*	17	8333	12
7	*Deutzia corymbosa*	25	5833	12
8	*Fragaria indica*	25	9167	15
9	*Gentiana kurroo*	25	20000	25
10	*Girardinia heterophylla*	33	6667	15
11	*Oxytropis mollis*	33	6667	15
12	*Polygonum bistorta*	25	8333	14
13	*Rumex acetosa*	17	3333	7

S. No.	Scientific Name	Frequency (%)	Density (ind./ha)	IVI
14	*Saussurea lappa*	25	5833	12
15	*Trifolium pratense*	17	6667	10
			110000	
	Monsoon			
1	*Ainsliaea latifolia*	20	6000	10
2	*Anemone rivularis*	27	8000	13
3	*Artemisia nilagirica*	27	5333	11
4	*Bromus japonicus*	20	4000	8
5	*Carex filicina*	20	3333	8
6	*Cirsium falconeri*	13	6667	9
7	*Cousinia thomsonii*	20	4667	9
8	*Dactylis glomerata*	20	7333	11
9	*Deutzia corymbosa*	20	8000	12
10	*Gentiana kurroo*	27	5333	11
11	*Origanum vulgare*	27	8667	14
12	*Oxytropis mollis*	20	5333	9
13	*Polygonum bistorta*	13	4667	7
14	*Roscoea alpina*	33	6667	14
15	*Rumex acetosa*	33	4667	12
16	*Salvia moorcroftiana*	27	6000	11
17	*Saussurea lappa*	20	7333	11
18	*Trifolium pratense*	27	8000	13
19	*Verbascum thapsus*	13	5333	8
			115333	
	Winter			
1	*Artemisia nilagirica*	17	4167	18
2	*Bromus japonicus*	25	3333	21
3	*Cousinia thomsonii*	8	4167	13
4	*Dactylis glomerata*	17	6667	22
5	*Deutzia corymbosa*	17	3333	16
6	*Gentiana kurroo*	25	5833	26
7	*Oxytropis mollis*	17	5000	19
8	*Rumex acetosa*	25	8333	30
9	*Trifolium pratense*	25	10833	35
			51667	

Site V6: Downstream of Diversion site of Allain Duhangan HE Project area – Dunhangan Nala

Table 6.16: Community structure –Site V6 (Trees)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	TBC (m^2ha^{-1})	IVI
1	*Cedrus deodara*	20	40	42.68	76
2	*Celtis australis*	10	10	1.79	12
3	*Fraxinus floribunda*	30	30	1.90	33
4	*Juglans regia*	10	20	8.12	23
5	*Picea smithiana*	20	20	12.29	35
6	*Pinus wallichiana*	20	20	4.01	25
7	*Quercus semecarpifolia*	40	130	18.38	95
			270		

Table 6.17: Community structure –Site V6 (Shrubs)

S.No.	Scientific Name	Frequency (%)	Density (ind./ha)	IVI
1	*Artemisia roxburghii*	30	800	21
2	*Berberis aristata*	40	700	26
3	*Colebrookea oppositifolia*	20	300	12
4	*Daphne cannabina*	40	800	26
5	*Girardinia heterophylla*	30	500	21
6	*Inula cuspidata*	20	500	24

7	*Leptodermis lanceolata*	20	300	12
8	*Rosa webbiana*	30	500	33
9	*Rubus niveus*	40	800	28
10	*Viburnum cotinifolium*	20	300	11
11	*Sorbaria tomentosa*	70	800	46
12	*Urtica dioica*	20	800	40
			7100	

Table 6.18: Community structure –Site V6 (Herbs)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	IVI
	Pre-Monsoon			
1	*Aconitum violaceum*	25	6667	13
2	*Arenaria serpyllifolia*	33	8333	17
3	*Bromus japonicus*	33	8333	17
4	*Circium wallichii*	33	8333	17
5	*Dactylis glomerata*	17	2500	7
6	*Deutzia corymbosa*	25	3333	10
7	*Fragaria nubicola*	25	13333	19
8	*Gentiana kurroo*	25	9167	16
9	*Iris kemaonesis*	25	4167	11
10	*Isodon rugosus*	17	5833	10
11	*Oxytropis mollis*	17	9167	13
12	*Poa alpina*	8	10000	11
13	*Trifolium repens*	25	20000	25
14	*Viburnum nervosum*	25	4167	11
			113333	
	Monsoon			
1	*Aconitum violaceum*	13	6667	9
2	*Adiantum lunulatum*	27	7333	13
3	*Arenaria serpyllifolia*	20	4667	9
4	*Arundinella nepalensis*	27	9333	14
5	*Bromus japonicus*	20	2667	7
6	*Celosia argentea*	27	4667	11
7	*Circium wallichii*	27	7333	13
8	*Dactylis glomerata*	13	11333	13
9	*Gentiana kurroo*	27	8000	13
10	*Inula cappa*	20	6667	11
11	*Iris kemaonesis*	27	5333	11
12	*Mentha longifolia*	20	8000	12
13	*Oenothera rosea*	27	11333	16
14	*Oxytropis mollis*	20	3333	8
15	*Phytolacca acinosa*	27	5333	11
16	*Trifolium repens*	20	6667	11
17	*Viburnum nervosum*	13	6000	8
18	*Viola canescens*	20	7333	11
			122000	
	Winter			
1	*Arenaria serpyllifolia*	25	6667	23
2	*Bromus japonicus*	25	5833	22
3	*Dactylis glomerata*	17	5000	16
4	*Deutzia corymbosa*	25	8333	26
5	*Gentiana kurroo*	17	2500	12
6	*Iris kemaonesis*	25	3333	17
7	*Isodon rugosus*	17	5833	18
8	*Poa alpina*	17	5000	16
9	*Rumex acetosa*	33	9167	31
10	*Trifolium repens*	17	5833	18
			57500	

Table 6.19: Community structure –Site V7 (Trees)

S.No.	Name of Species	Frequency (%)	Density (ind. /ha^{-1})	TBC (m^2ha^{-1})	IVI
1	*Ilex dipyrena*	20	20	8.702	24
2	*Quercus semecarpifolia*	20	20	13.63	29
3	*Ulmus villosa*	10	20	3.4	13
4	*Aesculus indica*	20	30	5.01	22
5	*Cedrus deodara*	30	30	24.41	48
6	*Pinus wallichiana*	20	30	12.28	30
7	*Abies pindrow*	40	70	14.16	52
8	*Pyrus pashia*	30	70	0.774	32
9	*Picea smithiana*	30	100	7.98	48
			390		

Table 6.20: Community structure –Site V7 (Shrubs)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	IVI
1	*Asparagus adscendens*	30	300	21
2	*Berberis aristata*	40	500	37
3	*Berberis lycium*	40	1200	34
4	*Daphne papyracea*	30	300	17
5	*Desmodium gangeticum*	20	500	24
6	*Girardinia heterophylla*	10	100	9
7	*Jasminum officinale*	30	300	23
8	*Juniperus communis*	40	800	25
9	*Lonicera angustifolia*	20	300	11
10	*Prinsepia utilis*	30	500	23
11	*Sarcococca pruniformis*	30	500	21
12	*Sinarundinaria falcata*	30	400	17
13	*Solanum indicum*	40	700	37
			6400	

Table 6.21: Community structure –Site V7 (Herbs)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	IVI
	Pre-Monsoon			
1	*Achyranthes bidentata*	13	3333	6
2	*Adiantum lunulatum*	13	11333	12
3	*Apluda mutica*	27	8000	13
4	*Arundinella nepalensis*	20	6667	10
5	*Caltha palustris*	27	5333	11
6	*Celosia argentea*	20	13333	16
7	*Cirsium wallichii*	20	3333	8
8	*Conyza stricta*	20	5333	9
9	*Inula cappa*	27	6667	12
10	*Mentha longifolia*	27	6667	12
11	*Oenothera rosea*	20	14667	17
12	*Phytolacca acinosa*	20	8000	12
13	*Pilea scripta*	27	11333	16
14	*Poa annua*	20	3333	8
15	*Trifolium pratense*	27	5333	11
16	*Urtica parviflora*	20	2000	7
17	*Viburnum nervosum*	27	4000	10
18	*Viola canescens*	13	7333	9
			126000	

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	IVI
	Monsoon			
1	*Aconitum heterophyllum*	13	4667	7
2	*Acorus calamus*	20	10000	13
3	*Andropogon nepalensis*	13	4667	7
4	*Arenaria serpyllifolia*	27	6667	12
5	*Bupleurum falcatum*	20	4000	8
6	*Cannabis sativa*	20	17333	18
7	*Carum copticum*	20	4000	8
8	*Cyperus niveus*	27	5333	11
9	*Datura stramonium*	13	8000	9
10	*Delphinium elatum*	27	6000	11
11	*Fragaria vesca*	13	4000	6
12	*Galium aparine*	27	6000	11
13	*Geranium wallichianum*	20	5333	9
14	*Impatiens balsamina*	13	6667	8
15	*Lilium giganteum*	20	4000	8
16	*Mentha longifolia*	27	8000	13
17	*Polygonatum verticillatum*	13	3333	6
18	*Potentilla nepalensis*	20	4000	8
19	*Thymus serpyllum*	13	8667	10
20	*Trifolium pratense*	20	5333	9
21	*Viburnum nervosum*	20	3333	7
			129333	
	Winter			
1	*Aconitum heterophyllum*	25	5833	16
2	*Acorus calamus*	33	10000	25
3	*Andropogon nepalensis*	17	5000	12
4	*Argemone mexicana*	25	8333	19
5	*Cannabis sativa*	25	4167	14
6	*Carum copticum*	17	5000	12
7	*Datura stramonium*	17	6667	14
8	*Delphinium elatum*	17	4167	11
9	*Impatiens balsamina*	33	9167	23
10	*Potentilla nepalensis*	33	8333	22
11	*Strobilanthes*	25	7500	18
12	*Thymus serpyllum*	17	4167	11
			78333	

Site V8: Downstream of Malan II HE Project Dam Site- Malana Nala

Table 6.22: Community structure -Site V8 (Trees)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	TBC (m^2ha^{-1})	IVI
1	*Pyrus pashia*	20	15	64.98	52
2	*Celtis australis*	50	16	1.62	29
3	*Abies pindrow*	30	17	28.88	36
4	*Aesculus indica*	30	23	2.02	24
5	*Prunus padus*	30	23	27.38	39
6	*Acer caesium*	20	30	33.62	41
7	*Cupressus torulosa*	30	30	15.68	35
8	*Picea smithiana*	10	30	0.82	18
9	*Cedrus deodara*	20	35	2.16	26
			219		

Table 6.23: Community structure -Site V8 (Shrubs)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	IVI
1	*Berberis chitria*	40	700	30
2	*Girardinia heterophylla*	30	300	29
3	*Elsholtzia fruticosa*	30	300	17
4	*Indigofera gerardiana*	30	400	19
5	*Leycesteria formosa*	40	800	33
6	*Phytolacca acinosa*	30	500	19
7	*Salvia moorcroftiana*	20	500	18
8	*Sorbaria tomentosa*	20	300	19
9	*Spiraea canescens*	30	500	18
10	*Viburnum nervosum*	20	300	23
11	*Sinarundinaria falcata*	40	800	36
12	*Zanthoxylum armatum*	30	800	38
			6200	

Table 6.24: Community structure -Site 8 (Herbs)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	IVI
	Pre Monsoon			
1	*Bupleurum falcatum*	20	6667	10
2	*Carum copticum*	27	11333	15
3	*Cannabis sativa*	13	6667	8
4	*Impatiens balsamina*	20	12000	14
5	*Andropogon nepalensis*	20	3333	8
6	*Mentha longifolia*	13	5333	7
7	*Thymus serpyllum*	27	13333	17
8	*Aconitum heterophyllum*	27	6667	12
9	*Acorus calamus*	27	10000	14
10	*Argemone mexicana*	27	9333	14
11	*Iris sp*	20	10667	13
12	*Polygonatum verticillatum*	27	3333	9
13	*Delphinium elatum*	20	2667	7
14	*Delphinium vestitum*	20	3333	8
15	*Lilium giganteum*	13	6667	8
16	*Strobilanthes*	20	6667	10
17	*Potentilla nepalensis*	13	2667	5
18	*Cynodon dactylon*	20	4667	9
19	*Datura stramonium*	20	7333	11
			132667	
	Monsoon			
1	*Achyranthes asper*	20	6000	9
2	*Anaphalis contorta*	27	7333	12
3	*Andropogon ischaemum*	33	6667	13
4	*Bistorta macrophylla*	13	7333	9
5	*Bromus japonicus*	33	8667	14
6	*Cannabis sativa*	20	14667	16
7	*Cyperus niveus*	27	9333	13
8	*Eremurus himalaicus*	20	8000	11
9	*Fragaria nubicola*	13	4000	6
10	*Gnaphalium hypoleucum*	13	3333	6
11	*Impatiens bicolor*	13	1333	4
12	*Iris kemaonesis*	13	2667	5
13	*Mentha longifolia*	13	4000	6
14	*Oxytropis mollis*	27	4667	10
15	*Pilea scripta*	20	8667	11
16	*Poa alpina*	20	5333	9
17	*Podophyllum hexandrum*	20	6667	10
18	*Rumex nepalensis*	40	11333	18

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	IVI
19	*Thymus serpyllum*	20	8000	11
20	*Trifolium repens*	13	5333	7
			133333	
	Winter			
1	*Andropogon ischaemum*	25	5000	13
2	*Bistorta macrophylla*	33	6667	18
3	*Eremurus himalaicus*	17	10000	16
4	*Gentiana kurroo*	33	7500	19
5	*Impatiens bicolor*	17	9167	15
6	*Inula obtusifolia*	25	5000	13
7	*Mentha longifolia*	17	10833	17
8	*Pilea scripta*	25	6667	15
9	*Poa alpina*	25	4167	12
10	*Rumex nepalensis*	33	10000	21
11	*Thymus serpyllum*	33	8333	19
12	*Trifolium repens*	25	13333	22
		308	96667	

Site V9: Upstream of Malana II Power House site

Table 6.25: Community structure -Site V9 (Trees)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	TBC (m^{2}ha^{-1})	IVI
1	*Alnus nepalensis*	20	30	2.21	24
2	*Cedrus deodara*	30	60	102.29	90
3	*Corylus colurna*	20	20	3.74	21
4	*Juglans regia*	20	20	4.22	21
5	*Pinus wallichiana*	30	100	2.40	55
6	*Populus ciliata*	20	20	19.05	28
7	*Salix wallichiana*	30	30	68.58	62
			280		

Table 6.26: Community structure -Site V9 (Shrubs)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	IVI
1	*Buddleja crispa*	10	500	12
2	*Berberis lycium*	20	700	17
3	*Girardinia diversifolia*	20	300	25
4	*Hypericum patulum*	20	400	16
5	*Cannabis sativa*	30	600	31
6	*Sinarundinaria falcata*	30	800	24
7	*Sinopodophyllum hexandrum*	30	500	20
8	*Rubus ellipticus*	30	800	20
9	*Rosa brunonii*	30	500	20
10	*Viburnum mullaha*	30	600	25
11	*Chenopodium album*	40	700	35
12	*Desmodium gangeticum*	40	400	20
13	*Rhamnus triqueter*	40	600	34
			7400	

Table 6.27: Community structure -Site V9 (Herbs)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	IVI
	Pre-Monsoon			
1	*Achyranthes asper*	27	8000	14
2	*Anaphalis contorta*	20	6667	11
3	*Andropogon ischaemum*	27	5333	12

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	IVI
4	*Bistorta macrophylla*	20	13333	16
5	*Fragaria nubicola*	13	6667	9
6	*Gentiana kurroo*	27	7333	13
7	*Gnaphalium hypoleucum*	20	2000	7
8	*Impatiens bicolor*	20	3333	8
9	*Inula obtusifolia*	20	5333	10
10	*Cyperus niveus*	27	6667	13
11	*Mentha longifolia*	27	6667	13
12	*Pilea scripta*	20	14667	17
13	*Poa alpina*	27	11333	16
14	*Poa pratensis*	13	6667	9
15	*Podophyllum hexandrum*	20	12000	15
16	*Rumex nepalensis*	20	3333	8
17	*Trifolium repens*	13	5333	8
			124667	
	Monsoon			
1	*Adiantum lunulatum*	13	6000	8
2	*Acorus calamus*	13	4667	7
3	*Agrimonia pilosa*	27	6667	12
4	*Andropogon nepalensis*	13	3333	6
5	*Arenaria serpyllifolia*	13	2667	5
6	*Bupleurum falcatum*	13	3333	6
7	*Cannabis sativa*	20	10667	13
8	*Carum copticum*	27	5333	11
9	*Clematis vestitum*	20	6000	10
10	*Datura stramonium*	13	4667	7
11	*Gentiana kurroo*	13	6667	9
12	*Isodon rugosus*	20	5333	9
13	*Onychium contiguum*	20	6000	10
14	*Oxytropis mollis*	20	4000	8
15	*Pedicularis hoffmeisteri*	27	4667	10
16	*Pilea scripta*	13	3333	6
17	*Poa alpina*	13	12667	13
18	*Rumex nepalensis*	20	6000	10
19	*Senecio chrysanthemoides*	20	6667	10
20	*Stellaria media*	13	3333	6
21	*Thymus serpyllum*	27	4667	10
22	*Trifolium pratense*	13	5333	8
23	*Viburnum nervosum*	13	4000	6
			126000	
	Winter			
1	*Agrimonia pilosa*	8	5000	8
2	*Androsace rotundifolia*	17	4167	10
3	*Clematis vestitum*	33	8333	20
4	*Cyperus niveus*	25	5833	14
5	*Gentiana kurroo*	33	9167	21
6	*Isodon rugosus*	25	10000	19
7	*Mentha longifolia*	25	8333	17
8	*Myosotis alpestris*	33	9167	21
9	*Pedicularis hoffmeisteri*	17	4167	10
10	*Persicaria capitata*	17	5833	12
11	*Poa alpina*	17	12500	18
12	*Stellaria media*	17	5833	12
13	*Trifolium pratense*	25	10833	19
			99167	

Table 6.28: Community structure -Site V10 (Trees)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	TBC (m^2ha^{-1})	IVI
1	*Acer caesium*	30	50	12.84	39.3
2	*Alnus nitida*	20	30	16.98	31.9
3	*Cedrus deodara*	30	100	2.91	43.7
4	*Pinus wallichiana*	30	120	3.50	48.9
5	*Populus ciliata*	20	40	11.31	29.9
6	*Corylus colurna*	10	10	79.13	68.6
7	*Salix fragilis*	30	70	4.42	37.7
			420		

Table 6.29: Community structure -Site V10 (Shrubs)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	IVI
1	*Buddleja crispa*	30	500	15
2	*Deutzia staminea*	40	600	21
3	*Elsholtzia fruticosa*	20	400	13
4	*Impatiens cristata*	30	500	16
5	*Indigofera gerardiana*	40	800	26
6	*Leycesteria formosa*	30	300	14
7	*Plectranthus rugosus*	40	600	18
8	*Prinsepia utilis*	10	100	30
9	*Rosa macrophylla*	30	300	15
10	*Rubus lasiocarpus*	30	400	15
11	*Rubus niveus*	40	500	44
12	*Salvia moorcroftiana*	30	500	28
13	*Sinarundinaria falcata*	40	500	20
14	*Sorbaria tomentosa*	20	300	13
15	*Viburnum nervosum*	20	500	13
			6800	

Table 6.30: Community structure -Site V10 (Herbs)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	IVI
	Pre-Monsoon			
1	*Adiantum lunulatum*	20	10667	15
2	*Agrimonia pilosa*	20	7333	12
3	*Androsace rotundifolia*	20	3333	8
4	*Circium wallichii*	27	9333	15
5	*Clematis vestitum*	20	2667	8
6	*Isodon rugosus*	27	3333	10
7	*Cyperus niveus*	20	2667	8
8	*Myosotis alpestris*	20	3333	8
9	*Onychium contiguum*	13	6667	9
10	*Pedicularis hoffmeisteri*	20	4667	9
11	*Persicaria capitata*	20	7333	12
12	*Senecio chrysanthemoides*	20	16000	19
13	*Stellaria media*	27	6667	13
14	*Trifolium pratense*	20	14667	18
15	*Viburnum nervosum*	13	3333	6
16	*Gentiana kurroo*	13	1333	5
17	*Gnaphalium hypoleucum*	13	2667	6
18	*Mentha longifolia*	13	4000	7
19	*Poa alpina*	27	4667	11
			114667	
	Monsoon			

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	IVI
1	*Adiantum lunulatum*	13	8000	10
2	*Ainsliaea latifolia*	20	4667	9
3	*Allium stracheyi*	13	4000	7
4	*Andropogon nepalensis*	20	6667	11
5	*Carex filicina*	27	8000	13
6	*Cyperus squarrosus*	20	5333	10
7	*Datura stramonium*	13	5333	8
8	*Deutzia corymbosa*	7	4000	5
9	*Eremurus himalaicus*	13	5333	8
10	*Gentiana kurroo*	33	12667	19
11	*Gnaphalium hypoleucum*	20	5333	10
12	*Isodon rugosus*	13	3333	6
13	*Origanum vulgare*	13	5333	8
14	*Pedicularis hoffmeisteri*	27	7333	13
15	*Pilea scripta*	20	6000	10
16	*Rumex nepalensis*	13	4000	7
17	*Senecio chrysanthemoides*	13	6000	8
18	*Stellaria media*	27	8000	13
19	*Trifolium pratense*	13	7333	9
20	*Verbascum thapsus*	20	5333	10
21	*Viola canescens*	13	4000	7
			126000	
S.No.	**Winter**			
1	*Ainsliaea latifolia*	25	6667	14
2	*Anemone rivularis*	8	5000	7
3	*Cannabis sativa*	25	7500	15
4	*Cousinia thomsonii*	25	9167	16
5	*Cyperus squarrosus*	25	6667	14
6	*Deutzia corymbosa*	25	5833	13
7	*Gentiana kurroo*	33	7500	17
8	*Gnaphalium hypoleucum*	25	6667	14
9	*Malva veticellata*	17	6667	11
10	*Pedicularis hoffmeisteri*	17	5833	11
11	*Roscoea alpina*	33	10000	20
12	*Rumex nepalensis*	25	8333	15
13	*Salvia moorcroftiana*	25	7500	15
14	*Trifolium pratense*	33	9167	19
			102500	

Site V11: Power House site Malana I HEP- Malana Nala

Table 6.31: Community structure -Site V11 (Trees)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	TBC (m^2ha^{-1})	IVI
1	*Cedrus deodara*	20	40	42.68	115
2	*Celtis australis*	10	20	1.79	25
3	*Fraxinus floribunda*	20	30	3.90	45
4	*Picea smithiana*	30	50	8.29	75
5	*Pinus wallichiana*	20	20	4.01	39
			160		

Table 6.32: Community structure -Site V11 (Shrubs)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	IVI
1	*Artemisia nilagirica*	20	500	24
2	*Buddleja crispa*	20	400	20
3	*Cotoneaster bacillaris*	30	500	24

4	*Desmodium elegans*	20	500	21
5	*Elsholtzia fruticosa*	20	200	58
6	*Impatiens cristata*	20	400	27
7	*Indigofera gerardiana*	20	600	23
8	*Indigofera pulchella*	40	700	42
9	*Salvia moorcroftiana*	10	300	14
10	*Sorbaria tomentosa*	10	200	14
11	*Spiraea canescens*	10	200	19
12	*Viburnum nervosum*	10	300	14
			4800	

Table 6.33: Community structure -Site 11 (Herbs)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	IVI
	Pre-Monsoon			
1	*Ainsliaea latifolia*	27	2667	10
2	*Allium stracheyi*	27	7333	15
3	*Anemone rivularis*	33	6667	17
4	*Carex filicina*	20	3333	9
5	*Cousinia thomsonii*	20	5333	11
6	*Cyperus squarrosus*	20	6667	13
7	*Deutzia corymbosa*	13	9333	14
8	*Fragaria nubicola*	13	2667	7
9	*Gentiana kurroo*	7	3333	5
10	*Malva verticillata*	20	8000	14
11	*Origanum vulgare*	27	11333	20
12	*Oxytropis mollis*	20	5333	11
13	*Roscoea alpina*	20	3333	9
14	*Rumex nepalensis*	27	4667	13
15	*Salvia moorcroftiana*	27	2667	10
16	*Verbascum thapsus*	13	2000	6
17	*Viola canescens*	20	8000	14
			92667	
	Monsoon			
1	*Achyranthes asper*	13	8667	10
2	*Adiantum lunulatum*	27	6667	12
3	*Anaphalis contorta*	13	4667	7
4	*Andropogon ischaemum*	27	6667	12
5	*Apluda mutica*	27	8667	14
6	*Arundinella nepalensis*	13	4000	7
7	*Celosia argentea*	20	4667	9
8	*Conyza stricta*	13	9333	11
9	*Delphinium denudatum*	27	10000	15
10	*Inula cappa*	20	8667	12
11	*Mentha longifolia*	13	4667	7
12	*Phytolacca acinosa*	13	5333	8
13	*Poa annua*	13	7333	9
14	*Poa pratensis*	20	6000	10
15	*Pogonatherum sacchaoidon*	20	6667	11
16	*Tagetes erecta*	7	4667	5
17	*Trifolium pratense*	13	6000	8
18	*Viburnum nervosum*	33	8000	15
19	*Vicoa biflora*	20	6000	10
20	*Viola canescens*	13	5333	8
			132000	
	Winter			
1	*Achyranthes bidentata*	17	5833	11
2	*Adiantum lunulatum*	17	12500	17
3	*Arundinella nepalensis*	33	8333	18

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	IVI
4	*Caltha palustris*	25	7500	15
5	*Cirsium wallichii*	33	6667	17
6	*Conyza stricta*	17	9167	14
7	*Inula cappa*	25	5833	13
8	*Oenothera rosea*	17	6667	11
9	*Phytolacca acinosa*	33	7500	17
10	*Poa annua*	25	8333	16
11	*Trifolium pratense*	25	10833	18
12	*Phytolacca acinosa*	17	7500	12
13	*Tagetes erecta*	33	11667	21
			108333	

Site V12: Tosh HEP near Power House site: Tosh Nala

Table 6.34: Community structure -Site V12 (Trees)

S. No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	TBC (m^{2}ha^{-1})	IVI
1	*Abies spectabilis*	10	20	3.00	20
2	*Acer caesium*	30	30	2.71	35
3	*Castanea sativa*	30	30	0.39	30
4	*Cedrus deodara*	10	10	1.99	14
5	*Corylus colurna*	10	20	5.18	24
6	*Juglans regia*	10	20	15.16	42
7	*Picea smithiana*	20	20	18.23	54
8	*Prunus avium*	10	10	3.56	17
9	*Populus ciliata*	10	10	0.49	11
10	*Pinus wallichiana*	10	40	0.51	23
11	*Salix wallichiana*	10	20	0.50	15
12	*Ulmus wallichiana*	10	20	1.33	16
			250		

Table 6.35: Community structure -Site V12 (Shrubs)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	IVI
1	*Berberis asiatica*	10	180	9
2	*Berberis aristata*	10	220	8
3	*Clematis graveolens*	10	580	18
4	*Cotoneaster bacillaris*	60	280	20
5	*Cotoneaster microphyllus*	20	320	19
6	*Desmodium elegans*	30	240	17
7	*Deutzia staminea*	20	80	8
8	*Elsholtzia fruticosa*	10	80	5
9	*Indigofera gerardiana*	10	40	41
10	*Leycesteria formosa*	30	440	18
11	*Phytolacca acinosa*	10	120	8
12	*Plectranthus rugosus*	10	200	9
13	*Rosa macrophylla*	30	200	12
14	*Rubus niveus*	30	340	16
15	*Salvia moorcroftiana*	20	160	9
16	*Sorbaria tomentosa*	70	100	20
17	*Spiraea canescens*	60	70	16
18	*Viburnum nervosum*	60	70	45
			3720	

Table 6.36: Community structure -Site V12 (Herbs)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	IVI
	Pre Monsoon			

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	IVI
1	*Adiantum lunulatum*	33	8600	7
2	*Androsace rotundifolia*	13	3867	3
3	*Arenaria serpyllifolia*	20	7800	5
4	*Artemisia vulgaris*	60	19867	14
5	*Cannabis sativa*	67	8167	10
6	*Circium wallichii*	67	5667	9
7	*Clematis vestitum*	75	11250	12
8	*Cyperus niveus*	25	4000	4
9	*Dioscorea deltoidea*	33	32000	17
10	*Fagopyrum esculentum*	33	2917	5
11	*Fragaria vesca*	50	8167	8
12	*Galium aparine*	58	3667	7
13	*Geranium wallichianum*	50	4833	7
14	*Heliotropium strigosum*	25	3833	4
15	*Inula cappa*	33	8083	7
16	*Pedicularis hoffmeisteri*	17	4667	4
17	*Persicaria capitata*	25	3583	4
18	*Poa annua*	33	13000	9
19	*Polygonatum verticillatum*	42	23167	14
20	*Potentilla argyrophylla*	58	19333	14
21	*Rumex nepalensis*	25	7250	6
22	*Salvia lanata*	42	16500	11
23	*Stellaria media*	25	8167	6
24	*Trifolium pratense*	17	3667	3
25	*Viburnum nervosum*	67	4833	9
			236883	
	Monsoon			
1	*Aconitum violaceum*	25	6667	7
2	*Adiantum lunulatum*	25	9167	9
3	*Arenaria serpyllifolia*	17	4167	5
4	*Bromus japonicus*	25	6667	7
5	*Cannabis sativa*	17	11667	8
6	*Clematis vestitum*	25	8333	8
7	*Cyperus niveus*	25	6667	7
8	*Delphinium elatum*	17	5833	6
9	*Dioscorea deltoidea*	8	5000	4
10	*Eremurus himalaicus*	17	5833	6
11	*Fagopyrum esculentum*	25	11667	10
12	*Galium aparine*	42	7500	11
13	*Geranium wallichianum*	25	10000	9
14	*Impatiens balsamina*	8	4167	3
15	*Inula cappa*	33	15000	13
16	*Iris kemaonesis*	33	6667	9
17	*Oxytropis mollis*	17	10000	8
18	*Persicaria capitata*	33	7500	9
19	*Poa annua*	17	20833	13
20	*Podophyllum hexandrum*	33	7500	9
21	*Polygonatum verticillatum*	25	6667	7
22	*Rumex nepalensis*	17	8333	7
23	*Stellaria media*	8	4167	3
24	*Thymus serpyllum*	33	10000	10
25	*Trifolium pratense*	17	5000	5
26	*Viburnum nervosum*	33	5833	8
			210833	
	Winter			
1	*Aconitum violaceum*	25	6667	11
2	*Adiantum lunulatum*	25	9167	12

S.No.	Name of Species	Frequency (%)	Density (ind./ha-1)	IVI
3	*Arenaria serpyllifolia*	17	4167	7
4	*Bromus japonicus*	25	6667	11
5	*Cannabis sativa*	17	11667	12
6	*Clematis vestitum*	25	8333	12
7	*Cyperus niveus*	25	6667	11
8	*Delphinium elatum*	17	5833	8
9	*Dioscorea deltoidea*	8	5000	6
10	*Eremurus himalaicus*	17	5833	8
11	*Geranium wallichianum*	25	11667	14
12	*Impatiens balsamina*	42	7500	15
13	*Iris kemaonesis*	25	10000	13
14	*Persicaria capitata*	8	4167	5
15	*Poa annua*	33	15000	19
16	*Rumex nepalensis*	33	6667	13
17	*Thymus serpyllum*	17	10000	11
18	*Trifolium pratense*	33	7500	13
			142500	

Site V13: Near Diversion site of Nakthan HEP- Tosh Nala

Table 6.37: Community structure -Site V13 (Trees)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	TBC (m^{2}ha^{-1})	IVI
1	*Acer caesium*	10	10	8.30	39
2	*Corylus colurna*	10	10	1.78	18
3	*Hippophae salicifolia*	10	10	0.51	14
4	*Picea smithiana*	10	10	7.19	35
5	*Pinus roxburghii*	10	10	0.89	15
6	*Prunus cornuta*	10	10	0.83	15
7	*Sorbaria tomentosa*	10	10	1.50	17
8	*Ulmus villosa*	10	10	4.35	26
9	*Cedrus deodara*	20	30	2.92	39
10	*Pinus wallichiana*	10	30	2.43	30
11	*Populus ciliata*	10	30	0.03	22
12	*Salix denticulata*	20	30	0.24	30
			200		

Table 6.38: Community structure -Site V13 (Shrubs)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	IVI
1	*Berberis asiatica*	30	80	12
2	*Berberis lycium*	40	420	32
3	*Cotoneaster bacillaris*	10	40	12
4	*Desmodium elegans*	40	160	34
5	*Elsholtzia fruticosa*	10	120	11
6	*Impatiens cristata*	10	60	6
7	*Indigofera gerardiana*	30	80	76
8	*Plectranthus rugosus*	20	100	11
9	*Rosa brunonii*	90	440	44
10	*Rubus niveus*	30	360	24
11	*Spiraea canescens*	20	520	28
12	*Viburnum nervosum*	20	60	10
			2440	

Table 6.39: Community structure -Site V13 (Herbs)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	IVI
	Pre Monsoon			
1	*Ainsliaea latifolia*	27	5533	6
2	*Anemone rivularis*	53	19067	16
3	*Arisaema intermedium*	13	3600	3
4	*Arthraxon lancifolius*	73	18533	19
5	*Cannabis sativa*	20	6467	6
6	*Carex filicina*	40	12267	11
7	*Clematis buchananiana*	33	8600	9
8	*Dioscorea deltoidea*	13	3867	4
9	*Duchesnea indica*	20	7800	6
10	*Fagopyrum esculentum*	60	19867	17
11	*Geranium nepalense*	27	12267	9
12	*Leonurus cardiaca*	40	18933	14
13	*Origanum vulgare*	20	3400	4
14	*Oxalis corniculata*	27	2933	5
15	*Plantago erosa*	60	16533	16
16	*Poa annua*	20	3067	4
17	*Roscoea alpina*	13	3733	4
18	*Rumex nepalensis*	47	8467	10
19	*Salvia moorcroftiana*	53	9467	12
20	*Silene conoidea*	27	4200	6
21	*Trifolium pratense*	47	12533	12
22	*Viola canescens*	33	5583	7
			206717	
	Monsoon			
1	*Ainsliaea latifolia*	25	7500	7
2	*Anemone rivularis*	8	6667	4
3	*Arisaema intermedium*	25	8333	7
4	*Arthraxon lancifolius*	33	7500	8
5	*Cannabis sativa*	25	10833	8
6	*Carex filicina*	25	7500	7
7	*Clematis buchananiana*	25	7500	7
8	*Dioscorea deltoidea*	33	6667	8
9	*Duchesnea indica*	33	7500	8
10	*Fagopyrum esculentum*	33	9167	9
11	*Galium aparine*	33	11667	10
12	*Geranium nepalense*	33	9167	9
13	*Inula cappa*	33	9167	9
14	*Iris kemaonesis*	42	8333	10
15	*Leonurus cardiaca*	25	8333	7
16	*Mentha longifolia*	42	10833	11
17	*Origanum vulgare*	33	8333	8
18	*Plantago erosa*	25	8333	7
19	*Poa annua*	42	9167	10
20	*Rumex nepalensis*	17	10000	7
21	*Thymus serpyllum*	17	9167	7
22	*Salvia moorcroftiana*	42	11667	11
23	*Silene conoidea*	17	7500	6
24	*Trifolium pratense*	33	7500	8
25	*Viola canescens*	33	8333	8
			216667	
	Winter			
1	*Ainsliaea latifolia*	25	6667	12
2	*Anemone rivularis*	8	5833	7
3	*Arthraxon lancifolius*	25	10000	15
4	*Cannabis sativa*	17	7500	11
5	*Clematis buchananiana*	25	9167	14
6	*Dioscorea deltoidea*	25	7500	13
7	*Fagopyrum esculentum*	17	5833	9

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	IVI
8	*Galium aparine*	17	6667	10
9	*Geranium nepalense*	25	7500	13
10	*Iris kemaonesis*	33	8333	16
11	*Leonurus cardiaca*	33	10833	18
12	*Mentha longifolia*	8	3333	5
13	*Plantago erosa*	17	5833	9
14	*Poa annua*	17	8333	11
15	*Rumex nepalensis*	8	2500	4
16	*Salvia moorcroftiana*	25	9167	14
17	*Trifolium pratense*	33	7500	15
			122500	

Site V14: Near Diversion site of Nakthan HEP- Parbati River

Table 6.40: Community structure - Site V14 (Trees)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	TBC (m^2ha^{-1})	IVI
1	*Abies pindrow*	40	70	15.2	45
2	*Acer caesium*	50	50	15.9	43
3	*Aesculus indica*	40	40	8.2	31
4	*Cedrus deodara*	50	50	15.2	43
5	*Corylus colurna*	20	30	1.1	15
6	*Juglans regia*	20	20	6.2	17
7	*Juglans regia*	20	30	2.2	16
8	*Picea smithiana*	30	30	49.2	60
9	*Pinus wallichiana*	10	20	0.5	9
10	*Populus ciliata*	10	10	3.3	9
11	*Ulmus villosa*	10	30	0.6	12
			380.0		

Table 6.41: Community structure - Site V14 (Shrubs)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	IVI
1	*Buddleja crispa*	40	320	36
2	*Cissus repanda*	30	160	21
3	*Cotoneaster bacillaris*	20.0	220	28
4	*Hedera nepalensis*	20	180	22
5	*Indigofera gerardiana*	30	320	37
6	*Lonicera angustifolia*	20	200	16
7	*Phytolacca acinosa*	20	200	28
8	*Rosa macrophylla*	30	340	38
9	*Staphylea emodi*	40	460	39
10	*Viburnum nervosum*	60	240	36
			2640	

Table 6.42: Community structure - Site V14 (Herbs)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	IVI
	Pre Monsoon			
1	*Achyranthes bidentata*	58	6500	10
2	*Ajuga parviflora*	58	8167	10
3	*Apluda mutica*	67	7250	11
4	*Cirsium wallichii*	92	15417	17
5	*Conyza stricta*	42	5750	7
6	*Fragaria vesca*	67	8167	11
7	*Geranium nepalense*	67	5667	10
8	*Gnaphalium affine*	75	11250	14

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	IVI
9	*Hedera nepalensis*	25	4000	5
10	*Inula cappa*	33	32000	19
11	*Mentha longifolia*	25	20250	12
12	*Poa annua*	33	3833	6
13	*Prinsepia utilis*	25	4833	5
14	*Rubus ellipticus*	42	15417	12
15	*Rumex nepalensis*	58	11917	12
16	*Salvia moorcroftiana*	25	4500	5
17	*Trifolium pratense*	33	18417	12
18	*Urtica parviflora*	25	9417	7
19	*Viburnum nervosum*	50	18583	14
			211333	
	Monsoon			
1	*Achyranthes bidentata*	25	6667	8
2	*Ajuga parviflora*	33	8333	10
3	*Apluda mutica*	33	8333	10
4	*Arundinella nepalensis*	25	18333	14
5	*Cirsium wallichii*	33	8333	10
6	*Bidens bipinnata*	25	10000	10
7	*Desmodium caudatum*	33	14167	13
8	*Equisetum ramossimum*	17	8333	7
9	*Geranium nepalense*	25	15000	13
10	*Gnaphalium affine*	25	4167	7
11	*Gnaphalium luteo-album*	25	5833	7
12	*Inula cappa*	33	11667	12
13	*Mentha longifolia*	25	3333	6
14	*Poa annua*	33	8333	10
15	*Plantago erosa*	17	3333	5
16	*Prinsepia utilis*	25	5833	7
17	*Rubus ellipticus*	17	6667	7
18	*Rumex nepalensis*	25	4167	7
19	*Salvia moorcroftiana*	17	5833	6
20	*Trifolium pratense*	25	2500	6
21	*Cyperus cuspidatus*	25	4167	7
22	*Urtica parviflora*	25	6667	8
23	*Viburnum nervosum*	33	8333	10
			178333	
	Winter			
1	*Achyranthes bidentata*	25	6667	11
2	*Ajuga parviflora*	33	8333	14
3	*Apluda mutica*	33	8333	14
4	*Arundinella nepalensis*	25	18333	19
5	*Desmodium caudatum*	33	8333	14
6	*Geranium nepalense*	25	10000	13
7	*Gnaphalium affine*	33	14167	18
8	*Inula cappa*	17	8333	10
9	*Mentha longifolia*	25	15000	17
10	*Poa annua*	25	4167	9
11	*Rubus ellipticus*	25	4167	9
12	*Rumex nepalensis*	33	11667	16
13	*Salvia moorcroftiana*	25	3333	8
14	*Trifolium pratense*	33	8333	14
15	*Urtica parviflora*	17	3333	6
16	*Viburnum nervosum*	25	5833	10
			138333	

Site 15: Proposed Power House Site Nakthan HEP – Tosh Nala

Table 6.43: Community structure – Site V15 (Trees)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	TBC (m^2ha^{-1})	IVI
1	*Abies pindrow*	50	80	0.53	50
2	*Acer caesium*	50	40	0.97	38
3	*Aesculus indica*	30	30	4.36	29
4	*Celtis australis*	10	20	0.46	12
5	*Hippophae salicifolia*	10	10	0.78	9
6	*Ilex dipyrena*	10	30	0.03	14
7	*Juglans regia*	10	10	1.99	10
8	*Picea wallichiana*	10	40	60.18	85
9	*Pinus roxburghii*	10	20	0.27	12
10	*Salix acutifolia*	10	10	0.84	9
11	*Ulmus villosa*	10	20	19.39	33
			310		

Table 6.44: Community structure – Site V15 (Shrubs)

S.No.	Name of Species	Frequency (%)	Density (ind. /ha^{-1})	IVI
1	*Berberis asiatica*	20	280	22
2	*Buddleja crispa*	20	480	23
3	*Cotoneaster bacillaris*	20	160	13
4	*Desmodium elegans*	20	240	27
5	*Elsholtzia fruticosa*	10	220	13
6	*Indigofera gerardiana*	10	580	24
7	*Plectranthus rugosus*	60	280	24
8	*Prinsepia utilis*	30	520	25
9	*Rubus ellipticus*	10	280	11
10	*Rubus niveus*	70	100	20
11	*Sorbaria tomentosa*	60	70	64
12	*Spiraea canescens*	60	70	25
13	*Viburnum nervosum*	30	40	9
			3320	

Table 6.45: Community structure – Site V15 (Herbs)

S.No.	Name of Species	Frequency (%)	Density (ind. /ha^{-1})	IVI
	Pre Monsoon			
1	*Achyranthes aspera*	58	9333	14
2	*Adiantum lunulatum*	50	6583	10
3	*Ageratum conyzoides*	33	2917	6
4	*Ainsliaea latifolia*	50	8167	12
5	*Artemisia scoparia*	58	3667	8
6	*Arundinella nepalensis*	50	4833	9
7	*Carex filicina*	42	4500	8
8	*Cirsium wallichii*	50	3667	8
9	*Cissus himalayana*	67	3833	9
10	*Cyperus cuspidatus*	92	7167	15
11	*Dioscorea deltoidea*	75	14667	20
12	*Fragaria vesca*	25	5500	7
13	*Geranium nepalense*	67	6500	12
14	*Gnaphalium luteo-album*	50	5667	10
15	*Inula cappa*	67	6250	12
16	*Oplismenus burmannii*	100	4833	13
17	*Prinsepia utilis*	92	5500	13
18	*Rumex nepalensis*	58	4333	9
19	*Trifolium pratense*	42	3167	7
			111083	
	Monsoon			

S.No.	Name of Species	Frequency (%)	Density (ind. /ha^{-1})	IVI
1	*Achyranthes aspera*	25	6667	8
2	*Adiantum lunulatum*	33	11667	12
3	*Ageratum conyzoides*	33	7500	10
4	*Artemisia scoparia*	25	9167	9
5	*Arundinella nepalensis*	33	6667	9
6	*Bidens bipinnata*	17	5833	6
7	*Cirsium wallichii*	17	11667	9
8	*Cyperus cuspidatus*	25	15833	13
9	*Dioscorea deltoidea*	33	7500	10
10	*Equisetum ramossimum*	33	6667	9
11	*Eragrostis nigra*	25	4167	7
12	*Fragaria vesca*	17	10833	9
13	*Geranium nepalense*	33	7500	10
14	*Gnaphalium luteo-album*	33	5833	9
15	*Oplismenus burmannii*	17	7500	7
16	*Plantago erosa*	33	8333	10
17	*Prinsepia utilis*	33	11667	12
18	*Rumex nepalensis*	25	8333	9
19	*Trifolium pratense*	25	9167	9
20	*Urena lobata*	33	12500	12
21	*Valeriana hardwickii*	17	6667	6
22	*Xanthium indicum*	17	5000	6
			186667	
	Winter			
1	*Achyranthes aspera*	25	5833	11
2	*Adiantum lunulatum*	33	11667	19
3	*Artemisia scoparia*	25	3333	9
4	*Arundinella nepalensis*	33	8333	16
5	*Bidens bipinnata*	17	3333	7
6	*Cirsium wallichii*	25	10000	15
7	*Cyperus cuspidatus*	33	14167	21
8	*Eragrostis nigra*	17	8333	11
9	*Geranium nepalense*	25	15000	19
10	*Oplismenus burmannii*	25	4167	10
11	*Plantago erosa*	25	4167	10
12	*Rumex nepalensis*	25	6667	12
13	*Trifolium pratense*	33	8333	16
14	*Urena lobata*	33	5833	14
15	*Xanthium indicum*	17	7500	11
			116667	

Site V16: Proposed Reservoir of Parbati-II HEP- Parbati River

Table 6.46: Community structure – Site V16 (Tree)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	TBC (m^2ha^{-1})	IVI
1	*Cedrus deodara*	40	40	0.51	37
2	*Ilex dipyrena*	30	30	0.03	27
3	*Juglans regia*	10	10	1.99	12
4	*Picea smithiana*	10	10	60.18	96
5	*Pinus wallichiana*	30	70	0.50	43
6	*Populus ciliata*	10	20	0.49	14
7	*Salix acutifolia*	20	30	0.84	23
8	*Salix wallichiana*	20	20	3.56	23
9	*Ulmus wallichiana*	20	30	1.33	24
			260		

Table 6.47: Community structure – Site V16 (Shrubs)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	IVI
1	*Boehmeria penduliflora*	20	220	18
2	*Brassiopsis mitis*	20	280	46
3	*Chromolaena odoratum*	20	480	45
4	*Debregeasia longifolia*	10	280	17
5	*Elatostema aquifolium*	10	240	24
6	*Leea asiatica*	20	160	30
7	*Maesa chisia*	30	240	32
8	*Melocalamus compactiflorus*	20	240	18
9	*Sinarundinaria falcata*	20	520	27
10	*Solanum surattense*	30	600	43
	Total		**3260**	

Table 6.48: Community structure – Site V16 (Herbs)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	IVI
	Pre-Monsoon			
1	*Adiantum lunulatum*	42	6500	13
2	*Artemisia nilagirica*	42	7000	13
3	*Arthraxon lancifolius*	42	8167	15
4	*Bidens bipinnata*	25	5667	10
5	*Capillipedium assimile*	17	4667	7
6	*Conyza japonica*	50	4917	13
7	*Cyperus rotundus*	25	4000	8
8	*Desmodium caudatum*	33	7000	12
9	*Digitaria cruciata*	25	3833	8
10	*Equisetum ramossimum*	33	8083	13
11	*Eragrostis nigra*	17	4667	7
12	*Hydrocotyle nepalensis*	25	3583	7
13	*Melilotus indica*	25	3417	7
14	*Oplismenus compositus*	17	4750	7
15	*Persicaria capitata*	17	4667	7
16	*Sida rhombifolia*	67	7250	18
17	*Urena lobata*	67	5667	16
18	*Valeriana hardwickii*	33	3833	9
19	*Xanthium indicum*	25	4833	9
		625	**102500**	**200**
	Monsoon			
1	*Adiantum lunulatum*	25	5833	7
2	*Artemisia nilagirica*	42	7500	11
3	*Arthraxon lancifolius*	42	5000	9
4	*Bidens bipinnata*	25	7500	8
5	*Capillipedium assimile*	17	10000	9
6	*Conyza japonica*	50	5000	11
7	*Cyperus rotundus*	25	5833	7
8	*Desmodium caudatum*	33	9167	11
9	*Digitaria cruciata*	25	11667	11
10	*Equisetum ramossimum*	33	4167	8
11	*Eragrostis nigra*	17	9167	8
12	*Hydrocotyle nepalensis*	25	8333	9
13	*Melilotus indica*	25	9167	10
14	*Oplismenus compositus*	17	8333	8
15	*Persicaria capitata*	17	6667	7
16	*Prinsepia utilis*	67	10000	16
17	*Sida rhombifolia*	67	7500	15
18	*Trifolium pratense*	33	8333	10

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	IVI
19	*Tagetes erecta*	25	7500	8
20	*Valeriana hardwickii*	26	6667	8
21	*Xanthium indicum*	27	5833	8
		661	159167	200
	Winter			
1	*Artemisia nilagirica*	17	5833	11
2	*Arthraxon lancifolius*	25	9167	17
3	*Bidens bipinnata*	17	5833	11
4	*Capillipedium assimile*	17	4167	9
5	*Cyperus rotundus*	25	9167	17
6	*Desmodium caudatum*	17	5000	10
7	*Equisetum ramossimum*	33	7500	18
8	*Eragrostis nigra*	17	4167	9
9	*Melilotus indica*	25	6667	14
10	*Persicaria capitata*	17	10000	15
11	*Prinsepia utilis*	33	7500	18
12	*Sida rhombifolia*	17	5833	11
13	*Tagetes erecta*	17	6667	12
14	*Valeriana hardwickii*	25	9167	17
15	*Xanthium indicum*	17	7500	12
		317	104167	200

Site V17: Near Parbati-II HEP Dam Site- Parbati River

Table 6.49: Community structure - Site V17 (Tree)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	TBC (m^2ha^{-1})	IVI
1	*Bauhinia variegata*	20	20	1.37	17
2	*Populus ciliata*	20	20	3.05	19
3	*Prunus americana*	20	20	5.05	21
4	*Juglans regia*	20	30	50.0	71
5	*Salix tetrasperma*	20	30	1.08	20
6	*Toona ciliata*	40	70	13.67	55
7	*Celtis australis*	40	70	2.89	44
8	*Pinus wallichiana*	20	80	17.92	52
			340		

Table 6.50: Community structure - Site V17 (Shrubs)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	IVI
1	*Arenga saccharifera*	10	240	24
2	*Boehmeria penduliflora*	10	220	14
3	*Boehmeria macrophylla*	10	180	29
4	*Hydrangea robusta*	10	520	38
5	*Luculia pinceana*	10	240	16
6	*Melocalamus compactiflorus*	50	280	62
7	*Oxyspora paniculata*	30	240	35
8	*Strobilanthes extensa*	60	280	43
9	*Trevesia palmata*	10	580	41
	Total		**2780**	

Table 6.51: Community structure - Site V17 (Herbs)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	IVI
	Pre-Monsoon			
1	*Artemisia nilagirica*	42	9333	11
2	*Athyrium angustum*	75	15250	18
3	*Bidens bipinnata*	25	6167	7

4	*Capillipedium assimile*	25	6583	7
5	*Carex filicina*	25	4667	6
6	*Cyperus rotundus*	67	2917	10
7	*Desmodium caudatum*	33	8000	9
8	*Desmodium gangeticum*	25	6917	7
9	*Digitaria cruciata*	25	6250	7
10	*Equisetum ramossimum*	83	20500	22
11	*Melilotus indica*	58	6500	11
12	*Miscanthus nudipes*	58	8167	12
13	*Nepeta ciliaris*	67	24000	22
14	*Persicaria capitata*	25	7250	7
15	*Selaginella indica*	50	9667	12
16	*Urena lobata*	42	12167	12
17	*Valeriana hardwickii*	25	4000	5
18	*Xanthium indicum*	50	14000	14
			172333	200
	Monsoon			
1	*Artemisia nilagirica*	25	6667	10
2	*Achyranthes asper*	33	10000	14
3	*Athyrium angustum*	17	7500	8
4	*Bidens bipinnata*	17	6667	8
5	*Capillipedium assimile*	50	12500	19
6	*Carex filicina*	25	6667	10
7	*Cyperus rotundus*	17	5833	7
8	*Desmodium gangeticum*	17	12500	12
9	*Digitaria cruciata*	8	7500	7
10	*Hydrocotyle nepalensis*	17	5833	7
11	*Inula cappa*	25	10000	12
12	*Melilotus indica*	8	5000	5
13	*Miscanthus nudipes*	33	10000	14
14	*Nepeta ciliaris*	17	5000	7
15	*Persicaria capitata*	33	7500	12
16	*Pilea scripta*	17	5833	7
17	*Tagetes erecta*	17	8333	9
18	*Urena lobata*	8	6667	6
19	*Valeriana hardwickii*	25	15000	15
20	*Xanthium indicum*	25	7500	10
			162500	
	Winter			
1	*Artemisia nilagirica*	25	6667	13
2	*Athyrium angustum*	33	10000	18
3	*Bidens bipinnata*	17	7500	11
4	*Capillipedium assimile*	17	6667	10
5	*Carex filicina*	50	12500	25
6	*Desmodium gangeticum*	25	6667	13
7	*Digitaria cruciata*	17	5833	10
8	*Inula cappa*	17	12500	15
9	*Melilotus indica*	8	7500	9
10	*Miscanthus nudipes*	17	5833	10
11	*Nepeta ciliaris*	25	10000	16
12	*Pilea scripta*	8	5000	7
13	*Tagetes erecta*	33	10000	18
14	*Urena lobata*	17	5000	9
15	*Xanthium indicum*	33	7500	16
			119167	

Site V 18: Parbati-II HEP near Adit I, downstream of Dam site- Parbati river

Table 6.52: Community structure -Site V18 (Trees)

S.No.	Name of Species	Frequency	Density	TBC	IVI

		(%)	(ind./ha^{-1})	(m^{2}ha^{-1})	
1	*Betula alnoides*	10	20	2.16	12
2	*Cedrela toona*	40	40	27.38	57
3	*Celtis australis*	20	30	15.68	34
4	*Juglans regia*	10	10	0.72	8
5	*Morus australis*	10	10	2.00	9
6	*Pinus wallichiana*	60	110	33.62	92
7	*Populus ciliata*	10	10	1.62	9
8	*Pyrus communis*	10	10	2.88	10
9	*Quercus leucotrichophora*	40	90	0.82	43
10	*Rhus succedanea*	30	30	5.78	27
			360		

Table 6.53: Community structure -Site V18 (Shrubs)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	IVI
1	*Boehmeria macrophylla*	20	200	16
2	*Debregeasia longifolia*	10	280	53
3	*Elatostema lineolatum*	40	840	45
4	*Maesa chisia*	30	520	54
5	*Melastoma malabathricum*	10	240	18
6	*Melocalamus compactiflorus*	10	240	20
7	*Oxyspora paniculata*	80	1280	73
8	*Rubus burkillii*	20	160	22
	Total		3760	

Table 6.54: Community structure -Site V18 (Herbs)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	IVI
	Pre-Monsoon			
1	*Artemisia nilagirica*	25	8083	8
2	*Athyrium angustum*	33	7250	9
3	*Carex filicina*	25	8167	8
4	*Commelina benghalensis*	33	7667	9
5	*Commelina paludosa*	67	7250	13
6	*Crassocephalum crepidioides*	17	8167	7
7	*Dicentra scandens*	75	3667	12
8	*Elatostema platyphyllum*	17	8167	7
9	*Equisetum ramossimum*	67	9333	14
10	*Gerardinia diversifolia*	50	6917	11
11	*Lecanthus peduncularis*	17	10750	9
12	*Molineria capitulata*	25	9750	9
13	*Oplismenus compositus*	25	15333	12
14	*Persicaria chinensis*	67	9667	14
15	*Pilea umbrosa*	17	4667	5
16	*Pollia subumbellata*	25	3583	5
17	*Pteris wallichiana*	25	4500	6
18	*Setaria palmifolia*	75	20083	22
19	*Solanum nigrum*	67	12167	16
20	*Urtica parviflora*	25	3417	5
			168583	
	Monsoon			
1	*Artemisia nilagirica*	17	5833	7
2	*Athyrium angustum*	17	10000	9
3	*Carex filicina*	33	7500	11
4	*Commelina benghalensis*	42	4167	11
5	*Crassocephalum crepidioides*	8	4167	4
6	*Dicentra scandens*	17	5833	7

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	IVI
7	*Elatostema platyphyllum*	25	7500	9
8	*Fimbristylis dichotoma*	33	9167	12
9	*Gerardinia diversifolia*	25	7500	9
10	*Hydrocotyle nepalensis*	17	5833	7
11	*Kyllinga brevifolia*	25	10000	11
12	*Lecanthus peduncularis*	33	8333	12
13	*Molineria capitulata*	25	6667	9
14	*Nepeta ciliaris*	25	5833	8
15	*Oplismenus compositus*	25	9167	10
16	*Pilea umbrosa*	17	7500	8
17	*Pimpinella diversifolia*	25	10000	11
18	*Pteris wallichiana*	25	6667	9
19	*Senecio scandens*	33	10833	13
20	*Setaria palmifolia*	17	5000	6
21	*Solanum nigrum*	17	4167	6
22	*Urtica parviflora*	25	9167	10
			160833	
	Winter			
1	*Artemisia nilagirica*	25	10000	14
2	*Athyrium angustum*	8	5000	6
3	*Bidens bipinnata*	33	10000	16
4	*Commelina benghalensis*	17	5000	8
5	*Dicentra scandens*	17	7500	10
6	*Digitaria ciliaris*	17	6667	9
7	*Elatostema platyphyllum*	50	10000	20
8	*Kyllinga brevifolia*	25	6667	11
9	*Lecanthus peduncularis*	25	7500	12
10	*Molineria capitulata*	17	5833	9
11	*Nepeta ciliaris*	25	10000	14
12	*Oplismenus compositus*	33	8333	15
13	*Pilea umbrosa*	25	6667	11
14	*Pimpinella diversifolia*	25	5833	11
15	*Pteris wallichiana*	25	9167	13
16	*Setaria palmifolia*	17	7500	10
17	*Solanum nigrum*	25	6667	11
			128333	

Site V19: Balargha HEP: Near Barrage site

Table 6.55: Community structure -Site V19 (Trees)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	TBC (m^2ha^{-1})	IVI
1	*Aesculus indica*	10	20	8.88	21
2	*Alnus nepalensis*	20	30	6.02	26
3	*Betula alnoides*	60	110	2.16	64
4	*Cedrela toona*	10	10	27.38	40
5	*Celtis australis*	10	10	15.68	26
6	*Juglans regia*	30	30	21.78	49
7	*Neolitsea chinense*	10	10	1.28	9
8	*Phoebe lanceolata*	20	20	0.98	17
9	*Pinus roxburghii*	40	90	1.62	48
			330		

Table 6.56: Community structure -Site V19 (Shrubs)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	IVI
1	*Aconogonum molle*	10	220	21
2	*Boehmeria macrophylla*	10	580	37

3	*Debregeasia longifolia*	60	280	45
4	*Leucosceptrum canum*	40	1040	90
5	*Maesa chisia*	30	520	52
6	*Melocalamus compactiflorus*	10	280	37
7	*Rubus burkillii*	10	240	17
	Total		3160	

Table 6.57: Community structure -Site V190 (Herbs)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	IVI
	Pre-Monsoon			
1	*Arenaria nilghiriensis*	27	5533	6
2	*Artemisia nilagirica*	53	19067	17
3	*Arthraxon hispidus*	13	3600	4
4	*Athyrium angustum*	73	18533	19
5	*Bidens bipinnata*	20	6467	6
6	*Carex filicina*	40	12267	12
7	*Commelina benghalensis*	33	8600	9
8	*Desmodium caudatum*	13	3867	4
9	*Digitaria ciliaris*	20	7800	7
10	*Hedychium spicatum*	60	19867	18
11	*Hydrocotyle nepalensis*	27	12267	10
12	*Impatiens chinensis*	40	18933	15
13	*Kyllinga brevifolia*	20	3400	4
14	*Melilotus indica*	27	2933	5
15	*Nepeta ciliaris*	60	16533	16
16	*Persicaria capitata*	20	3067	4
17	*Pilea umbrosa*	13	3733	4
18	*Pimpinella diversifolia*	47	8467	11
19	*Setaria glauca*	53	9467	12
20	*Thysanolaena latifolia*	27	4200	6
21	*Urena lobata*	47	12533	13
			201133	
	Monsoon			
1	*Artemisia nilagirica*	33	9167	9
2	*Arthraxon hispidus*	53	7500	11
3	*Athyrium angustum*	13	12500	8
4	*Bidens bipinnata*	73	6667	14
5	*Carex filicina*	20	11667	9
6	*Commelina benghalensis*	40	9167	10
7	*Desmodium caudatum*	33	12500	11
8	*Digitaria ciliaris*	13	9167	6
9	*Hedychium spicatum*	20	15833	11
10	*Hydrocotyle nepalensis*	60	8333	13
11	*Kyllinga brevifolia*	27	10833	9
12	*Melilotus indica*	40	6667	9
13	*Persicaria capitata*	20	10000	8
14	*Pilea umbrosa*	27	8333	8
15	*Pimpinella diversifolia*	60	7500	12
16	*Setaria glauca*	20	10833	8
17	*Thysanolaena latifolia*	13	12500	8
18	*Urena lobata*	47	10833	12
19	*Solanum nigrum*	53	7500	11
20	*Urtica parviflora*	27	13333	10
			200833	
	Winter			
1	*Artemisia nilagirica*	17	5000	7
2	*Arthraxon hispidus*	53	9167	17
3	*Athyrium angustum*	13	10833	11

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	IVI
4	*Bidens bipinnata*	73	9167	21
5	*Commelina benghalensis*	20	7500	9
6	*Desmodium caudatum*	40	6667	13
7	*Digitaria ciliaris*	33	10000	14
8	*Kyllinga brevifolia*	13	5833	7
9	*Melilotus indica*	20	11667	13
10	*Persicaria capitata*	60	7500	17
11	*Pilea umbrosa*	27	10833	13
12	*Setaria glauca*	40	6667	13
13	*Solanum nigrum*	20	5833	8
14	*Thysanolaena latifolia*	27	10833	13
15	*Urena lobata*	60	5833	16
16	*Xanthium indicum*	20	8333	10
			131667	

Site V20: Parbati HEP- Proposed Project area of Parbati HEP

Table 6.58: Community structure -Site V20 (Trees)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	TBC (m^2ha^{-1})	IVI
1	*Alnus nepalensis*	30	50	13.52	61
2	*Cedrela toona*	30	30	3.38	39
3	*Celtis australis*	10	30	15.68	41
4	*Ficus hispida*	10	20	2.03	19
5	*Juglans regia*	10	10	2.16	14
6	*Pinus roxburghii*	40	60	6.48	64
7	*Populus ciliata*	10	20	35.28	61
			220		

Table 6.59: Community structure –Site V20 (Shrubs)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	IVI
1	*Ardisia khasiana*	10	80	16
2	*Arenga saccharifera*	10	120	29
3	*Boehmeria macrophylla*	20	320	24
4	*Debregeasia longifolia*	20	120	13
5	*Hydrangea robusta*	30	160	22
6	*Leea asiatica*	10	40	6
7	*Luculia pinceana*	20	80	28
8	*Maesa chisia*	30	240	26
9	*Melocalamus compactiflorus*	40	1040	71
10	*Rubus burkillii*	20	160	15
11	*Rubus ellipticus*	40	360	27
12	*Strobilanthes extensa*	20	360	24
	Total		**3080**	

Table 6.60: Community structure -Site V20 (Herbs)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	IVI
	Pre Monsoon			
1	*Achyranthes aspera*	33	9167	10
2	*Artemisia nilagirica*	75	9333	15
3	*Arthraxon lancifolius*	33	3667	6
4	*Capillipedium assimile*	42	6833	10
5	*Carex longipes*	33	5333	8
6	*Drymaria diandra*	17	3000	4
7	*Elsholtzia strobilifera*	25	6000	7

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	IVI
8	*Fimbristylis dichotoma*	33	7250	9
9	*Girardinia diversifolia*	75	9833	16
10	*Hydrocotyle nepalensis*	67	14833	18
11	*Imperata cylindrica*	25	4833	6
12	*Isachne albens*	42	5167	8
13	*Lecanthus peduncularis*	42	6333	9
14	*Mimosa pudica*	50	3250	8
15	*Molineria capitulata*	75	12167	17
16	*Oplismenus compositus*	33	9333	10
17	*Persicaria capitata*	33	10250	11
18	*Senecio scandens*	25	5250	7
19	*Setaria glauca*	25	3667	5
20	*Urena lobata*	67	10333	15
			145833	
	Monsoon			
1	*Achyranthes aspera*	25	7500	10
2	*Artemisia nilagirica*	25	9167	11
3	*Arthraxon lancifolius*	8	4167	4
4	*Capillipedium assimile*	17	14167	12
5	*Carex filicina*	25	6667	10
6	*Desmodium caudatum*	17	5000	7
7	*Drymaria diandra*	8	5833	5
8	*Elsholtzia strobilifera*	17	6667	8
9	*Hydrocotyle nepalensis*	8	10833	8
10	*Isachne albens*	25	8333	11
11	*Kyllinga brevifolia*	25	9167	11
12	*Lecanthus peduncularis*	25	7500	10
13	*Molineria capitulata*	25	9167	11
14	*Oplismenus compositus*	25	5833	9
15	*Persicaria capitata*	33	9167	13
16	*Pilea umbrosa*	33	8333	12
17	*Senecio scandens*	25	10000	12
18	*Setaria glauca*	33	8333	12
19	*Thysanolaena latifolia*	17	6667	8
20	*Urena lobata*	25	5833	9
21	*Urtica parviflora*	17	5000	7
			163333	
	Winter			
1	*Artemisia nilagirica*	8	5000	6
2	*Arthraxon lancifolius*	33	10000	16
3	*Capillipedium assimile*	17	5000	8
4	*Desmodium caudatum*	17	7500	10
5	*Drymaria diandra*	17	6667	9
6	*Elsholtzia strobilifera*	50	10000	20
7	*Fimbristylis dichotoma*	25	9167	13
8	*Isachne albens*	33	8333	15
9	*Kyllinga brevifolia*	25	6667	11
10	*Lecanthus peduncularis*	25	5833	11
11	*Molineria capitulata*	25	9167	13
12	*Nepeta ciliaris*	17	7500	10
13	*Persicaria capitata*	25	6667	11
14	*Pilea umbrosa*	25	5833	11
15	*Setaria glauca*	33	9167	15
16	*Thysanolaena latifolia*	33	8333	15
17	*Urena lobata*	8	4167	5
			125000	

Table 6.61: Community structure -Site V21 (Trees)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	TBC (m^2ha^{-1})	IVI
1	*Pinus wallichiana*	70	200	6.4	111
2	*Alnus nepalensis*	50	90	1.96	53
3	*Rhododendron arboreum*	30	40	0.48	25
4	*Cedrus deodara*	40	70	3.66	54
5	*Celtis australis*	20	30	3.05	33
6	*Litsea umbrosa*	20	30	1.77	25
			460		

Table 6.62: Community structure -Site V21 (Shrubs)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	IVI
1	*Boehmeria platyphylla*	50	320	56
2	*Debregeasia longifolia*	50	280	50
3	*Berberis lycium*	40	280	43
4	*Girardinia diversifolia*	30	200	26
5	*Rabdosia rugosa*	30	240	38
6	*Rubus ellipticus*	30	160	26
7	*Zanthoxylum armatum*	20	80	25
8	*Ricinus communis*	10	80	15
9	*Arundinaria falconeri*	20	120	23
			1760	

Table 6.63: Community structure -Site V21 (Herbs)

S.No.	Name of Species	F(%)	D ha-1	IVI
	Pre Monsoon			
1	*Artemisia vulgaris*	55	9000	23
2	*Rumex hastatus*	45	8000	20
3	*Chrysopogon fulvus*	50	7500	20
4	*Anaphalis contorta*	40	6500	17
5	*Strobilanthes alatus*	30	5000	13
6	*Lindenbergia grandiflora*	35	5500	15
7	*Pteridium aquilinum*	30	4000	12
8	*Urtica dioica*	35	4500	13
9	*Oxalis corniculata*	30	4000	12
10	*Thalictrum elegans*	25	3500	10
11	*Achyranthes bidentata*	25	4000	10
12	*Centella asiatica*	20	3000	8
13	*Tagetes minuta*	25	4000	10
14	*Plantago major*	20	3000	8
15	*Apluda mutica*	20	3500	9
	Total		**75000**	
	Monsoon			
1	*Achyranthes bidentata*	13	2667	6
2	*Anaphalis contorta*	20	2667	8
3	*Apluda mutica*	27	3333	11
4	*Artemisia vulgaris*	13	4000	8
5	*Aster peduncularis*	20	4000	10
6	*Bidens pilosa*	13	4000	8
7	*Centella asiatica*	20	3333	9
8	*Chrysopogon fulvus*	20	4000	10
9	*Fragaria nubicola*	13	4667	9
10	*Gnaphalium affine*	13	2667	6
11	*Impatiens brachycentra*	13	4667	9

S.No.	Name of Species	F(%)	D ha-1	IVI
12	*Plantago major*	33	6000	15
13	*Polygonum glabrum*	20	4667	10
14	*Pteridium aquilinum*	27	5333	13
15	*Rumex hastatus*	20	3333	9
16	*Strobilanthes alatus*	27	6667	14
17	*Thalictrum elegans*	13	5333	9
18	*Trifolium repens*	20	8000	14
19	*Urtica dioica*	20	6000	12
20	*Verbascum thapsus*	13	4000	8
	Total		**89333**	
	Winter			
1	*Achyranthes bidentata*	17	4800	12
2	*Artemisia vulgaris*	25	2400	11
3	*Aster peduncularis*	33	2700	14
4	*Bidens pilosa*	25	4000	13
5	*Eriophorum comosum*	17	4800	12
6	*Fragaria nubicola*	25	4400	14
7	*Gnaphalium affine*	17	4200	11
8	*Impatiens brachycentra*	25	4400	14
9	*Lindenbergia grandiflora*	17	4800	12
10	*Plantago major*	8	7200	13
11	*Pteridium aquilinum*	17	5400	13
12	*Rumex hastatus*	33	3600	15
13	*Strobilanthes alatus*	25	3200	12
14	*Tagetes minuta*	17	3000	9
15	*Thalictrum elegans*	33	3300	14
16	*Trifolium repens*	17	4800	12
	Total		**67000**	

Site V22: Sarbari II HEP: Near Power House Site

Table 6.64: Community structure -Site V22 (Trees)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	TBC (m^2ha^{-1})	IVI
1	*Celtis australis*	80	220	12.1	145
2	*Alnus nepalensis*	50	80	3.28	58
3	*Aesculus indica*	40	60	3.54	49
4	*Pinus wallichiana*	30	40	5.52	48
			400		

Table 6.65: Community structure -Site V22 (Shrubs)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	IVI
1	*Berberis lycium*	70	640	104
2	*Berberis aristata*	50	320	48
3	*Boehmeria platyphylla*	40	280	47
4	*Rubus ellipticus*	40	240	32
5	*Viburnum grandiflorum*	30	200	28
6	*Debregeasia longifolia*	30	120	19
7	*Desmodium elegans*	30	160	23
			1960	

Table 6.66: Community structure -Site V22 (Herbs)

S.No.	Name of Species	F(%)	D ha-1	IVI
	Pre Monsoon			
1	*Rumex hastatus*	60	10500	32
2	*Anaphalis contorta*	45	8000	24

S.No.	Name of Species	F(%)	D ha-1	IVI
3	*Lindenbergia grandiflora*	45	9000	26
4	*Eriophorum comosum*	35	6000	18
5	*Pteridium aquilinum*	30	5000	16
6	*Chrysopogon fulvus*	30	6000	17
7	*Artemisia vulgaris*	30	4500	15
8	*Strobilanthes alatus*	25	4000	13
9	*Urtica dioica*	20	3500	11
10	*Oxalis corniculata*	20	3000	10
11	*Thalictrum elegans*	15	3000	9
12	*Trifolium pratens*	10	1000	4
13	*Plantago major*	15	2000	7
	Total		**65500**	
	Monsoon			
1	*Anaphalis contorta*	13	2667	7
2	*Anemone obtusifolia*	27	2667	10
3	*Artemisia vulgaris*	13	3333	7
4	*Bergenia ciliata*	13	4000	8
5	*Bistorta amplexicaulis*	20	5333	11
6	*Centella asiatica*	13	4667	9
7	*Chrysopogon fulvus*	13	3333	7
8	*Cirsium arvense*	27	5333	13
9	*Eriophorum comosum*	20	4000	10
10	*Fagopyrum dibotrys*	27	6000	14
11	*Fragaria nubicola*	27	4667	12
12	*Gnaphalium affine*	20	5333	11
13	*Impatiens brachycentra*	13	6000	10
14	*Nepeta laevigata*	13	4667	9
15	*Plantago major*	27	4667	12
16	*Polygonum glabrum*	27	5333	13
17	*Pteridium aquilinum*	13	4667	9
18	*Rumex hastatus*	13	4000	8
19	*Thalictrum elegans*	13	3333	7
20	*Urtica dioica*	20	4000	10
	Total		**88000**	
	Winter			
1	*Anaphalis contorta*	8	2500	7
2	*Anemone obtusifolia*	17	3333	12
3	*Artemisia vulgaris*	17	4167	13
4	*Bergenia ciliata*	8	2500	7
5	*Bistorta amplexicaulis*	25	6667	21
6	*Chrysopogon fulvus*	8	4167	10
7	*Eriophorum comosum*	25	5833	19
8	*Gnaphalium affine*	17	6667	17
9	*Nepeta laevigata*	25	5833	19
10	*Plantago major*	25	6667	21
11	*Pteridium aquilinum*	17	4167	13
12	*Rumex hastatus*	17	5833	16
13	*Thalictrum elegans*	33	5833	23
	Total		**64167**	

Site V23: Fozal HEP: Near Diversion Site

Table 6.67: Community structure -Site V23 (Trees)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	TBC (m^{2}ha^{-1})	IVI
1	*Asculus indica*	50	60	3.14	47
2	*Melia azedarach*	40	50	0.68	26

3	*Toona ciliata*	30	30	1.06	22
4	*Bauhinia variegata*	60	120	0.93	46
5	*Prunus domestica*	20	20	0.32	12
6	*Pinus roxburghii*	40	40	2.66	37
7	*Juglans regia*	50	80	3.68	55
8	*Pinus roxburghii*	60	130	2.04	56
			530		

Table 6.68: Community structure -Site V23 (Shrubs)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	IVI
1	*Desmodium elegans*	30	480	48
2	*Sarcococca saligna*	50	840	88
3	*Rhus parviflora*	10	40	7
4	*Rubus foliolosus*	10	120	23
5	*Viburnum grandiflorum*	30	160	30
6	*Rubus ellipticus*	20	240	44
7	*Indigofera tinctoria*	20	120	19
8	*Prinsepia utilis*	10	80	18
9	*Indigofera tinctoria*	10	40	24
			2120	

Table 6.69: Community structure -Site V23 (Herbs)

S.No.	Name of Species	F(%)	D ha-1	IVI
	Pre Monsoon			
1	*Fragaria vesca*	40	2760	12
2	*Trifolium pratense*	50	5910	20
3	*Stellaria media*	60	6940	23
4	*Plantago major*	30	3600	12
5	*Anaphalis busua*	40	3980	14
6	*Bidens pilosa*	40	4770	16
7	*Rumex hastatus*	50	5090	18
8	*Strobilanthes alatus*	50	5430	19
9	*Pteridium aquilinum*	40	3580	14
10	*Oxalis corniculata*	50	4760	18
11	*Arundinella nepalensis*	40	4540	15
12	*Arisaema jacquemontii*	50	5770	19
	Total		**57130**	
	Monsoon			
1	*Achyranthes bidentata*	20	4000	9
2	*Ajuga parviflora*	13	2667	6
3	*Anaphalis contorta*	20	5333	10
4	*Arisaema concinnum*	27	4667	11
5	*Artemisia vulgaris*	33	6000	14
6	*Aster peduncularis*	27	6000	13
7	*Bidens pilosa*	20	4667	10
8	*Bistorta amplexicaulis*	20	6000	11
9	*Chenopodium album*	13	4667	8
10	*Chrysopogon fulvus*	27	6000	13
11	*Fragaria nubicola*	27	8667	15
12	*Impatiens brachycentra*	20	4000	9
13	*Nepeta laevigata*	40	8000	18
14	*Plantago major*	27	6000	13
15	*Pteridium aquilinum*	20	6667	12
16	*Rumex hastatus*	13	3333	7
17	*Thalictrum elegans*	33	4667	13
18	*Trifolium repens*	13	6000	9
	Total		**97333**	
	Winter			
1	*Anaphalis busua*	33	5000	17
2	*Anemone obtusifolia*	33	5833	18

S.No.	Name of Species	F(%)	D ha-1	IVI
3	*Artemisia capillaris*	33	6667	19
4	*Arundinella nepalensis*	33	5833	18
5	*Aster peduncularis*	17	4167	11
6	*Bidens pilosa*	33	6667	19
7	*Nepeta laevigata*	42	9167	25
8	*Pteridium aquilinum*	25	7500	18
9	*Rumex hastatus*	42	5000	19
10	*Themeda triandra*	33	5833	18
11	*Trifolium pratense*	25	7500	18
	Total		**69167**	

Site V24: Sharni HEP: Proposed project area near Sharni Village

Table 6.70: Community structure -Site V24 (Trees)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	TBC (m^{2}ha^{-1})	IVI
1	*Pinus wallichiana*	60	140	7.56	92
2	*Alnus nepalensis*	50	80	2.88	52
3	*Cedrus deodara*	40	60	2.88	44
4	*Albizia lebbeck*	30	50	2.2	34
5	*Melia azedarach*	30	50	2.1	34
6	*Toona ciliata*	30	60	3.96	44
		240	**440**	**21.58**	**300**

Table 6.71: Community structure -Site V24 (Shrubs)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	IVI
1	*Berberis aristata*	60	560	97
2	*Colebrookea oppositifolia*	50	360	59
3	*Rabdosia rugosa*	40	280	43
4	*Rosa brunei*	50	320	48
5	*Boehmeria platyphylla*	30	200	35
6	*Rubus ellipticus*	20	120	18
		250	**1840**	**300**

Table 6.72: Community structure -Site V24 (Herbs)

S.No.	Name of Species	Frequency (%)	Density (ind./ha-1)	IVI
	Pre Monsoon			
1	*Rumex hastatus*	70	11500	31
2	*Anaphalis contorta*	50	8500	22
3	*Chrysopogon fulvus*	40	8000	20
4	*Lindenbergia grandiflora*	40	7000	18
5	*Artemisia vulgaris*	35	5500	15
6	*Tagetes minuta*	25	4000	11
7	*Strobilanthes alatus*	30	4500	13
8	*Urtica dioica*	30	4000	12
9	*Oxalis corniculata*	25	4500	12
10	*Eriophorum comosum*	15	2500	7
11	*Achyranthes bidentata*	25	4000	11
12	*Polygonum nepalensis*	20	4000	10
13	*Apluda mutica*	15	3500	8
14	*Pteridium aquilinum*	10	2000	5
15	*Thalictrum elegans*	15	2500	7
		445	**76000**	
	Monsoon			
1	*Agrostis munroan*	20	3333	9
2	*Anaphalis contorta*	13	4000	8

S.No.	Name of Species	Frequency (%)	Density (ind./ha-1)	IVI
3	*Apluda mutica*	20	4667	10
4	*Aster peduncularis*	20	4000	10
5	*Bergenia ciliata*	20	5333	11
6	*Bistorta amplexicaulis*	27	6000	13
7	*Chrysopogon fulvus*	27	6667	14
8	*Cirsium arvense*	27	8000	16
9	*Gnaphalium affine*	20	6000	12
10	*Impatiens brachycentra*	27	7333	15
11	*Lindenbergia grandiflora*	13	6000	10
12	*Nepeta laevigata*	20	6667	12
13	*Pteridium aquilinum*	13	8000	12
14	*Rumex hastatus*	13	6667	10
15	*Tagetes minuta*	20	7333	13
16	*Thalictrum elegans*	27	4667	12
17	*Urtica dioica*	33	4000	13
	Total		**98667**	
	Winter			
1	*Agrostis munroan*	25	3333	15
2	*Anaphalis contorta*	8	4167	10
3	*Bergenia ciliata*	25	5000	18
4	*Bistorta amplexicaulis*	25	4167	17
5	*Cirsium arvense*	25	5833	19
6	*Gnaphalium affine*	33	8333	27
7	*Lindenbergia grandiflora*	25	5000	18
8	*Nepeta laevigata*	17	4167	13
9	*Pteridium aquilinum*	25	6667	21
10	*Rumex hastatus*	17	3333	12
11	*Tagetes minuta*	17	6667	17
12	*Thalictrum elegans*	17	4167	13
			60833	

Site V25: Sarsadi HEP: Proposed project area near Sarsadi Village

Table 6.73: Community structure –Site V25 (Trees)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	Basal Cover (m^{2}ha^{-1})	IVI
1	*Pinus wallichiana*	60	180	3.52	87
2	*Cedrus deodara*	50	80	6.72	79
3	*Alnus nepalensis*	40	70	1.43	41
4	*Aesculus indica*	30	50	2.8	41
5	*Bauhinia variegata*	20	30	0.35	17
6	*Pinus roxburghii*	30	40	2.2	35
			450		

Table 6.74: Community structure –Site V25 (Shrubs)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	TBC (m^{2}ha^{-1})	IVI
1	*Sarcococca saligna*	70	560	2.16	85
2	*Zanthoxylum armatum*	50	320	0.37	36
3	*Rabdosia rugosa*	40	280	0.72	38
4	*Berberis aristata*	40	240	0.49	32
5	*Rubus ellipticus*	30	200	0.31	24
6	*Boehmeria platyphylla*	40	240	1.01	41
7	*Viburnum grandiflorum*	30	120	0.31	20
8	*Girardinia diversifolia*	20	120	0.08	13
9	*Prinsepia utilis*	20	80	0.18	13
			2160		

Table 6.75: Community structure -Site V25 (Herbs)

S.No.	Name of Species	Frequency (%)	Density (ind./ha-1)	IVI
	Pre Monsoon			
1	*Tagetes minuta*	60	13000	38
2	*Anaphalis contorta*	50	8000	27
3	*Rumex hastatus*	45	7000	24
4	*Chrysopogon fulvus*	35	5500	19
5	*Strobilanthes alatus*	35	5000	18
6	*Artemisia vulgaris*	30	4000	15
7	*Lindenbergia grandiflora*	30	5000	17
8	*Pteridium aquilinum*	20	2000	9
9	*Urtica dioica*	15	2500	8
10	*Bidens pilosa*	20	3000	11
11	*Polygonum nepalensis*	15	2500	8
12	*Apluda mutica*	10	1500	5
			59000	
	Monsoon			
1	*Ajuga parviflora*	27	4000	11
2	*Anaphalis contorta*	13	5333	9
3	*Apluda mutica*	33	6000	14
4	*Artemisia vulgaris*	27	4667	11
5	*Aster peduncularis*	20	5333	10
6	*Bergenia ciliata*	13	4667	8
7	*Bidens pilosa*	27	8000	15
8	*Bistorta amplexicaulis*	20	5333	10
9	*Chrysopogon fulvus*	13	6667	10
10	*Cyperus rotundus*	27	6000	13
11	*Heteropogon contortus*	20	4667	10
12	*Poa annua*	20	7333	12
13	*Polygonum nepalensis*	20	4000	9
14	*Pteridium aquilinum*	20	8000	13
15	*Rumex hastatus*	27	4667	11
16	*Tagetes minuta*	33	6000	14
17	*Thalictrum elegans*	27	4000	11
18	*Urtica dioica*	20	4667	10
	Total		**99333**	
	Winter			
1	*Ajuga parviflora*	33	2700	15
2	*Anaphalis contorta*	17	4800	14
3	*Artemisia vulgaris*	17	3000	11
4	*Aster peduncularis*	8	3600	9
5	*Bergenia ciliata*	25	3200	14
6	*Bidens pilosa*	8	8400	17
7	*Bistorta amplexicaulis*	25	3600	14
8	*Cyperus rotundus*	33	3600	17
9	*Heteropogon contortus*	33	2700	15
10	*Poa annua*	25	5200	17
11	*Pteridium aquilinum*	25	4400	16
12	*Rumex hastatus*	17	4200	13
13	*Tagetes minuta*	25	3200	14
14	*Thalictrum elegans*	17	5400	15
			58000	

Site V26: Sarsadi II HEP: Proposed project area near Sarsadi Village

Table 6.76: Community structure -Site V20 (Trees)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	TBC (m^{2}ha^{-1})	IVI
1	*Aesculus indica*	60	140	4.84	76
2	*Alnus nepalensis*	50	80	2.12	46
3	*Juglans regia*	30	30	2.96	33
3	*Cupressus torulosa*	40	60	1.52	35
4	*Celtis australis*	30	60	3.76	43
5	*Cedrus deodara*	30	50	0.852	26
6	*Prunus domestica*	20	40	0.87	20
7	*Pinus roxburghii*	20	30	1.5	21
			490		

Table 6.77: Community structure -Site V26 (Shrubs)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	TBC (m^{2}ha^{-1})	IVI
1	*Indigofera tinctoria*	60	480	1.38	56
2	*Sarcococca saligna*	50	400	1.4	50
3	*Berberis aristata*	50	320	1.02	41
4	*Boehmeria platyphylla*	40	240	0.92	34
5	*Rabdosia rugosa*	40	200	0.41	25
6	*Girardinia diversifolia*	30	200	0.16	19
7	*Viburnum grandiflorum*	30	160	0.37	20
8	*Rubus ellipticus*	40	200	0.41	25
9	*Ricinus communis*	20	80	0.37	14
10	*Prinsepia utilis*	20	80	0.46	15
		380	**2360**	**6.9**	**300**

Table 6.78: Community structure -Site V26 (Herbs)

S.No.	Name of Species	Frequency (%)	Density (ind./ha-1)	IVI	
	Pre Monsoon				
1	*Chenopodium album*	10	2000	5	0.03
2	*Plantago major*	20	3500	9	0.05
3	*Pteridium aquilinum*	25	3500	10	0.05
4	*Thalictrum elegans*	25	3500	10	0.05
5	*Achyranthes bidentata*	25	4000	11	0.05
6	*Bidens pilosa*	30	4000	12	0.05
7	*Oxalis corniculata*	30	4000	12	0.05
8	*Strobilanthes alatus*	35	4500	13	0.06
9	*Chrysopogon fulvus*	35	5000	14	0.07
10	*Artemisia vulgaris*	35	5500	15	0.07
11	*Rumex hastatus*	45	7000	19	0.09
12	*Lindenbergia grandiflora*	45	8000	20	0.11
13	*Eriophorum comosum*	50	8500	22	0.11
14	*Anaphalis contorta*	65	11500	29	0.15
	Total		**74500**		
	Monsoon				
1	*Achyranthes bidentata*	20	4000	9	0.04
2	*Ajuga parviflora*	13	2667	6	0.03
3	*Anaphalis contorta*	20	5333	10	0.05
4	*Arisaema concinnum*	27	4667	11	0.05
5	*Artemisia vulgaris*	33	6000	14	0.06
6	*Aster peduncularis*	27	6000	13	0.06
7	*Bidens pilosa*	20	4667	10	0.05
8	*Bistorta amplexicaulis*	20	6000	11	0.06
9	*Chenopodium album*	13	4667	8	0.05
10	*Chrysopogon fulvus*	27	6000	13	0.06
11	*Fragaria nubicola*	27	8667	15	0.09
12	*Impatiens brachycentra*	20	4000	9	0.04
13	*Nepeta laevigata*	40	8000	18	0.08
14	*Plantago major*	27	6000	13	0.06

S.No.	Name of Species	Frequency (%)	Density (ind./ha-1)	IVI	
15	*Pteridium aquilinum*	20	6667	12	0.07
16	*Rumex hastatus*	13	3333	7	0.03
17	*Thalictrum elegans*	33	4667	13	0.05
18	*Trifolium repens*	13	6000	9	0.06
	Total		**97333**		
	Winter				
1	*Achyranthes bidentata*	25	5000	16	0.07
2	*Anaphalis contorta*	17	3333	10	0.05
3	*Artemisia vulgaris*	25	6667	18	0.09
4	*Bidens pilosa*	33	5833	20	0.08
5	*Bistorta amplexicaulis*	42	7500	25	0.11
6	*Chrysopogon fulvus*	17	5000	13	0.07
7	*Impatiens brachycentra*	25	5833	17	0.08
8	*Nepeta laevigata*	25	7500	19	0.11
9	*Pteridium aquilinum*	17	5833	14	0.08
10	*Rumex hastatus*	33	7500	22	0.11
11	*Thalictrum elegans*	33	10833	27	0.15
			70833		

Site V27: Hurla HEP: Proposed Project area of Hurla HEP

Table 6.79: Community structure -Site V27 (Trees)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	TBC (m^{2}ha^{-1})	IVI
1	*Aesculus indica*	20	15	28.88	25
2	*Alnus nepalensis*	20	35	64.98	50
3	*Betula alnoides*	30	23	2.16	16
4	*Toona ciliata*	30	30	27.38	31
5	*Celtis australis*	20	20	15.68	20
6	*Juglans regia*	30	30	33.62	35
7	*Morus australis*	20	20	2.00	12
8	*Populus ciliata*	10	10	1.62	6
9	*Pinus roxburghii*	30	120	5.78	41
10	*Pyrus communis*	20	40	0.82	16
11	*Quercus leucotrichophora*	40	40	2.88	24
12	*Rhus succedanea*	40	40	0.72	23
			423		

Table 6.80: Community structure -Site V27 (Shrubs)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	IVI
1	*Artemisia nilagirica*	40	500	22
2	*Berberis lycium*	20	200	15
3	*Cannabis sativa*	60	700	27
4	*Chenopodium*	40	800	23
5	*Desmodium gangeticum*	50	500	27
6	*Girardinia diversifolia*	60	600	27
7	*Pyracantha crenulata*	40	400	21
8	*Rhamnus triquetra*	30	300	22
9	*Rosa brunonii*	30	300	19
10	*Sinarundinaria falcata*	50	500	30
11	*Viburnum mullaha*	20	200	43
12	*Zanthoxylum armatum*	20	200	26
			5200	

Table 6.81: Community structure -Site V27 (Herbs)

S. No.	Plants	Frequency (%)	Density (ind.ha-1)	IVI
	Pre Monsoon			

S. No.	Plants	Frequency (%)	Density (ind.ha-1)	IVI
1	*Achyranthes asper*	25	4167	7.50
2	*Anaphalis contorta*	30	10000	14
3	*Andropogon ischaemum*	50	7500	14
4	*Bistorta macrophylla*	80	6667	18
5	*Bupleurum hamiltonii*	30	9167	13
6	*Fagopyrum esculentum*	80	6667	18
7	*Fragaria nubicola*	50	9167	16
8	*Gnaphalium hypoleucum*	50	10833	17
9	*Impatiens bicolor*	80	12500	23
10	*Mentha longifolia*	70	6667	16
11	*Poa pratensis*	60	11667	20
12	*Pilea scripta*	80	13333	24
			108333	
	Monsoon			
1	*Achyranthes asper*	25	13333	18
2	*Anaphalis contorta*	25	4167	10
3	*Andropogon ischaemum*	17	8333	11
4	*Bupleurum hamiltonii*	25	7500	13
5	*Cyperus niveus*	33	10000	17
6	*Fagopyrum esculentum*	33	7500	15
7	*Fragaria nubicola*	25	9167	14
8	*Gnaphalium hypoleucum*	25	6667	12
9	*Lilium giganteum*	33	5833	14
10	*Mentha longifolia*	25	12500	17
11	*Poa pratensis*	17	10000	13
12	*Potentilla nepalensis*	33	6667	15
13	*Rumex nepalensis*	25	8333	14
14	*Tagetes erecta*	17	4167	8
15	*Vicoa biflora*	8	8333	9
	Total		**122500**	
	Winter			
1	*Achyranthes asper*	25	7500	18
2	*Anaphalis contorta*	25	6667	17
3	*Andropogon ischaemum*	17	5000	12
4	*Cyperus niveus*	25	7500	18
5	*Fagopyrum esculentum*	33	10000	24
6	*Fragaria nubicola*	33	8333	22
7	*Gnaphalium hypoleucum*	25	5833	16
8	*Mentha longifolia*	25	6667	17
9	*Poa pratensis*	33	8333	22
10	*Rumex nepalensis*	25	7500	18
11	*Tagetes erecta*	17	10000	18
		283	**83333**	200

Site V28: Sainj HEP: Upstream of Dam site

Table 6.82: Community structure -Site V28 (Trees)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	TBC (m^2ha^{-1})	IVI
1	*Albizia julibrissin*	30	30	6.48	19
2	*Alnus nepalensis*	40	40	35.28	51
3	*Boehmeria rugulosa*	50	50	6.48	27
4	*Celtis australis*	30	30	13.52	26
5	*Ficus oligodon*	30	40	0.98	15
6	*Juglans regia*	20	20	21.78	30
7	*Morus australis*	40	40	1.62	18
8	*Neolitsea chinense*	20	20	1.28	10
9	*Phoebe lanceolata*	20	20	0.98	9
10	*Populus ciliata*	50	50	1.28	22
11	*Prunus armeniaca*	40	40	1.28	18

12	*Pyrus pashia*	40	60	1.28	22
13	*Pinus roxburghii*	50	60	9.68	32
			500		

Table 6.83: Community structure -Site V28 (Shrubs)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	IVI
1	*Artemisia nilagirica*	60	900	27
2	*Berberis lycium*	50	500	26
3	*Cannabis sativa*	60	700	22
4	*Chenopodium*	70	1000	29
5	*Desmodium gangeticum*	60	700	30
6	*Girardinia diversifolia*	70	800	26
7	*Rhamnus triquetra*	30	400	24
8	*Sinarundinaria falcata*	70	1200	39
9	*Solanum surattense*	60	700	27
10	*Viburnum mullaha*	30	400	50
			7300	

Table 6.84: Community structure -Site V28 (Herbs)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	IVI
1	*Achyranthes asper*	8	2500	6
2	*Anaphalis contorta*	33	12500	25
3	*Andropogon ischaemum*	33	11667	24
4	*Cymbopogon martini*	25	13333	23
5	*Fagopyrum esculentum*	25	4167	14
6	*Impatiens bicolor*	17	8333	15
7	*Mentha longifolia*	25	5833	15
8	*Poa pratensis*	25	9167	19
9	*Pilea scripta*	25	20000	30
10	*Rumex nepalensis*	33	8333	21
11	*Tagetes erecta*	17	2500	9
			98333	
	Monsoon			
1	*Achyranthes asper*	17	8333	13
2	*Anaphalis contorta*	33	9167	19
3	*Fagopyrum esculentum*	25	2500	10
4	*Fragaria nubicola*	25	9167	17
5	*Impatiens bicolor*	25	4167	12
6	*Inula cappa*	33	11667	22
7	*Gnaphalium hypoleucum*	25	8333	16
8	*Mentha longifolia*	17	11667	16
9	*Oxalis corniculata*	25	7500	15
10	*Pilea scripta*	17	5000	10
11	*Poa pratensis*	33	10833	21
12	*Rumex nepalensis*	17	5833	11
13	*Tagetes erecta*	25	10000	17
			104167	
	Winter			
1	*Achyranthes asper*	17	6667	15
2	*Anaphalis contorta*	42	9167	29
3	*Fagopyrum esculentum*	17	5000	13
4	*Inula cappa*	25	8333	21
5	*Mentha longifolia*	17	5833	14
6	*Oxalis corniculata*	42	9167	29
7	*Pilea scripta*	25	8333	21
8	*Poa pratensis*	33	10000	27

9	*Rumex nepalensis*	25	9167	22
10	*Tagetes erecta*	8	4167	9
			75833	

Site V29: Sainj HEP: Near Power House Site

Table 6.85: Community structure -Site V29 (Trees)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	TBC (m^{2}ha^{-1})	IVI
1	*Albizia julibrissin*	30	30	4.5	48
2	*Toona ciliata*	40	40	3.38	49
3	*Ficus hispida*	50	50	2.00	49
4	*Juglans regia*	20	20	2.16	27
5	*Populus ciliata*	50	50	1.62	46
6	*Pinus roxburghii*	50	50	1.28	44
7	*Pyrus pashia*	30	30	2.42	36
			270		

Table 6.86: Community structure -Site V29 (Shrubs)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	IVI
1	*Artemisia nilagirica*	70	800	26
2	*Berberis lycium*	20	200	17
3	*Cannabis sativa*	60	700	20
4	*Chenopodium album*	70	1100	29
5	*Clematis connata*	70	700	28
6	*Desmodium gangeticum*	60	800	31
7	*Girardinia diversifolia*	60	600	21
8	*Hypericum patulum*	40	400	17
9	*Rubus ellipticus*	40	500	21
10	*Solanum surattense*	50	700	24
11	*Spermadictyon suaveolens*	60	600	23
12	*Zanthoxylum armatum*	30	300	43
			7400	

Table 6.87: Community structure -Site V29 (Herbs)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	IVI
	Pre Monsoon			
1	*Achyranthes asper*	25	9167	20
2	*Andropogon ischaemum*	25	10000	21
3	*Cymbopogon martini*	33	11667	27
4	*Cyprus niveus*	25	7500	18
5	*Cynodon dactylon*	33	10000	25
6	*Oxalis corniculata*	33	7500	22
7	*Pogonatherum sacchaoidon*	25	9167	20
8	*Rumex nepalensis*	33	6667	21
9	*Tagetes erecta*	33	10833	26
			82500	
	Monsoon			
1	*Achyranthes asper*	25	6667	16
2	*Andropogon ischaemum*	33	5833	18
3	*Cynodon dactylon*	25	12500	22
4	*Fagopyrum esculentum*	17	10000	16
5	*Fragaria nubicola*	17	4167	10
6	*Impatiens bicolor*	8	8333	11
7	*Oxalis corniculata*	25	12500	22
8	*Pilea scripta*	33	6667	19
9	*Pogonatherum sacchaoidon*	25	8333	17
10	*Rumex nepalensis*	17	6667	13
11	*Tagetes erecta*	17	10000	16
12	*Vicoa biflora*	33	7500	20
			99167	
	Winter			
1	*Achyranthes asper*	25	8333	20
2	*Andropogon ischaemum*	33	10000	26
3	*Fagopyrum esculentum*	25	7500	19
4	*Impatiens bicolor*	17	5833	14
5	*Pilea scripta*	17	9167	18
6	*Pogonatherum sacchaoidon*	42	13333	33
7	*Rumex nepalensis*	25	14167	27
8	*Tagetes erecta*	33	11667	28
9	*Vicoa biflora*	17	5833	14
			85833	

Table 6.88: Community structure -Site V30 (Trees)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	TBC (m^2ha^{-1})	IVI
1	*Aesculus indica*	70	80	28.88	50
2	*Alnus nepalensis*	70	80	64.98	73
3	*Betula alnoides*	40	40	2.16	18
4	*Boehmeria rugulosa*	40	40	2.00	18
5	*Toona ciliata*	70	80	27.38	49
6	*Celtis australis*	60	70	15.68	38
7	*Populus ciliata*	30	30	13.52	21
8	*Pyrus communis*	20	20	0.98	9
9	*Rhus succedanea*	50	50	1.28	22
			490		

Table 6.89: Community structure -Site V30 (Shrubs)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	IVI
1	*Artemisia nilagirica*	40	500	22
2	*Berberis lycium*	20	200	15
3	*Cannabis sativa*	60	600	27
4	*Chenopodium*	40	600	23
5	*Desmodium gangeticum*	50	500	27
6	*Girardinia diversifolia*	60	600	27
7	*Pyracantha crenulata*	40	400	21
8	*Rhamnus triquetra*	30	300	22
9	*Rosa brunonii*	30	300	19
10	*Sinarundinaria falcata*	50	500	30
11	*Viburnum mullaha*	20	200	43
12	*Zanthoxylum armatum*	20	200	26
			4900	

Table 6.90: Community structure -Site V30 (Herbs)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	IVI
	Pre Monsoon			
1	*Achyranthes asper*	25	5000	10
2	*Anaphalis contorta*	17	4167	8
3	*Andropogon ischaemum*	17	7500	10
4	*Bistorta macrophylla*	17	5833	9
5	*Bupleurum hamiltonii*	8	10000	10
6	*Delphinium denudatum*	25	15833	19
7	*Fagopyrum esculentum*	33	7500	15
8	*Fragaria nubicola*	25	6667	12
9	*Geranium nepalense*	33	5833	13
10	*Gnaphalium hypoleucum*	25	12500	16
11	*Impatiens bicolor*	17	10000	12
12	*Inula cappa*	33	6667	14
13	*Mentha longifolia*	25	4167	10
14	*Poa pratensis*	17	10833	13
15	*Pilea scripta*	33	7500	15
16	*Vicoa biflora*	33	5833	13
			125833	
	Monsoon			
1	*Achyranthes asper*	25	9167	12
2	*Anaphalis contorta*	33	12500	16
3	*Andropogon ischaemum*	17	7500	9
4	*Carex filicina*	25	4167	9
5	*Delphinium denudatum*	33	12500	16

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	IVI
6	*Drymaria diandra*	25	5000	9
7	*Fagopyrum esculentum*	33	8333	13
8	*Fragaria nubicola*	25	5000	9
9	*Conyza stricta*	25	8333	11
10	*Gnaphalium hypoleucum*	25	5833	10
11	*Impatiens bicolor*	33	10833	15
12	*Inula cappa*	25	7500	11
13	*Kyllinga brevifolia*	17	10000	11
14	*Mentha longifolia*	25	10833	13
15	*Poa pratensis*	17	8333	9
16	*Senecio scandens*	17	6667	8
17	*Tagetes erecta*	8	5833	6
18	*Vicoa biflora*	25	10000	13
			148333	
	Winter			
1	*Achyranthes asper*	33	10833	19
2	*Anaphalis contorta*	42	13333	24
3	*Carex filicina*	25	9167	15
4	*Conyza stricta*	17	5833	10
5	*Delphinium denudatum*	50	12500	25
6	*Fagopyrum esculentum*	25	6667	13
7	*Gnaphalium hypoleucum*	33	10000	18
8	*Impatiens bicolor*	17	6667	11
9	*Kyllinga brevifolia*	25	10000	16
10	*Mentha longifolia*	25	7500	14
11	*Poa pratensis*	42	10833	22
12	*Tagetes erecta*	17	8333	12
			111667	

Site V31: Parbati III HEP : Downstream of Diversion Site

Table 6.91: Community structure -Site V31 (Trees)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	TBC (m^2ha^{-1})	IVI
1	*Albizia julibrissin*	30	30	6.48	26
2	*Alnus nepalensis*	40	40	35.28	69
3	*Celtis australis*	30	30	13.52	35
4	*Morus australis*	40	40	1.62	25
5	*Neolitsea chinense*	30	40	5.78	28
6	*Phoebe lanceolata*	20	20	0.98	13
7	*Populus ciliata*	50	50	1.28	30
8	*Pyrus pashia*	40	60	1.28	30
9	*Pinus roxburghii*	50	60	9.68	44
			370		

Table 6.92: Community structure -Site V31 (Shrubs)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	IVI
1	*Artemisia nilagirica*	60	900	27
2	*Berberis lycium*	50	500	26
3	*Cannabis sativa*	60	700	22
4	*Chenopodium*	70	200	29
5	*Desmodium gangeticum*	60	700	30
6	*Girardinia diversifolia*	70	800	26
7	*Rhamnus triquetra*	30	400	24
8	*Sinarundinaria falcata*	70	1200	39
9	*Solanum surattense*	60	700	27
10	*Viburnum mullaha*	30	400	50
			6500	

Table 6.93: Community structure -Site V31 (Herbs)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	IVI
	Pre Monsoon			
1	*Achyranthes asper*	33	10000	19
2	*Anaphalis contorta*	25	10833	18
3	*Andropogon ischaemum*	25	6667	14
4	*Cymbopogon citratus*	17	7500	12
5	*Fagopyrum esculentum*	33	8333	18
6	*Geranium nepalense*	33	11667	21
7	*Impatiens bicolor*	25	8333	15
8	*Mentha longifolia*	17	4167	9
9	*Poa pratensis*	8	8333	10
10	*Pilea scripta*	25	12500	19
11	*Rumex nepalensis*	33	6667	16
12	*Tagetes erecta*	25	8333	15
13	*Urtica dioica*	25	5833	13
			109167	
	Monsoon			
1	*Achyranthes asper*	25	10000	14
2	*Andropogon ischaemum*	33	9167	15
3	*Fagopyrum esculentum*	17	5833	9
4	*Impatiens bicolor*	33	7500	14
5	*Inula cappa*	42	8333	17
6	*Mentha longifolia*	33	10833	17
7	*Conyza stricta*	42	9167	17
8	*Oxalis corniculata*	25	6667	11
9	*Pilea scripta*	33	11667	17
10	*Poa pratensis*	25	10000	14
11	*Pogonatherum sacchaoidon*	17	6667	9
12	*Rumex nepalensis*	17	7500	10
13	*Tagetes erecta*	25	9167	13
14	*Tripogon filiformis*	25	7500	12
15	*Vicoa biflora*	25	5833	11
			125833	
	Winter			
1	*Achyranthes asper*	25	8333	16
2	*Anaphalis contorta*	33	9167	19
3	*Andropogon ischaemum*	17	6667	12
4	*Conyza stricta*	33	8333	18
5	*Fagopyrum esculentum*	42	9167	22
6	*Impatiens bicolor*	17	5833	11
7	*Inula cappa*	42	9167	22
8	*Mentha longifolia*	25	7500	15
9	*Oxalis corniculata*	17	5833	11
10	*Pilea scripta*	25	10000	18
11	*Poa pratensis*	17	7500	13
12	*Rumex nepalensis*	8	4167	7
13	*Tagetes erecta*	25	10000	18
			101667	

Site V32: Parbati III HEP: Near Power House Site

Table 6.94: Community structure -Site V32 (Trees)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	TBC (m^2ha^{-1})	IVI
1	*Albizia julibrissin*	30	30	4.5	49
2	*Toona ciliata*	20	40	3.38	42
3	*Ficus hispida*	50	50	2.00	50
4	*Juglans regia*	20	20	2.16	28

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	TBC (m^2ha^{-1})	IVI
5	*Populus ciliata*	50	50	1.62	48
6	*Pinus roxburghii*	50	50	1.28	46
7	*Pyrus pashia*	30	30	2.42	37
			270		

Table 6.95: Community structure -Site V32 (Shrubs)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	IVI
1	*Artemisia nilagirica*	70	800	26
2	*Berberis lycium*	20	200	17
3	*Cannabis sativa*	60	700	20
4	*Chenopodium*	70	500	29
5	*Viburnum mullaha*	70	700	28
6	*Desmodium gangeticum*	60	800	31
7	*Girardinia diversifolia*	60	600	21
8	*Hypericum patulum*	40	400	17
9	*Rubus ellipticus*	40	500	21
10	*Solanum surattense*	50	700	24
11	*Spermadictyon suaveolens*	60	600	23
12	*Zanthoxylum armatum*	30	300	43
			6800	

Table 6.96: Community structure -Site V32 (Herbs)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	IVI
	Pre Monsoon			
1	*Achyranthes asper*	17	7500	13
2	*Andropogon ischaemum*	25	10833	19
3	*Cymbopogon martini*	25	6667	15
4	*Cyprus*	25	8333	17
5	*Cynodon dactylon*	50	14167	31
6	*Ipomea nil*	25	7500	16
7	*Oxalis corniculata*	17	6667	12
8	*Pogonatherum sacchaoidon*	17	10000	15
9	*Rumex nepalensis*	8	10833	13
10	*Tagetes erecta*	42	22500	35
11	*Tripogon filiformis*	25	6667	15
			111667	
	Monsoon			
1	*Achyranthes asper*	33	9167	17
2	*Andropogon ischaemum*	25	7500	13
3	*Carex filicina*	33	12500	20
4	*Conyza stricta*	25	6667	13
5	*Cyperus squarrosus*	17	11667	14
6	*Ipomea nil*	33	9167	17
7	*Oxalis corniculata*	25	8333	14
8	*Pogonatherum sacchaoidon*	33	7500	16
9	*Rumex nepalensis*	17	15000	17
10	*Pilea scripta*	33	8333	17
11	*Tagetes erecta*	25	10833	16
12	*Tripogon filiformis*	17	6667	10
13	*Vicoa biflora*	25	10000	15
			123333	
	Winter			
1	*Achyranthes asper*	33	9167	20
2	*Andropogon ischaemum*	17	7500	13
3	*Carex filicina*	33	11667	23

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	IVI
4	*Cyperus squarrosus*	25	8333	17
5	*Fagopyrum esculentum*	17	10833	16
6	*Oxalis corniculata*	33	8333	20
7	*Pilea scripta*	25	9167	18
8	*Poa pratensis*	33	11667	23
9	*Rumex nepalensis*	17	8333	14
10	*Tagetes erecta*	33	7500	19
11	*Tripogon filiformis*	25	10000	18
		292	102500	

Site V33: Lambadug HEP: Downstream of Diversion Site

Table 6.97: Community structure -Site V33 (Trees)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	TBC (m^2ha^{-1})	IVI
1	*Salix tetrasperma*	10	10	2.83	7
2	*Fraxinus excelsior*	20	30	12.08	18
3	*Robinia pseudoacacia*	10	30	3.77	11
4	*Cedrus deodara*	40	60	14.19	33
5	*Picea smithiana*	30	60	112.81	58
6	*Abies pindrow*	40	70	104.18	62
7	*Pinus wallichiana*	90	230	85.09	110
			490		

Table 6.98: Community structure -Site V33 (Shrubs)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	IVI
1	*Berberis lycium*	10	120	40
2	*Rubus niveus*	30	160	52
3	*Juniperus communis*	20	180	58
4	*Rosa webbiana*	30	320	84
5	*Spiraea sorbifolia*	30	320	66
			1100	

Table 6.99: Community structure -Site V33 (Herbs)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	IVI
	Pre Monsoon			
1	*Axyris hybrida*	42	15000	36
2	*Argemone mexicana*	25	17500	30
3	*Fragaria vasica*	33	15833	32
4	*Gerardiana heterophylla*	42	18333	39
5	*Carex obscura*	33	14167	31
6	*Ranunculus arvensis*	33	15833	32
			96667	
	Monsoon			
1	*Achyranthes bidentata*	33	13333	23
2	*Argemone mexicana*	42	10833	23
3	*Axyris hybrida*	33	12500	22
4	*Centella asiatica*	8	11667	13
5	*Chrysopogon fulvus*	25	8333	16
6	*Fragaria vasica*	33	9167	19
7	*Gerardiana heterophylla*	33	7500	18
8	*Gnaphalium affine*	33	12500	22
9	*Pteridium aquilinum*	25	8333	16
10	*Ranunculus arvensis*	17	7500	12
11	*Strobilanthes alatus*	25	9167	16

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	IVI
			110833	
	Winter			
1	*Achyranthes bidentata*	33	12500	29
2	*Argemone mexicana*	8	11667	17
3	*Centella asiatica*	25	8333	20
4	*Chrysopogon fulvus*	33	9167	25
5	*Fragaria vasica*	33	7500	23
6	*Gerardiana heterophylla*	33	12500	29
7	*Pteridium aquilinum*	25	8333	20
8	*Ranunculus arvensis*	17	7500	16
9	*Rumex hastatus*	25	8333	20
			85833	

Site V34: Uhl I HEP: Upstream of Barrage Site

Table 6.100: Community structure –Site V34 (Trees)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	TBC (m^{2}ha^{-1})	IVI
1	*Malus baccata*	20	20	14.17	20
2	*Toona ciliata*	20	20	7.05	16
3	*Bauhinia variegata*	20	40	4.07	18
4	*Cedrus deodara*	30	40	23.49	33
5	*Pinus wallichiana*	30	40	82.13	64
6	*Robinia pseudoacacia*	40	60	5.36	31
7	*Juglans regia*	90	290	49.05	119
			510		

Table 6.101: Community structure –Site V34 (Shrubs)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	IVI
1	*Ephedra vulgaris*	20	100	34
2	*Gerardiana heterophylla*	20	200	52
3	*Rosa webbiana*	20	200	47
4	*Desmodium ovalifolium*	30	240	45
5	*Sorbaria tomentosa*	10	320	39
6	*Lonicera quinquelocularis*	50	460	82
	Total		**1520**	

Table 6.102: Community structure –Site V34 (Herbs)

S.No.	Species	Frequency%	Density (Ha-1)	
	Monsoon			
1	*Ranunculus pulchellus*	25	12500	24
2	*Saxifraga diversifolia*	25	15833	27
3	*Bromus gracillimus*	17	20833	28
4	*Ricinus communis*	33	15000	31
5	*Carex obscura*	42	12500	32
6	*Cotoneaster bacillaris*	33	15000	31
7	*Caltha palustris*	25	15833	27
			107500	
	Pre Monsoon			
1	*Bromus gracillimus*	17	10833	16
2	*Caltha palustris*	33	9167	20
3	*Carex obscura*	33	12500	23
4	*Centella asiatica*	17	8333	14
5	*Lindenbergia grandiflora*	42	11667	26
6	*Plantago major*	25	13333	21
7	*Pteridium aquilinum*	25	8333	17
8	*Ranunculus pulchellus*	33	15833	27

S.No.	Species	Frequency%	Density (Ha-1)	
9	*Ricinus communis*	33	9167	20
10	*Thalictrum elegans*	17	10833	16
			110000	
	Winter			
1	*Bromus gracillimus*	25	11667	23
2	*Carex obscura*	33	11667	27
3	*Centella asiatica*	25	12500	24
4	*Lindenbergia grandiflora*	50	14167	37
5	*Rumex hastatus*	42	11667	30
6	*Ranunculus pulchellus*	25	13333	25
7	*Ricinus communis*	25	8333	20
8	*Thalictrum elegans*	17	5833	13
			89167	

Site V35: Uhl HEP: Proposed Diversion Site

Table 6.103: Community structure -Site V35 (Trees)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	TBC (m^2ha^{-1})	IVI
1	*Bauhinia variegata*	20	20	1.37	17
2	*Populus ciliata*	20	20	3.05	19
3	*Toona ciliata*	20	20	5.05	21
4	*Juglans regia*	20	30	50.0	71
5	*Salix tetrasperma*	20	30	1.08	20
6	*Pinus wallichiana*	40	70	13.67	55
7	*Prunus americana*	40	70	2.89	44
8	*Celtis australis*	20	80	17.92	52
			340		

Table 6.104: Community structure -Site V35 (Shrubs)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	IVI
1	*Juniperus communis*	20	260	46
2	*Berberis lycium*	20	280	42
3	*Viburnum cotinifolium*	30	340	38
4	*Sorbaria tomentosa*	40	460	89
5	*Rosa webbiana*	30	840	86
			2180	

Table 6.105: Community structure -Site V35 (Herbs)

S.No.	Species	Frequency%	Density (Ha-1)	IVI
	Monsoon			
1	*Ricinus communis*	33	14167	33
2	*Desmodium tiliaefolium*	42	11667	34
3	*Rumex hastatus*	25	13333	28
4	*Saxifraga diversifolia*	25	24167	41
5	*Cotoneaster bacillaris*	50	11667	39
6	*Girardinia heterophylla*	25	10833	25
			85833	
	Pre Monsoon			
1	*Axyris hybrida*	25	10833	19
2	*Caltha palustris*	50	15833	32
3	*Carex obscura*	25	11667	20
4	*Cotoneaster bacillaris*	33	11667	23
5	*Desmodium tiliaefolium*	25	12500	20
6	*Pteridium aquilinum*	50	14167	31
7	*Ricinus communis*	17	10000	15
8	*Rumex hastatus*	8	10833	13
9	*Saxifraga diversifolia*	25	8333	17

S.No.	Species	Frequency%	Density (Ha-1)	IVI
10	*Thalictrum elegans*	17	5833	11
			111667	
	Winter			
1	*Axyris hybrida*	25	10833	20
2	*Carex obscura*	50	15833	34
3	*Datura stramonium*	25	11667	21
4	*Desmodium tiliaefolium*	33	11667	24
5	*Pteridium aquilinum*	25	12500	21
6	*Ranunculus pulchellus*	50	14167	33
7	*Ricinus communis*	17	10000	16
8	*Rumex hastatus*	8	10833	13
9	*Thalictrum elegans*	25	8333	18
			105833	

Site V36: Lower Uhl HEP: Downstream of Proposed Diversion Weir

Table 6.106: Community structure -Site V36 (Trees)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	TBC (m^{2}ha^{-1})	IVI
1	*Robinia pseudoacacia*	10	10	0.73	10
2	*Bauhinia variegata*	10	10	3.9	16
3	*Celtis australis*	10	20	22.8	55
4	*Toona ciliata*	20	20	2.58	22
5	*Prunus americana*	10	40	2.83	21
6	*Platanus orientalis*	10	40	0.35	16
7	*Malus baccata*	40	70	2.33	45
8	*Salix tetrasperma*	20	80	0.71	33
9	*Populus ciliata*	40	120	15.53	83
			410		

Table 6.107: Community structure -Site V36 (Shrubs)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	IVI
1	*Juniperus communis*	20	200	37
2	*Rosa webbiana*	60	220	70
3	*Cotoneaster affinis*	60	240	56
4	*Ribes glaciale*	40	320	46
5	*Lonicera hypoleuca*	20	360	35
6	*Berberis lycium*	50	460	57
			1800	

Table 6.108: Community structure -Site V36 (Herbs)

S.No.	Species	Frequency%	Density (Ha-1)	IVI
	Monsoon			
1	*Potentilla nepalensis*	33	18333	34
2	*Corydalis crassifolia*	33	15000	31
3	*Datura stramonium*	25	12500	24
4	*Axyris hybrida*	25	13333	25
5	*Carex infuscata*	42	14167	34
6	*Ranunculus pulchellus*	25	8333	20
7	*Saxifraga diversifolia*	33	15833	32
			97500	
	Pre Monsoon			
1	*Axyris hybrida*	25	9167	17
2	*Carex infuscata*	33	8333	19
3	*Corydalis crassifolia*	17	12500	17
4	*Datura stramonium*	33	14167	24
5	*Desmodium tiliaefolium*	25	8333	16
6	*Mentha longifolia*	25	7500	15

S.No.	Species	Frequency%	Density (Ha-1)	IVI
7	*Potentilla nepalensis*	25	8333	16
8	*Pteridium aquilinum*	33	9167	19
9	*Ranunculus pulchellus*	25	8333	16
10	*Saxifraga diversifolia*	42	13333	26
11	*Thalictrum elegans*	25	7500	15
			106667	
	Winter			
1	*Axyris hybrida*	17	9167	17
2	*Carex infuscata*	33	12500	27
3	*Corydalis crassifolia*	33	10000	25
4	*Datura stramonium*	25	12500	24
5	*Desmodium tiliaefolium*	50	14167	36
6	*Mentha longifolia*	17	10000	18
7	*Potentilla nepalensis*	8	10833	15
8	*Ranunculus pulchellus*	25	8333	19
9	*Thalictrum elegans*	33	5833	20
			93333	

Site V37: Uhl Khad HEP" Proposed Power House Site-Right bank of Beas river

Table 6.109: Community structure -Site V37 (Trees)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	TBC (m^{2}ha^{-1})	IVI
1	*Bauhinia variegata*	20	35	2.58	29
2	*Bombax ceiba*	30	100	11.73	80
3	*Celtis australis*	20	30	22.38	77
4	*Grewia optiva*	20	30	1.41	25
5	*Mallotus philippensis*	40	70	0.97	48
6	*Phoenix humilis*	50	30	0.79	40
			295		

Table 6.110: Community structure -Site V37(Shrubs)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	IVI
1	*Artemisia capillaris*	50	230	43
2	*Buddleja asiatica*	60	210	29
3	*Caryopteris odorata*	50	240	19
4	*Debregeasia salicifolia*	60	240	35
5	*Adhatoda zeylanica*	50	230	19
6	*Eupatorium adenophorum*	60	240	38
7	*Indigofera astragalina*	60	240	22
8	*Myrsine africana*	40	250	22
9	*Rhamnus virgatus*	50	320	40
10	*Rhus parviflora*	70	320	32
			2520	

Table 6.111: Community structure -Site V37 (Herbs)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	IVI
	Pre Monsoon			
1	*Ageratum conyzoides*	25	20000	32
2	*Bidens pilosa*	50	12500	34
3	*Cannabis sativa*	30	10833	24
4	*Epilobium hirsutum*	40	15833	33
5	*Achyranthes bidentata*	30	10000	23
6	*Colocasia esculenta*	40	9167	26
7	*Mentha longifolia*	30	15000	28
			93333	

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	IVI
	Monsoon			
1	*Ageratum conyzoides*	50	15833	31
2	*Bidens pilosa*	25	10000	17
3	*Cannabis sativa*	17	9167	14
4	*Epilobium hirsutum*	33	12500	22
5	*Achyranthes bidentata*	33	15833	25
6	*Colocasia esculenta*	25	9167	16
7	*Mentha longifolia*	33	10000	20
8	*Carex infuscata*	33	8333	18
9	*Datura stramonium*	25	10833	18
10	*Potentilla nepalensis*	33	9167	19
			110833	
	Winter			
1	*Achyranthes bidentata*	50	15833	37
2	*Ageratum conyzoides*	25	10833	22
3	*Bidens pilosa*	17	9167	16
4	*Cannabis sativa*	33	12500	27
5	*Carex infuscata*	33	15833	30
6	*Colocasia esculenta*	25	9167	20
7	*Datura stramonium*	33	11667	26
8	*Trigonella corniculata*	33	8333	22
			93333	

Site V38: Uhl II HEP: Near Bassi Power House

Table 6.112: Community structure -Site V38 (Trees)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	TBC (m^2ha^{-1})	IVI
1	*Adina cordifolia*	20	20	3.58	18
2	*Bauhinia variegata*	20	20	1.73	15
3	*Bombax ceiba*	30	30	11.38	40
4	*Celtis australis*	20	20	13.41	39
5	*Dalbergia sissoo*	30	100	10.43	53
6	*Eucalyptus citriodora*	20	30	1.14	15
7	*Ficus palmata*	40	40	2.60	27
8	*Mallotus philippensis*	70	150	2.96	61
9	*Grewia optiva*	50	60	0.93	31
			470		

Table 6.113: Community structure -Site V38 (Shrubs)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	IVI
1	*Artemisia capillaris*	60	310	28
2	*Buddleja asiatica*	50	200	19
3	*Cannabis sativa*	60	520	29
4	*Adhatoda zeylanica*	60	230	17
5	*Colebrookea oppositifolia*	50	240	19
6	*Debregeasia salicifolia*	70	260	37
7	*Desmodium elegans*	50	210	14
8	*Eupatorium adenophorum*	50	190	15
9	*Indigofera astragalina*	20	70	5
10	*Inula cuspidata*	50	210	19
11	*Rosa brunonii*	50	150	27
12	*Rubus ellipticus*	60	150	21
13	*Urtica dioica*	80	350	35
14	*Zanthoxylum armatum*	50	200	17
			3290	

Table 6.114: Community structure -Site V38 (Herbs)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	IVI
	Pre Monsoon			
1	*Ageratum conyzoides*	33	12500	28
2	*Ajuga bracteosa*	33	15833	31
3	*Aster peduncularis*	25	10000	22
4	*Bidens pilosa*	17	9167	17
5	*Cannabis sativa*	8	12500	16
6	*Epilobium hirsutum*	25	15000	27
7	*Fragaria indica*	25	8333	20
8	*Impatiens glandulifera*	25	10833	22
9	*Trigonella corniculata*	17	9167	17
			103333	
	Monsoon			
1	*Ageratum conyzoides*	25	11667	20
2	*Ajuga bracteosa*	33	10000	22
3	*Aster peduncularis*	25	7500	16
4	*Bidens pilosa*	33	8333	20
5	*Cannabis sativa*	17	10833	16
6	*Epilobium hirsutum*	33	7500	19
7	*Euphorbia hirta*	25	8333	17
8	*Fragaria indica*	17	11667	17
9	*Potentilla gerardiana*	17	8333	14
10	*Rumex hastatus*	17	10000	15
11	*Trigonella corniculata*	25	14167	22
			108333	
	Winter			
1	*Ageratum conyzoides*	25	8333	20
2	*Aster peduncularis*	33	10000	26
3	*Bidens pilosa*	17	9167	18
4	*Cannabis sativa*	33	13333	29
5	*Euphorbia hirta*	25	10833	23
6	*Fragaria indica*	33	12500	28
7	*Mentha longifolia*	17	7500	16
8	*Rumex hastatus*	25	5000	16
9	*Trigonella corniculata*	25	11667	24
			88333	

Site V39: Uhl III HEP: Along the Power Channel

Table 6.115: Community structure -Site V39 (Trees)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	TBC (m^2ha^{-1})	IVI
1	*Bauhinia variegata*	60	130	2.73	58
2	*Celtis australis*	50	80	14.29	60
3	*Grewia optiva*	20	20	2.43	16
4	*Juglans regia*	30	30	21.04	51
5	*Mangifera indica*	20	30	11.97	33
6	*Lannea grandis*	40	50	4.79	34
7	*Morus alba*	30	40	0.96	22
8	*Toona hexandra*	20	30	7.20	26
			410		

Table 6.116: Community structure -Site V39 (Shrubs)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	IVI
1	*Artemisia capillaris*	60	140	25
2	*Berberis asiatica*	50	240	41
3	*Caryopteris odorata*	70	200	33

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	IVI
4	*Adhatoda zeylanica*	50	240	34
5	*Debregeasia salicifolia*	50	180	18
6	*Eupatorium adenophorum*	60	150	29
7	*Inula cuspidata*	50	150	18
8	*Lantana camara*	60	170	27
9	*Rhamnus virgatus*	50	210	20
10	*Rosa brunonii*	40	100	16
11	*Urtica dioica*	70	280	41
			2060	

Table 6.117: Community structure -Site V39 (Herbs)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	IVI
	Pre Monsoon			
1	*Achyranthes bidentata*	25	13333	21
2	*Ageratum conyzoides*	33	11667	22
3	*Ajuga parviflora*	25	9167	17
4	*Andropogon contortus*	33	10000	21
5	*Bidens pilosa*	33	8333	19
6	*Colocasia esculenta*	25	10833	19
7	*Echinops niveus*	25	8333	16
8	*Mentha longifolia*	17	12500	17
9	*Podophyllum hexandrum*	33	9167	20
10	*Rumex hastatus*	25	8333	16
11	*Thalictrum foliolosum*	17	5833	11
			107500	
	Monsoon			
1	*Achyranthes bidentata*	33	11667	20
2	*Ageratum conyzoides*	42	12500	23
3	*Ajuga parviflora*	25	6667	13
4	*Bidens pilosa*	33	8333	17
5	*Cannabis sativa*	17	7500	11
6	*Carex infuscata*	33	14167	22
7	*Colocasia esculenta*	25	8333	15
8	*Datura stramonium*	17	7500	11
9	*Epilobium hirsutum*	25	10833	17
10	*Euphorbia hirta*	25	7500	14
11	*Mentha longifolia*	17	8333	12
12	*Rumex hastatus*	33	6667	16
13	*Thalictrum foliolosum*	17	5833	10
			115833	
	Winter			
1	*Ageratum conyzoides*	42	13333	28
2	*Bidens pilosa*	33	10000	22
3	*Cannabis sativa*	42	12500	27
4	*Carex infuscata*	17	3333	9
5	*Colocasia esculenta*	25	7500	16
6	*Datura stramonium*	17	2500	8
7	*Euphorbia hirta*	33	12500	24
8	*Mentha longifolia*	33	8333	20
9	*Rumex hastatus*	25	10833	20
10	*Thalictrum foliolosum*	42	12500	27
			93333	

Site V40: Uhl III HEP: Near Balancing reservoir along Rana Khad

Table 6.118: Community structure -Site V40 (Trees)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	TBC (m^2ha^{-1})	IVI

1	*Bauhinia variegata*	20	20	1.73	22
2	*Bombax ceiba*	20	20	9.38	45
3	*Celtis australis*	30	30	12.41	62
4	*Grewia optiva*	20	20	2.73	25
5	*Mangifera indica*	20	30	2.43	28
6	*Lannea grandis*	40	50	2.97	46
7	*Morus alba*	30	40	1.04	32
8	*Toona hexandra*	40	50	0.97	40
			260		

Table 6.119: Community structure -Site V40 (Shrubs)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	IVI
1	*Artemisia capillaris*	60	180	34
2	*Berberis asiatica*	40	120	24
3	*Caryopteris odorata*	50	180	28
4	*Adhatoda zeylanica*	70	240	44
5	*Eupatorium adenophorum*	50	240	44
6	*Lantana camara*	50	170	33
7	*Myrsine africana*	40	140	20
8	*Rhus parviflora*	50	210	31
9	*Urtica dioica*	60	220	42
			1700	

Table 6.120: Community structure -Site V40 (Herbs)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	IVI
	Pre Monsoon			
1	*Ageratum conyzoides*	25	12500	18
2	*Ajuga parviflora*	40	11667	21
3	*Aster peduncularis*	40	8333	18
4	*Cannabis sativa*	50	10000	22
5	*Cassia obtusifolia*	20	7500	12
6	*Delphinium vestitum*	40	12500	22
7	*Euphorbia hirta*	40	9167	18
8	*Fragaria indica*	60	10833	25
9	*Mentha longifolia*	50	17500	29
10	*Potentilla gerardiana*	40	6667	16
		405	106667	200
	Monsoon			
1	*Achyranthes bidentata*	17	9167	14
2	*Ageratum conyzoides*	33	10833	21
3	*Ajuga parviflora*	25	8333	16
4	*Bidens pilosa*	17	9167	14
5	*Cannabis sativa*	33	12500	23
6	*Carex infuscata*	33	11667	22
7	*Cassia obtusifolia*	25	13333	21
8	*Datura stramonium*	33	6667	17
9	*Delphinium vestitum*	25	9167	17
10	*Mentha longifolia*	17	7500	12
11	*Potentilla gerardiana*	17	6667	12
12	*Thalictrum foliolosum*	17	5833	11
			110833	
	Winter			
1	*Achyranthes bidentata*	25	10833	20
2	*Ageratum conyzoides*	33	9167	20
3	*Bidens pilosa*	42	13333	28
4	*Cannabis sativa*	17	5000	11
5	*Cassia obtusifolia*	50	14167	31
6	*Datura stramonium*	25	8333	17

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	IVI
7	*Delphinium vestitum*	25	5833	14
8	*Mentha longifolia*	58	15000	35
9	*Thalictrum foliolosum*	33	13333	25
			95000	

Site V41: Beas Satluj Link: Right Bank of Reservoir

Table 6.121: Community structure -Site V41 (Trees)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	TBC (m^2ha^{-1})	IVI
1	*Albizia chinensis*	10	20	2.73	28
2	*Boehmeria rugulosa*	10	20	0.90	19
3	*Cedrela toona*	20	30	2.29	36
4	*Celtis australis*	10	30	3.43	35
5	*Dalbergia sissoo*	20	20	2.83	34
6	*Ficus palmata*	10	10	3.66	28
7	*Morus alba*	30	40	0.97	40
8	*Populus ciliata*	20	40	0.85	33
9	*Syzygium cumini*	30	40	2.71	48
			250		

Table 6.122: Community structure -Site V41 (Shrubs)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	IVI
1	*Artemisia capillaris*	30	700	31
2	*Buddleja asiatica*	30	500	31
3	*Caryopteris odorata*	10	400	24
4	*Debregeasia salicifolia*	30	500	41
5	*Adhatoda zeylanica*	20	500	47
6	*Colebrookea oppositifolia*	50	800	46
7	*Debregeasia salicifolia*	30	600	49
8	*Eupatorium adenophorum*	20	800	31
			4800	

Table 6.123: Community structure -Site V41 (Herbs)

S. No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	IVI
	Pre Monsoon			
1	*Ageratum conyzoides*	25	10000	15
2	*Ajuga parviflora*	25	4167	10
3	*Bidens pilosa*	8	11667	11
4	*Cannabis sativa*	17	12500	14
5	*Cuscuta reflexa*	33	8333	16
6	*Datura stramonium*	25	12500	16
7	*Epilobium hirsutum*	17	9167	12
8	*Euphorbia hirta*	25	11667	16
9	*Fragaria indica*	17	14167	15
10	*Impatiens glandulifera*	33	6667	15
13	*Oxalis acetosella*	25	8333	13
14	*Rumex hastatus*	17	10000	12
15	*Solanum nigrum*	33	6667	15
16	*Xanthium indicum*	42	11667	21
			137500	
	Monsoon			
1	*Ageratum conyzoides*	25	9167	12
2	*Ajuga parviflora*	25	7500	11
3	*Artemisia nilagirica*	25	12500	15
4	*Arundo donax*	17	5833	8
5	*Bidens pilosa*	33	10000	15

S. No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	IVI
6	*Thysanolaena maxima*	17	7500	9
7	*Cannabis sativa*	17	6667	9
8	*Chenopodium album*	50	12500	21
9	*Cymbopogon martini*	25	7500	11
10	*Cyprus niveus*	17	5833	8
13	*Datura stramonium*	25	6667	11
14	*Impatiens glandulifera*	33	10000	15
15	*Ipomea nil*	25	5833	10
16	*Parthenium hysterophorus*	33	7500	13
17	*Rumex hastatus*	25	8333	12
18	*Solanum nigrum*	25	9167	12
19	*Xanthium indicum*	17	5833	8
			138333	
	Winter			
1	*Ageratum conyzoides*	33	10000	19
2	*Ajuga parviflora*	25	7500	14
3	*Artemisia nilagirica*	33	12500	21
4	*Bidens pilosa*	17	6667	11
5	*Cannabis sativa*	33	10000	19
6	*Chenopodium album*	17	7500	12
7	*Datura stramonium*	25	6667	13
8	*Parthenium hysterophorus*	50	12500	26
9	*Rumex hastatus*	25	8333	15
10	*Solanum nigrum*	17	5833	10
13	*Xanthium indicum*	25	6667	13
14	*Nasturtium officinale*	17	5833	10
15	*Thysanolaena maxima*	25	10833	17
			110833	

Site V42: Beas Satluj Link : Upstream of Dam Site

Table 6.124: Community structure -Site V42 (Trees)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	TBC (m^2ha^{-1})	IVI
1	*Acacia modesta*	20	30	0.98	25
2	*Albizia lebbeck*	20	20	6.48	43
3	*Bombax ceiba*	10	30	0.98	20
4	*Dalbergia sissoo*	20	20	1.62	23
5	*Delonix regia*	40	30	5.78	53
6	*Ficus palmata*	40	30	3.92	46
7	*Sapium insigne*	20	20	0.72	20
8	*Pinus roxburghii*	50	80	3.92	70
			260		

Table 6.125: Community structure -Site V42 (Shrubs)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	IVI
1	*Artemisia capillaris*	20	600	28
2	*Caryopteris odorata*	30	500	50
3	*Adhatoda zeylanica*	20	400	25
4	*Debregeasia salicifolia*	20	300	34
5	*Eupatorium adenophorum*	30	500	41
6	*Lantana camara*	20	400	31
7	*Rhamnus virgatus*	20	400	43
8	*Myrsine africana*	30	500	47
			3600	

Table 6.126: Community structure -Site V42 (Herbs)

S.No.	Name of Species	Frequency	Density	IVI

		(%)	(ind./ha^{-1})	
	Pre Monsoon			
1	*Artemisia nilagirica*	33	12500	20
2	*Arundo donax*	17	6667	10
3	*Bidens pilosa*	25	11667	17
4	*Cannabis sativa*	25	1667	8
5	*Chenopodium album*	25	10833	16
6	*Cymbopogon martini*	25	7500	13
7	*Cynodon dactylon*	25	6667	12
8	*Cyperus rotundus*	33	9167	17
9	*Cyprus niveus*	25	5000	11
10	*Parthenium hysterophorus*	33	5833	14
11	*Poa annua*	25	7500	13
12	*Solanum nigrum*	33	10000	18
13	*Urginea indica*	25	8333	14
14	*Xanthium indicum*	25	12500	17
			115833	
	Monsoon			
1	*Artemisia nilagirica*	33	9167	15
2	*Bidens pilosa*	17	6667	9
3	*Cannabis sativa*	17	5833	9
4	*Cynodon dactylon*	50	13333	22
5	*Cyperus rotundus*	25	6667	11
6	*Datura stramonium*	33	10833	16
7	*Eulaliopsis binata*	25	7500	12
8	*Ipomea nil*	17	5833	9
9	*Nasturtium officinale*	25	10000	14
10	*Parthenium hysterophorus*	33	8333	14
11	*Poa annua*	25	11667	15
12	*Rumex hastatus*	25	1667	7
13	*Solanum nigrum*	33	9167	15
14	*Thysanolaena maxima*	25	5000	10
15	*Urginea indica*	33	5833	12
16	*Xanthium indicum*	17	7500	10
			125000	
	Winter			
1	*Artemisia nilagirica*	33	9167	19
2	*Cannabis sativa*	17	6667	12
3	*Cyperus rotundus*	17	5833	11
4	*Datura stramonium*	50	13333	28
5	*Eulaliopsis binata*	25	6667	14
6	*Nasturtium officinale*	33	10833	21
7	*Parthenium hysterophorus*	25	7500	15
8	*Poa annua*	17	5833	11
9	*Rumex hastatus*	25	10000	17
10	*Solanum nigrum*	33	8333	18
11	*Thysanolaena maxima*	25	11667	19
12	*Xanthium indicum*	25	6667	14
			102500	

Site V43: Beas Satluj Link : Downstream of Dam Site

Table 6.127: Community structure –Site V43 (Trees)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	TBC (m^2ha^{-1})	IVI
1	*Acacia modesta*	30	70	1.03	58
2	*Bombax ceiba*	30	60	3.54	71
3	*Dalbergia sissoo*	20	30	2.73	46
4	*Ficus palmata*	20	20	1.14	31
5	*Ougenia oojeinensis*	10	20	3.66	41
6	*Pinus roxburghii*	20	50	2.48	52
7			**250**		

Table 6.128: Community structure -Site V43 (Shrubs)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	IVI
1	*Inula cuspidata*	20	500	30
2	*Rosa brunonii*	10	400	23
3	*Adhatoda zeylanica*	10	200	39
4	*Lantana camara*	30	700	43
5	*Myrsine africana*	30	600	43
6	*Urtica dioica*	20	500	34
7	*Caryopteris odorata*	30	700	62
8	*Rhamnus virgatus*	20	500	26
		170	4100	

Table 6.129: Community structure -Site V43 (Herbs)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	IVI
	Pre Monsoon			
1	*Achyranthes aspera*	33	10833	18
2	*Ageratum conyzoides*	33	6667	14
3	*Ajuga parviflora*	25	7500	13
4	*Argemone mexicana*	25	8333	13
5	*Bidens bipinnata*	25	6667	12
6	*Cannabis sativa*	25	11667	16
7	*Cassia tora*	17	5000	8
8	*Chenopodium album*	33	9167	16
9	*Cymbopogon martini*	42	10833	20
10	*Cynodon dactylon*	50	9167	20
11	*Fragaria indica*	58	12500	25
12	*Impatiens balsamina*	25	3333	9
13	*Solanum nigrum*	33	9167	16
			110833	
	Monsoon			
1	*Achyranthes aspera*	33	7500	13
2	*Ageratum conyzoides*	42	8333	15
3	*Ajuga parviflora*	33	10833	16
4	*Argemone mexicana*	42	9167	16
5	*Bidens bipinnata*	25	6667	11
6	*Cannabis sativa*	33	11667	16
7	*Cassia tora*	33	9167	14
8	*Chenopodium album*	25	7500	11
9	*Cymbopogon martini*	33	12500	17
10	*Fragaria indica*	25	6667	11
11	*Impatiens balsamina*	17	11667	12
12	*Solanum nigrum*	33	9167	14
13	*Datura stramonium*	25	8333	12
14	*Thalictrum foliolosum*	33	7500	13
15	*Parthenium hysterophorus*	25	5000	9
			131667	
	Winter			
1	*Ageratum conyzoides*	17	4167	9
2	*Argemone mexicana*	33	8333	18
3	*Bidens bipinnata*	25	10000	17
4	*Cannabis sativa*	33	10833	21
5	*Cassia tora*	42	14167	26
6	*Chenopodium album*	17	7500	12
7	*Datura stramonium*	25	6667	14
8	*Parthenium hysterophorus*	33	10000	20
9	*Rumex hastatus*	25	8333	16
10	*Solanum nigrum*	25	7500	15

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	IVI
11	*Thalictrum foliolosum*	17	9167	14
12	*Urginea indica*	33	7500	17
			104167	

Site V44: Larji HEP : Right Bank of the Reservoir

Table 6.130: Community structure –Site V44 (Trees)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	TBC (m^2ha^{-1})	IVI
1	*Adina cordifolia*	20	30	0.86	20
2	*Bauhinia variegata*	30	60	0.73	30
3	*Bombax ceiba*	20	40	1.38	26
4	*Celtis australis*	20	30	2.41	30
5	*Dalbergia sissoo*	40	50	2.43	42
6	*Eucalyptus citriodora*	20	40	1.14	24
7	*Grewia optiva*	30	60	0.93	32
8	*Mallotus philippensis*	50	70	2.96	54
9	*Pinus roxburghii*	20	50	3.60	42
			430		

Table 6.131: Community structure –Site V44 (Shrubs)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	IVI
1	*Artemisia capillaris*	50	1100	51
2	*Berberis asiatica*	70	800	32
3	*Caryopteris odorata*	50	900	29
4	*Adhatoda zeylanica*	50	600	28
5	*Debregeasia salicifolia*	60	500	33
6	*Lantana camara*	50	400	30
7	*Rhamnus virgatus*	60	600	28
8	*Rosa brunonii*	10	300	17
9	*Urtica dioica*	40	300	52
			5500	

Table 6.132: Community structure –Site V44 (Herbs)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	IVI
	Pre Monsoon			
1	*Ageratum conyzoides*	33	11667	18
2	*Apluda mutica*	25	5833	11
3	*Artemisia capillaries*	33	9167	16
4	*Bidens bipinnata*	17	6667	10
5	*Cassia tora*	17	5833	9
6	*Colocasia esculenta*	50	13333	24
7	*Commelina benghalensis*	25	6667	12
8	*Datura stramonium*	17	5000	8
9	*Gnaphalium hypoleucum*	25	5833	11
10	*Poa annua*	33	10833	18
11	*Taraxacum officinale*	25	7500	13
12	*Thalictrum foliolosum*	17	5833	9
13	*Thamnocalamus falconeri*	25	10000	15
14	*Urginea indica*	33	8333	16
15	*Viola pilosa*	17	5833	9
			118333	
	Monsoon			
1	*Ageratum conyzoides*	25	9167	14
2	*Apluda mutica*	8	5000	6
3	*Artemisia capillaries*	17	11667	14
4	*Bidens bipinnata*	25	6667	12
5	*Cannabis sativa*	17	5000	9

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	IVI
6	*Cassia tora*	8	5833	7
7	*Commelina benghalensis*	17	6667	10
8	*Datura stramonium*	33	10000	17
9	*Gnaphalium hypoleucum*	25	7500	13
10	*Impatiens balsamina*	33	9167	16
11	*Rumex hastatus*	25	7500	13
12	*Solanum nigrum*	17	9167	12
13	*Taraxacum officinale*	25	5833	11
14	*Thalictrum foliolosum*	33	10000	17
15	*Urginea indica*	33	8333	16
16	*Viola pilosa*	25	7500	13
			125000	
	Winter			
1	*Ageratum conyzoides*	25	8333	17
2	*Artemisia capillaries*	8	10000	13
3	*Bidens bipinnata*	17	9167	15
4	*Cannabis sativa*	33	10833	22
5	*Cassia tora*	17	8333	14
6	*Datura stramonium*	33	7500	19
7	*Impatiens balsamina*	8	5833	9
8	*Rumex hastatus*	33	9167	20
9	*Solanum nigrum*	42	10833	25
10	*Thalictrum foliolosum*	33	8333	20
11	*Urginea indica*	25	7500	16
12	*Viola pilosa*	17	5833	11
			101667	

Site V45: Larji HEP : Downstream of Dam Site

Table 6.133: Community structure -Site V45 (Trees)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	TBC (m^2ha^{-1})	IVI
1	*Adina cordifolia*	20	20	1.73	37
2	*Bombax ceiba*	20	20	2.38	42
3	*Dalbergia sissoo*	30	30	1.41	45
4	*Eucalyptus citriodora*	10	40	2.43	45
5	*Lannea grandis*	20	40	0.96	39
6	*Mallotus philippensis*	20	30	1.14	36
7	*Mangifera indica*	30	50	1.60	56
			230		

Table 6.134: Community structure -Site V45 (Shrubs)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	TBC (m^2ha^{-1})	IVI
1	*Artemisia capillaris*	30	600	1.32	61
2	*Buddleja asiatica*	30	800	0.12	34
3	*Cannabis sativa*	30	500	0.23	30
4	*Desmodium elegans*	40	700	0.72	52
5	*Eupatorium adenophorum*	40	400	0.32	34
6	*Urtica dioica*	30	500	0.12	27
7	*Lantana camara*	40	800	1.03	62
			4300		

Table 6.135: Community structure -Site V45 (Herbs)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	IVI
	Pre Monsoon			
1	*Achyranthes aspera*	17	9167	11
2	*Ageratum conyzoides*	25	11667	15
3	*Ajuga parviflora*	17	14167	15

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	IVI
4	*Apluda mutica*	33	6667	13
5	*Argemone mexicana*	17	6667	9
6	*Artemisia capillaries*	25	11667	15
7	*Bidens bipinnata*	25	1667	7
8	*Cannabis sativa*	33	9167	15
9	*Cassia tora*	25	5000	10
10	*Chenopodium album*	33	5833	13
11	*Commelina benghalensis*	25	7500	12
12	*Datura stramonium*	25	7500	12
13	*Gnaphalium hypoleucum*	25	8333	13
14	*Poa annua*	25	6667	11
15	*Solanum nigrum*	8	2500	4
16	*Taraxacum officinale*	17	4167	7
17	*Urginea indica*	8	2500	4
18	*Xanthium indicum*	33	5833	13
			126667	
	Monsoon			
1	*Achyranthes aspera*	17	10833	14
2	*Ageratum conyzoides*	25	9167	15
3	*Ajuga parviflora*	17	12500	15
4	*Argemone mexicana*	17	9167	12
5	*Artemisia capillaries*	25	10833	16
6	*Cannabis sativa*	33	9167	18
7	*Cassia tora*	25	5833	12
8	*Chenopodium album*	33	7500	16
9	*Commelina benghalensis*	17	6667	10
10	*Datura stramonium*	8	5833	7
11	*Gnaphalium hypoleucum*	25	8333	14
12	*Solanum nigrum*	8	5000	7
13	*Taraxacum officinale*	25	8333	14
14	*Urginea indica*	25	9167	15
15	*Xanthium indicum*	25	7500	14
			125833	
	Winter			
1	*Ageratum conyzoides*	42	6667	16
2	*Argemone mexicana*	33	10000	17
3	*Artemisia capillaries*	17	8333	12
4	*Cannabis sativa*	33	12500	20
5	*Cassia tora*	58	13333	27
6	*Commelina benghalensis*	33	10000	17
7	*Datura stramonium*	58	8333	22
8	*Solanum nigrum*	17	3333	7
9	*Taraxacum officinale*	25	9167	15
10	*Urginea indica*	25	6667	12
11	*Xanthium indicum*	33	7500	15
12	*Parthenium hysterophorus*	42	10000	19
			105833	

Site V46: Patikari HEP: Upstream of Power House site

Table 6.136: Community structure -Site V46 (Trees)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	TBC (m^2ha^{-1})	IVI
1	*Albizia lebbeck*	40	30	0.77	35
2	*Alnus nepalensis*	50	70	3.40	74
3	*Bauhinia variegata*	40	50	0.79	42
4	*Celtis australis*	40	50	1.01	44
5	*Juglans regia*	10	20	3.12	36
6	*Pinus roxburghii*	30	70	3.90	68

			290		

Table 6.137: Community structure -Site V46 (Shrubs)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	IVI
1	*Berberis asiatica*	20	700	44
2	*Buddleja crispa*	20	300	17
3	*Elsholtzia fruticosa*	30	500	28
4	*Maesa chisia*	20	300	17
5	*Rosa brunonii*	10	300	21
6	*Sinarundinaria falcata*	20	500	48
7	*Solanum surattense*	10	300	20
8	*Spiraea canescens*	30	500	28
9	*Trevesia palmata*	40	700	43
10	*Vitex negundo*	20	600	33
			4700	

Table 6.138: Community structure -Site V46 (Herbs)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	IVI
	Pre Monsoon			
1	*Achyranthes asper*	8	4167	6
2	*Anaphalis contorta*	25	10000	15
3	*Andropogon ischaemum*	33	9167	17
4	*Impatiens bicolor*	17	8333	12
5	*Mentha longifolia*	25	15000	19
6	*Poa pratensis*	33	11667	19
7	*Bistorta macrophylla*	25	13333	18
8	*Bupleurum hamiltonii*	25	9167	14
9	*Delphinium denudatum*	25	7500	13
10	*Fagopyrum esculentum*	33	8333	16
11	*Fragaria nubicola*	33	4167	12
12	*Mentha longifolia*	25	6667	12
13	*Tagetes erecta*	33	1667	10
14	*Urtica dioica*	42	6667	17
			115833	
S. No.	**Name of the Species**			
1	*Achyranthes asper*	33	8333	16
2	*Anaphalis contorta*	17	7500	11
3	*Bistorta macrophylla*	25	9167	14
4	*Bupleurum hamiltonii*	17	7500	11
5	*Commelina benghalensis*	25	8333	14
6	*Delphinium denudatum*	17	5833	9
7	*Duchesnea indica*	17	7500	11
8	*Fagopyrum esculentum*	25	5000	11
9	*Fragaria nubicola*	33	8333	16
10	*Impatiens bicolor*	17	5833	9
11	*Mentha longifolia*	17	6667	10
12	*Pogostemon benghalense*	33	8333	16
13	*Rumex hastatus*	25	7500	13
14	*Solanum nigrum*	17	6667	10
15	*Tagetes erecta*	8	5833	7
16	*Taraxacum officinale*	17	7500	11
17	*Urena lobata*	17	9167	12
			125000	
S. No.	**Name of the Species**			
1	*Anaphalis contorta*	42	9167	20
2	*Bistorta macrophylla*	33	11667	20
3	*Bupleurum hamiltonii*	42	10000	21
4	*Delphinium denudatum*	33	7500	17
5	*Duchesnea indica*	33	10000	19

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	IVI
6	*Fagopyrum esculentum*	25	7500	14
7	*Mentha longifolia*	33	9167	18
8	*Pogostemon benghalense*	25	7500	14
9	*Rumex hastatus*	17	9167	13
10	*Solanum nigrum*	17	10833	15
11	*Taraxacum officinale*	17	6667	11
12	*Urena lobata*	33	8333	17
			107500	

Site V47: Khauli Khad HEP: Near Diversion Wier

Table 6.139: Community structure -Site V47 (Trees)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	TBC (m^2ha^{-1})	IVI
1	*Aesculus indica*	50	60	3.14	47
2	*Melia azedarach*	40	50	0.68	26
3	*Toona ciliata*	30	30	1.06	22
4	*Bauhinia variegata*	60	120	0.93	46
5	*Prunus domestica*	20	20	0.32	12
6	*Pinus roxburghii*	40	40	2.66	37
7	*Juglans regia*	50	80	3.68	55
8	*Quercus baloot*	60	130	2.04	56
			530		

Table 6.140: Community structure -Site V47 (Shrubs)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	IVI
1	*Desmodium elegans*	30	480	56
2	*Sarcococca saligna*	50	840	83
3	*Rhus parviflora*	10	40	8
4	*Rubus foliolosus*	10	120	33
5	*Viburnum grandiflorum*	30	160	36
6	*Rubus ellipticus*	20	240	24
7	*Indigofera tinctoria*	20	120	21
8	*Prinsepia utilis*	10	80	25
9	*Indigofera tinctoria*	10	40	15
			2120	

Table 6.141: Community structure -Site V47 (Herbs)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	IVI
	Pre Monsoon			
1	*Fragaria vesca*	33	14167	28
2	*Trifolium pratense*	17	8333	15
3	*Stellaria media*	8	2500	6
4	*Plantago major*	33	12500	26
5	*Anaphalis busua*	25	4167	14
6	*Bidens pilosa*	33	6667	20
7	*Rumex hastatus*	25	5833	16
8	*Strobilanthes alatus*	25	8333	18
9	*Pteridium aquilinum*	17	11667	19
10	*Oxalis corniculata*	17	3333	10
11	*Arundinella nepalensis*	8	4167	8
12	*Arisaema jacquemontii*	25	10000	20
			91667	
	Monsoon			
1	*Arisaema jacquemontii*	33	7500	16
2	*Artemisia nilagirica*	25	6667	13
3	*Arundinella nepalensis*	17	5833	10

4	*Arundo donax*	17	9167	13
5	*Bidens pilosa*	33	6667	16
6	*Chenopodium album*	25	8333	15
7	*Cymbopogon martini*	17	5833	10
8	*Cyperus rotundus*	25	7500	14
9	*Fragaria vesca*	25	6667	13
10	*Ipomea nil*	25	7500	14
11	*Oxalis corniculata*	25	5833	12
12	*Parthenium hysterophorus*	25	7500	14
13	*Pteridium aquilinum*	25	5000	12
14	*Solanum nigrum*	25	9167	16
15	*Stellaria media*	17	7500	12
			106667	
	Winter			
1	*Anaphalis busua*	33	8333	22
2	*Artemisia nilagirica*	25	5833	16
3	*Arundinella nepalensis*	17	6667	14
4	*Bidens pilosa*	17	8333	16
5	*Chenopodium album*	33	7500	21
6	*Cymbopogon martini*	25	9167	20
7	*Cyperus rotundus*	17	5000	12
8	*Parthenium hysterophorus*	25	8333	19
9	*Pteridium aquilinum*	25	5833	16
10	*Rumex hastatus*	25	9167	20
11	*Solanum nigrum*	25	6667	17
12	*Trifolium pratense*	8	4167	8
			85000	

Table 6.142: Community structure -Site V48 (Trees)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	TBC (m^{2}ha^{-1})	IVI
1	*Broussonetia papyrifera*	10	20	16	16
2	*Cassine glauca*	10	20	15	15
3	*Dalbergia sissoo*	10	10	29	29
4	*Ficus palmata*	30	40	32	32
5	*Grewia optiva*	10	10	14	14
6	*Holoptelea integrifolia*	20	30	39	39
7	*Kydia calycina*	20	20	29	29
8	*Moringa oleifera*	20	20	24	24
9	*Naringi crenulata*	40	60	43	43
10	*Ougenia oojeinensis*	10	10	21	21
11	*Sapium insigne*	30	40	38	38
	Total	210	**280**	**300**	

Table 6.143: Community structure -Site V48 (Shrubs)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	IVI
1	*Adhatoda zeylanica*	20	300	38
2	*Carissa spinarum*	30	400	44
3	*Murraya koenigii*	40	500	53
4	*Ziziphus jujuba*	20	200	42
5	*Lantana camara*	60	700	58
6	*Mimosa himalayana*	30	300	26
7	*Caryopteris odorata*	20	200	20
8	*Vitex negundo*	20	200	18
	Total	240	**2800**	**300**

Table 6.144: Community structure -Site V48 (Herbs)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	IVI
	Pre Monsoon			
1	*Ageratum conyzoides*	42	11667	26
2	*Cenchrus cilaris*	33	10000	21
3	*Cynodon dactylon*	33	12500	24
4	*Cyperus rotundus*	50	15000	32
5	*Duchesnea indica*	25	10000	18
6	*Eulaliopsis binata*	33	12500	24
7	*Poa annua*	42	20000	34
8	*Solanum nigrum*	33	10833	22
	Total		**102500**	
	Monsoon			
1	*Achyranthes bidentata*	33	6667	18
2	*Ageratum conyzoides*	25	12500	20
3	*Cenchrus cilaris*	17	10000	15
4	*Centella asiatica*	33	7500	19
5	*Chrysopogon fulvus*	17	9167	14
6	*Cyperus rotundus*	17	7500	13
7	*Duchesnea indica*	17	9167	14
8	*Eulaliopsis binata*	33	8333	20
9	*Euphorbia hirta*	25	9167	17
10	*Nasturtium officinale*	17	6667	12
11	*Pilea umbrosa*	17	9167	14
12	*Ranunculus arvensis*	17	7500	13
13	*Solanum nigrum*	8	6667	9
			110000	
	Winter			
1	*Achyranthes bidentata*	17	9167	17

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	IVI
2	*Ageratum conyzoides*	33	12500	27
3	*Centella asiatica*	17	7500	15
4	*Chrysopogon fulvus*	33	8333	23
5	*Duchesnea indica*	25	9167	20
6	*Eulaliopsis binata*	17	6667	14
7	*Euphorbia hirta*	17	11667	20
8	*Nasturtium officinale*	33	9167	24
9	*Ranunculus arvensis*	17	8333	16
10	*Solanum nigrum*	33	10000	25
			92500	

Site V49: Neogal HEP: Upstream of Power House site

Table 6.145: Community structure -Site V49 (Trees)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	TBC (m^2ha^{-1})	IVI
1	*Alnus nepalensis*	50	70	14.16	30
2	*Bauhinia variegata*	10	20	10.01	15
3	*Cedrus deodara*	40	70	42.41	29
4	*Celtis australis*	20	20	8.70	13
5	*Juglans regia*	10	20	11.79	27
6	*Pinus wallichiana*	30	40	3.90	20
7	*Pyrus pashia*	10	30	2.29	24
8	*Quercus semecarpifolia*	30	40	14.01	20
		200	310	107.27	300

Table 6.146: Community structure -Site V49 (Shrubs)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	IVI
1	*Adhatoda zeylanica*	30	400	25
2	*Berberis aristata*	50	700	35
3	*Cotoneaster microphyllus*	10	300	10
4	*Debregeasia salicifolia*	20	400	40
5	*Desmodium elegans*	10	200	8
6	*Indigofera heterantha*	10	500	13
7	*Indigofera tinctoria*	20	300	39
8	*Prinsepia utilis*	30	700	30
9	*Rhamnus virgatus*	20	600	19
10	*Rosa brunonii*	30	500	42
11	*Sarcococca saligna*	30	400	20
12	*Viburnum grandiflorum*	20	600	18
		280	**5600**	**300**

Table 6.147: Community structure -Site V49 (Herbs)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	IVI
	Pre Monsoon			
1	*Artemisia capillaris*	25	6667	17
2	*Berberis asiatica*	17	5833	12
3	*Buddleja asiatica*	33	15000	28
4	*Cannabis sativa*	25	12500	22
5	*Colebrookea oppositifolia*	25	4167	14
6	*Begonia picta*	8	11667	15
7	*Eupatorium adenophorum*	17	12500	19
8	*Inula cuspidata*	33	8333	22
9	*Lantana camara*	25	5833	16
10	*Rhus parviflora*	25	13333	23
11	*Urtica dioica*	17	5000	12
			100833	

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	IVI
	Monsoon			
1	*Artemisia capillaris*	25	10833	17
2	*Aster peduncularis*	17	8333	13
3	*Begonia picta*	25	10000	17
4	*Buddleja asiatica*	17	7500	12
5	*Cannabis sativa*	33	10000	19
6	*Chenopodium album*	25	8333	15
7	*Colebrookea oppositifolia*	17	5833	10
8	*Eragrostis pilosa*	25	8333	15
9	*Eupatorium adenophorum*	25	10833	17
10	*Inula cuspidata*	25	6667	14
11	*Lantana camara*	33	9167	18
12	*Rhus parviflora*	33	7500	17
13	*Urtica dioica*	25	9167	16
			112500	
	Winter			
1	*Artemisia capillaris*	25	8333	17
2	*Begonia picta*	17	10833	16
3	*Buddleja asiatica*	33	8333	20
4	*Cannabis sativa*	25	9167	18
5	*Colebrookea oppositifolia*	33	11667	23
6	*Eragrostis pilosa*	17	8333	14
7	*Eupatorium adenophorum*	33	13333	25
8	*Inula cuspidata*	25	10000	19
9	*Rumex hastatus*	25	10833	19
10	*Trigonella corniculata*	50	11667	29
			102500	

Site V50: Binwa HEP: Near Power House Site

Table 6.148: Community structure -Site V50 (Trees)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	TBC (m^2ha^{-1})	IVI
1	*Bombax ceiba*	20	20	2.40	17
2	*Pyrus pashia*	20	30	0.48	16
3	*Toona hexandra*	20	20	3.66	19
4	*Populus ciliata*	10	30	1.03	14
5	*Grewia optiva*	30	40	0.54	23
6	*Morus alba*	20	20	0.56	14
7	*Bauhinia variegata*	30	40	5.01	30
8	*Juglans regia*	30	20	24.41	58
9	*Celtis australis*	30	50	7.98	38
10	*Pinus roxburghii*	30	50	12.28	45
11	*Alnus nepalensis*	40	40	0.77	27
			360		

Table 6.149: Community structure -Site V50 (Shrubs)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	IVI
1	*Artemisia capillaris*	30	600	34
2	*Buddleja asiatica*	20	500	20
3	*Debregeasia salicifolia*	10	300	22
4	*Indigofera tinctoria*	30	500	36
5	*Inula cuspidata*	20	600	23
7	*Rhus parviflora*	30	500	26
8	*Rosa brunonii*	20	400	25
9	*Rubus ellipticus*	40	600	35
10	*Sarcococca saligna*	60	500	40

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	IVI
11	*Urtica dioica*	20	400	22
12	*Zanthoxylum armatum*	20	300	17
			5200	

Table 6.150: Community structure -Site V50 (Herbs)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	IVI
	Pre Monsoon			
1	*Ageratum conyzoides*	25	5833	14
2	*Amaranthus hybridus*	8	12500	14
3	*Apluda mutica*	33	6667	17
4	*Aster peduncularis*	17	8333	13
5	*Begonia picta*	25	5000	13
6	*Cannabis sativa*	25	12500	20
7	*Chenopodium album*	17	9167	14
8	*Datura stramonium*	25	11667	19
9	*Desmodium microphyllum*	17	5833	11
10	*Eragrostis pilosa*	33	12500	22
11	*Fragaria indica*	25	10000	17
12	*Oxalis acetosella*	17	5000	10
13	*Polygonum plebeium*	25	8333	16
			113333	
	Monsoon			
1	*Ageratum conyzoides*	25	5833	12
2	*Apluda mutica*	8	12500	13
3	*Aster peduncularis*	33	6667	16
4	*Begonia picta*	17	8333	12
5	*Cannabis sativa*	25	5000	12
6	*Chenopodium album*	25	12500	18
7	*Datura stramonium*	17	9167	13
8	*Desmodium microphyllum*	25	11667	17
9	*Eragrostis pilosa*	17	5833	10
10	*Polygonum plebeium*	33	12500	20
11	*Bidens pilosa*	25	10000	16
12	*Impatiens glandulifera*	17	5000	9
13	*Rumex hastatus*	25	8333	14
14	*Stellaria media*	33	9167	18
			122500	
	Winter			
1	*Ageratum conyzoides*	25	5833	15
2	*Apluda mutica*	8	12500	15
3	*Aster peduncularis*	33	6667	19
4	*Begonia picta*	17	8333	14
5	*Bidens pilosa*	25	5000	14
6	*Colebrookea oppositifolia*	25	12500	21
7	*Datura stramonium*	17	9167	15
8	*Eragrostis pilosa*	25	11667	20
9	*Parthenium hysterophorus*	17	5833	12
10	*Polygonum plebeium*	33	12500	24
11	*Rumex hastatus*	25	10000	19
12	*Stellaria media*	17	5000	11
			105000	

Site V51: Baner I: Upstream of Power House Site

Table 6.151: Community structure -Site V51 (Trees)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	TBC (m^2ha^{-1})	IVI
1	*Alnus nepalensis*	40	60	11.38	52
2	*Juglans regia*	40	20	13.41	46

3	*Populus ciliata*	20	20	10.43	34
4	*Olea ferruginea*	40	30	1.14	22
5	*Pinus roxburghii*	50	130	2.73	54
6	*Morus alba*	50	50	2.43	33
7	*Ficus palmata*	60	20	2.97	29
8	*Quercus leucotrichophora*	40	60	1.04	29
			390		

Table 6.152: Community structure -Site V51 (Shrubs)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	IVI
1	*Myrsine africana*	30	400	19
2	*Rosa brunonii*	40	700	32
3	*Cannabis sativa*	30	300	29
4	*Debregeasia salicifolia*	40	600	36
5	*Rubus ellipticus*	20	300	27
6	*Colebrookea oppositifolia*	40	800	25
7	*Viburnum grandiflorum*	20	300	11
8	*Inula cuspidata*	30	500	16
9	*Berberis aristata*	40	400	33
10	*Indigofera tinctoria*	20	400	14
11	*Rhamnus virgatus*	30	500	16
12	*Sarcococca saligna*	40	700	25
13	*Zanthoxylum armatum*	20	300	17
			6200	

Table 6.153: Community structure -Site V51 (Herbs)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	IVI
	Pre Monsoon			
1	*Ageratum conyzoides*	17	7500	13
2	*Achyranthes bidentata*	17	14167	20
3	*Ajuga parviflora*	33	10000	22
4	*Artemisia vulgaris*	25	8333	17
5	*Bidens pilosa*	33	6667	19
6	*Colocasia esculenta*	25	16667	25
7	*Cannabis sativa*	17	8333	14
8	*Fragaria vesca*	33	9167	21
9	*Impatiens glandulifera*	25	10000	19
10	*Rumex hastatus*	25	4167	13
11	*Stellaria media*	25	6667	16
			101667	
	Monsoon			
1	*Ageratum conyzoides*	25	9167	16
2	*Ajuga parviflora*	33	10833	20
3	*Artemisia vulgaris*	17	8333	13
4	*Aster peduncularis*	25	10000	17
5	*Bidens pilosa*	25	8333	15
6	*Cannabis sativa*	25	5000	12
7	*Datura stramonium*	33	9167	18
8	*Desmodium microphyllum*	25	10833	18
9	*Eragrostis pilosa*	17	8333	13
10	*Impatiens glandulifera*	33	9167	18
11	*Polygonum plebeium*	25	7500	14
12	*Rumex hastatus*	25	5000	12
13	*Stellaria media*	25	6667	14
			108333	
	Winter			
1	*Ageratum conyzoides*	33	14167	30
2	*Artemisia vulgaris*	17	9167	17

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	IVI
3	*Aster peduncularis*	17	5833	13
4	*Bidens pilosa*	17	9167	17
5	*Cannabis sativa*	25	10000	22
6	*Datura stramonium*	8	4167	8
7	*Eragrostis pilosa*	17	8333	16
8	*Impatiens glandulifera*	17	6667	14
9	*Parthenium hysterophorus*	17	15000	23
10	*Rumex hastatus*	33	5833	21
11	*Stellaria media*	25	7500	19
			95833	

Site V52: Baner HEP: Downstream of Diversion Weir

Table 6.154: Community structure -Site V52 (Trees)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	TBC (m^2ha^{-1})	IVI
1	*Alnus nepalensis*	30	40	11.38	44
2	*Bauhinia variegata*	30	20	13.41	43
3	*Toona hexandra*	20	20	10.43	33
4	*Celtis australis*	40	30	1.14	23
5	*Pinus roxburghii*	50	130	2.73	57
6	*Populus ciliata*	50	50	2.73	35
7	*Dalbergia sissoo*	40	20	2.43	23
8	*Naringi crenulata*	20	20	2.97	18
9	*Ougeinia oojeinensis*	40	30	1.04	23
			360		

Table 6.155: Community structure -Site V52 (Shrubs)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	IVI
1	*Artemisia capillaris*	20	400	30
2	*Berberis asiatica*	20	500	36
3	*Buddleja asiatica*	20	300	20
4	*Cannabis sativa*	20	500	26
5	*Colebrookea oppositifolia*	10	300	22
6	*Debregeasia salicifolia*	30	500	40
7	*Eupatorium adenophorum*	20	600	38
8	*Inula cuspidata*	60	500	37
9	*Lantana camara*	20	400	33
10	*Urtica dioica*	20	300	17
			4300	

Table 6.156: Community structure -Site V52 (Herbs)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	IVI
	Pre Monsoon			
1	*Ageratum conyzoides*	33	8333	16
2	*Ajuga parviflora*	33	8333	16
3	*Apluda mutica*	25	10000	15
4	*Aster peduncularis*	33	14167	20
5	*Cannabis sativa*	17	8333	11
6	*Colocasia esculenta*	25	15000	19
7	*Datura stramonium*	25	4167	10
8	*Eragrostis pilosa*	17	6667	10
9	*Fragaria indica*	17	8333	11
10	*Geranium ocellatum*	25	15000	19
11	*Girardinia heterophylla*	25	4167	10
12	*Micromeria biflora*	33	14167	20

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	IVI
13	*Polygonum plebeium*	25	4167	10
14	*Rumex hastatus*	33	6667	14
		367	127500	
	Monsoon			
1	*Ageratum conyzoides*	25	7500	12
2	*Ajuga parviflora*	17	8333	10
3	*Aster peduncularis*	25	5000	10
4	*Cannabis sativa*	25	12500	15
5	*Colocasia esculenta*	17	9167	11
6	*Datura stramonium*	33	10000	16
7	*Echinops niveus*	25	8333	12
8	*Eragrostis pilosa*	33	6667	14
9	*Euphorbia hirta*	25	16667	18
10	*Fragaria indica*	17	8333	10
11	*Geranium ocellatum*	33	9167	15
12	*Impatiens glandulifera*	33	14167	19
13	*Polygonum plebeium*	17	8333	10
14	*Rumex hastatus*	25	15000	17
15	*Trigonella corniculata*	25	4167	10
			143333	
	Winter			
1	*Ageratum conyzoides*	33	12500	24
2	*Aster peduncularis*	17	6667	12
3	*Cannabis sativa*	25	10000	18
4	*Datura stramonium*	8	5833	8
5	*Eragrostis pilosa*	17	10000	15
6	*Euphorbia hirta*	25	13333	21
7	*Fragaria indica*	17	5833	12
8	*Geranium ocellatum*	8	7500	10
9	*Begonia picta*	25	10833	19
10	*Rumex hastatus*	17	11667	17
11	*Stellaria media*	33	14167	25
12	*Trigonella corniculata*	25	10000	18
			118333	

Site V53: Kilhi Bahl HEP: Proposed Project Area of Kilhi Bahl HEP

Table 6.157: Community structure –Site V53 (Trees)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	TBC (m^2ha^{-1})	IVI
1	*Alnus nepalensis*	30	40	1.60	28
2	*Bombax ceiba*	10	30	2.43	19
3	*Cupressus torulosa*	20	30	1.84	22
4	*Grevillea robusta*	20	20	1.97	19
5	*Lyonia ovalifolia*	10	30	2.12	18
6	*Pinus roxburghii*	30	40	5.52	39
7	*Prunus cerasoides*	20	20	3.76	24
8	*Pyrus pashia*	40	70	3.79	46
9	*Quercus leucotrichophora*	20	30	6.90	36
10	*Symplocos paniculata*	30	30	2.01	26
11	*Toona hexandra*	20	20	3.12	22
			360		

Table 6.158: Community structure –Site V53 (Shrubs)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	IVI
1	*Artemisia roxburghii*	10	300	18
2	*Cannabis sativa*	40	700	41

3	*Cotoneaster acuminatus*	10	100	19
4	*Debregeasia salicifolia*	40	700	41
5	*Desmodium elegans*	30	300	29
6	*Colebrookea oppositifolia*	30	300	17
7	*Debregeasia longifolia*	30	400	18
8	*Eupatorium adenophorum*	40	800	32
9	*Inula cuspidata*	30	500	31
10	*Rubus ellipticus*	20	500	31
11	*Urtica dioica*	30	500	24
			5100	

Table 6.159: Community structure -Site V53 (Herbs)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	IVI
	Pre Monsoon			
1	*Ageratum conyzoides*	25	6667	14
2	*Apluda mutica*	33	8333	19
3	*Colocasia esculenta*	33	8333	19
4	*Datura stramonium*	25	18333	25
5	*Geranium ocellatum*	25	10000	18
6	*Fragaria indica*	33	12500	23
7	*Oxalis acetosella*	25	4167	12
8	*Polygonum plebeium*	33	15000	25
9	*Sonchus asper*	25	10833	18
10	*Polygonum plebeium*	33	5000	16
11	*Rumex hastatus*	17	6667	12
			105833	
	Monsoon			
1	*Ageratum conyzoides*	25	6667	14
2	*Apluda mutica*	33	8333	19
3	*Colocasia esculenta*	33	8333	19
4	*Datura stramonium*	25	18333	25
5	*Geranium ocellatum*	25	10000	18
6	*Polygonum plebeium*	33	12500	23
7	*Parthenium hysterophorus*	25	4167	12
8	*Rumex hastatus*	33	15000	25
9	*Bidens pilosa*	25	10833	18
10	*Desmodium microphyllum*	33	5000	16
11	*Eragrostis pilosa*	17	6667	12
			105833	
	Winter			
1	*Ageratum conyzoides*	25	9167	18
2	*Apluda mutica*	33	10000	22
3	*Bidens pilosa*	17	6667	13
4	*Colocasia esculenta*	25	10000	19
5	*Datura stramonium*	50	8333	26
6	*Eragrostis pilosa*	25	13333	23
7	*Euphorbia hirta*	17	7500	14
8	*Parthenium hysterophorus*	33	10833	23
9	*Trigonella corniculata*	33	12500	25
10	*Rumex hastatus*	25	8333	17
			96667	

Site V54: Pong HEP: Right Bank of Reservoir

Table 6.160: Community structure -Site V54 (Trees)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	TBC (m^2ha^{-1})	IVI
1	*Acacia modesta*	20	30	8.00	47
2	*Albizia lebbeck*	20	30	9.70	51
3	*Bombax ceiba*	20	20	13.50	54

4	*Dalbergia sissoo*	20	20	5.40	36
5	*Ficus palmata*	20	20	1.00	26
6	*Grewia optiva*	10	10	1.60	16
7	*Mallotus philippensis*	30	50	2.90	53
8	*Punica granatum*	10	10	2.00	16
	Total		**190**		

Table 6.161: Community structure -Site V54 (Shrubs)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	IVI
1	*Adhatoda zeylanica*	20	300	41
2	*Ampelocissus latifolia*	20	200	33
3	*Arundinella nepalensis*	10	100	13
4	*Asparagus adscendens*	20	200	20
5	*Carissa spinarum*	30	400	35
6	*Caryopteris odorata*	20	200	35
7	*Lantana camara*	50	700	73
8	*Solanum erianthum*	20	200	24
9	*Ziziphus jujuba*	20	200	26
	Total		**2500**	

Table 6.162: Community structure -Site V54 (Herbs)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	IVI
	Pre Monsoon			
1	*Ageratum conyzoides*	33	14167	29
2	*Cynodon dactylon*	25	10833	22
3	*Cyperus rotundus*	33	8333	23
4	*Nasturtium officinale*	25	12500	23
5	*Parthenium hysterophorus*	17	20000	27
6	*Poa annua*	33	15833	30
7	*Solanum nigrum*	33	10000	25
8	*Urginea indica*	25	10833	22
	Total		**102500**	
	Monsoon			
1	*Ageratum conyzoides*	25	9167	16.64
2	*Cyperus rotundus*	50	12500	27.84
3	*Curcuma aromatica*	25	10000	17.41
4	*Eulaliopsis binata*	17	10000	14.71
5	*Nasturtium officinale*	33	7500	17.79
6	*Parthenium hysterophorus*	17	10833	15.48
7	*Solanum nigrum*	33	10000	20.11
8	*Urena lobata*	33	12500	22.44
9	*Urginea indica*	50	15000	30.17
10	*Xanthium indicum*	25	10000	17.41
			107500	
	Winter			
1	*Ageratum conyzoides*	42	14167	31
2	*Artemisia nilagirica*	25	10000	20
3	*Eulaliopsis binata*	8	5000	8
4	*Bidens pilosa*	17	7500	14
5	*Nasturtium officinale*	33	9167	22
6	*Parthenium hysterophorus*	17	10833	18
7	*Solanum nigrum*	50	18333	38
8	*Urginea indica*	50	15000	35
9	*Xanthium indicum*	17	6667	13
			96667	

Site V55: Pong HEP: Left Bank of Reservoir

Table 6.163: Community structure -Site V55 (Trees)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	TBC (m^2ha^{-1})	IVI
1	*Acacia catechu*	20	30	6.48	88
2	*Lannea coromandelica*	40	50	1.62	74
3	*Prunus persica*	10	10	0.72	20
4	*Sapium insigne*	20	20	1.28	38
5	*Syzygium cumini*	40	60	1.62	80
	Total		**170**		

Table 6.164: Community structure -Site V55 (Shrubs)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	IVI
1	*Adhatoda zeylanica*	20	200	38
2	*Asparagus adscendens*	20	200	30
3	*Boehmeria macrophylla*	40	600	53
4	*Carissa spinarum*	40	400	47
5	*Mimosa himalayana*	20	300	30
6	*Murraya koenigii*	40	500	43
7	*Solanum erianthum*	20	200	36
8	*Ziziphus jujuba*	20	200	23
	Total		**2600**	

Table 6.165: Community structure -Site V55 (Herbs)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	IVI
	Pre Monsoon			
1	*Ageratum conyzoides*	25	15000	23
2	*Curculingo orchioides*	17	15833	21
3	*Curcuma aromatica*	25	9167	18
4	*Cuscuta reflexa*	50	12500	31
5	*Cynodon dactylon*	25	10000	19
6	*Eulaliopsis binata*	17	10833	16
7	*Oxalis corniculata*	33	13333	25
8	*Poa annua*	17	10000	16
9	*Urena lobata*	25	7500	17
10	*Xanthium indicum*	17	8333	14
	Monsoon			
1	*Ageratum conyzoides*	25	11667	19.5
2	*Bidens pilosa*	17	9167	14.3
3	*Curculingo orchioides*	8	10000	12
4	*Curcuma aromatica*	33	10833	21.8
5	*Cymbopogon martini*	25	8333	16.6
6	*Eulaliopsis binata*	25	10000	18
7	*Nasturtium officinale*	17	10833	15.8
8	*Oxalis corniculata*	25	11667	19.5
9	*Poa annua*	25	10833	18.8
10	*Urena lobata*	50	10000	27.1
11	*Xanthium indicum*	25	8333	16.6
			111667	
	Winter			
1	*Ageratum conyzoides*	33	15000	28
2	*Bidens pilosa*	42	7500	24
3	*Curcuma aromatica*	25	9167	19
4	*Cymbopogon martini*	17	10833	17
5	*Eulaliopsis binata*	25	9167	19
6	*Nasturtium officinale*	25	8333	18
7	*Parthenium hysterophorus*	33	13333	26
8	*Poa annua*	17	8333	15
9	*Urena lobata*	25	10833	20
10	*Xanthium indicum*	17	8333	15

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	IVI
			100833	

Site V56: Thana Palun I: Near Proposed Dam Site

Table 6.166: Community structure –Site V56 (Trees)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	TBC (m^2ha^{-1})	IVI
1	*Bombax ceiba*	50	800	2.14	64
2	*Bombax ceiba*	30	400	2.43	47
3	*Grewia optiva*	40	500	1.04	40
4	*Lannea grandis*	40	600	1.97	52
5	*Mallotus philippensis*	40	500	0.60	36
6	*Toona hexandra*	60	700	1.79	61
			3500		

Table 6.167: Community structure –Site V56 (Shrubs)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	IVI
1	*Artemisia capillaris*	30	400	46
2	*Buddleja asiatica*	40	700	38
3	*Eupatorium adenophorum*	30	300	25
4	*Indigofera astragalina*	20	300	29
5	*Myrsine africana*	30	500	44
6	*Colebrookea oppositifolia*	40	800	39
7	*Urtica dioica*	20	300	21
8	*Lantana camara*	70	800	58
			4100	

Table 6.168: Community structure –Site V56 (Herbs)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	IVI
	Pre Monsoon			
1	*Ageratum conyzoides*	25	11667	20
2	*Anaphalis adnata*	17	9167	15
3	*Apluda mutica*	25	12500	21
4	*Bidens bipinnata*	17	5833	12
5	*Cassia tora*	17	9167	15
6	*Colocasia affinis*	8	10000	12
7	*Cynodon dactylon*	25	20000	27
8	*Euphorbia hirta*	25	4167	14
9	*Fragaria nubicola*	17	6667	13
10	*Hedychium spicatum*	17	10833	16
11	*Malva parviflora*	25	11667	20
12	*Oxalis corniculata*	17	12500	17
		233	124167	1.54
	Monsoon			
1	*Ageratum conyzoides*	42	8333	17
2	*Anaphalis adnata*	25	5000	10
3	*Bidens bipinnata*	33	6667	14
4	*Cassia tora*	25	5833	11
5	*Colocasia affinis*	33	10000	16
6	*Curculingo orchioides*	33	11667	18
7	*Duchesnea indica*	42	10000	18
8	*Euphorbia hirta*	33	7500	14
9	*Fragaria nubicola*	33	10000	16
10	*Malva parviflora*	25	7500	12
11	*Oxalis corniculata*	33	9167	16
12	*Solanum nigrum*	25	7500	12
13	*Urena lobata*	17	9167	12

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	IVI
14	*Gnaphalium hypoleucum*	17	10833	13
		417	119167	200
	Winter			
1	*Ageratum conyzoides*	42	8333	21
2	*Bidens bipinnata*	25	5000	12
3	*Cassia tora*	33	6667	17
4	*Duchesnea indica*	25	5833	13
5	*Eragrostis pilosa*	33	10000	20
6	*Euphorbia hirta*	33	11667	22
7	*Fragaria nubicola*	42	10000	23
8	*Malva parviflora*	33	7500	17
9	*Parthenium hysterophorus*	33	10000	20
10	*Solanum nigrum*	25	7500	15
11	*Urena lobata*	33	9167	19
			91667	

Site V57: Thana Palun II: Downstream of Proposed Dam Site

Table 6.169: Community structure -Site V57 (Trees)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	TBC (m^2ha^{-1})	IVI
1	*Azadirachta indica*	30	50	0.85	40
2	*Eucalyptus citriodora*	30	50	1.52	45
3	*Lannea grandis*	20	40	3.76	52
4	*Mallotus philippensis*	20	60	4.84	66
5	*Phoenix humilis*	30	50	2.12	49
6	*Populus deltoides*	40	60	0.87	49
			310		

Table 6.170: Community structure -Site V57 (Shrubs)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	IVI
1	*Boehmeria macrophylla*	30	500	29
2	*Carissa spinarum*	20	400	25
3	*Buddleja crispa*	20	300	19
4	*Ziziphus jujuba*	10	300	31
5	*Carissa spinarum*	20	500	24
6	*Murraya koenigii*	10	300	17
7	*Ziziphus jujuba*	40	700	44
8	*Mimosa himalayana*	30	300	37
9	*Caryopteris odorata*	30	300	24
10	*Vitex negundo*	10	200	20
12	*Urtica dioica*	30	800	32
			4600	

Table 6.171: Community structure -Site V57 (Herbs)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	IVI
	Pre Monsoon			
1	*Achyranthes asper*	25	7500	12
2	*Ajuga parviflora*	33	8333	14
3	*Andropogon ischaemum*	25	6667	11
4	*Artemisia capillaries*	33	1667	8
5	*Bidens bipinnata*	42	8333	16
6	*Cynodon dactylon*	25	5000	9
7	*Euphorbia hirta*	33	6667	13
8	*Gnaphalium hypoleucum*	25	5833	10

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	IVI
9	*Malva parviflora*	33	10000	16
10	*Pilea scripta*	33	11667	17
11	*Pogostemon benghalense*	42	10000	17
12	*Rumex nepalensis*	33	7500	13
13	*Tagetes erecta*	42	9167	16
14	*Thalictrum foliolosum*	25	6667	11
15	*Urtica dioica*	50	7500	17
			112500	
	Monsoon			
1	*Achyranthes asper*	25	7500	12
2	*Andropogon ischaemum*	33	9167	15
3	*Artemisia capillaries*	42	8333	16
4	*Bidens bipinnata*	25	6667	11
5	*Commelina benghalensis*	25	9167	13
6	*Duchesnea indica*	25	8333	12
7	*Euphorbia hirta*	17	6667	9
8	*Gnaphalium hypoleucum*	17	7500	10
9	*Pilea scripta*	33	10000	16
10	*Pogostemon benghalense*	42	8333	16
11	*Rumex hastatus*	17	7500	10
12	*Solanum nigrum*	25	9167	13
13	*Tagetes erecta*	33	8333	14
14	*Taraxacum officinale*	17	5833	8
15	*Thalictrum foliolosum*	33	7500	14
16	*Urena lobata*	17	9167	11
			129167	
	Winter			
1	*Achyranthes asper*	17	8333	13
2	*Artemisia capillaries*	33	12500	21
3	*Bidens bipinnata*	58	13333	28
4	*Euphorbia hirta*	33	10000	19
5	*Gnaphalium hypoleucum*	58	8333	23
6	*Malva parviflora*	17	3333	8
7	*Rumex hastatus*	25	5833	12
8	*Solanum nigrum*	33	10000	19
9	*Taraxacum officinale*	33	11667	20
10	*Urena lobata*	42	10000	21
11	*Xanthium indicum*	33	7500	16
			100833	

Site V58: Trivani Mahadev HEP: Upstream of Proposed Dam Site

Table 6.172: Community structure –Site V58 (Trees)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	TBC (m^2ha^{-1})	IVI
1	*Acacia catechu*	20	30	6.48	27
2	*Albizia lebbeck*	20	20	7.22	26
3	*Bombax ceiba*	20	20	11.52	36
4	*Bridelia retusa*	20	30	2.42	18
5	*Cassia fistula*	10	10	1.62	9
6	*Emblica officinalis*	50	60	1.62	33
7	*Ficus semicordata*	10	20	1.28	10
8	*Ficus religiosa*	10	10	2.88	12
9	*Flacourtia indica*	20	40	1.28	18
10	*Lannea coromandelica*	20	40	1.28	18
11	*Litsea glutinosa*	40	60	0.82	28
12	*Mallotus philippensis*	30	40	2.88	25
13	*Pyrus pashia*	10	10	0.50	6
14	*Sapium insigne*	20	30	3.08	20

15	*Syzygium cumini*	20	20	1.28	14
16	**Total**		**440**		

Table 6.173: Community structure -Site V58 (Shrubs)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	IVI
1	*Adhatoda zeylanica*	20	300	32
2	*Asparagus adscendens*	30	400	30
3	*Boehmeria macrophylla*	50	600	61
4	*Carissa spinarum*	40	400	47
5	*Mimosa himalayana*	30	300	20
6	*Murraya koenigii*	100	1200	69
7	*Solanum erianthum*	20	200	18
8	*Ziziphus jujuba*	20	200	24
	Total		**3600**	

Table 6.174: Community structure -Site V58 (Herbs)

S.No.	Plants	F	D	IVI
	Pre Monsoon			
1	*Ageratum conyzoides*	33	9167	23
2	*Curculigo orchioides*	33	6667	20
3	*Curcuma aromatica*	25	15833	26
4	*Cuscuta reflexa*	17	10000	16
5	*Cynodon dactylon*	33	7500	21
6	*Eulaliopsis binata*	17	10833	17
7	*Oxalis corniculata*	25	11667	22
8	*Poa annua*	25	14167	24
9	*Urena lobata*	17	8333	15
10	*Xanthium indicum*	17	10000	16
	Total	242	**104167**	**200**
	Monsoon			
1	*Ageratum conyzoides*	33	10833	22
2	*Bidens pilosa*	25	10000	18
3	*Curcuma aromatica*	25	11667	20
4	*Duchesnea indica*	25	8333	17
5	*Eulaliopsis binata*	17	9167	14
6	*Nasturtium officinale*	25	5833	14
7	*Parthenium hysterophorus*	25	8333	17
8	*Poa annua*	17	9167	14
9	*Pteridium aquilinum*	17	6667	12
10	*Solanum nigrum*	17	9167	14
11	*Urena lobata*	33	8333	20
12	*Xanthium indicum*	25	9167	17
			106667	
	Winter			
1	*Ageratum conyzoides*	33	12500	27
2	*Bidens pilosa*	25	10000	21
3	*Duchesnea indica*	33	11667	27
4	*Nasturtium officinale*	17	14167	22
5	*Parthenium hysterophorus*	17	14167	22
6	*Poa annua*	17	10000	17
7	*Pteridium aquilinum*	25	13333	25
8	*Solanum nigrum*	17	5000	12
9	*Xanthium indicum*	42	8333	27
			99167	

Site V59: Dhaulasidh HEP I: Upstream of Proposed Dam Site

Table 6.175: Community structure -Site V59 (Trees)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	TBC (m^2ha^{-1})	IVI

1	*Acacia catechu*	50	50	7.22	46
2	*Acacia modesta*	40	50	8.01	45
3	*Albizia lebbeck*	20	20	9.68	33
4	*Cassia fistula*	40	40	5.12	36
5	*Dalbergia sissoo*	30	50	5.38	36
6	*Delonix regia*	30	30	6.48	32
7	*Euphorbia royleana*	50	50	1.28	34
8	*Flacourtia indica*	30	30	1.28	21
9	*Lannea coromandelica*	20	20	2.42	17
	Total		**340**		

Table 6.176: Community structure -Site V59 (Shrubs)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	IVI
1	*Datura stramonium*	20	200	29
2	*Ipomea fistulosa*	30	400	46
3	*Jatropha curcas*	20	200	29
4	*Lantana camara*	50	700	68
5	*Murraya koenigii*	40	500	53
6	*Woodfordia fruticosa*	40	500	53
7	*Yucca aloifolia*	10	100	21
	Total		**2600**	

Table 6.177: Community structure -Site V59 (Herbs)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	IVI
	Pre Monsoon			
1	*Artemisia nilagirica*	33	11667	22
2	*Arundo donax*	33	10000	21
3	*Bidens pilosa*	25	3333	12
4	*Cannabis sativa*	17	9167	14
5	*Cyprus niveus*	8	10000	12
6	*Chenopodium album*	33	9167	20
7	*Cymbopogon martini*	25	8333	16
8	*Cynodon dactylon*	17	3333	9
9	*Cyperus rotundus*	33	8333	19
10	*Ipomea nil*	17	8333	14
11	*Parthenium hysterophorus*	25	11667	20
12	*Solanum nigrum*	25	13333	21
	Total		**106667**	
	Monsoon			
1	*Artemisia nilagirica*	25	8333	15
2	*Arundo donax*	33	10833	19
3	*Bidens pilosa*	25	10000	16
4	*Cannabis sativa*	33	8333	17
5	*Cymbopogon martini*	17	7500	11
6	*Cyperus rotundus*	33	10000	18
7	*Fragaria vesca*	25	8333	15
8	*Ipomea nil*	33	6667	15
9	*Nasturtium officinale*	17	5000	9
10	*Oxalis corniculata*	17	7500	11
11	*Parthenium hysterophorus*	33	9167	18
12	*Pteridium aquilinum*	17	6667	11
13	*Solanum nigrum*	25	5833	12
14	*Urginea indica*	17	7500	11
			111667	
	Winter			
1	*Artemisia nilagirica*	33	9167	20
2	*Bidens pilosa*	17	5000	11
3	*Cannabis sativa*	17	5833	11
4	*Cymbopogon martini*	33	8333	19

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	IVI
5	*Cyperus rotundus*	17	6667	12
6	*Fragaria vesca*	33	10833	22
7	*Ipomea nil*	25	9167	17
8	*Nasturtium officinale*	17	5833	11
9	*Chenopodium album*	17	7500	13
10	*Parthenium hysterophorus*	25	9167	17
11	*Pteridium aquilinum*	25	8333	17
12	*Solanum nigrum*	17	9167	15
13	*Urginea indica*	25	5833	14
			100833	

Site V60: Dhaulasidh HEP II: Near Proposed Dam Site

Table 6.178: Community structure -Site V60 (Trees)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	TBC (m^2ha^{-1})	IVI
1	*Acacia catechu*	20	40	6.48	32
2	*Albizia lebbeck*	30	30	8.00	35
3	*Bombax ceiba*	20	20	13.52	38
4	*Cedrela toona*	20	20	2.00	18
5	*Dalbergia sissoo*	40	60	5.12	44
6	*Delonix regia*	20	20	6.48	26
7	*Flacourtia indica*	10	10	1.28	9
8	*Lannea coromandelica*	40	60	1.28	37
9	*Mallotus philippensis*	20	30	3.92	24
10	*Phoenix humilis*	10	10	2.00	11
11	*Pinus roxburghii*	10	30	8.00	27
	Total		**330**		

Table 6.179: Community structure -Site V60 (Shrubs)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	IVI
1	*Adhatoda zeylanica*	20	300	45
2	*Ampelocissus latifolia*	20	200	31
3	*Arundinella nepalensis*	10	100	12
4	*Asparagus adscendens*	30	400	30
5	*Carissa spinarum*	30	400	32
6	*Caryopteris odorata*	20	200	38
7	*Lantana camara*	60	700	55
8	*Solanum erianthum*	20	200	19
9	*Ziziphus jujuba*	20	200	39
	Total		**2700**	

Table 6.180: Community structure -Site V60 (Herbs)

S.No.	Name of Species	Frequency (%)	Density (ind./ha^{-1})	IVI
	Pre Monsoon			
1	*Ageratum conyzoides*	25	10000	22
2	*Cynodon dactylon*	25	15833	28
3	*Cyperus rotundus*	33	17500	34
4	*Nasturtium officinale*	25	15833	28
5	*Parthenium hysterophorus*	33	14167	30
6	*Poa annua*	17	8333	16
7	*Solanum nigrum*	25	10000	22
8	*Urginea indica*	25	7500	20
	Total		**99167**	
	Monsoon			
1	*Ageratum conyzoides*	33	9167	21
2	*Curcuma aromatica*	33	13333	25
3	*Cuscuta reflexa*	25	13333	22
4	*Cyperus rotundus*	17	9167	15

5	*Nasturtium officinale*	33	8333	20
6	*Parthenium hysterophorus*	42	13333	28
7	*Poa annua*	17	10833	16
8	*Solanum nigrum*	33	8333	20
9	*Urginea indica*	17	9167	15
10	*Xanthium indicum*	25	10833	19
			105833	
	Winter			
1	*Ageratum conyzoides*	33	10833	25
2	*Curcuma aromatica*	33	11667	26
3	*Cyperus rotundus*	17	10000	18
4	*Nasturtium officinale*	33	9167	24
5	*Parthenium hysterophorus*	42	13333	32
6	*Poa annua*	17	10833	19
7	*Solanum nigrum*	33	9167	24
8	*Xanthium indicum*	17	4167	11
9	*Urginea indica*	25	10000	21
			89167	

Annexure IV

Distribution and conservation status of mammalian fauna in different sub basins

				Conservation status		Sub basins										
Family	**Common Name**	**Scientific Name**	**Distribution Range (in m)**	**IUCN**	**IWPA**	**BSI**	**BS II**	**MIN**	**PVI**	**PVII**	**SK**	**TT**	**BSIII**	**Uhl**	**BSIV**	**BSV**
Cercopithetidae	Rhesus Macaque	*Macaca mulatta*	Up to 3100	LC	II	+	+	+	+	+	+	+	+	+	+	+
	Hanuman Langur	*Semnopithecus entellus*	1800-3200	LC	II	+	+	+	+	+	+	+	+	+	+	+
Felidae	Common Leopard	*Panthera pardus*	up to 3000	VU	I	+	+	+	+	+	+	+	+	+	+	+
	Leopard Cat	*Prionailurus bengalensis*	up to 1400	LC	I		+			+	+	+	+	+	+	+
	Snow Leopard	*Panthera uncia*	above 3000	EN	I	+	+	+	+		+	+		+	+	
	Jungle Cat	*Felis chaus*	up to 3000	LC	II	+	+	+	+	+	+	+	+	+	+	+
Viverridae	Small Civet	*Viverricula indica*	Foothills	LC	II										+	+
	Common Palm Civet	*Paradoxurus hermaphroditus*	Lower Reaches	LC	II								+	+	+	+
Herpestidae	Common Mongoose	*Herpestes edwardsii*	Foothills	LC	IV										+	+
Hyaenidae	Striped Hyaena	*Hyaena hyaena*	Foothills	NT	III										+	+
Canidae	Jackal	*Canis aureus*	up to 3500	LC	II	+	+	+	+	+	+	+	+	+	+	+
	Indian Fox	*Vulpes bengalensis*	Foothills	LC	II										+	+
Ursidae	Asiatic Black Bear	*Ursus thibetanus*	1500-3500	VU	II	+	+	+	+	+	+	+	+	+	+	+
	Brown Bear	*Ursus arctos*	above 3000	LC	I	+	+	+	+	+	+	+		+	+	
Mustelidae	Common Otter	*Lutra lutra*	up to 3600	NT	II	+	+	+	+	+	+	+	+	+	+	+
	Stone Marten	*Martes foina*	above 1500	LC	II	+	+	+	+	+	+	+	+	+	+	+
	Yellow-thrioated Marten	*Martes flavigula*	1200-2700	LC	II	+	+	+	+	+	+	+	+	+	+	+
	Himalayan Weasal	*Mustela sibirica*	1500-4800	LC	II	+	+	+	+	+	+	+	+	+	+	+
Bovidae	Blue Sheep	*Pseudois nayaur*	above 3500	LC	I	+	+	+	+	+	+	+		+	+	+
	Siberian Ibex	*Capra sibirica*	3800-4400	LC	I			+	+	+	+	+		+	+	
	Himalayan Tahr	*Hemitragus jemlahicus*	2000-3800	NT	I	+	+	+	+	+	+	+	+	+	+	

	Serow	*Capricornis sumatraensis*	1800-3400	VU	I	+	+	+	+	+	+	+	+	+	+	+
	Goral	*Naemorhedus goral*		NT	III	+	+	+	+	+	+	+	+	+	+	+
Cervidae	Sambar	*Cervus unicolor*	Foothills	VU	III										+	+
	Barking Deer	*Muntiacus muntjak*	500-2500	LC	III	+	+	+	+	+	+	+	+	+	+	+
	Musk Deer	*Moschus chrysogaster*	above 2400	EN	I	+	+	+	+	+	+	+	+	+	+	
	Indian Wild Boar	*Sus scrofa*	up to 1500	LC	III		+			+	+	+	+	+	+	+
Hystricidae	Indian Porcupine	*Hystrix indica*	1300-2700	LC	IV	+	+	+	+	+	+	+	+	+	+	+
Leporidae	Black-naped Hare	*Lepus nigricollis*	up to 1200	LC	IV		+			+	+	+	+	+	+	+
Pteropodidae	Flying Fox	*Pteropus giganteus*	up to 2100	LC		+	+	+	+	+	+	+	+	+	+	+
	Fulvous Fruit Bat	*Rousettus leschenaulti*	upto 2100	LC	V	+	+	+	+	+	+	+	+	+	+	+
Rhinopomoatidae	Common Yellow Bat	*Scotophilus hardwickii*	up to 2100	LC	V	+	+	+	+	+	+	+	+	+	+	+
Sciuridae	Kashmir Flying Squirrel	*Eoglaucomys fimbriatus*	1800-3000	LC	II	+	+	+	+	+	+	+	+	+	+	+
	Red Flying Squirrel	*Petaurista Petaurista*	up to 3500	LC	II	+	+	+	+	+	+	+	+	+	+	+
Muridae	House Rat	*Rattus rattus*	all human settlement	LC	V	+	+	+	+	+	+	+	+	+	+	+
	House Mouse	*Mus musculus*	all human settlement	LC	V	+	+	+	+	+	+	+	+	+	+	+
	Lesser Bandicoo rat	*Bandicota bengalensis*	all human settlement	LC		+	+	+	+	+	+	+	+	+	+	+
Cricetidae	Royle's Vole	*Alticola roylei*	1700-2800	NT		+	+	+	+	+	+	+	+	+	+	+
Soricidae	Himalayan Water Shrew	*Chimarrogale himalayica*	above 3000	LC	V	+	+	+	+	+	+	+	+	+	+	
	House Shrew	*Suncus murinus*	up to 3000	LC	V	+	+	+	+	+	+	+	+	+	+	

BSI = Beas I, BSII = Beas II, BSIII = Beas III, BSIV = Beas IV, BSV = Beas V, MLN = Malana, PVI= Pavati I, PVII = Parvati II, SK = Sainj Khad, TT= Tirthan, Uhl = Uhl; LC = least concerned, NT = near threatened, VU = vulnerable, EN = endangered

Annexure-V

List of Avi-fauna reportedly found in Beas basin based upon secondary data

S.No.	Order	Family	Scientific Name	Common Name	Conservation Status IUCN Red List
1	Accipitriformes	Accipitridae	*Accipiter badius*	Shikra	LC
2	Accipitriformes	Accipitridae	*Accipiter gentilis*	Northern Goshawk	LC
3	Accipitriformes	Accipitridae	*Accipiter nisus*	Eurasian Sparrowhawk	LC
4	Accipitriformes	Accipitridae	*Accipiter virgatus*	Besra	LC
5	Accipitriformes	Accipitridae	*Aegypius monachus*	Cinereous Vulture	NT
6	Accipitriformes	Accipitridae	*Aquila chrysaetos*	Golden Eagle	LC
7	Accipitriformes	Accipitridae	*Aquila fasciata*	Bonelli's Eagle	LC
8	Accipitriformes	Accipitridae	*Aquila heliaca*	Eastern Imperial Eagle	VU
9	Accipitriformes	Accipitridae	*Aquila nipalensis*	Steppe Eagle	EN
10	Accipitriformes	Accipitridae	*Aquila rapax*	Tawny Eagle	LC
11	Accipitriformes	Accipitridae	*Butastur teesa*	White-eyed Buzzard	LC
12	Accipitriformes	Accipitridae	*Buteo buteo*	Eurasian Buzzard	LC
13	Accipitriformes	Accipitridae	*Buteo hemilasius*	Upland Buzzard	LC
14	Accipitriformes	Accipitridae	*Buteo rufinus*	Long-legged Buzzard	LC
15	Accipitriformes	Accipitridae	*Circaetus gallicus*	Short-toed Eagle	LC
16	Accipitriformes	Accipitridae	*Circus aeruginosus*	Western Marsh Harrier	LC
17	Accipitriformes	Accipitridae	*Circus cyaneus*	Hen Harrier	LC
18	Accipitriformes	Accipitridae	*Circus hudsonius*	Northern Harrier	LC
19	Accipitriformes	Accipitridae	*Circus macrourus*	Pallid Harrier	NT
20	Accipitriformes	Accipitridae	*Circus melanoleucos*	Pied Harrier	LC
21	Accipitriformes	Accipitridae	*Circus pygargus*	Montagu's Harrier	LC
22	Accipitriformes	Accipitridae	*Clanga clanga*	Greater Spotted Eagle	VU
23	Accipitriformes	Accipitridae	*Clanga hastata*	Indian Spotted Eagle	VU

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24	Accipitriformes	Accipitridae	*Clanga pomarina*	Lesser Spotted Eagle	LC
25	Accipitriformes	Accipitridae	*Elanus caeruleus*	Black-winged Kite	LC
26	Accipitriformes	Accipitridae	*Gypaetus barbatus*	Bearded Vulture/ Lammergeier	NT
27	Accipitriformes	Accipitridae	*Gyps bengalensis*	White-rumped Vulture	CR
28	Accipitriformes	Accipitridae	*Gyps fulvus*	Griffon Vulture	LC
29	Accipitriformes	Accipitridae	*Gyps himalayensis*	Himalayan Griffon	NT
30	Accipitriformes	Accipitridae	*Gyps tenuirostris*	Slender-billed Vulture	CR
31	Accipitriformes	Accipitridae	*Haliaeetus albicilla*	White-tailed Sea Eagle	LC
32	Accipitriformes	Accipitridae	*Haliaeetus leucoryphus*	Pallas fishing eagle	VU
33	Accipitriformes	Accipitridae	*Haliastur indus*	Brahminy Kite	LC
34	Accipitriformes	Accipitridae	*Hieraaetus pennatus*	Booted Eagle	LC
35	Accipitriformes	Accipitridae	*Icthyophaga humilis*	Lesser Fish Eagle	NT
36	Accipitriformes	Accipitridae	*Icthyophaga ichthyaetus*	Grey-headed Fish Eagle	NT
37	Accipitriformes	Accipitridae	*Ictinaetus malayensis*	Black Eagle	LC
38	Accipitriformes	Accipitridae	*Milvus migrans*	Black Kite	LC
39	Accipitriformes	Accipitridae	*Neophron percnopterus*	Egyptian Vulture	EN
40	Accipitriformes	Accipitridae	*Nisaetus cirrhatus*	Changeable Hawk Eagle	LC
41	Accipitriformes	Accipitridae	*Nisaetus nipalensis*	Mountain Hawk Eagle	LC
42	Accipitriformes	Accipitridae	*Pernis ptilorhynchus*	Oriental Honey Buzzard	LC
43	Accipitriformes	Accipitridae	*Sarcogyps calvus*	Red-headed Vulture	CR
44	Accipitriformes	Accipitridae	*Spilornis cheela*	Crested Serpent Eagle	LC
45	Accipitriformes	Pandionidae	*Pandion haliaetus*	Osprey	LC
46	Anseriformes	Anatidae	*Anas acuta*	Northern Pintail	LC
47	Anseriformes	Anatidae	*Anas crecca*	Common Teal	LC
48	Anseriformes	Anatidae	*Anas platyrhynchos*	Mallard	LC
49	Anseriformes	Anatidae	*Anas poecilorhyncha*	Indian Spot-billed Duck	LC
50	Anseriformes	Anatidae	*Anas strepera*	Gadwal	LC

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51	Anseriformes	Anatidae	*Anser albifrons*	Greater White-fronted Goose	LC
52	Anseriformes	Anatidae	*Anser anser*	Greylag Goose	LC
53	Anseriformes	Anatidae	*Anser indicus*	Bar-headed Goose	LC
54	Anseriformes	Anatidae	*Aythya ferina*	Common Pochard	LC
55	Anseriformes	Anatidae	*Aythya fuligula*	Tufted Duck	LC
56	Anseriformes	Anatidae	*Aythya marila*	Greater Scaup	LC
57	Anseriformes	Anatidae	*Aythya nyroca*	Ferruginous Duck	NT
58	Anseriformes	Anatidae	*Dendrocygna bicolor*	Fulvous Whistling Duck	LC
59	Anseriformes	Anatidae	*Dendrocygna javanica*	Lesser Whistling Duck	LC
60	Anseriformes	Anatidae	*Mareca falcata*	Falcated Duck	NT
61	Anseriformes	Anatidae	*Mareca penelope*	Eurasian Wigeon	LC
62	Anseriformes	Anatidae	*Mareca strepera*	Gadwall	LC
63	Anseriformes	Anatidae	*Marmaronetta angustirostris*	Marbled Teal	LC
64	Anseriformes	Anatidae	*Mergus merganser*	Goosander	LC
65	Anseriformes	Anatidae	*Netta rufina*	Red-crested Pochard	LC
66	Anseriformes	Anatidae	*Nettapus coromandelianus*	Asian Pygmy Goose	LC
67	Anseriformes	Anatidae	*Sarkidiornis melanotos*	Comb Duck	LC
68	Anseriformes	Anatidae	*Spatula clypeata*	Northern Shoveler	LC
69	Anseriformes	Anatidae	*Spatula querquedula*	Garganey	LC
70	Anseriformes	Anatidae	*Tadorna ferruginea*	Ruddy shelduck	LC
71	Anseriformes	Anatidae	*Tadorna tadorna*	Common shelduck	LC
72	Apodiformes	Apodidae	*Tachornis squamata*	Fork-tailed Swift	LC
73	Bucerotiformes	Bucerotidae	*Anthracoceros albirostris*	Oriental Pied Hornbill	LC
74	Bucerotiformes	Bucerotidae	*Ocyceros birostris*	Indian Grey Hornbill	LC
75	Bucerotiformes	Upupidae	*Upupa epops*	Common Hoopoe	LC
76	Caprimulgiformes	Apodidae	*Aerodramus brevirostris*	Himalayan Swiftlet	LC
77	Caprimulgiformes	Apodidae	*Apus affinis*	Little Swift	LC

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78	Caprimulgiformes	Apodidae	*Apus apus*	Common Swift	LC
79	Caprimulgiformes	Apodidae	*Apus pacificus*	Pacific Swift	LC
80	Caprimulgiformes	Apodidae	*Cypsiurus balasiensis*	Asian Palm Swift	LC
81	Caprimulgiformes	Apodidae	*Hirundapus caudacutus*	White-throated Needletail	LC
82	Caprimulgiformes	Apodidae	*Tachymarptis melba*	Alpine Swift	LC
83	Caprimulgiformes	Caprimulgidae	*Caprimulgus affinis*	Savanna Nightjar	LC
84	Caprimulgiformes	Caprimulgidae	*Caprimulgus asiaticus*	Indian Nightjar	LC
85	Caprimulgiformes	Caprimulgidae	*Caprimulgus indicus*	Grey Nightjar	LC
86	Caprimulgiformes	Caprimulgidae	*Caprimulgus macrurus*	Large-tailed Nightjar	LC
87	Caprimulgiformes	Caprimulgidae	*Caprimulgus mahrattensis*	Sykes's Nightjar	LC
88	Charadriiformes	Burhinidae	*Burhinus oedicnemus*	Eurasian Thick-knee	LC
89	Charadriiformes	Burhinidae	*Esacus recurvirostris*	Great Thick-knee	NT
90	Charadriiformes	Charadriidae	*Charadrius alexandrinus*	Kentish Plover	LC
91	Charadriiformes	Charadriidae	*Charadrius dubius*	Little Ringed Plover	LC
92	Charadriiformes	Charadriidae	*Charadrius hiaticula*	Common Ringed Plover	LC
93	Charadriiformes	Charadriidae	*Charadrius mongolus*	Lesser Sand Plover	LC
94	Charadriiformes	Charadriidae	*Pluvialis fulva*	Pacific Golden Plover	LC
95	Charadriiformes	Charadriidae	*Pluvialis squatarola*	Grey Plover	LC
96	Charadriiformes	Charadriidae	*Vanellus cinereus*	Grey-headed Lapwing	LC
97	Charadriiformes	Charadriidae	*Vanellus duvaucelii*	River Lapwing	NT
98	Charadriiformes	Charadriidae	*Vanellus gregarius*	Sociable Lapwing	CR
99	Charadriiformes	Charadriidae	*Vanellus indicus*	Red-wattled Lapwing	LC
100	Charadriiformes	Charadriidae	*Vanellus leucurus*	White-tailed Lapwing	LC
101	Charadriiformes	Charadriidae	*Vanellus malabaricus*	Yellow-wattled Lapwing	LC
102	Charadriiformes	Charadriidae	*Vanellus vanellus*	Northern Lapwing	NT
103	Charadriiformes	Glareolidae	*Cursorius coromandelicus*	Indian Courser	LC
104	Charadriiformes	Glareolidae	*Glareola lactea*	Little Pratincole	LC

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105	Charadriiformes	Glareolidae	*Glareola maldivarum*	Oriental Pratincole	LC
106	Charadriiformes	Haematopodidae	*Haematopus ostralegus*	Eurasian Oystercatcher	NT
107	Charadriiformes	Jacanidae	*Hydrophasianus chirurgus*	Pheasant-tailed Jacana	NA
108	Charadriiformes	Jacanidae	*Metopidius indicus*	Bronze-winged Jacana	LC
109	Charadriiformes	Laridae	*Chlidonias hybrida*	Whiskered Tern	NA
110	Charadriiformes	Laridae	*Chroicocephalus brunnicephalus*	Brown-headed Gull	NA
111	Charadriiformes	Laridae	*Chroicocephalus genei*	Slender-billed Gull	NA
112	Charadriiformes	Laridae	*Chroicocephalus ridibundus*	Black-headed Gull	NA
113	Charadriiformes	Laridae	*Gelochelidon nilotica*	Gull-billed Tern	NA
114	Charadriiformes	Laridae	*Hydrocoloeus minutus*	Little Gull	NA
115	Charadriiformes	Laridae	*Hydroprogne caspia*	Caspian Tern	LC
116	Charadriiformes	Laridae	*Ichthyaetus ichthyaetus*	Pallas's Gull	NA
117	Charadriiformes	Laridae	*Larus cachinnans*	Caspian Gull	NA
118	Charadriiformes	Laridae	*Larus canus*	Mew Gull	NA
119	Charadriiformes	Laridae	*Larus ridibundus*	Black Headed Gull	LC
120	Charadriiformes	Laridae	*Rynchops albicollis*	Indian Skimmer	NA
121	Charadriiformes	Laridae	*Sterna acuticauda*	Black-bellied Tern	NA
122	Charadriiformes	Laridae	*Sterna aurantia*	River Tern	NA
123	Charadriiformes	Laridae	*Sterna hirundo*	Common Tern	NA
124	Charadriiformes	Laridae	*Sternula albifrons*	Little Tern	NA
125	Charadriiformes	Recurvirostridae	*Himantopus himantopus*	Black Winged Stilt	LC
126	Charadriiformes	Recurvirostridae	*Recurvirostra avosetta*	Pied avocet	LC
127	Charadriiformes	Rostratulidae	*Rostratula benghalensis*	Greater Painted-snipe	LC
128	Charadriiformes	Scolopacidae	*Actitis hypoleucos*	Common Sandpiper	LC
129	Charadriiformes	Scolopacidae	*Arenaria interpres*	Ruddy Turnstone	LC
130	Charadriiformes	Scolopacidae	*Calidris alpina*	Dunlin	LC

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131	Charadriiformes	Scolopacidae	*Calidris ferruginea*	Curlew Sandpiper	NT
132	Charadriiformes	Scolopacidae	*Calidris minuta*	Little Stint	LC
133	Charadriiformes	Scolopacidae	*Calidris pugnax*	Ruff	LC
134	Charadriiformes	Scolopacidae	*Calidris temminckii*	Temminck's Stint	LC
135	Charadriiformes	Scolopacidae	*Gallinago gallinago*	Common Snipe	LC
136	Charadriiformes	Scolopacidae	*Gallinago nemoricola*	Wood Snipe	VU
137	Charadriiformes	Scolopacidae	*Gallinago solitaria*	Solitary Snipe	LC
138	Charadriiformes	Scolopacidae	*Gallinago stenura*	Pintail Snipe	LC
139	Charadriiformes	Scolopacidae	*Limosa limosa*	Black-tailed Godwit	NT
140	Charadriiformes	Scolopacidae	*Lymnocryptes minimus*	Jack Snipe	LC
141	Charadriiformes	Scolopacidae	*Numenius arquata*	Eurasian Curlew	NT
142	Charadriiformes	Scolopacidae	*Numenius phaeopus*	Whimbrel	LC
143	Charadriiformes	Scolopacidae	*Phalaropus lobatus*	Red-necked Phalarope	LC
144	Charadriiformes	Scolopacidae	*Scolopax rusticola*	Eurasian Woodcock	LC
145	Charadriiformes	Scolopacidae	*Tringa erythropus*	Spotted Redshank	LC
146	Charadriiformes	Scolopacidae	*Tringa glareola*	Wood Sandpiper	LC
147	Charadriiformes	Scolopacidae	*Tringa nebularia*	Common Greenshank	LC
148	Charadriiformes	Scolopacidae	*Tringa ochropus*	Green Sandpiper	LC
149	Charadriiformes	Scolopacidae	*Tringa stagnatilis*	Marsh Sandpiper	LC
150	Charadriiformes	Scolopacidae	*Tringa totanus*	Common Redshank	LC
151	Charadriiformes	Scolopacidae	*Xenus cinereus*	Terek Sandpiper	LC
152	Charadriiformes	Turnicidae	*Turnix suscitator*	Barred Buttonquail	LC
153	Charadriiformes	Turnicidae	*Turnix sylvaticus*	Common Buttonquail	LC
154	Charadriiformes	Turnicidae	*Turnix tanki*	Yellow-legged Buttonquail	LC
155	Ciconiiformes	Ardeidae	*Ardeola grayii*	Indian Pond Heron	LC
156	Ciconiiformes	Ardeidae	*Bubulcus ibis*	Cattle Egret	LC
157	Ciconiiformes	Ardeidae	*Egretta garzetta*	Little Egret	LC

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158	Ciconiiformes	Ciconiidae	*Leptoptilos dubius*	Greater Adjutant	EN
159	Ciconiiformes	Ciconiidae	*Leptoptilos javanicus*	Lesser Adjutant	VU
160	Ciconiiformes	Ciconiidae	*Mycteria leucocephala*	Painted Stork	NT
161	Columbiformes	Columbidae	*Chalcophaps indica*	Emerald Dove	LC
162	Columbiformes	Columbidae	*Columba eversmanni*	Pale-backed Pigeon	VU
163	Columbiformes	Columbidae	*Columba hodgsonii*	Speckled Wood Pigeon	LC
164	Columbiformes	Columbidae	*Columba leuconota*	Snow Pigeon	LC
165	Columbiformes	Columbidae	*Columba livia*	Rock Pigeon	LC
166	Columbiformes	Columbidae	*Columba palumbus*	Wood Pigeon	LC
167	Columbiformes	Columbidae	*Streptopelia chinensis*	Spotted Dove	LC
168	Columbiformes	Columbidae	*Streptopelia decaocto*	Eurasian Collared Dove	LC
169	Columbiformes	Columbidae	*Streptopelia orientalis*	Oriental Turtle Dove	LC
170	Columbiformes	Columbidae	*Streptopelia senegalensis*	Laughing Dove	LC
171	Columbiformes	Columbidae	*Streptopelia tranquebarica*	Red Collared Dove	LC
172	Columbiformes	Columbidae	*Treron phoenicopterus*	Yellow-legged Green Pigeon	LC
173	Columbiformes	Columbidae	*Treron sphenurus*	Wedge Tailed Green Pigeon	LC
174	Coraciiformes	Alcedinidae	*Alcedo atthis*	Small Blue Kingfisher	LC
175	Coraciiformes	Alcedinidae	*Ceryle rudis*	Pied Kingfisher	LC
176	Coraciiformes	Alcedinidae	*Halcyon albiventris*	Brown headed Kingfisher	LC
177	Coraciiformes	Alcedinidae	*Halcyon smyrnensis*	White Breasted Kingfisher	LC
178	Coraciiformes	Alcedinidae	*Megaceryle lugubris*	Crested Kingfisher	LC
179	Coraciiformes	Coraciiae	*Coracias benghalensis*	Indian Roller	LC
180	Coraciiformes	Coraciidae	*Coracias garrulus*	European Roller	LC
181	Coraciiformes	Meropidae	*Merops leschenaulti*	Chestnut-headed Bee-eater	NA
182	Coraciiformes	Meropidae	*Merops orientalis*	Small Bee Eater	LC
183	Coraciiformes	Meropidae	*Merops persicus*	Blue-cheeked Bee-eater	NA
184	Coraciiformes	Meropidae	*Merops philippinus*	Blue-tailed Bee-eater	NA

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185	Cuculiformes	Cuculidae	*Cacomantis passerinus*	Grey-bellied Cuckoo	LC
186	Cuculiformes	Cuculidae	*Cacomantis sonneratii*	Banded Bay Cuckoo	LC
187	Cuculiformes	Cuculidae	*Centropus sinensis*	Greater Coucal	LC
188	Cuculiformes	Cuculidae	*Clamator coromandus*	Chestnut-winged Cuckoo	LC
189	Cuculiformes	Cuculidae	*Clamator jacobinus*	Jacobin Cuckoo/ Pied Cuckoo	LC
190	Cuculiformes	Cuculidae	*Cuculus canorus*	Common Cuckoo	LC
191	Cuculiformes	Cuculidae	*Cuculus micropterus*	Indian Cuckoo	LC
192	Cuculiformes	Cuculidae	*Cuculus poliocephalus*	Lesser Cuckoo	LC
193	Cuculiformes	Cuculidae	*Cuculus saturatus*	Oriental Cuckoo	LC
194	Cuculiformes	Cuculidae	*Eudynamys scolopacea*	Asian Koel	LC
195	Cuculiformes	Cuculidae	*Eudynamys scolopaceus*	Common Koel	LC
196	Cuculiformes	Cuculidae	*Hierococcyx sparverioides*	Large Hawk-cuckoo	LC
197	Cuculiformes	Cuculidae	*Hierococcyx varius*	Common Hawk Cuckoo	LC
198	Cuculiformes	Cuculidae	*Surniculus lugubris*	Drongo Cuckoo	LC
199	Cuculiformes	Cuculidae	*Taccocua leschenaultii*	Sirkeer Malkoha	LC
200	Falconiformes	Falconidae	*Falco amurensis*	Amur Falcon	LC
201	Falconiformes	Falconidae	*Falco cherrug*	Saker Falcon	EN
202	Falconiformes	Falconidae	*Falco chicquera*	Red-necked Falcon	EN
203	Falconiformes	Falconidae	*Falco jugger*	Laggar Falcon	NT
204	Falconiformes	Falconidae	*Falco naumanni*	Lesser Kestrel	LC
205	Falconiformes	Falconidae	*Falco peregrinus*	Peregrine Falcon	LC
206	Falconiformes	Falconidae	*Falco severus*	Oriental Hobby	LC
207	Falconiformes	Falconidae	*Falco subbuteo*	Eurasian Hobby	LC
208	Falconiformes	Falconidae	*Falco tinnunculus*	Common Kestrel	LC
209	Galliformes	Phasianidae	*Alectoris chukar*	Chukar Partridge	LC
210	Galliformes	Phasianidae	*Arborophila torqueola*	Hill Partridge	LC
211	Galliformes	Phasianidae	*Catreus wallichii*	Cheer Pheasant	VU

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212	Galliformes	Phasianidae	*Coturnix coromandelica*	Rain Quail	LC
213	Galliformes	Phasianidae	*Coturnix coturnix*	Common Quail	LC
214	Galliformes	Phasianidae	*Francolinus francolinus*	Black Francolin	LC
215	Galliformes	Phasianidae	*Francolinus pictus*	Painted Francolin	LC
216	Galliformes	Phasianidae	*Francolinus pondicerianus*	Grey Francolin	LC
217	Galliformes	Phasianidae	*Galloperdix lunulata*	Painted Spurfowl	LC
218	Galliformes	Phasianidae	*Gallus gallus*	Red Junglefowl	LC
219	Galliformes	Phasianidae	*Lerwa lerwa*	Snow Partridge	LC
220	Galliformes	Phasianidae	*Lophophorus impejanus*	Monal	LC
221	Galliformes	Phasianidae	*Lophura leucomelana*	Kalij	NA
222	Galliformes	Phasianidae	*Lophura leucomelanos*	Kalij Pheasant	LC
223	Galliformes	Phasianidae	*Pavo cristatus*	Indian Peafowl	LC
224	Galliformes	Phasianidae	*Perdicula asiatica*	Jungle Bush Quail	LC
225	Galliformes	Phasianidae	*Pucrasia macrolopha*	Koklas	LC
226	Galliformes	Phasianidae	*Synoicus chinensis*	Blue-breasted Quail	LC
227	Galliformes	Phasianidae	*Tetraogallus himalayensis*	Himalayan Snowcock	LC
228	Galliformes	Phasianidae	*Tragopan melanocephalus*	Western Tragopan	VU
229	Gruiformes	Gruidae	*Antigone antigone*	Sarus Crane	VU
230	Gruiformes	Gruidae	*Grus grus*	Common Crane	LC
231	Gruiformes	Gruidae	*Grus virgo*	Demoiselle Crane	LC
232	Gruiformes	Rallidae	*Amaurornis phoenicurus*	White-breasted Waterhen	LC
233	Gruiformes	Rallidae	*Amaurornis phoenicurus*	White breasted Waterhen	LC
234	Gruiformes	Rallidae	*Fulica atra*	Coots	LC
235	Gruiformes	Rallidae	*Gallicrex cinerea*	Watercock	LC
236	Gruiformes	Rallidae	*Gallinula chloropus*	Waterhen	LC
237	Gruiformes	Rallidae	*Porphyrio porphyrio*	Purple Swamphen	LC
238	Gruiformes	Rallidae	*Rallus aquaticus*	Western Water Rail	LC

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239	Gruiformes	Rallidae	*Zapornia akool*	Brown Crake	LC
240	Gruiformes	Rallidae	*Zapornia fusca*	Ruddy-breasted Crake	LC
241	Gruiformes	Rallidae	*Zapornia pusilla*	Baillon's Crake	LC
242	Otidiformes	Otididae	*Ardeotis nigriceps*	Great Indian Bustard	CR
243	Otidiformes	Otididae	*Sypheotides indicus*	Lesser Florican	EN
244	Passeriformes	Acrocephalidae	*Acrocephalus agricola*	Paddyfield Warbler	LC
245	Passeriformes	Acrocephalidae	*Acrocephalus dumetorum*	Blyth's Reed Warbler	LC
246	Passeriformes	Acrocephalidae	*Acrocephalus melanopogon*	Moustached Warbler	LC
247	Passeriformes	Acrocephalidae	*Acrocephalus stentoreus*	Clamorous Reed Warbler	LC
248	Passeriformes	Acrocephalidae	*Iduna caligata*	Booted Warbler	NA
249	Passeriformes	Acrocephalidae	*Phylloscopus humei*	Hume's Warbler	LC
250	Passeriformes	Acrocephalidae	*Phylloscopus xanthoschistos*	Grey-hooded Warbler	LC
251	Passeriformes	Aegithalidae	*Aegithalos concinnus*	Black Throated Tit	LC
252	Passeriformes	Aegithalidae	*Aegithalos niveogularis*	White Throated Tit	LC
253	Passeriformes	Aegithinidae	*Aegithina nigrolutea*	White Tailed Lora	LC
254	Passeriformes	Aegithinidae	*Aegithina tiphia*	Common Iora	LC
255	Passeriformes	Alaudidae	*Alauda arvensis*	Eurasian Sky Lark	LC
256	Passeriformes	Alaudidae	*Alauda gulgula*	Oriental Sky Lark	LC
257	Passeriformes	Alaudidae	*Ammomanes phoenicura*	Rufous-tailed Lark	LC
258	Passeriformes	Alaudidae	*Calandrella acutirostris*	Hume's Short-toed Lark	LC
259	Passeriformes	Alaudidae	*Calandrella brachydactyla*	Greater Short-toed Lark	LC
260	Passeriformes	Alaudidae	*Calandrella raytal*	Indian sand lark	LC
261	Passeriformes	Alaudidae	*Eremophila alpestris*	Horned Lark	LC
262	Passeriformes	Alaudidae	*Eremopterix griseus*	Ashy-crowned Sparrow Lark	LC
263	Passeriformes	Alaudidae	*Galerida cristata*	Crested Lark	LC
264	Passeriformes	Alaudidae	*Galerida deva*	Sykes's Lark	LC
265	Passeriformes	Alaudidae	*Melanocorypha bimaculata*	Bimaculated Lark	LC

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266	Passeriformes	Alaudidae	*Mirafra assamica*	Bengal Lark	LC
267	Passeriformes	Alaudidae	*Mirafra erythroptera*	Indian Bush Lark	LC
268	Passeriformes	Campephagidae	*Coracina javensis*	Large Cuckooshrike	LC
269	Passeriformes	Campephagidae	*Coracina melanoptera*	Black-winged Cuckooshrike	LC
270	Passeriformes	Campephagidae	*Lalage melanoptera*	Black-headed Cuckooshrike	LC
271	Passeriformes	Campephagidae	*Pericrocotus cinnamomeus*	Small Minivet	LC
272	Passeriformes	Campephagidae	*Pericrocotus erythropygius*	White-bellied Minivet	LC
273	Passeriformes	Campephagidae	*Pericrocotus ethologus*	Long-tailed Minivet	LC
274	Passeriformes	Campephagidae	*Pericrocotus roseus*	Rosy Minivet	LC
275	Passeriformes	Certhiidae	*Certhia familiaris*	Eurasian Treecreeper	LC
276	Passeriformes	Certhiidae	*Certhia himalayana*	Bar-tailed Tree Creeper	LC
277	Passeriformes	Certhiidae	*Salpornis spilonotus*	Spotted Treecreeper	LC
278	Passeriformes	Chloropseidae	*Chloropsis jerdoni*	Jerdon's Leafbird	LC
279	Passeriformes	Cinclidae	*Cinclus pallasii*	Brown Dipper	LC
280	Passeriformes	Cisticolidae	*Cisticola juncidis*	Zitting Cisticola	LC
281	Passeriformes	Cisticolidae	*Prinia buchanani*	Rufous-fronted Prinia	LC
282	Passeriformes	Cisticolidae	*Prinia burnesii*	Long-tailed Grass Babbler	NT
283	Passeriformes	Cisticolidae	*Prinia burnesii*	Rufous-vented prinia	NT
284	Passeriformes	Cisticolidae	*Prinia flaviventris*	Yellow-bellied Prinia	LC
285	Passeriformes	Cisticolidae	*Prinia gracilis*	Graceful Prinia	LC
286	Passeriformes	Cisticolidae	*Prinia hodgsonii*	Grey-breasted Prinia	LC
287	Passeriformes	Corvidae	*Corvus corax*	Common Raven	LC
288	Passeriformes	Corvidae	*Corvus macrorhynchos*	Large-billed Crow	LC
289	Passeriformes	Corvidae	*Corvus splendens*	House Crow	LC
290	Passeriformes	Corvidae	*Dendrocitta formosae*	Grey Treepie	LC
291	Passeriformes	Corvidae	*Dendrocitta vagabunda*	Indian Treepie	LC
292	Passeriformes	Corvidae	*Garrulus glandarius*	Eurasian Jay	LC

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293	Passeriformes	Corvidae	*Garrulus lanceolatus*	Black-headed Jay	LC
294	Passeriformes	Corvidae	*Nucifraga caryocatactes*	Eurasian Nutcracker	LC
295	Passeriformes	Corvidae	*Pyrrhocorax graculus*	Alpine Chough	LC
296	Passeriformes	Corvidae	*Urocissa erythrorhyncha*	Red-billed Blue Magpie	LC
297	Passeriformes	Corvidae	*Urocissa flavirostris*	Yellow-billed Blue Magpie	LC
298	Passeriformes	Dicaeidae	*Dicaeum agile*	Thick-billed Flowerpecker	LC
299	Passeriformes	Dicaeidae	*Dicaeum erythrorhynchos*	Pale-billed Flowerpecker	LC
300	Passeriformes	Dicaeidae	*Dicaeum ignipectus*	Fire-breasted Flowerpecker	LC
301	Passeriformes	Dicruridae	*Dicrurus caerulescens*	White-bellied Drongo	LC
302	Passeriformes	Dicruridae	*Dicrurus hottentottus*	Spangled Drongo	LC
303	Passeriformes	Dicruridae	*Dicrurus leucophaeus*	Ashy Drongo	LC
304	Passeriformes	Dicruridae	*Dicrurus macrocercus*	Black Drongo	LC
305	Passeriformes	Dicuridae	*Dicrurus paradiseus*	Greater Racket-tailed Drongo	LC
306	Passeriformes	Emberizidae	*Emberiza bruniceps*	Red-headed Bunting	LC
307	Passeriformes	Emberizidae	*Emberiza buchanani*	Grey-necked Bunting	LC
308	Passeriformes	Emberizidae	*Emberiza cia*	Rock Bunting	LC
309	Passeriformes	Emberizidae	*Emberiza citrinella*	Yellowhammer	LC
310	Passeriformes	Emberizidae	*Emberiza fucata*	Chestnut-eared Bunting	LC
311	Passeriformes	Emberizidae	*Emberiza leucocephalos*	Pine Bunting	LC
312	Passeriformes	Emberizidae	*Emberiza melanocephala*	Black-headed Bunting	LC
313	Passeriformes	Emberizidae	*Emberiza pusillus*	Little Bunting	LC
314	Passeriformes	Emberizidae	*Emberiza stewarti*	White-capped Bunting	LC
315	Passeriformes	Emberizidae	*Melophus lathami*	Crested Bunting	LC
316	Passeriformes	Estrildidae	*Amandava amandava*	Red munia/ Red Avadavat	LC
317	Passeriformes	Estrildidae	*Lonchura malabarica*	Indian Silverbill	LC
318	Passeriformes	Estrildidae	*Lonchura punctulata*	Scaly-breasted Munia	LC
319	Passeriformes	Fringillidae	*Callacanthis burtoni*	Spectacled Finch	LC

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320	Passeriformes	Fringillidae	*Carduelis cannabina*	Common Linnet	LC
321	Passeriformes	Fringillidae	*Carduelis carduelis*	European Goldfinch	LC
322	Passeriformes	Fringillidae	*Carduelis grandis*	Blyth's Rosefinch	NA
323	Passeriformes	Fringillidae	*Carduelis spinoides*	Yellow-breasted Greenfinch	LC
324	Passeriformes	Fringillidae	*Carpodacus erythrinus*	Common Rose Finch	LC
325	Passeriformes	Fringillidae	*Carpodacus nipalensis*	Dark-breasted Rosefinch	LC
326	Passeriformes	Fringillidae	*Carpodacus puniceus*	Red-fronted Rosefinch	LC
327	Passeriformes	Fringillidae	*Carpodacus rodochroa*	Pink-browed Rosefinch	LC
328	Passeriformes	Fringillidae	*Carpodacus thura*	Himalayan White-browed Rosefinch	LC
329	Passeriformes	Fringillidae	*Fringilla coelebs*	Common Chaffinch	LC
330	Passeriformes	Fringillidae	*Fringilla montifringilla*	Brambling	LC
331	Passeriformes	Fringillidae	*Leucosticte nemoricola*	Plain Mountain Finch	LC
332	Passeriformes	Fringillidae	*Mycerobas affinis*	Collared Grosbeak	LC
333	Passeriformes	Fringillidae	*Mycerobas carnipes*	White-winged Grosbeak	LC
334	Passeriformes	Fringillidae	*Mycerobas icterioides*	Black-and-yellow Grosbeak	LC
335	Passeriformes	Fringillidae	*Mycerobas melanozanthos*	Spot-winged Grosbeak	LC
336	Passeriformes	Fringillidae	*Pyrrhula aurantiaca*	Orange Bullfinch	LC
337	Passeriformes	Fringillidae	*Pyrrhula erythrocephala*	Red-headed Bullfinch	LC
338	Passeriformes	Fringillidae	*Pyrrhula nipalensis*	Brown Bullfinch	LC
339	Passeriformes	Fringillidae	*Serinus pusillus*	Red-fronted Serin	LC
340	Passeriformes	Hirundinidae	*Delichon dasypus*	Asian House Martin	LC
341	Passeriformes	Hirundinidae	*Delichon urbicum*	House Martin	LC
342	Passeriformes	Hirundinidae	*Hirundo daurica*	Red-rumped Swallow	LC
343	Passeriformes	Hirundinidae	*Hirundo rustica*	Barn Swallow	LC
344	Passeriformes	Hirundinidae	*Hirundo smithii*	Wire-tailed Swallow	LC
345	Passeriformes	Hirundinidae	*Petrochelidon fluvicola*	Streak-throated Swallow	NA
346	Passeriformes	Hirundinidae	*Ptyonoprogne concolor*	Dusky Crag Martin	NA

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347	Passeriformes	Hirundinidae	*Ptyonoprogne rupestris*	Eurasian Crag Martin	NA
348	Passeriformes	Hirundinidae	*Riparia diluta*	Pale Martin	NA
349	Passeriformes	Hirundinidae	*Riparia paludicola*	Plain Martin	NA
350	Passeriformes	Hirundinidae	*Riparia riparia*	Sand Martin	NA
351	Passeriformes	Laniidae	*Lanius collurio*	Red-backed Shrike	LC
352	Passeriformes	Laniidae	*Lanius cristatus*	Brown Shrike	NA
353	Passeriformes	Laniidae	*Lanius excubitor*	Great Grey Shrike	NA
354	Passeriformes	Laniidae	*Lanius isabellinus*	Isabelline Shrike	NA
355	Passeriformes	Laniidae	*Lanius schach*	Long-tailed Shrike	LC
356	Passeriformes	Laniidae	*Lanius tephronotus*	Grey-backed Shrike	NA
357	Passeriformes	Laniidae	*Lanius vittatus*	Bay-backed Shrike	NA
358	Passeriformes	Leiothrichidae	*Garrulax albogularis*	White-throated Laughing-thrush	NA
359	Passeriformes	Leiothrichidae	*Garrulax erythrocephalus*	Chestnut-crowned Laughing Thrush	LC
360	Passeriformes	Leiothrichidae	*Garrulax leucolophus*	White-crested Laughing-thrush	NA
361	Passeriformes	Leiothrichidae	*Garrulax striata*	Striated Laughing-thrush	LC
362	Passeriformes	Leiothrichidae	*Garrulax variegatus*	Variegated Laughing Thrush	LC
363	Passeriformes	Leiothrichidae	*Heterophasia capistrata*	Rufous Sibia	LC
364	Passeriformes	Leiothrichidae	*Leiothrix lutea*	Red-billed Leiothrix	NA
365	Passeriformes	Leiothrichidae	*Trochalopteron erythrocephalum*	Chestnut-crowned Laughing-thrush	NA
366	Passeriformes	Leiothrichidae	*Trochalopteron lineatum*	Streaked Laughing-thrush	NA
367	Passeriformes	Leiothrichidae	*Trochalopteron variegatum*	Variegated Laughing-thrush	NA
368	Passeriformes	Locustellidae	*Locustella naevia*	Grasshopper Warbler	NA
369	Passeriformes	Monarchidae	*Hypothymis azurea*	Black-naped Monarch	LC
370	Passeriformes	Monarchidae	*Terpsiphone paradisi*	Asian Paradise flycatcher	LC
371	Passeriformes	Motacillidae	*Anthus campestris*	Tawny Pipit	LC
372	Passeriformes	Motacillidae	*Anthus cervinus*	Red-throated Pipit	NA

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373	Passeriformes	Motacillidae	*Anthus godlewskii*	Blyth's Pipit	LC
374	Passeriformes	Motacillidae	*Anthus hodgsoni*	Olive-backed Pipit	NA
375	Passeriformes	Motacillidae	*Anthus richardi*	Richard's Pipit	LC
376	Passeriformes	Motacillidae	*Anthus roseatus*	Rosy Pipit	NA
377	Passeriformes	Motacillidae	*Anthus rufulus*	Paddyfield Pipit	NA
378	Passeriformes	Motacillidae	*Anthus similis*	Long-billed Pipit	NA
379	Passeriformes	Motacillidae	*Anthus spinoletta*	Water Pipit	NA
380	Passeriformes	Motacillidae	*Anthus sylvanus*	Upland Pipit	NA
381	Passeriformes	Motacillidae	*Anthus trivialis*	Tree Pipit	NA
382	Passeriformes	Motacillidae	*Motacilla alba*	Indian white wagtail	LC
383	Passeriformes	Motacillidae	*Motacilla cinerea*	Grey Wagtail	LC
384	Passeriformes	Motacillidae	*Motacilla citreola*	Citrine Wagtail	NA
385	Passeriformes	Motacillidae	*Motacilla flava*	Yellow wagtail	LC
386	Passeriformes	Motacillidae	*Motacilla maderaspatensis*	Large pied wagtail	NA
387	Passeriformes	Muscicapidae	*Brachypteryx montana*	White-browed Shortwing	LC
388	Passeriformes	Muscicapidae	*Cercomela fusca*	Brown Rock Chat	LC
389	Passeriformes	Muscicapidae	*Chaimarrornis leucocephalus*	White-capped Water Redstart	LC
390	Passeriformes	Muscicapidae	*Copsychus saularis*	Oriental Magpie Robin	LC
391	Passeriformes	Muscicapidae	*Culicicapa ceylonensis*	Grey-headed Canary Flycatcher	LC
392	Passeriformes	Muscicapidae	*Cyornis rubeculoides*	Blue-throated Blue Flycatcher	LC
393	Passeriformes	Muscicapidae	*Cyornis tickelliae*	Tickell's Blue Flycatcher	LC
394	Passeriformes	Muscicapidae	*Enicurus maculatus*	Spotted Forktail	LC
395	Passeriformes	Muscicapidae	*Enicurus scouleri*	Little Forktail	LC
396	Passeriformes	Muscicapidae	*Eumyias thalassinus*	Asian Verditer Flycatcher	LC
397	Passeriformes	Muscicapidae	*Ficedula albicilla*	Taiga Flycatcher	LC
398	Passeriformes	Muscicapidae	*Ficedula parva*	Red-breasted Flycatcher	LC
399	Passeriformes	Muscicapidae	*Ficedula strophiata*	Rufous-gorgetted Flycatcher	LC

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400	Passeriformes	Muscicapidae	*Ficedula subrubra*	Kashmir Flycatcher	VU
401	Passeriformes	Muscicapidae	*Ficedula superciliaris*	Ultramarine Flycatcher	LC
402	Passeriformes	Muscicapidae	*Ficedula tricolor*	Slaty blue Flycatcher	LC
403	Passeriformes	Muscicapidae	*Ficedula westermanni*	Little Pied Flycatcher	LC
404	Passeriformes	Muscicapidae	*Hodgsonius phaenicuroides*	White-bellied Redstart	LC
405	Passeriformes	Muscicapidae	*Luscinia brunnea*	Indian Blue Robin	LC
406	Passeriformes	Muscicapidae	*Luscinia calliope*	Siberian Rubythroat	LC
407	Passeriformes	Muscicapidae	*Luscinia pectoralis*	White-tailed Rubythroat	LC
408	Passeriformes	Muscicapidae	*Luscinia svecica*	Bluethroat	LC
409	Passeriformes	Muscicapidae	*Monticola cinclorhynchus*	Blue-capped Rock Thrush	LC
410	Passeriformes	Muscicapidae	*Monticola rufiventris*	Chestnut-bellied Rock Thrush	LC
411	Passeriformes	Muscicapidae	*Monticola solitarius*	Blue Rock Thrush	LC
412	Passeriformes	Muscicapidae	*Muscicapa dauurica*	Asian Brown Flycatcher	LC
413	Passeriformes	Muscicapidae	*Muscicapa ruficauda*	Rusty-tailed Flycatcher	LC
414	Passeriformes	Muscicapidae	*Muscicapa sibirica*	Dark-sided Flycatcher	LC
415	Passeriformes	Muscicapidae	*Myophonus caeruleus*	Blue Whistling Thrush	LC
416	Passeriformes	Muscicapidae	*Niltava sundara*	Rufous-bellied Niltava	LC
417	Passeriformes	Muscicapidae	*Oenanthe deserti*	Desert Wheatear	LC
418	Passeriformes	Muscicapidae	*Oenanthe isabellina*	Isabelline Wheatear	LC
419	Passeriformes	Muscicapidae	*Oenanthe picata*	Variable Wheatear	LC
420	Passeriformes	Muscicapidae	*Oenanthe pleschanka*	Pied Wheatear	LC
421	Passeriformes	Muscicapidae	*Orthotomus sutorius*	Common Tailorbird	LC
422	Passeriformes	Muscicapidae	*Phoenicurus caeruleocephalus*	Blue-capped Redstart	LC
423	Passeriformes	Muscicapidae	*Phoenicurus erythrogastrus*	Guldenstadt's Redstart	LC
424	Passeriformes	Muscicapidae	*Phoenicurus erythronota*	Rufous-backed Redstart	LC
425	Passeriformes	Muscicapidae	*Phoenicurus frontalis*	Blue-fronted Redstart	LC
426	Passeriformes	Muscicapidae	*Phoenicurus ochruros*	Black Redstart	LC

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427	Passeriformes	Muscicapidae	*Prinia crinigera*	Striated Prinia	LC
428	Passeriformes	Muscicapidae	*Prinia inornata*	Plain Prinia	LC
429	Passeriformes	Muscicapidae	*Prinia socialis*	Ashy Prinia	LC
430	Passeriformes	Muscicapidae	*Prinia sylvatica*	Jungle Prinia	LC
431	Passeriformes	Muscicapidae	*Rhyacornis fuliginosa*	Plumbeous Water Redstart	LC
432	Passeriformes	Muscicapidae	*Saxicola caprata*	Pied Bushchat	LC
433	Passeriformes	Muscicapidae	*Saxicola ferreus*	Grey Bush Chat	LC
434	Passeriformes	Muscicapidae	*Saxicola leucurus*	White-tailed Stonechat	LC
435	Passeriformes	Muscicapidae	*Saxicola maurus*	Eastern Stonechat	NA
436	Passeriformes	Muscicapidae	*Saxicola torquata*	Collared Bushchat	LC
437	Passeriformes	Muscicapidae	*Saxicoloides fulicatus*	Indian Robin	LC
438	Passeriformes	Muscicapidae	*Tarsiger chrysaeus*	Golden Bush Robin	LC
439	Passeriformes	Muscicapidae	*Turdoides caudatus*	Common Babbler	LC
440	Passeriformes	Nectariniidae	*Aethopyga nipalensis*	Green-tailed Sunbird	LC
441	Passeriformes	Nectariniidae	*Aethopyga siparaja*	Crimson sunbird	LC
442	Passeriformes	Nectariniidae	*Nectarinia asiatica*	Purple Sunbird	LC
443	Passeriformes	Oriolidae	*Oriolus kundoo*	Indian Golden Oriole	NA
444	Passeriformes	Oriolidae	*Oriolus oriolus*	Eurasian Golden Oriole	LC
445	Passeriformes	Oriolidae	*Oriolus traillii*	Maroon Oriole	LC
446	Passeriformes	Oriolidae	*Oriolus xanthornus*	Black-hooded Oriole	LC
447	Passeriformes	Paridae	*Baeolophus atricristatus*	Black Crested Tit	LC
448	Passeriformes	Paridae	*Lophophanes dichrous*	Fulvous Tit	NA
449	Passeriformes	Paridae	*Parus cinereus*	Cinereous Tit	NA
450	Passeriformes	Paridae	*Parus dichrous*	Grey Crested Tit	LC
451	Passeriformes	Paridae	*Parus major*	Great Tit	LC
452	Passeriformes	Paridae	*Parus monticolus*	Green Backed Tit	LC
453	Passeriformes	Paridae	*Parus rubidiventris*	Rufous-vented Tit	LC

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454	Passeriformes	Paridae	*Parus rufonuchalis*	Dark Grey Tit	LC
455	Passeriformes	Paridae	*Parus spilonotus*	Yellow-cheeked Tit	LC
456	Passeriformes	Paridae	*Periparus ater*	Coal Tit	NA
457	Passeriformes	Paridae	*Periparus rufonuchalis*	Rufous-naped Tit	NA
458	Passeriformes	Paridae	*Sylviparus modestus*	Yellow Browed Tit	LC
459	Passeriformes	Passeridae	*Passer domesticus*	House Sparrow	LC
460	Passeriformes	Passeridae	*Passer rutilans*	Russet Sparrow	LC
461	Passeriformes	Passeridae	*Petronia xanthocollis*	Chestnut shouldered petronia	LC
462	Passeriformes	Pellorneidae	*Pellorneum ruficeps*	Puff-throated Babbler	LC
463	Passeriformes	Phylloscopidae	*Phylloscopus affinis*	Tickell's leaf warbler	LC
464	Passeriformes	Pittidae	*Pitta brachyura*	Indian Pitta	LC
465	Passeriformes	Ploceidae	*Ploceus benghalensis*	Black-breasted Weaver	LC
466	Passeriformes	Ploceidae	*Ploceus manyar*	Streaked Weaver	LC
467	Passeriformes	Ploceidae	*Ploceus philippinus*	Baya Weaver	LC
468	Passeriformes	Prunellidae	*Prunella atrogularis*	Black-throated Accentor	LC
469	Passeriformes	Prunellidae	*Prunella collaris*	Alpine Accentor	LC
470	Passeriformes	Prunellidae	*Prunella himalayana*	Rufous-streaked accentor	LC
471	Passeriformes	Prunellidae	*Prunella strophiata*	Rufous-breasted Accentor	LC
472	Passeriformes	Pycnonotidae	*Hypsipetes leucocephalus*	Black Bulbul	LC
473	Passeriformes	Pycnonotidae	*Pycnonotus cafer*	Red-vented Bulbul	LC
474	Passeriformes	Pycnonotidae	*Pycnonotus leucogenys*	Himalayan Bulbul	LC
475	Passeriformes	Reguliidae	*Regulus regulus*	Gold Crest	LC
476	Passeriformes	Remizidae	*Cephalopyrus flammiceps*	Fire Capped tit	LC
477	Passeriformes	Rhipiduridae	*Rhipidura albicollis*	White-throated Fantail	LC
478	Passeriformes	Rhipiduridae	*Rhipidura aureola*	White-browed Fantail	LC
479	Passeriformes	Scotocercidae	*Horornis fortipes*	Brown-flanked Bush Warbler	NA
480	Passeriformes	Sittidae	*Sitta carolinensis*	White breasted Nuthatch	LC

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481	Passeriformes	Sittidae	*Sitta cashmirensis*	Kashmir Nuthatch	LC
482	Passeriformes	Sittidae	*Sitta cinnamoventris*	Chestnut-bellied nuthatch	LC
483	Passeriformes	Sittidae	*Sitta himalayensis*	White Tailed Nuthatch	LC
484	Passeriformes	Sittidae	*Sitta leucopsis*	White-cheeked Nuthatch	LC
485	Passeriformes	Sittidae	*Tichodroma muraria*	Wall Creeper	LC
486	Passeriformes	Stenostiridae	*Rhipidura hypoxantha*	Yellow bellied Fantail	LC
487	Passeriformes	Sturnidae	*Acridotheres fuscus*	Jungle Myna	LC
488	Passeriformes	Sturnidae	*Acridotheres ginginianus*	Bank Myna	LC
489	Passeriformes	Sturnidae	*Acridotheres tristis*	Common Myna	LC
490	Passeriformes	Sturnidae	*Agropsar sturninus*	Purple-backed Starling	NA
491	Passeriformes	Sturnidae	*Gracupica contra*	Asian Pied Starling	NA
492	Passeriformes	Sturnidae	*Pastor roseus*	Rosy Starling	NA
493	Passeriformes	Sturnidae	*Saroglossa spiloptera*	Spot-winged Starling	LC
494	Passeriformes	Sturnidae	*Sturnia malabarica*	Chestnut-tailed Starling	NA
495	Passeriformes	Sturnidae	*Sturnus pagodarum*	Brahminy starling	LC
496	Passeriformes	Sturnidae	*Sturnus vulgaris*	Common Starling	LC
497	Passeriformes	Sylvidae	*Cettia brunnifrons*	Grey-sided Bush-warbler	LC
498	Passeriformes	Sylvidae	*Cettia fortipes*	Brownish Flanked Bush Warbler	LC
499	Passeriformes	Sylvidae	*Megalurus palustris*	Stariated marsh warbler/ Striated Grassbird	LC
500	Passeriformes	Sylvidae	*Phylloscopus chloronotus*	Pale rumped Warbler	LC
501	Passeriformes	Sylvidae	*Phylloscopus inornatus*	Inornate Warbler/ Yellow Browed Warbler	LC
502	Passeriformes	Sylvidae	*Phylloscopus maculipennis*	Ashy Throated Warbler	LC
503	Passeriformes	Sylvidae	*Phylloscopus occipitalis*	Western Crowned Warbler	LC
504	Passeriformes	Sylvidae	*Phylloscopus pulcher*	Buff-barred Warbler	LC
505	Passeriformes	Sylvidae	*Phylloscopus trochiloides*	Greenish Warbler	LC

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506	Passeriformes	Sylvidae	*Seicercus burkii*	Green Crowned Warbler	LC
507	Passeriformes	Sylvidae	*Tesia castaneocoronata*	Chestnut Headed Tesia	LC
508	Passeriformes	Sylviidae	*Acrocephalus aedon*	Thick-billed Warbler	LC
509	Passeriformes	Sylviidae	*Chrysomma sinense*	Yellow-eyed Babbler	LC
510	Passeriformes	Sylviidae	*Hippolais rama*	Sykes's Warbler	LC
511	Passeriformes	Sylviidae	*Phylloscopus collybita*	Common Chiffchaff	LC
512	Passeriformes	Sylviidae	*Phylloscopus griseolus*	Sulphur-bellied Warbler	LC
513	Passeriformes	Sylviidae	*Phylloscopus magnirostris*	Large-billed Leaf Warbler	LC
514	Passeriformes	Sylviidae	*Phylloscopus reguloides*	Blyth's Leaf Warbler	LC
515	Passeriformes	Sylviidae	*Phylloscopus sindianus*	Kashmir Chiffchaff	LC
516	Passeriformes	Sylviidae	*Phylloscopus subviridis*	Brooks's Leaf Warbler	LC
517	Passeriformes	Sylviidae	*Phylloscopus tytleri*	Tytler's Leaf Warbler	NT
518	Passeriformes	Sylviidae	*Sylvia curruca*	Lesser Whitethroat	LC
519	Passeriformes	Sylviidae	*Sylvia nana*	Asian Desert Warbler	LC
520	Passeriformes	Sylviidae	*Sylvia crassirostris*	Eastern Orphean Warbler	NA
521	Passeriformes	Timaliidae	*Alcippe vinipectus*	White-browed Fulvetta	LC
522	Passeriformes	Timaliidae	*Dumetia hyperythra*	Tawny-bellied Babbler	LC
523	Passeriformes	Timaliidae	*Minla strigula*	Chestnut-tailed Minla	LC
524	Passeriformes	Timaliidae	*Pnoepyga albiventer*	Scaly-breasted Wren-babbler	LC
525	Passeriformes	Timaliidae	*Pomatorhinus erythrogenys*	Rusty cheeked Scimitar babbler	LC
526	Passeriformes	Timaliidae	*Pteruthius flaviscapis*	White Browed Shrike Babbler	LC
527	Passeriformes	Timaliidae	*Pteruthius xanthochlorus*	Green Shrike-babbler	LC
528	Passeriformes	Timaliidae	*Stachyris pyrrhops*	Black-chinned Babbler	LC
529	Passeriformes	Timaliidae	*Turdoides earlei*	Striated babbler	LC
530	Passeriformes	Timaliidae	*Turdoides malcolmi*	Large Grey Babbler	LC
531	Passeriformes	Troglodytidae	*Troglodytes troglodytes*	Winter Wren	LC
532	Passeriformes	Turdidae	*Grandala coelicolor*	Grandala	LC

S.No.	Order	Family	Scientific Name	Common Name	Conservation Status IUCN Red List
533	Passeriformes	Turdidae	*Turdus albocinctus*	White-collared Blackbird	LC
534	Passeriformes	Turdidae	*Turdus boulboul*	Grey-winged Blackbird	LC
535	Passeriformes	Turdidae	*Turdus rubrocanus*	Chestnut Thrush	LC
536	Passeriformes	Turdidae	*Turdus ruficollis*	Red-throated Thrush	LC
537	Passeriformes	Turdidae	*Turdus simillimus*	Indian Blackbird	NA
538	Passeriformes	Turdidae	*Turdus unicolor*	Tickell's Thrush	LC
539	Passeriformes	Turdidae	*Turdus viscivorus*	Mistle Thrush	LC
540	Passeriformes	Turdidae	*Zoothera citrina*	Orange-headed Thrush	LC
541	Passeriformes	Turdidae	*Zoothera dixoni*	Long-tailed Thrush	LC
542	Passeriformes	Turdidae	*Zoothera mollissima*	Plain-backed Thrush	LC
543	Passeriformes	Turdidae	*Zoothera monticola*	Long-billed Thrush	LC
544	Passeriformes	Vangidae	*Tephrodornis pondicerianus*	Common Woodshrike	LC
545	Passeriformes	Vireonidae	*Pteruthius ripleyi*	Himalayan Shrike-babbler	NA
546	Passeriformes	Zosteropidae	*Yuhina flavicollis*	Whiskered Yuhina	LC
547	Passeriformes	Zosteropidae	*Zosterops palpebrosus*	Oriental white-eye	LC
548	Pelecaniformes	Anhingidae	*Anhinga melanogaster*	Oriental Darter	NT
549	Pelecaniformes	Ardeidae	*Ardea alba*	Large Egret	LC
550	Pelecaniformes	Ardeidae	*Ardea cinerea*	Grey Heron	LC
551	Pelecaniformes	Ardeidae	*Ardea intermedia*	Intermediate Egret	LC
552	Pelecaniformes	Ardeidae	*Ardea purpurea*	Purple heron	LC
553	Pelecaniformes	Ardeidae	*Botaurus stellaris*	Eurasian Bittern	LC
554	Pelecaniformes	Ardeidae	*Butorides striata*	Striated Heron	LC
555	Pelecaniformes	Ardeidae	*Ixobrychus cinnamomeus*	Cinnamon Bittern	LC
556	Pelecaniformes	Ardeidae	*Ixobrychus flavicollis*	Black Bittern	LC
557	Pelecaniformes	Ardeidae	*Ixobrychus sinensis*	Yellow Bittern	LC
558	Pelecaniformes	Ardeidae	*Nycticorax nycticorax*	Black-crowned Night Heron	LC
559	Pelecaniformes	Ciconiidae	*Anastomus oscitans*	Asian Openbill	LC

S.No.	Order	Family	Scientific Name	Common Name	Conservation Status IUCN Red List
560	Pelecaniformes	Ciconiidae	*Ciconia ciconia*	European White Stork	LC
561	Pelecaniformes	Ciconiidae	*Ciconia episcopus*	White necked strock	VU
562	Pelecaniformes	Ciconiidae	*Ciconia nigra*	Black Stork	LC
563	Pelecaniformes	Ciconiidae	*Ephippiorhynchus asiaticus*	Black-necked Stork	NT
564	Pelecaniformes	Pelecanidae	*Pelecanus crispus*	Dalmatian Pelican	VU
565	Pelecaniformes	Pelecanidae	*Pelecanus onocrotalus*	Great White Pelican	LC
566	Pelecaniformes	Pelecanidae	*Pelecanus philippensis*	Spot-billed Pelican	NT
567	Pelecaniformes	Threskiornithidae	*Platalea leucorodia*	Eurasian spoonbill	LC
568	Pelecaniformes	Threskiornithidae	*Plegadis falcinellus*	Glossy Ibis	LC
569	Pelecaniformes	Threskiornithidae	*Pseudibis papillosa*	Red-naped Ibis	LC
570	Pelecaniformes	Threskiornithidae	*Threskiornis melanocephalus*	Oriental white ibis	NT
571	Phoenicopteriformes	Phoenicopteridae	*Phoenicopterus roseus*	Greater Flamingo	LC
572	Piciformes	Capitonidae	*Megalaima virens*	Great barbet	LC
573	Piciformes	Indicatoridae	*Indicator xanthonotus*	Yellow-rumped Honeyguide	NA
574	Piciformes	Megalaimidae	*Psilopogon asiaticus*	Blue-throated Barbet	LC
575	Piciformes	Megalaimidae	*Psilopogon haemacephalus*	Coppersmith Barbet	LC
576	Piciformes	Megalaimidae	*Psilopogon zeylanicus*	Brown-headed Barbet	LC
577	Piciformes	Picidae	*Dendrocopos auriceps*	Brown-fronted Woodpecker	LC
578	Piciformes	Picidae	*Dendrocopos canicapillus*	Grey-capped Pygmy Woodpecker	LC
579	Piciformes	Picidae	*Dendrocopos hyperythrus*	Rufous-bellied Woodpecker	LC
580	Piciformes	Picidae	*Dendrocopos macei*	Fulvous-breasted Woodpecker	LC
581	Piciformes	Picidae	*Dendrocopos mahrattensis*	Yellow-crowned Woodpecker	LC
582	Piciformes	Picidae	*Dendrocopos moluccensis*	Brown-capped Woodpecker	LC
583	Piciformes	Picidae	*Dinopium benghalense*	Black-rumped Flameback	LC
584	Piciformes	Picidae	*Dinopium shorii*	Himalayan Flame-backed Woodpecker	LC
585	Piciformes	Picidae	*Jynx torquilla*	Northern Wryneck	LC

S.No.	Order	Family	Scientific Name	Common Name	Conservation Status IUCN Red List
586	Piciformes	Picidae	*Leiopicus auriceps*	Brown Fronted Woodpecker	LC
587	Piciformes	Picidae	*Picumnus innominatus*	Speckled Piculet	LC
588	Piciformes	Picidae	*Picus canus*	Grey-headed Woodpecker	LC
589	Piciformes	Picidae	*Picus chlorolophus*	Lesser Yellow-naped Woodpecker	LC
590	Piciformes	Picidae	*Picus squamatus*	Scaly Bellied Woodpecker	LC
591	Piciformes	Picidae	*Picus xanthopygaeus*	Little scaly bellied green Woodpecker	LC
592	Piciformes	Ramphastidae	*Psilopogon virens*	Great Himalayan Barbets	LC
593	Podicipediformes	Podicipedidae	*Podiceps auritus*	Slavonian Grebe	VU
594	Podicipediformes	Podicipedidae	*Podiceps cristatus*	Great Crested Grebe	LC
595	Podicipediformes	Podicipedidae	*Podiceps grisegena*	Red-necked Grebe	LC
596	Podicipediformes	Podicipedidae	*Podiceps nigricollis*	Black-necked Grebe	LC
597	Podicipediformes	Podicipedidae	*Tachybaptus ruficollis*	Little Grabe	LC
598	Psittaciformes	Psittacidae	*Psittacula cyanocephala*	Plum-headed Parakeet	LC
599	Psittaciformes	Psittacidae	*Psittacula eupatria*	Alexandrine Parakeet	NT
600	Psittaciformes	Psittacidae	*Psittacula himalayana*	Slaty-headed Parakeet	LC
601	Psittaciformes	Psittacidae	*Psittacula krameri*	Rose-ringed Parakeet	LC
602	Pterocliformes	Pteroclidae	*Pterocles exustus*	Chestnut-bellied Sandgrouse	LC
603	Pterocliformes	Pteroclidae	*Pterocles indicus*	Painted Sandgrouse	LC
604	Pterocliformes	Pteroclidae	*Pterocles senegallus*	Spotted Sandgrouse	LC
605	Strigiformes	Strigidae	*Asio flammeus*	Short-eared Owl	LC
606	Strigiformes	Strigidae	*Asio otus*	Northern Long-eared Owl	LC
607	Strigiformes	Strigidae	*Athene brama*	Spotted Owlet	LC
608	Strigiformes	Strigidae	*Bubo bengalensis*	Rock Eagle Owl	LC
609	Strigiformes	Strigidae	*Bubo bubo*	Eurasian Eagle Owl	LC
610	Strigiformes	Strigidae	*Bubo coromandus*	Dusky Eagle Owl	LC
611	Strigiformes	Strigidae	*Bubo nipalensis*	Forest eagle Owl	LC

S.No.	Order	Family	Scientific Name	Common Name	Conservation Status IUCN Red List
612	Strigiformes	Strigidae	*Glaucidium brodiei*	Collared Owlet	LC
613	Strigiformes	Strigidae	*Glaucidium cuculoides*	Asian Barred Owlet	LC
614	Strigiformes	Strigidae	*Glaucidium radiatum*	Jungle Owlet	LC
615	Strigiformes	Strigidae	*Ketupa flavipes*	Tawny Fish Owl	LC
616	Strigiformes	Strigidae	*Ketupa zeylonensis*	Brown Fish Owl	LC
617	Strigiformes	Strigidae	*Otus bakkamoena*	Collared Scops Owl	LC
618	Strigiformes	Strigidae	*Otus spilocephalus*	Mountain Scops Owl	LC
619	Strigiformes	Strigidae	*Otus sunia*	Oriental Scops Owl	LC
620	Strigiformes	Strigidae	*Strix aluco*	Tawny Wood-Owl	LC
621	Strigiformes	Strigidae	*Strix ocellata*	Mottled Wood Owl	LC
622	Strigiformes	Tytonidae	*Tyto alba*	Barn owl	LC
623	Suliformes	Phalacrocoracidae	*Microcarbo niger*	Little Cormorant	LC
624	Suliformes	Phalacrocoracidae	*Phalacrocorax carbo*	Great Cormorant	LC
625	Suliformes	Phalacrocoracidae	*Phalacrocorax fuscicollis*	Indian Cormorant	LC

CR= Critically Endangered, EN = Endangered, NT = Near Threatened, VU = Vulnerable, LC = Least Concern

Annexure VI

Sub basin wise distribution of butterflies and their habit and conservation status in Beas Basin

Family	Common Name	Scientific Name	Distribution Range (in m)	Conservation Status		Sub basins										
				IUICN	IWPA	BSI	BSII	MLN	PVI	PVII	SK	TT	BSIII	UHL	BSIV	BSV
Papilionidae	Common Peacock	*Papilio polyctor*	up to 800										+	+	+	
	Blue Peacock	*Papilio arcturus*	up to 2500			+	+	+	+	+	+	+	+	+	+	+
	Krishna Peacok	*Papilio krishna*	up to 2500			+	+	+	+	+	+	+	+	+	+	+
	Common Mormon	*Papilio polytes*	up to 2500				+	+	+	+	+	+	+	+	+	+
	Common Yellow Swallowtail	*Papilio machaon*	up to 3500		II		+	+	+	+	+	+	+	+	+	
	Spangle	*Papilio protenor*	up to 800										+	+	+	+
	Common blue bottle	*Graphium sarpedon*	up to 2800			+	+	+	+	+	+	+	+	+	+	+
	Bluebottle	*Graphium cloanthus*	up to 2500			+	+	+	+	+	+	+	+	+	+	+
	Common Lime	*Papilio demoleus*	up to 2500			+	+	+	+	+	+	+	+	+	+	+
	Tawny Mime	*Chilasa agestor*	up to 800										+	+	+	+
	Common Mime	*Chilasa clytia*	up to 800										+	+	+	+
	Common Windmill	*Byasa polyeuctes*	up to 2500					+	+	+	+	+			+	
	Great Windmill	*Byasa dasarada*	up to 2800										+	+	+	+
	Regal Apollo	*Parnassius charltonius*	above 3000		II	+	+	+	+		+	+		+	+	
	Common Blue Apollo	*Parnassius hardwickei*	above 3000					+	+		+	+		+	+	
Pieridae	Bath white	*Pontia daplidice*	up to 2000	LC				+	+	+	+	+	+	+	+	+
	Lofty Bath White	*Pontia callidice*	up to 2800			+	+	+	+	+	+	+	+	+	+	+
	Psyche	*Leptosia nina nina*	up to 900										+	+	+	+
	Common Brimstone	*Gonepteryx rhamni*	up to 2800			+	+	+	+	+	+	+	+	+	+	
	Lesser Brimstone	*Gonepteryx mahaguru*	up to 3500			+	+	+	+	+	+	+	+	+	+	+
	Common Wanderer	*Parenonia valeria*	up to 2000			+	+	+	+	+	+	+				
	Common Emigrant	*Catopsilia pomona*	up to 2800			+	+	+	+	+	+	+	+	+	+	+

	Mottled Emigrant	*Catopsilia pyranthe*	up to 1000										+	+	+	+
	Common Grass Yellow	*Eurema hecabe*	up to 900										+	+	+	+
	Small Grass Yellow	*Eurema brigitta*	up to 900	LC									+	+	+	+
	Spotless grass	*Eurema laeta*	up to 1000										+	+	+	+
	Three spot grass yellow	*Eurema blanda*	up to 900										+	+	+	+
	Dark Clouded Yellow	*Colias electo*	up to 2800			+	+	+	+	+	+	+	+	+	+	+
	Pale Clouded Yellow	*Colias erate*	above 2000			+	+	+	+	+	+	+	+	+	+	+
	Hill Jezebal	*Delias belladonna*	up to 2800			+	+	+	+	+	+	+	+	+		+
	Common Jezebel	*Delias eucharis*	up to 800										+	+	+	+
	Indian Cabbage White	*Pieris canidia*	up to 2800			+	+	+	+	+	+	+	+	+	+	+
	Large Cabbage White	*Pieris brassicae*	up to 2800			+	+	+	+	+	+	+	+	+	+	+
	Chumbi White	*Pieris dubernardi*	up to 2000			+	+	+	+	+	+	+	+	+	+	+
	Himalayan Blackvein	*Aporia leucodice*	up to 1500				+	+	+	+	+	+	+	+	+	+
	Pioneer	*Belenois aurota*	up to 2800			+	+	+	+	+	+	+			+	+
	Yellow Orange Tip	*Ixias pyrene*	up to 1000										+	+	+	
	The White Orange Tip	*Ixias marianne*	up to 1000										+	+	+	+
	Spootted Sawtooth	*Prioneris thestylis thestylis*	up to 2000			+	+	+	+	+	+	+	+	+	+	+
Lycaenidae	Common Silverline	*Spindasis vulcanus*	up to 900										+	+	+	+
	Pulm Judy	*Abisara echerius*	up to 2500			+	+	+	+	+	+	+	+	+	+	+
	Dark Judy	*Abisara fylla*	up to 2500			+	+	+	+	+	+	+	+	+	+	+
	Tawny Coster	*Acraea violae*	up to 2500			+	+	+	+	+	+	+	+	+	+	+
	Yellow Coster	*Pareba vesta*	u to 2500			+	+	+	+	+	+	+	+	+	+	+
	White Bordered Copper	*Lycaena pavana*	up to 2800			+	+								+	
	Common Copper	*Lycaena phlaeas*	up to 2800			+	+	+	+	+	+	+	+	+	+	
	Green Copper	*Lycaena kasyapa*	up to 2800			+	+	+	+	+	+	+	+	+	+	+
	Common Line Blue	*Prosota nora*	up to 900										+	+	+	+
	Common Onyx	*Horaga onyx*	up to 900		II								+	+	+	+

	Common Punch	*Dodona durga*	up to 2800			+	+	+	+	+	+	+	+	+	+	+
	Guava Blue	*Deudurix isocrates*	up to 900										+	+		+
	Cornelian	*Deudurix epijarbus*	up to 2500			+	+	+	+	+	+	+	+	+	+	+
	Comma	*Polygonia c-album*	up to 3500			+	+	+	+	+	+	+	+	+	+	+
	Large Hedge Blue	*Celastrina huegelii*	up to 2800			+	+	+	+	+	+	+	+	+	+	
	Dark Glass Blue	*Zizeeria karsandra*	up to 900										+	+	+	+
	Pale Grass Blue	*Pseudozizeeria maha*	up to 2500			+	+	+	+	+	+	+	+	+	+	+
	Dark Grass Blue	*Zizeeria lysimon*	up to 2500			+	+	+	+	+	+	+	+	+	+	+
	Pea Blue	*Lampides boeticus*	up to 2800		II	+	+	+	+	+	+	+		+	+	
	Red Pierrot	*Talicada nyseus*	up to 800												+	+
	Pale Hedge Blue	*Udara dilecta*	upto 800												+	
	Purple Sapphire	*Heliophorus epicles*	upto 800										+	+	+	
	Sorrel Sapphire	*Heliophorus sena*	up to 2800			+	+	+	+	+	+	+	+	+	+	+
	Green Sapphire	*Heliophorus androcles*	up to 2500			+	+	+	+	+	+	+	+	+	+	+
	Western Blue Sapphire	*Heliophorus bakeri*	up to 2800			+	+	+	+	+	+	+	+	+	+	+
	Eastern Blue Sapphire	*Heliophorus oda*	up to 2800			+	+	+	+	+	+	+	+	+	+	+
	Yam Fly	*Loxura atymnus*	up to 2500			+	+	+	+	+	+	+	+	+	+	+
	Zebra Blue	*Leptotes plinius*	up to 800			+	+	+	+	+	+	+	+	+	+	+
	Rounded Pierrot	*Tarucus nara*	up to 800			+	+	+	+	+	+	+	+	+	+	+
	Common Hedge Blue	*Acytolepis puspa*	up to 2500			+	+	+	+	+	+	+	+	+	+	+
Nymphalidae	Large Silverstrip	*Argynnis childreni*	up to 4000			+	+	+	+	+	+	+	+	+	+	+
	Indian Fritilary	*Argyreus hyperbius*	up to 2800			+	+	+	+	+	+	+	+	+	+	+
	Club Beak	*Libythea myrrha*	up to 800										+	+	+	+
	Common Beak	*Libythea lepita*	up to 2800		II	+	+								+	
	Common Baron	*Euthalia aconthea*	up to 800												+	+
	Baronet	*Euthalia nais*	up to 800										+	+	+	
	Blue Pansy	*Junonia orithiya*	up to 2800			+	+	+	+	+	+	+	+	+	+	+

	Chocolate Pansy	*Junonia iphita*	up to 2800			+	+	+	+	+	+	+	+	+	+	+
	Grey Pansy	*Junonia atlites*	up to 800										+	+	+	
	Lemon Pansy	*Junonia lemonias*	up to 1000										+	+	+	+
	Peacock Pansy	*Junonia almana*	up to 800	LC									+	+	+	+
	Yellow Pansy	*Junonia hierta*	up to 2500	LC				+	+	+	+	+	+	+	+	+
	Common Jester	*Symbrenthia hippoclus*	up to 800										+	+	+	+
	Himalayan Jester	*Symbrenthia hypselis*	up to 2500			+	+	+	+	+	+	+	+	+	+	+
	Common Leopard	*Phalanta phalantha*	up to 800										+	+	+	+
	Common Map	*Cyrestis thyodamas*	up to 800										+	+	+	
	Common Sailer	*Neptis hylas*	up to 2800			+	+	+	+	+	+	+	+	+	+	+
	Yerburis Sailer	*Neptis yerburii*	up to 2800			+	+	+	+	+	+	+	+	+	+	+
	Himalayan Sailer	*Neptis mehendra*	up to 1000										+	+	+	+
	Common Sergeant	*Athyma perius*	up to 800										+	+	+	+
	Common Wall	*Lasiommata schakra*	up to 2800			+	+	+	+	+	+	+	+	+	+	
	Danaid Eggfly	*Hypolimnas misippus*	up to 1000		II								+	+	+	+
	Indian Red Admiral	*Vanessa indica*	up to 2800			+	+	+	+	+	+	+	+	+	+	+
	Blue Admiral	*Vanessa canace*	up to 2800			+	+	+	+	+	+	+	+	+	+	+
	Painted Lady	*Vanessa cardui*	Above 2000					+	+	+	+	+	+	+	+	+
	Indian Tortoiseshell	*Aglais caschmiriensis*	up to 2800			+	+	+	+	+	+	+	+	+	+	+
	Cruiser	*Cynthia erota*	up to 2500			+	+	+	+	+	+	+	+	+	+	+
	Orange Oak leaf	*Kallima inachus*	up to 800										+	+	+	+
	Pallid Argus	*Callerebia scandal*	up to 800										+	+	+	
	Mountain Srgus	*Erebia shallada*	1700-2800			+	+									
	Western Courtier	*Sephisa dichroa*	up to 2500													
	Queen of Spain Fritilary	*Issoria lathonia*	up to 2800			+	+	+	+	+	+	+	+	+	+	
	Rustic	*Cupha erymanthis*	up to 800										+	+	+	
	The Commodore	*Auzakia danava*	up to 1000										+	+	+	+

Satyridae	Small Tawny Wall	*Raphicera moorei*	up to 3000					+	+	+	+	+	+	+	+	+
	Striated Satyr	*Aulocera sarswati*	up to 3000			+	+	+	+	+	+	+	+	+	+	+
	Great Satyr	*Aulocera padma*	up to 3000			+	+	+	+	+	+	+	+	+	+	+
	Common Satyr	*Aulocera swaha*	up to 3000			+	+	+	+	+	+	+	+	+	+	+
	Lilacin Bush Brown	*Mycalesis francisca*	up to 2500					+	+	+	+	+	+	+		
	Common Bush Brown	*Mycalesis perseus*	up to 800												+	+
	Dark Banded Bush Brown	*Mycalesis mineus*	up to 800										+			
	Common Fourring	*Ypthima huebneri*	up to 2800			+	+	+	+	+	+	+	+	+	+	+
	Common Fivering	*Ypthima baldus*	up to 1000			+	+	+	+	+	+	+	+	+	+	+
	Himalayan Five Ring	*Ypthima sakra*	up to 2800			+	+	+	+	+	+	+	+	+	+	+
	Large Three Ring	*Ypthima nareda*	up to 800										+	+	+	+
	Common Castor	*Ariadne merione*	up to 800										+	+	+	+
	Bamboo Treebrown	*Lethe europa*	up to 800										+	+	+	+
	Banded Tree brown	*Lethe confusa*	up to 800										+	+	+	+
	Common Woodbrown	*Lethe nicetas*	up to 3500			+	+	+	+	+	+	+	+	+	+	+
	Veined Labyrinth	*Lethe pulaha*	up to 3500		II	+	+	+	+	+	+	+	+	+	+	+
	Strait Banded Tree Brown	*Lethe verma*	up to 2500			+	+	+	+	+	+	+	+	+	+	+
	Common Treebrown	*Lethe rohria*	up to 1000										+	+	+	+
	Common Fiorester	*Lethe insana insana*	up to 1000		II								+	+	+	+
	Evening Brown	*Melanitis leda*	up to 1000										+	+	+	+
Danaidae	Common Crow	*Euploea core*	up to 2800	LC	IV	+	+	+	+	+	+	+	+	+	+	+
	Striped Blue Crow	*Euploea mulciber*	up to 2800		IV	+	+	+	+	+	+	+	+	+	+	+
	Blue Tiger	*Tirumala limniace*													+	+
	Dark Blue Tiger	*Tirumala septentrionis*	up to 800										+	+	+	+
	Common Sergent	*Parathyma perius*	up to 2500			+	+	+	+	+	+	+	+	+	+	+
	Chestnut Tiger	*Parantica sita*	up to 2500			+	+	+	+	+	+	+	+	+	+	+
	Glassy Tiger	*Parantica aglea*	up to 2800			+	+	+	+	+	+	+	+	+	+	+

	Striped Tiger	*Danaus genutia*	up to 2800			+	+	+	+	+	+	+	+	+	+	+
	Plain Tiger	*Danaus chrysippus*	up to 2800			+	+	+	+	+	+	+	+	+	+	+
Hesperiidae	Common Redeye	*Matapa aria*	up to 800										+	+	+	+
	Common small Flat	*Sarangesa dasahara*	up to 800										+	+	+	+
	Fulvous Pied Flat	*Pseudocoladenia dan*	up to 800										+	+	+	+
	Common Spotted Flat	*Celaenorrhinus leucocera*	up to 2500			+	+	+	+	+	+	+	+	+	+	+
	Snow Flat	*Tagiades litigiosa*	up to 2500			+	+	+	+	+	+	+	+	+	+	+
	Spotted Snow Flat	*Tagiades menaka*	up to 2500			+	+	+	+	+	+	+	+	+	+	+
	Grass demon	*Udaspes folus*	up to 800										+	+		+
	Indian Skipper	*Spialia galba*	up to 800										+	+	+	+
	Paint brush Swift	*Baoris farri*	up to 800		IV								+	+	+	+
	Pale palm dart	*Telicota colon*	up to 800										+	+		+
	Himalayan Grass Dark Dart	*Taractrocera danna*	up to 2800			+	+	+	+	+	+	+	+	+	+	+
	Rice Swift	*Borbo cinnara*	up to 800										+	+	+	+
	Bevan's Swift	Pseudoborbo bevani	up to 800										+	+		+
	Large Banded Swift	*Pelopidas sinensis*	uo to 2500		IV			+	+	+	+	+	+	+	+	+

BSI = Beas I, BSII = Beas II, BSIII = Beas III, BSIV = Beas IV, BSV = Beas V, MLN = Malana, PVI= Pavati I, PVII = Parvati II, SK = Sainj Khad, TT= Tirthan, Uhl = Uhl

Annexure VII: Physico-Chemical characteristics of water at different sampling sites in the Study Area (March 2016)

Physical / Chemical Characteristics	Sampling Locations														
	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13	W14	W15
Water Temperature (°C)	16.4	17.2	17.12	18.3	17.8	17.6	18.92	5.12	16.25	16.38	18.76	19.2	18.78	20.1	19.7
Dissolved Oxygen (mg/l)	7.93	7.89	7.87	7.82	7.9	7.94	7.79	8.49	7.98	7.99	7.85	7.89	7.83	7.82	7.8
Turbidity (NTU)	1.3	1.23	1.7	1.43	0.4	0.42	0.59	0	1.15	1.21	1.32	1.12	1.15	1.04	0.84
Total Suspended Solids (mg/l)	3.61	3.45	2.98	2.43	2.18	2.26	2.43	2.18	2.98	3.01	1.94	1.86	1.96	1.42	1.54
pH	8.15	8.23	8.09	8.04	8.03	8.11	8.02	7.41	8.13	8.01	7.92	8.18	7.91	7.86	7.74
Electrical Conductivity (µS/cm)	96.86	81.83	90.18	81.83	75.15	76.82	91.85	78	81.83	78.49	80.16	83.5	68.47	76.82	80.16
Total Dissolved Solids (mg/l)	58	49	54	49	45	46	55	54	49	47	48	50	41	46	48
Total alkalinity (mg/l of $CaCO_3$)	26.1	21.8	26	23	21	22	24	26	23	20	22	22	20	22	20
Sulphate (mg/l)	5.48	3.21	4.12	4.96	4.03	3.86	7.13	6.87	5.12	4.93	5.28	4.98	4.28	5.12	6.14
Chloride (mg/l)	8.03	8.29	8.16	7.18	6.13	6.1	7.84	5.6	6.97	7.99	6.54	6.13	5.14	6.27	7.13
Nitrates (NO_3) (mg/l)	0.86	0.46	0.43	0.24	0.31	0.52	0.32	0.04	0.21	0.24	0.18	0.95	0.13	0.12	0.12
Phosphate (PO_4) (mg/l)	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.01	0.01	0.01	0.02	0.01	0.01
Total Hardness (mg/l)	33.473	29.849	31.179	30.424	26.297	26.296	32.924	37	28.998	27.685	30.19	27.917	25.358	28.702	29.139
Calcium ions (mg/ l)	8.42	7.61	7.65	7.84	6.14	6.32	8.02	10	7.45	8.04	7.73	7.69	6.24	7.43	7.49
Magnesium ions (mg/l)	3.03	2.64	2.94	2.64	2.67	2.56	3.14	3	2.53	1.85	2.65	2.12	2.38	2.47	2.54
Sodium (mg/l)	2.97	1.95	2.12	1.76	1.96	2.39	2.05	0.8	1.89	1.99	1.75	1.73	0.93	1.42	1.98
Potassium (mg/l)	1.84	1.39	1.05	1.26	1.21	1.21	1.06	0.6	1.43	1.04	1.17	1.21	1.14	0.95	1.58
Iron (mg/l)	0.13	0.11	0.12	0.1	0.13	0.15	0.1	0.03	0.14	0.12	0.01	0.02	0.11	0.12	0.12
Cadmium (Cd) (mg/l)	ND	ND	ND	ND	ND	ND	ND	0.007	ND	ND	ND	ND	ND	ND	ND
Arsenic (As) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Mercury (Hg) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Copper (Cu) (mg/l)	ND	ND	ND	ND	ND	ND	ND	0.0003	ND	ND	ND	ND	ND	ND	ND
Zinc (Zn) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total Chromium (Cr) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Manganese (Mn) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Lead (Pb) (mg/l)	ND	ND	ND	ND	ND	ND	ND	0.032	ND	ND	ND	ND	ND	ND	ND
Biological Oxygen Demand (mg/l)	0.15	0.2	0.19	0.2	0.23	0.28	0.12	0.2	0.18	0.25	0.18	0.5	0.7	0.58	0.89
Chemical Oxygen Demand (mg/l)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Coliform (MPN /100 ml)	P	P	P	P	P	A	A	A	P	P	P	P	P	P	P

Contd…

Physical / Chemical Characteristics	W16	W17	W18	W19	W20	W21	W22	W23	W24	W25	W26	W27	W28	W29	W30
Water Temperature (°C)	18.86	18.92	19.4	18.86	19.4	19.1	18.7	18.9	19.1	18.8	18.7	18.9	19.2	19.1	20.1
Dissolved Oxygen (mg/l)	7.84	7.65	7.62	7.98	7.59	7.72	7.81	7.84	7.82	7.74	7.82	7.61	7.79	7.59	7.87
Turbidity (NTU)	0.78	0.98	0.92	0.74	0.97	1.1	0.8	0.85	0.89	0.69	0.71	0.76	0.54	0.72	0.43
Total Suspended Solids (mg/l)	1.48	2.63	2.59	1.76	2.29	2.1	2.2	2.31	2.42	1.78	1.68	1.75	1.56	1.62	1.67
pH	7.86	7.73	7.84	7.84	7.73	7.73	7.78	7.85	7.75	7.89	8.04	8.01	7.94	8.05	7.95
Electrical Conductivity (µS/cm)	78.49	75.15	80.16	76.82	71.81	78.49	71.81	61.79	71.81	73.48	75.15	73.48	76.82	71.81	75.15
Total Dissolved Solids (mg/l)	47	45	48	46	43	47	43	37	43	44	45	44	46	43	45
Total alkalinity (mg/l of CaCO3)	19	24	23	20	20	23	22	20	22	26	23	25	21	21	24
Sulphate (mg/l)	6.15	2.75	4.59	6.03	4.12	4.8	2.69	3.12	4.68	3.02	3.51	2.95	2.78	2.53	2.13
Chloride (mg/l)	7.42	5.79	6.31	6.47	5.29	6.47	5.01	3.25	4.01	2.93	4.63	3.99	7.64	7.31	6.21
Nitrates (NO3) (mg/l)	0.11	0.16	0.73	0.12	0.13	0.12	0.19	0.13	0.11	0.08	0.08	0.14	0.15	0.11	0.07
Phosphate (PO4) (mg/l)	0.02	0.01	0.01	0.001	0.01	0.02	0.01	0.02	0.01	0.02	0.01	0.01	0.02	0.02	0.01
Total Hardness (mg/l)	29.706	26.563	26.225	28.866	24.679	28.27	24.629	20.472	24.722	24.372	25.668	26.997	26.374	25.004	27.563
Calcium ions (mg/ l)	8.34	6.64	5.98	7.43	6.28	6.47	6.26	5.86	5.92	6.19	7.02	7.24	7.45	6.41	7.45
Magnesium ions (mg/l)	2.16	2.43	2.75	2.51	2.19	2.95	2.19	1.42	2.42	2.17	1.98	2.17	1.89	2.19	2.18
Sodium (mg/l)	1.95	1.64	2.07	1.97	2.06	1.67	1.02	1.19	1.28	1.8	1.75	1.02	1.78	1.98	1.65
Potassium (mg/l)	1.05	1.36	1.43	1.03	0.94	1.12	0.96	0.89	0.84	1.03	1.03	1.19	1.02	1.12	0.68
Iron (mg/l)	0.11	0.12	0.11	0.12	0.12	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Cadmium (Cd) (mg/l)	ND	<0.01	ND	<0.01	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Arsenic (As) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Mercury (Hg) (mg/l)	ND	<0.001	ND	<0.001	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Copper (Cu) (mg/l)	ND	<0.1	ND	<0.1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Zinc (Zn) (mg/l)	ND	<0.1	ND	<0.1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total Chromium (Cr) (mg/l)	ND	<0.05	ND	<0.05	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Manganese (Mn) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Lead (Pb) (mg/l)	ND	<0.1	ND	<0.1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Biological Oxygen Demand (mg/l)	0.23	0.45	0.34	0.78	0.65	0.35	0.21	0.22	0.19	0.2	0.16	0.12	0.2	0.14	0.21
Chemical Oxygen Demand (mg/l)	0	0	0	0	1.5	1.6	0	0	0	0	0	0	0	0	0
Total Coliform (MPN /100 ml)	A	P	P	P	P	P	P	P	P	P	P	P	P	P	A

Contd.

Physical / Chemical Characteristics	W31	W32	W33	W34	W35	W36	W37	W38	W39	W40	W41	W42	W43	W44	W45
Water Temperature (°C)	19.2	19.5	19.4	19.6	18.54	18.7	18.1	18.25	1.8.18	18.9	19.4	18.7	18.7	18.8	18.5
Dissolved Oxygen (mg/l)	7.74	7.56	7.81	7.74	7.84	7.79	8.05	8.09	7.89	7.78	7.82	7.89	7.77	7.99	7.87
Turbidity (NTU)	0.21	0.43	0.22	0.19	0.36	0.21	0.13	0.17	0.19	0.17	0	0	0.3	0.2	0.2
Total Suspended Solids (mg/l)	1.52	1.32	1.2	1.02	1.38	1.27	1.56	1.48	1.56	1.38	1.48	1.39	1.15	1.37	1.29
pH	8.02	7.98	7.99	8.12	8.14	8.11	8.06	8.02	8.01	8.02	8.11	7.95	8.02	7.89	7.89
Electrical Conductivity (µS/cm)	65.13	63.46	71.81	76.82	71.81	75.15	76.82	80.16	83.5	75.15	83.5	81.83	93.52	85.17	75.15
Total Dissolved Solids (mg/l)	39	38	43	46	43	45	46	48	50	45	50	49	56	51	45
Total alkalinity (mg/l of CaCO3)	21	20	23	24	24	24	25	26	27	24	28	26	30	27	23
Sulphate (mg/l)	2.31	2.01	2.31	2.41	2.68	2.98	2.89	2.76	2.89	2.96	2.95	3.31	4.28	3.89	3.54
Chloride (mg/l)	4.21	4.79	5.28	5.84	4.86	5.87	5.76	5.63	5.78	5.75	5.03	4.84	5.83	5.86	6.13
Nitrates (NO3) (mg/l)	0.09	0.06	0.2	0.09	0.21	0.11	0.1	0.12	0.12	0.09	0.1	0.09	0.11	0.08	0.12
Phosphate (PO4) (mg/l)	0.001	0.02	0.01	0.02	0.02	0.01	0.02	0.001	0.02	0.01	0.02	0.02	0.01	0.01	0.01
Total Hardness (mg/l)	21.339	23.515	25.068	24.307	24.596	26.014	28.315	27.639	28.233	24.658	30.895	28.307	32.073	28.924	27.061
Calcium ions (mg/ l)	5.19	6.29	6.78	6.82	5.64	5.83	6.98	6.89	6.98	5.96	7.52	7.19	7.45	6.83	5.97
Magnesium ions (mg/l)	2.04	1.9	1.98	1.77	2.56	2.79	2.65	2.54	2.63	2.38	2.95	2.52	3.28	2.89	2.96
Sodium (mg/l)	1.96	1.26	1.74	2.54	1.69	1.84	1.32	2.12	2.18	2.02	1.63	1.29	2.53	1.95	1.83
Potassium (mg/l)	1.04	0.95	1.28	1.03	1.04	1.3	1.1	1.35	1.4	1.45	1.03	1.03	1.83	1.45	1.02
Iron (mg/l)	<0.1	<0.01	<0.01	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.01	<0.01	<0.01	<0.01	<0.01
Cadmium (Cd) (mg/l)	ND	ND	ND	ND	ND	ND	<0.01	ND	<0.01	ND	ND	ND	ND	ND	ND
Arsenic (As) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Mercury (Hg) (mg/l)	ND	ND	ND	ND	ND	ND	<0.001	ND	<0.001	ND	ND	ND	ND	ND	ND
Copper (Cu) (mg/l)	ND	ND	ND	ND	ND	ND	<0.1	ND	<0.1	ND	ND	ND	ND	ND	ND
Zinc (Zn) (mg/l)	ND	ND	ND	ND	ND	ND	<0.1	ND	<0.1	ND	ND	ND	ND	ND	ND
Total Chromium (Cr) (mg/l)	ND	ND	ND	ND	ND	ND	<0.05	ND	<0.05	ND	ND	ND	ND	ND	ND
Manganese (Mn) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Lead (Pb) (mg/l)	ND	ND	ND	ND	ND	ND	<0.1	ND	<0.1	ND	ND	ND	ND	ND	ND
Biological Oxygen Demand (mg/l)	0.22	0.56	0.88	0.58	0.86	0.35	0.88	0.58	0.98	0.58	0.66	0.65	0.45	0.44	0.55
Chemical Oxygen Demand (mg/l)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Coliform (MPN /100 ml)	P	P	P	P	P	A	P	P	P	P	A	A	P	A	A

Contd.

Physical / Chemical Characteristics	W46	W47	W48	W49	W50	W51	W52	W53	W54	W55	W56	W57	W58	W59
Water Temperature (°C)	18.3	18.6	19.2	19.1	19.4	18.3	18.1	19.8	18.9	18.2	19.11	18.89	18.3	19.25
Dissolved Oxygen (mg/l)	7.98	7.89	7.68	7.73	7.72	7.78	7.93	7.84	7.92	7.91	7.89	7.83	7.78	7.85
Turbidity (NTU)	0.3	0.25	0	0	0	0.22	2.5	0.55	0.2	0.18	0.2	0.21	0.35	0.43
Total Suspended Solids (mg/l)	1.14	1.24	1.05	1.21	1.19	1.24	1.26	1.29	1.1	1.05	1.12	0.98	1.03	1.05
pH	8.04	8.05	7.87	7.79	7.82	7.75	7.85	7.79	8.04	8.06	8.01	7.99	8.01	8.02
Electrical Conductivity (µS/cm)	80.16	78.49	71.81	76.82	85.17	75.15	76.82	76.82	83.5	71.81	81.83	86.84	95.19	85.17
Total Dissolved Solids (mg/l)	48	47	43	46	51	45	46	46	50	43	49	52	57	51
Total alkalinity (mg/l of CaCO3)	26	25	23	25	29	25	25.6	24.7	28	23	28	31	33.2	28
Sulphate (mg/l)	2.89	2.98	2.98	2.87	2.76	3.1	2.67	2.78	3.45	3.13	3.29	3.34	3.12	3.6
Chloride (mg/l)	5.84	6.05	4.78	5.28	4.87	4.7	5.29	5.87	4.89	5.39	3.45	3.78	4.55	5.67
Nitrates (NO3) (mg/l)	0.09	0.12	0.12	0.1	0.13	0.1	0.12	0.1	0.12	0.14	0.12	0.11	0.12	0.14
Phosphate (PO4) (mg/l)	0.01	0.01	0.01	0.01	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Total Hardness (mg/l)	28.015	26.701	25.138	25.98	29.096	26.148	27.579	26.397	28.536	24.61	26.348	26.923	29.66	27.199
Calcium ions (mg/ l)	6.86	5.99	5.66	5.8	5.8	5.9	6.21	6.18	6.56	5.99	5.98	6.21	6.78	6.14
Magnesium ions (mg/l)	2.65	2.86	2.68	2.8	3.56	2.78	2.94	2.67	2.96	2.35	2.78	2.78	3.1	2.89
Sodium (mg/l)	1.39	1.94	1.49	1.89	1.74	1.69	1.68	1.98	1.54	1.67	2.5	2.34	3.58	2.54
Potassium (mg/l)	1.22	1.46	1.12	1.23	1.21	1.45	1.28	1.47	1.32	1.29	1.48	1.89	1.45	1.68
Iron (mg/l)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.1	<0.01	<0.01	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Cadmium (Cd) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	<0.01	ND	<0.01
Arsenic (As) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Mercury (Hg) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	<0.001	ND	<0.001
Copper (Cu) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	<0.1	ND	<0.1
Zinc (Zn) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	<0.1	ND	<0.1
Total Chromium (Cr) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	<0.05	ND	<0.05
Manganese (Mn) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Lead (Pb) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	<0.1	ND	<0.1
Biological Oxygen Demand (mg/l)	0.2	0.1	0.22	0.15	0.25	0.85	1.3	1.22	1.35	0.95	0.25	1.2	0.5	1.05
Chemical Oxygen Demand (mg/l)	0	0	0	0	0	2.1	2.3	2.2	2.5	1.3	0	1.2	0	1.1
Total Coliform (MPN /100 ml)	A	P	P	P	P	A	A	P	P	P	P	A	P	P

Table 7.1: Physico-Chemical characteristics of water at different sampling sites in the Study Area (April 2016)

Physical / Chemical Characteristics	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13	W14	W15
Water Temperature (°C)	19.8	19.7	20.1	21.2	20.1	20.2	22.15	9.1	19.6	19.7	21.6	22.1	21.8	22.1	22.3
Dissolved Oxygen (mg/l)	7.89	7.86	7.81	7.78	7.89	7.91	7.72	8.12	7.9	7.89	7.68	7.81	7.73	7.75	7.74
Turbidity (NTU)	2.1	2	2.3	2.04	1.05	0.92	0.98	0	1.6	1.21	1.56	1.2	1.43	1.2	1.05
Total Suspended Solids (mg/l)	4.22	4.1	4.02	2.95	2.56	3.01	2.67	1.78	2.59	2.89	2.01	2.05	2.12	1.57	1.62
pH	8.23	8.26	8.16	8.14	8.12	8.18	8.05	8.16	8.24	8.05	8.02	8.23	7.98	7.99	7.82
Electrical Conductivity (µS/cm)	103.54	88.51	95.19	86.84	81.83	85.17	100.2	88.51	88.51	86.84	86.84	88.51	70.14	86.84	86.84
Total Dissolved Solids (mg/l)	62	53	57	52	49	51	60	53	53	52	52	53	42	52	52
Total alkalinity (mg/l of CaCO3)	27.6	24.5	28	25	24	25	28	29	25	23	25	24.1	19	25	22.1
Sulphate (mg/l)	5.75	3.67	4.37	5.1	4.35	4.17	7.26	4.54	5.43	5.1	5.38	5.21	4.02	5.31	6.34
Chloride (mg/l)	8.21	8.52	8.35	7.47	6.6	6.5	8.06	4.76	7.16	8.12	6.26	6.45	4.98	6.68	7.43
Nitrates (NO3) (mg/l)	0.95	0.92	0.8	0.32	0.65	0.8	0.56	0.21	0.45	0.7	0.41	1.2	0.29	0.3	0.28
Phosphate (PO4) (mg/l)	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.01	0.01	0.01	0.02	0.01	0.01
Total Hardness (mg/l)	34.825	31.299	32.701	31.92	27.89	27.83	35.046	32.431	30.184	29.135	31.48	29.455	23.86	30.638	30.725
Calcium ions (mg/ l)	8.6	7.78	7.98	7.93	6.4	6.54	8.18	8.2	7.58	8.21	8	8.01	6.1	7.86	7.78
Magnesium ions (mg/l)	3.25	2.89	3.11	2.95	2.9	2.8	3.56	2.91	2.74	2.1	2.8	2.3	2.1	2.68	2.75
Sodium (mg/l)	3.1	2.1	2.3	1.98	2.1	2.6	2.39	1.58	2.1	2.45	1.89	1.82	1.02	1.59	2.1
Potassium (mg/l)	1.8	1.54	1.29	1.3	1.35	1.35	1.28	1.1	1.6	1.19	1.26	1.39	1.21	1.02	1.65
Iron (mg/l)	0.13	0.11	0.12	0.1	0.13	0.15	0.1	0.11	0.14	0.12	0.01	0.02	0.11	0.12	0.12
Cadmium (Cd) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Arsenic (As) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Mercury (Hg) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Copper (Cu) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Zinc (Zn) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total Chromium (Cr) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Manganese (Mn) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Lead (Pb) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Biological Oxygen Demand (mg/l)	0.18	0.25	0.21	0.26	0.29	0.36	0.27	0.32	0.25	0.39	0.26	0.78	0.98	0.92	1.1
Chemical Oxygen Demand (mg/l)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Coliform (MPN /100 ml)	P	P	P	P	P	A	A	A	P	P	P	P	P	P	P

Contd.

Physical / Chemical Characteristics	W16	W17	W18	W19	W20	W21	W22	W23	W24	W25	W26	W27	W28	W29	W30
Water Temperature (°C)	21.3	21.3	21.4	22.3	22.3	22.6	22.3	22.5	22.1	21.8	21.4	22.4	22.7	23.1	24.18
Dissolved Oxygen (mg/l)	7.71	7.54	7.56	7.91	7.43	7.68	7.78	7.59	7.45	7.71	7.75	7.54	7.68	7.45	7.79
Turbidity (NTU)	1.06	1.2	1.28	0.96	1.3	1.45	1.12	1.34	1.26	1.02	1.13	1.02	0.67	0.89	0.56
Total Suspended Solids (mg/l)	1.59	2.8	2.8	1.85	2.8	2.1	2.2	2.31	2.42	1.78	1.68	1.75	1.56	1.62	1.67
pH	7.95	7.89	7.91	7.99	7.84	7.85	7.82	7.81	7.69	7.84	8.11	8.05	7.99	8.02	7.98
Electrical Conductivity (µS/cm)	83.5	70.14	78.49	86.84	83.5	75.15	66.8	65.13	68.47	83.5	81.83	85.17	81.83	80.16	83.5
Total Dissolved Solids (mg/l)	50	42	47	52	50	45	40	39	41	50	49	51	49	48	50
Total alkalinity (mg/l of CaCO3)	21	20	22	22	25	21	20	19	20	29	26	28	23	24	26
Sulphate (mg/l)	6.37	2.87	4.48	6.21	4.25	4.7	2.56	3.29	4.3	3.21	3.86	3.1	3.02	2.65	2.45
Chloride (mg/l)	7.85	5.45	6.19	6.9	5.56	6.31	4.98	3.87	4.21	3.27	4.98	4.24	7.85	7.45	6.54
Nitrates (NO3) (mg/l)	0.15	0.21	0.56	0.16	0.18	0.28	0.32	0.21	0.2	0.15	0.12	0.2	0.2	0.18	0.12
Phosphate (PO4) (mg/l)	0.02	0.01	0.01	0.001	0.01	0.02	0.01	0.02	0.01	0.02	0.01	0.01	0.02	0.02	0.01
Total Hardness (mg/l)	30.987	24.485	26.155	30.667	26.445	26.77	23.389	21.421	23.335	26.17	26.708	28.166	27.96	29.721	30.34
Calcium ions (mg/ l)	8.59	6.35	5.87	7.56	6.56	6.28	6.01	6.01	5.89	6.45	7.19	7.56	7.74	7.69	7.79
Magnesium ions (mg/l)	2.32	2.1	2.8	2.87	2.45	2.7	2.04	1.56	2.1	2.45	2.13	2.26	2.1	2.56	2.65
Sodium (mg/l)	2.01	1.78	1.98	2.12	2.32	1.56	1.21	1.27	1.16	2.1	2.02	2.16	1.9	2.12	1.8
Potassium (mg/l)	1.32	1.21	1.34	1.2	1.12	0.98	1.1	1.1	0.98	1.28	1.18	1.45	1.25	1.21	0.95
Iron (mg/l)	0.11	0.12	0.11	0.12	0.12	0.11	0.1	0.01	0.01	0.11	0.11	0.1	0.01	0.11	0.12
Cadmium (Cd) (mg/l)	ND	<0.01	ND	<0.01	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Arsenic (As) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Mercury (Hg) (mg/l)	ND	<0.001	ND	<0.001	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Copper (Cu) (mg/l)	ND	<0.1	ND	<0.1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Zinc (Zn) (mg/l)	ND	<0.1	ND	<0.1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total Chromium (Cr) (mg/l)	ND	<0.05	ND	<0.05	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Manganese (Mn) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Lead (Pb) (mg/l)	ND	<0.1	ND	<0.1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Biological Oxygen Demand (mg/l)	0.36	0.89	0.78	1.01	0.95	0.85	0.25	0.32	0.17	0.26	0.25	0.19	0.3	0.28	0.3
Chemical Oxygen Demand (mg/l)	0	0	0	0	1.8	1.9	0	0	0	0	0	0	0	0	0
Total Coliform (MPN /100 ml)	A	P	P	P	P	P	P	P	P	P	P	P	P	P	A

Contd.

Physical / Chemical Characteristics	W31	W32	W33	W34	W35	W36	W37	W38	W39	W40	W41	W42	W43	W44	W45
Water Temperature (°C)	23.1	24.2	23.3	23.1	21.1	21.2	20.9	20.85	20.57	23.1	23.1	22.15	22.45	22.67	22.1
Dissolved Oxygen (mg/l)	7.45	7.42	7.68	7.6	7.8	7.7	7.98	7.75	7.68	7.58	7.68	7.82	7.75	7.94	7.71
Turbidity (NTU)	0.45	0.86	0.45	0.6	0.54	0.67	0.48	0.78	0.94	0.51	0.86	0.72	1.04	0.76	0.52
Total Suspended Solids (mg/l)	1.52	1.32	1.2	1.02	1.38	1.27	1.56	1.48	1.56	1.38	1.7	1.54	1.28	1.63	1.53
pH	8.08	7.93	8.02	8.09	8.16	8.17	8.04	7.98	8.05	8.11	8.19	8.02	8.14	8.02	7.72
Electrical Conductivity (µS/cm)	71.81	73.48	66.8	73.48	66.8	68.47	71.81	70.14	75.15	71.81	88.51	80.16	90.18	83.5	76.82
Total Dissolved Solids (mg/l)	43	44	40	44	40	41	43	42	45	43	53	48	54	50	46
Total alkalinity (mg/l of CaCO3)	23	23	21	22	21	20	23	22	24	22	29	25	28	26	24
Sulphate (mg/l)	2.46	2.26	2.15	2.58	2.34	2.85	2.54	2.45	2.53	2.78	3.04	3.45	4.13	3.74	3.21
Chloride (mg/l)	4.87	5.1	5.12	6.12	4.59	5.65	5.43	5.21	5.12	5.47	5.12	5.02	5.61	5.73	6.02
Nitrates (NO3) (mg/l)	0.14	0.12	0.21	0.14	0.1	0.12	0.12	0.17	0.12	0.11	0.13	0.11	0.12	0.09	0.18
Phosphate (PO4) (mg/l)	0.001	0.02	0.01	0.02	0.02	0.01	0.02	0.001	0.02	0.01	0.02	0.02	0.01	0.01	0.01
Total Hardness (mg/l)	22.527	24.91	24.149	25.643	21.735	23.251	26.445	25.066	24.859	23.374	31.466	29.386	31.263	27.809	26.574
Calcium ions (mg/ l)	5.37	6.52	6.56	7.01	5.25	5.43	6.56	6.32	6.27	5.84	7.65	7.31	7.29	6.63	5.89
Magnesium ions (mg/l)	2.22	2.1	1.89	1.98	2.1	2.36	2.45	2.26	2.24	2.14	3.01	2.71	3.18	2.74	2.89
Sodium (mg/l)	2.1	1.56	1.56	1.67	1.54	1.52	1.23	1.89	1.78	1.89	1.73	1.43	2.45	2.03	1.65
Potassium (mg/l)	1.27	1.21	1.21	1.23	1.27	1.2	1.03	1.27	1.12	1.3	1.18	1.12	1.67	1.86	1.13
Iron (mg/l)	0.11	0.11	0.1	0.11	0.1	0.12	0.11	0.13	0.11	0.12	0.11	0.1	0.11	0.1	0.11
Cadmium (Cd) (mg/l)	ND	ND	ND	ND	ND	ND	<0.01	ND	<0.01	ND	ND	ND	ND	ND	ND
Arsenic (As) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Mercury (Hg) (mg/l)	ND	ND	ND	ND	ND	ND	<0.001	ND	<0.001	ND	ND	ND	ND	ND	ND
Copper (Cu) (mg/l)	ND	ND	ND	ND	ND	ND	<0.1	ND	<0.1	ND	ND	ND	ND	ND	ND
Zinc (Zn) (mg/l)	ND	ND	ND	ND	ND	ND	<0.1	ND	<0.1	ND	ND	ND	ND	ND	ND
Total Chromium (Cr) (mg/l)	ND	ND	ND	ND	ND	ND	<0.05	ND	<0.05	ND	ND	ND	ND	ND	ND
Manganese (Mn) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Lead (Pb) (mg/l)	ND	ND	ND	ND	ND	ND	<0.1	ND	<0.1	ND	ND	ND	ND	ND	ND
Biological Oxygen Demand (mg/l)	0.35	0.89	1.1	0.95	1.1	0.54	1.1	0.78	1.2	1.1	0.45	0.38	0.25	0.2	0.35
Chemical Oxygen Demand (mg/l)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Coliform (MPN /100 ml)	P	P	P	P	P	A	P	P	P	P	A	A	P	A	A

Contd.

Physical / Chemical Characteristics	W46	W47	W48	W49	W50	W51	W52	W53	W54	W55	W56	W57	W58	W59
Water Temperature (°C)	21.9	22.3	23.54	22.3	23.8	21.7	21.9	24.2	22.3	21.6	22.25	22.56	21.46	23.1
Dissolved Oxygen (mg/l)	7.89	7.83	7.57	7.61	7.63	7.69	7.7	7.64	7.81	7.72	7.76	7.69	7.63	7.73
Turbidity (NTU)	0.67	0.48	0.29	0.46	0.58	0.52	0.69	0.72	0.61	0.63	0.48	0.52	0.84	0.97
Total Suspended Solids (mg/l)	1.41	1.49	1.47	1.43	1.38	1.42	1.53	1.57	1.05	1.04	1.18	1.03	1.32	1.21
pH	7.99	7.98	7.78	7.65	7.64	7.63	7.72	7.68	7.99	8.03	8.04	7.93	7.98	7.92
Electrical Conductivity (µS/cm)	75.15	70.14	66.8	70.14	78.49	70.14	71.81	75.15	78.49	65.13	85.17	81.83	91.85	78.49
Total Dissolved Solids (mg/l)	45	42	40	42	47	42	43	45	47	39	51	49	55	47
Total alkalinity (mg/l of CaCO3)	24	21	21	22	27	22	23.1	22.2	26	19	30	29	32.1	25
Sulphate (mg/l)	2.85	2.75	2.87	2.64	2.21	2.8	2.14	2.53	3.17	2.89	3.14	3.03	2.86	3.21
Chloride (mg/l)	5.19	5.91	4.53	5.19	4.63	4.32	5.02	5.43	4.62	5.18	3.27	3.41	4.25	5.32
Nitrates (NO3) (mg/l)	0.12	0.16	0.17	0.12	0.16	0.12	0.13	0.12	0.18	0.18	0.15	0.13	0.21	0.18
Phosphate (PO4) (mg/l)	0.01	0.01	0.01	0.01	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Total Hardness (mg/l)	25.543	23.688	23.063	24.12	27.236	25.221	25.815	23.988	26.438	23.014	25.672	25.958	28.352	25.649
Calcium ions (mg/ l)	6.15	5.49	5.24	5.63	5.63	5.89	5.98	6.02	6.18	5.86	5.89	6.07	6.47	5.93
Magnesium ions (mg/l)	2.48	2.43	2.43	2.45	3.21	2.56	2.65	2.18	2.68	2.04	2.67	2.63	2.97	2.64
Sodium (mg/l)	1.54	1.63	1.29	1.62	1.58	1.42	1.58	1.69	1.96	1.43	2.32	2.19	3.43	2.23
Potassium (mg/l)	1.32	1.19	1.04	1.02	1.29	1.21	1.15	1.13	1.04	1.02	1.57	1.72	1.36	1.37
Iron (mg/l)	0.1	0.1	0.14	0.12	0.13	0.14	0.1	0.11	0.01	0.1	0.01	0.01	0.01	0.01
Cadmium (Cd) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	<0.01	ND	<0.01
Arsenic (As) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Mercury (Hg) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	<0.001	ND	<0.001
Copper (Cu) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	<0.1	ND	<0.1
Zinc (Zn) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	<0.1	ND	<0.1
Total Chromium (Cr) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	<0.05	ND	<0.05
Manganese (Mn) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Lead (Pb) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	<0.1	ND	<0.1
Biological Oxygen Demand (mg/l)	0.32	0.23	0.36	0.29	0.37	1.69	1.76	2.2	1.9	1.1	0.3	1.16	0.75	1.19
Chemical Oxygen Demand (mg/l)	0	0	0	0	0	3.1	3.15	3.8	3.2	2.2	0	2.25	0	0
Total Coliform (MPN /100 ml)	A	P	P	P	P	A	A	P	P	P	P	A	P	P

Table 7.2: Physico-Chemical characteristics of water at different sampling sites in the Study Area (May 2016)

Physical / Chemical Characteristics	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13	W14	W15
Water Temperature (°C)	25.6	25.4	26.1	26.3	26.8	26.5	26.2	14.2	26.2	26.4	25.8	26.6	26.7	26.8	27.4
Dissolved Oxygen (mg/l)	7.73	7.69	7.73	7.63	7.85	7.82	7.68	8.05	7.85	7.82	7.61	7.72	7.62	7.62	7.69
Turbidity (NTU)	2.9	2.2	3.05	2.25	1.29	1.16	1.25	0	2.1	1.9	1.8	1.54	1.95	1.98	1.85
Total Suspended Solids (mg/l)	4.86	4.78	4.2	3.1	2.95	3.26	2.98	1.56	2.85	3.1	2.37	2.21	2.31	1.65	1.74
pH	8.2	8.25	8.14	8.18	8.16	8.22	8.12	8.21	8.26	8.09	8.07	8.2	7.95	7.92	7.75
Electrical Conductivity (µS/cm)	101.87	83.5	91.85	86.84	76.82	81.83	105.21	85.17	101.87	93.52	90.18	91.85	78.49	81.83	90.18
Total Dissolved Solids (mg/l)	61	50	55	52	46	49	63	51	61	56	54	55	47	49	54
Total alkalinity (mg/l of CaCO3)	27	22	26	23	22	23	28	27	27	25	27	25.3	22	23	24.3
Sulphate (mg/l)	5.89	3.54	4.1	4.9	4.02	4.03	7.14	4.38	5.12	5.22	5.24	5.64	4.12	5.42	6.28
Chloride (mg/l)	8.65	8.75	8.23	7.35	6.52	6.29	7.95	4.63	8.42	8.53	6.11	6.89	5.24	6.41	7.58
Nitrates (NO3) (mg/l)	0.82	0.87	0.76	0.21	0.65	0.74	0.32	0.26	0.87	1	0.92	1.02	0.53	0.42	0.21
Phosphate (PO4) (mg/l)	0.02	0.02	0.01	0.02	0.01	0.01	0.01	0.01	0.02	0.01	0.01	0.01	0.02	0.01	0.01
Total Hardness (mg/l)	35.042	30.289	33.52	31.287	27.23	25.897	35.9	31.648	33.77	31.021	33.135	31.144	26.759	29.598	31.826
Calcium ions (mg/ l)	8.9	7.54	8.16	7.89	6.3	6.39	8.21	8.1	8.67	8.62	8.17	8.21	6.62	7.69	8.04
Magnesium ions (mg/l)	3.12	2.79	3.2	2.82	2.8	2.42	3.75	2.78	2.95	2.31	3.1	2.59	2.49	2.53	2.86
Sodium (mg/l)	2.9	1.98	2	1.89	1.9	2.51	2.54	1.36	2.6	2.63	2.03	1.92	1.29	1.42	2.03
Potassium (mg/l)	1.6	1.49	1.35	1.24	1.28	1.24	1.36	0.95	1.48	1.48	1.2	1.56	1.42	1.13	1.72
Iron (mg/l)	0.13	0.11	0.12	0.1	0.13	0.15	0.1	0.11	0.14	0.12	0.01	0.02	0.11	0.12	0.12
Cadmium (Cd) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Arsenic (As) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Mercury (Hg) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Copper (Cu) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Zinc (Zn) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total Chromium (Cr) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Manganese (Mn) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Lead (Pb) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Biological Oxygen Demand (mg/l)	0.15	0.26	0.24	0.18	0.26	0.25	0.18	0.32	0.24	0.29	0.31	0.82	1.1	0.98	1..05
Chemical Oxygen Demand (mg/l)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Coliform (MPN /100 ml)	P	P	P	P	P	A	A	A	P	P	P	P	P	P	P

Contd.

Physical / Chemical Characteristics	**W16**	**W17**	**W18**	**W19**	**W20**	**W21**	**W22**	**W23**	**W24**	**W25**	**W26**	**W27**	**W28**	**W29**	**W30**
Water Temperature (°C)	26.8	26.4	26.8	26.5	27.1	26.3	26.5	26.7	26.4	24.8	24.9	25.1	26.3	26.1	26.14
Dissolved Oxygen (mg/l)	7.62	7.42	7.48	7.82	7.38	7.42	7.56	7.65	7.38	7.72	7.68	7.43	7.58	7.32	7.67
Turbidity (NTU)	1.92	2.2	2.25	1.2	2.4	2.3	2.1	2.05	2.08	1.62	1.49	1.42	1.1	1.05	0.95
Total Suspended Solids (mg/l)	1.65	3.2	3.1	1.9	3.14	2.8	2.57	2.65	2.74	1.68	1.74	1.84	1.71	1.65	1.59
pH	7.92	7.83	7.84	8.02	7.68	7.81	7.79	7.86	7.73	7.87	8.15	8.17	8.02	7.99	7.95
Electrical Conductivity (µS/cm)	90.18	71.81	76.82	91.85	81.83	73.48	68.47	70.14	66.8	96.86	90.18	96.86	90.18	88.51	90.18
Total Dissolved Solids (mg/l)	54	43	46	55	49	44	41	42	40	58	54	58	54	53	54
Total alkalinity (mg/l of CaCO3)	23	21	21	24	23	20	21	22	18	32	28	31	25	27	28
Sulphate (mg/l)	6.58	2.48	4.56	6.47	4.19	4.5	2.42	3.42	4.6	3.56	3.75	3.4	3.3	2.89	2.6
Chloride (mg/l)	7.92	5.87	6.36	7.41	5.79	6.23	5.13	4.02	4.98	3.89	4.91	4.8	8.02	7.67	6.9
Nitrates (NO3) (mg/l)	0.19	0.31	0.41	0.18	0.23	0.31	0.3	0.22	0.25	0.18	0.16	0.28	0.14	0.22	0.17
Phosphate (PO4) (mg/l)	0.02	0.01	0.01	0.001	0.01	0.02	0.01	0.02	0.01	0.02	0.01	0.01	0.02	0.02	0.01
Total Hardness (mg/l)	31.218	23.761	25.09	31.697	27.444	26.25	24.383	22.773	22.941	28.589	28.745	30.153	29.431	30.19	31.075
Calcium ions (mg/ l)	8.42	6.29	5.69	7.89	6.73	6.4	6.26	6.19	6.29	6.86	7.48	7.83	7.82	7.73	7.92
Magnesium ions (mg/l)	2.48	1.96	2.65	2.92	2.59	2.5	2.13	1.78	1.76	2.79	2.45	2.58	2.41	2.65	2.75
Sodium (mg/l)	2.16	1.63	1.83	2.31	2.02	1.67	1.27	1.36	1.21	2.27	2.18	2.37	2.13	2.35	2.02
Potassium (mg/l)	1.26	1.34	1.42	1.31	1.04	1.02	1.08	1.18	1.08	1.98	1.56	1.69	1.43	1.39	1.05
Iron (mg/l)	0.11	0.12	0.11	0.12	0.12	0.11	0.1	0.01	0.01	0.11	0.11	0.1	0.01	0.11	0.12
Cadmium (Cd) (mg/l)	ND	<0.01	ND	<0.01	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Arsenic (As) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Mercury (Hg) (mg/l)	ND	<0.001	ND	<0.001	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Copper (Cu) (mg/l)	ND	<0.1	ND	<0.1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Zinc (Zn) (mg/l)	ND	<0.1	ND	<0.1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total Chromium (Cr) (mg/l)	ND	<0.05	ND	<0.05	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Manganese (Mn) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Lead (Pb) (mg/l)	ND	<0.1	ND	<0.1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Biological Oxygen Demand (mg/l)	0.38	1.2	0.8	1.15	1.1	1.2	0.8	0.6	0.4	0.3	0.5	0.4	0.3	0.4	0.35
Chemical Oxygen Demand (mg/l)	0	0	0	0	1.5	1.7	0	0	0	0	0	0	0	0	0
Total Coliform (MPN /100 ml)	A	P	P	P	P	P	P	P	P	P	P	P	P	P	A

Contd.

Physical / Chemical Characteristics	**W31**	**W32**	**W33**	**W34**	**W35**	**W36**	**W37**	**W38**	**W39**	**W40**	**W41**	**W42**	**W43**	**W44**	**W45**
Water Temperature (°C)	26.3	26.4	26.15	25.95	24.4	24.56	25.8	26.12	26.05	26.2	26.3	26.4	26.1	27.8	26.4
Dissolved Oxygen (mg/l)	7.32	7.36	7.59	7.47	7.71	7.64	7.84	7.62	7.58	7.45	7.59	7.74	7.67	7.89	7.68
Turbidity (NTU)	1.02	1.52	0.95	0.82	1.03	1.12	1.29	1.38	1.43	1.08	1.07	0.87	1.36	0.95	0.68
Total Suspended Solids (mg/l)	1.55	1.43	1.34	1.1	1.58	1.98	1.76	1.73	1.75	1.63	2.1	1.78	1.52	1.83	1.73
pH	8.12	7.89	7.98	8.02	8.12	8.11	7.98	7.89	8.04	8.05	8.25	8.05	8.18	8.06	7.68
Electrical Conductivity (µS/cm)	78.49	80.16	75.15	76.82	63.46	73.48	81.83	73.48	71.81	75.15	93.52	90.18	96.86	88.51	83.5
Total Dissolved Solids (mg/l)	47	48	45	46	38	44	49	44	43	45	56	54	58	53	50
Total alkalinity (mg/l of CaCO3)	26	25	23	23	19	22	25	24	22	21	31	28	31	28	26
Sulphate (mg/l)	2.56	2.36	2.23	2.65	2.19	2.98	2.68	2.58	2.65	2.57	3.37	3.96	4.21	3.92	3.49
Chloride (mg/l)	5.01	5.68	5.84	6.23	4.98	5.89	5.59	5.35	5.32	5.89	5.21	5.82	5.72	5.99	6.21
Nitrates (NO3) (mg/l)	0.21	0.14	0.28	0.18	0.12	0.12	0.14	0.21	0.15	0.13	0.17	0.13	0.18	0.12	0.18
Phosphate (PO4) (mg/l)	0.001	0.02	0.01	0.02	0.02	0.01	0.02	0.001	0.02	0.01	0.02	0.02	0.01	0.01	0.01
Total Hardness (mg/l)	24.708	25.87	25.673	26.266	20.479	24.368	27.803	25.138	23.983	24.462	32.57	30.317	33.25	28.974	28.185
Calcium ions (mg/ l)	5.98	6.74	6.94	7.21	5.01	5.68	6.89	6.48	6.1	5.98	7.78	7.42	7.56	6.85	6.19
Magnesium ions (mg/l)	2.38	2.2	2.03	2.01	1.94	2.48	2.58	2.18	2.13	2.32	3.2	2.87	3.5	2.89	3.1
Sodium (mg/l)	2.31	1.74	1.78	2.08	1.39	1.57	1.39	1.73	1.69	2.16	1.89	1.58	2.65	2.18	1.85
Potassium (mg/l)	1.45	1.57	1.49	1.62	1.15	1.38	1.21	1.34	1.03	1.2	1.25	1.42	1.98	1.94	1.24
Iron (mg/l)	0.11	0.11	0.1	0.11	0.1	0.12	0.11	0.13	0.11	0.12	0.11	0.1	0.11	0.1	0.11
Cadmium (Cd) (mg/l)	ND	ND	ND	ND	ND	ND	<0.01	ND	<0.01	ND	ND	ND	ND	ND	ND
Arsenic (As) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Mercury (Hg) (mg/l)	ND	ND	ND	ND	ND	ND	<0.001	ND	<0.001	ND	ND	ND	ND	ND	ND
Copper (Cu) (mg/l)	ND	ND	ND	ND	ND	ND	<0.1	ND	<0.1	ND	ND	ND	ND	ND	ND
Zinc (Zn) (mg/l)	ND	ND	ND	ND	ND	ND	<0.1	ND	<0.1	ND	ND	ND	ND	ND	ND
Total Chromium (Cr) (mg/l)	ND	ND	ND	ND	ND	ND	<0.05	ND	<0.05	ND	ND	ND	ND	ND	ND
Manganese (Mn) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Lead (Pb) (mg/l)	ND	ND	ND	ND	ND	ND	<0.1	ND	<0.1	ND	ND	ND	ND	ND	ND
Biological Oxygen Demand (mg/l)	0.31	0.82	1.1	0.92	1.1	0.36	1.1	0.8	1.2	1.06	0.26	0.4	0.36	0.26	0.35
Chemical Oxygen Demand (mg/l)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Coliform (MPN /100 ml)	P	P	P	P	P	A	P	P	P	P	A	A	P	A	A

Contd.

Physical / Chemical Characteristics	**W46**	**W47**	**W48**	**W49**	**W50**	**W51**	**W52**	**W53**	**W54**	**W55**	**W56**	**W57**	**W58**	**W59**
Water Temperature (°C)	25.9	25.7	27.1	26.8	26.9	26.1	26.9	27.2	25.8	26.18	27.65	25.98	25.23	25.57
Dissolved Oxygen (mg/l)	7.85	7.78	7.48	7.58	7.59	7.62	7.64	7.58	7.72	7.64	7.65	7.58	7.57	7.62
Turbidity (NTU)	0.95	0.68	0.45	0.77	0.94	0.67	0.83	1.1	0.82	0.99	0.94	0.79	1.05	1.16
Total Suspended Solids (mg/l)	1.56	1.82	1.65	1.82	1.79	1.62	1.78	1.69	1.36	1.28	1.62	1.27	1.87	1.72
pH	8.03	7.95	7.71	7.69	7.62	7.59	7.69	7.61	7.95	8.01	8.02	7.98	7.94	7.88
Electrical Conductivity (µS/cm)	86.84	76.82	73.48	76.82	83.5	75.15	76.82	80.16	85.17	71.81	91.85	90.18	100.2	81.83
Total Dissolved Solids (mg/l)	52	46	44	46	50	45	46	48	51	43	55	54	60	49
Total alkalinity (mg/l of CaCO3)	28	23	24	25	29	24	25.3	25.1	28.2	21	34	32	35.4	27
Sulphate (mg/l)	2.96	2.84	2.95	2.78	2.34	3.1	2.45	2.63	3.6	3.1	2.99	3.12	3.1	3.5
Chloride (mg/l)	5.36	6.12	4.64	5.25	4.89	4.89	5.15	5.57	4.95	5.6	3.1	3.67	4.74	5.48
Nitrates (NO3) (mg/l)	0.15	0.22	0.21	0.16	0.21	0.14	0.17	0.16	0.3	0.21	0.21	0.16	0.35	0.26
Phosphate (PO4) (mg/l)	0.01	0.01	0.01	0.01	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Total Hardness (mg/l)	28.166	25.039	24.928	25.93	29.414	26.197	27.067	25.796	27.89	24.229	27.468	27.417	29.935	27.124
Calcium ions (mg/ l)	6.74	5.85	5.74	5.78	5.96	6.1	6.12	6.12	6.4	6.1	6.1	6.26	6.89	6.11
Magnesium ions (mg/l)	2.76	2.54	2.58	2.8	3.54	2.67	2.87	2.56	2.9	2.19	2.98	2.87	3.1	2.89
Sodium (mg/l)	1.89	1.85	1.53	1.74	1.78	1.56	1.67	1.98	2.1	1.54	2.8	2.53	3.67	2.1
Potassium (mg/l)	1.46	1.32	1.28	1.18	1.46	1.35	1.21	1.27	1.23	1.18	1.89	1.98	1.54	1.45
Iron (mg/l)	0.1	0.1	0.14	0.12	0.13	0.14	0.1	0.11	0.01	0.1	0.01	0.01	0.01	0.01
Cadmium (Cd) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	<0.01	ND	<0.01
Arsenic (As) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Mercury (Hg) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	<0.001	ND	<0.001
Copper (Cu) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	<0.1	ND	<0.1
Zinc (Zn) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	<0.1	ND	<0.1
Total Chromium (Cr) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	<0.05	ND	<0.05
Manganese (Mn) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Lead (Pb) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	<0.1	ND	<0.1
Biological Oxygen Demand (mg/l)	0.3	0.2	0.5	0.29	1.88	1.99	2.1	2.3	2.1	1.2	0.4	1.1	1.05	1.2
Chemical Oxygen Demand (mg/l)	0	0	0	0	0	2.6	2.9	3.9	3.6	1.92	0	0	1.75	0
Total Coliform (MPN /100 ml)	A	P	P	P	P	A	A	P	P	P	P	A	P	P

Table 7.3: Physico-Chemical characteristics of water at different sampling sites in the Study Area (June 2016)

Physical / Chemical Characteristics	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13	W14	W15
Water Temperature (°C)	23.6	23.5	24.1	24.2	23.9	23.8	24.6	13.5	23.8	23.7	24.6	25.9	25.2	25.8	26.1
Dissolved Oxygen (mg/l)	7.81	7.79	7.82	7.75	7.92	7.89	7.71	8.21	7.92	7.9	7.68	7.76	7.69	7.71	7.74
Turbidity (NTU)	2.8	2.1	2.9	2.2	1.2	1.1	1.18	0	1.8	1.6	1.55	1.18	1.9	1.88	1.78
Total Suspended Solids (mg/l)	5.1	4.9	4.4	3.2	3.1	3.6	3.1	1.6	2.9	3.2	2.5	2.2	2.4	1.7	1.85
pH	8.18	8.24	8.22	8.12	8.21	8.29	8.18	8.24	8.21	8.15	8.19	8.24	7.85	7.8	7.76
Electrical Conductivity (µS/cm)	108.55	95.19	98.53	90.18	81.83	86.84	115.23	90.18	106.88	100.2	98.53	96.86	81.83	86.84	98.53
Total Dissolved Solids (mg/l)	65	57	59	54	49	52	69	54	64	60	59	58	49	52	59
Total alkalinity (mg/l of CaCO3)	29	25	29	24	24	24	31	29	30	27	30	27.6	24	24	26.2
Sulphate (mg/l)	6.1	3.8	4.7	5.2	4.1	4.25	7.52	4.65	5.36	5.32	5.65	5.9	4.61	5.65	6.72
Chloride (mg/l)	8.7	8.9	8.81	7.1	6.67	6.71	8.12	4.92	8.77	8.67	6.45	7.1	5.6	6.7	8.1
Nitrates (NO3) (mg/l)	0.95	0.92	0.89	0.15	0.72	0.65	0.25	0.21	0.95	1.05	1.01	1.09	0.67	0.5	0.15
Phosphate (PO4) (mg/l)	0.02	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.001	0.02	0.01	0.01
Total Hardness (mg/l)	38.465	31.3	35.335	30.363	28.14	27.446	37.74	31.91	34.88	32.22	35.065	32.319	27.517	30.49	33.335
Calcium ions (mg/ l)	9.4	7.6	8.23	7.75	6.5	6.78	8.7	8.5	8.95	8.87	8.45	8.27	6.71	7.85	8.25
Magnesium ions (mg/l)	3.65	3	3.6	2.68	2.9	2.56	3.9	2.6	3.05	2.45	3.4	2.84	2.62	2.65	3.1
Sodium (mg/l)	2.8	1.7	2.1	1.75	1.75	2.6	2.67	1.27	2.7	2.75	2.2	2.05	1.35	1.58	2.19
Potassium (mg/l)	1.7	1.58	1.4	1.28	1.1	1.12	1.43	0.89	1.5	1.58	1.4	1.78	1.55	1.22	1.81
Iron (mg/l)	0.13	0.11	0.12	0.1	0.12	0.15	0.1	0.11	0.11	0.12	0.01	0.02	0.11	0.12	0.12
Cadmium (Cd) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Arsenic (As) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Mercury (Hg) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Copper (Cu) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Zinc (Zn) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total Chromium (Cr) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Manganese (Mn) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Lead (Pb) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Biological Oxygen Demand (mg/l)	0.11	0.2	0.2	0.1	0.2	0.2	0.1	0.28	0.18	0.23	0.22	0.76	0.95	0.86	1
Chemical Oxygen Demand (mg/l)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Coliform (MPN /100 ml)	P	P	P	P	P	A	A	A	P	P	P	P	P	P	P

Contd.

Physical / Chemical Characteristics	W16	W17	W18	W19	W20	W21	W22	W23	W24	W25	W26	W27	W28	W29	W30
Water Temperature (°C)	25.9	25.8	25.6	24.7	26.1	25.1	25.8	25.2	26.1	24.7	23.5	22.9	24.8	24.3	24.5
Dissolved Oxygen (mg/l)	7.68	7.49	7.51	7.86	7.4	7.5	7.7	7.78	7.48	7.8	7.78	7.59	7.7	7.46	7.8
Turbidity (NTU)	1.75	2.1	2.6	1	2.2	2.7	1.9	2.2	2.1	1.5	1.4	1.32	0.9	1	0.78
Total Suspended Solids (mg/l)	1.7	3.8	3.4	1.6	3.5	3.2	2.6	2.7	2.8	1.55	1.6	1.7	1.82	1.75	1.62
pH	7.81	7.79	7.9	8.16	7.72	7.76	7.73	7.83	7.82	7.99	8.19	8.21	8.11	8.07	8.01
Electrical Conductivity (µS/cm)	100.2	83.5	81.83	98.53	90.18	81.83	71.81	71.81	73.48	90.18	95.19	98.53	86.84	86.84	93.52
Total Dissolved Solids (mg/l)	60	50	49	59	54	49	43	43	44	54	57	59	52	52	56
Total alkalinity (mg/l of CaCO3)	27	24	23	26	26	21	23	23	20	28	30	30	24	25	30
Sulphate (mg/l)	6.91	2.62	4.8	6.98	4.74	4.9	2.51	3.56	4.9	3.78	3.92	3.9	3.5	2.6	2.2
Chloride (mg/l)	8.15	6.11	4.68	7.52	6.12	6.51	5.22	4.12	5.12	4.12	5.03	5.2	8.12	7.54	7.11
Nitrates (NO3) (mg/l)	0.19	0.27	0.38	0.18	0.15	0.22	0.26	0.25	0.21	0.12	0.19	0.32	0.19	0.24	0.14
Phosphate (PO4) (mg/l)	0.02	0.01	0.01	0.001	0.01	0.02	0.01	0.01	0.01	0.02	0.01	0.01	0.02	0.02	0.01
Total Hardness (mg/l)	33.441	25.28	24.996	32.555	28.773	27.986	24.995	23.99	24.568	27.763	29.61	31.191	30.471	29.671	32.218
Calcium ions (mg/ l)	8.85	6.75	5.8	8.02	6.95	6.75	6.39	6.48	6.58	6.71	7.58	7.95	7.99	7.67	8
Magnesium ions (mg/l)	2.76	2.05	2.56	3.05	2.78	2.71	2.2	1.9	1.98	2.68	2.6	2.76	2.56	2.56	2.98
Sodium (mg/l)	2.49	1.86	1.72	2.45	2.1	1.8	1.3	1.45	1.13	2.15	2.79	2.54	2.2	2.2	2.12
Potassium (mg/l)	1.58	1.39	1.35	1.47	1.17	1.18	1.19	1.22	1.02	1.9	1.75	1.84	1.56	1.58	1.2
Iron (mg/l)	0.11	0.12	0.11	0.12	0.12	0.11	0.1	0.01	0.01	0.11	0.11	0.1	0.01	0.11	0.12
Cadmium (Cd) (mg/l)	ND	<0.01	ND	<0.01	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Arsenic (As) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Mercury (Hg) (mg/l)	ND	<0.001	ND	<0.001	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Copper (Cu) (mg/l)	ND	<0.1	ND	<0.1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Zinc (Zn) (mg/l)	ND	<0.1	ND	<0.1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total Chromium (Cr) (mg/l)	ND	<0.05	ND	<0.05	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Manganese (Mn) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Lead (Pb) (mg/l)	ND	<0.1	ND	<0.1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Biological Oxygen Demand (mg/l)	0.24	1	0.67	1.1	0.8	0.9	0.2	0.2	0.1	0.2	0.2	0.1	0.28	0.18	0.23
Chemical Oxygen Demand (mg/l)	0	0	0	0	2	2.1	0	0	0	0	0	0	0	0	0
Total Coliform (MPN /100 ml)	A	P	P	P	P	P	P	P	P	P	P	P	P	P	A

Contd.

Physical / Chemical Characteristics	W31	W32	W33	W34	W35	W36	W37	W38	W39	W40	W41	W42	W43	W44	W45
Water Temperature (°C)	24.9	24.6	25.2	25.1	22.9	22.1	23.7	24.3	23.1	24.8	24.1	23.9	23.78	26.1	24.2
Dissolved Oxygen (mg/l)	7.4	7.48	7.65	7.58	7.82	7.99	7.92	7.75	7.69	7.5	7.68	7.89	7.75	8.02	7.75
Turbidity (NTU)	1.1	1.67	0.87	0.74	1	1.04	1.05	1.45	1.57	1.02	1.02	0.67	1.2	0.69	0.5
Total Suspended Solids (mg/l)	1.59	1.56	1.29	1.19	1.98	2.1	1.8	1.85	1.9	1.75	2	1.7	1.43	1.76	1.65
pH	8.15	7.9	8.1	8.12	8.19	8.15	8.04	8.03	8.12	8.15	8.36	8.13	8.2	8.11	7.9
Electrical Conductivity (µS/cm)	75.15	76.82	80.16	81.83	65.13	75.15	78.49	80.16	75.15	78.49	90.18	86.84	95.19	81.83	80.16
Total Dissolved Solids (mg/l)	45	46	48	49	39	45	47	48	45	47	54	52	57	49	48
Total alkalinity (mg/l of CaCO3)	24	23	25	25	20	24	23	25	24	23	29	27	29	26	24
Sulphate (mg/l)	2.31	2.12	1.9	2.1	2.24	2.8	2.45	2.43	2.46	2.44	3.28	3.85	3.98	3.65	3.18
Chloride (mg/l)	5.18	5.9	5.98	6.17	5.11	5.78	5.67	5.11	5.21	6.1	5.35	5.76	5.67	5.82	5.91
Nitrates (NO3) (mg/l)	0.14	0.16	0.24	0.15	0.15	0.15	0.18	0.17	0.11	0.14	0.19	0.15	0.16	0.16	0.21
Phosphate (PO4) (mg/l)	0.001	0.02	0.001	0.02	0.02	0.01	0.02	0.001	0.02	0.01	0.02	0.02	0.01	0.01	0.01
Total Hardness (mg/l)	24.68	25.735	26.401	26.617	21.041	25.262	26.961	25.364	24.275	25.32	31.91	30.493	31.41	28.102	27.943
Calcium ions (mg/ l)	6.1	6.85	7.1	7.17	5.12	5.89	6.75	6.39	6.02	6.11	7.68	7.31	7.48	6.78	6.29
Magnesium ions (mg/l)	2.3	2.1	2.11	2.12	2.01	2.57	2.46	2.29	2.25	2.45	3.1	2.98	3.1	2.72	2.98
Sodium (mg/l)	2.21	1.67	1.9	2.05	1.65	1.68	1.42	1.64	1.85	2.05	1.6	1.88	2.15	2.01	1.59
Potassium (mg/l)	1.56	1.49	1.5	1.54	1.25	1.45	1.29	1.28	1.14	1.12	1.12	1.54	1.82	1.72	1.18
Iron (mg/l)	0.11	0.11	0.1	0.11	0.1	0.12	0.11	0.12	0.11	0.12	0.11	0.1	0.11	0.1	0.11
Cadmium (Cd) (mg/l)	ND	ND	ND	ND	ND	ND	<0.01	ND	<0.01	ND	ND	ND	ND	ND	ND
Arsenic (As) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Mercury (Hg) (mg/l)	ND	ND	ND	ND	ND	ND	<0.001	ND	<0.001	ND	ND	ND	ND	ND	ND
Copper (Cu) (mg/l)	ND	ND	ND	ND	ND	ND	<0.1	ND	<0.1	ND	ND	ND	ND	ND	ND
Zinc (Zn) (mg/l)	ND	ND	ND	ND	ND	ND	<0.1	ND	<0.1	ND	ND	ND	ND	ND	ND
Total Chromium (Cr) (mg/l)	ND	ND	ND	ND	ND	ND	<0.05	ND	<0.05	ND	ND	ND	ND	ND	ND
Manganese (Mn) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Lead (Pb) (mg/l)	ND	ND	ND	ND	ND	ND	<0.1	ND	<0.1	ND	ND	ND	ND	ND	ND
Biological Oxygen Demand (mg/l)	0.22	0.76	0.95	0.86	1	0.24	1	0.67	1.1	1	0.11	0.2	0.2	0.1	0.2
Chemical Oxygen Demand (mg/l)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Coliform (MPN /100 ml)	P	P	P	P	P	A	P	P	P	P	A	A	P	A	A

Contd.

Physical / Chemical Characteristics	W46	W47	W48	W49	W50	W51	W52	W53	W54	W55	W56	W57	W58	W59
Water Temperature (°C)	23.98	23.1	25.3	24.87	25.1	24.6	25.12	26.1	23.6	24.66	26.5	24.7	23.4	23.9
Dissolved Oxygen (mg/l)	7.91	7.85	7.57	7.69	7.67	7.75	7.72	7.46	7.58	7.78	7.72	7.64	7.69	7.71
Turbidity (NTU)	0.73	0.54	0.3	0.68	0.85	0.56	0.72	0.95	0.68	0.98	0.86	0.67	0.92	1.1
Total Suspended Solids (mg/l)	1.45	1.76	1.45	1.76	1.67	1.51	1.85	1.75	1.29	1.2	1.53	1.4	1.82	1.62
pH	8.12	8	7.67	7.72	7.68	7.65	7.74	7.68	8.05	8.11	8.16	7.85	8.05	8.02
Electrical Conductivity (µS/cm)	85.17	75.15	80.16	75.15	85.17	73.48	71.81	78.49	81.83	73.48	86.84	93.52	96.86	75.15
Total Dissolved Solids (mg/l)	51	45	48	45	51	44	43	47	49	44	52	56	58	45
Total alkalinity (mg/l of CaCO3)	26	22	25	23	27	24	23.1	25.2	27	22	31	33	34.7	24
Sulphate (mg/l)	2.76	2.65	2.56	2.64	2.51	2.98	2.32	2.56	3.1	3.2	2.8	3.02	2.67	3.1
Chloride (mg/l)	5.18	5.98	4.1	5.11	5.02	4.78	4.96	5.45	4.82	5.2	2.89	3.54	4.68	5.2
Nitrates (NO3) (mg/l)	0.18	0.21	0.26	0.19	0.19	0.16	0.16	0.19	0.2	0.18	0.19	0.12	0.2	0.19
Phosphate (PO4) (mg/l)	0.01	0.01	0.01	0.01	0.02	0.01	0.01	0.02	0.01	0.01	0.01	0.01	0.01	0.01
Total Hardness (mg/l)	26.864	24.602	25.672	25.122	27.681	25.364	25.393	25.897	27.271	25.57	26.476	26.773	29.168	24.572
Calcium ions (mg/ l)	6.58	5.79	5.89	5.67	5.89	5.98	5.68	5.98	6.3	6.21	5.9	6.15	6.78	5.45
Magnesium ions (mg/l)	2.54	2.47	2.67	2.67	3.16	2.54	2.73	2.67	2.81	2.45	2.86	2.78	2.98	2.67
Sodium (mg/l)	1.76	1.76	1.5	1.6	1.69	1.45	1.56	1.92	1.98	1.65	2.6	2.86	3.56	1.9
Potassium (mg/l)	1.31	1.21	1.19	1.21	1.34	1.16	1.18	1.21	1.15	1.25	1.67	2.35	1.36	1.22
Iron (mg/l)	0.1	0.1	0.14	0.12	0.15	0.11	0.1	0.11	0.01	0.1	0.01	0.01	0.01	0.01
Cadmium (Cd) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	<0.01	ND	<0.01
Arsenic (As) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Mercury (Hg) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	<0.001	ND	<0.001
Copper (Cu) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	<0.1	ND	<0.1
Zinc (Zn) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	<0.1	ND	<0.1
Total Chromium (Cr) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	<0.05	ND	<0.05
Manganese (Mn) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Lead (Pb) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	<0.1	ND	<0.1
Biological Oxygen Demand (mg/l)	0.2	0.1	0.28	0.18	0.23	1.9	1.7	2.1	1.8	1	0.24	1	0.67	1.1
Chemical Oxygen Demand (mg/l)	0	0	0	0	0	2.8	2.5	3.2	3.1	0	0	0	0	0
Total Coliform (MPN /100 ml)	A	P	P	P	P	A	A	P	P	P	P	A	P	P

Table 7.4: Physico-Chemical characteristics of water at different sampling sites in the Study Area (July 2016)

Physical / Chemical Characteristics	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13	W14	W15
Water Temperature (°C)	20.4	21.3	20.5	21.6	21	21.8	22.4	10.1	20.9	21.6	23.5	23.1	23	23.1	22.1
Dissolved Oxygen (mg/l)	7.95	7.86	7.9	7.83	8.01	7.94	7.78	8.3	8.01	7.99	7.62	7.83	7.72	7.85	7.85
Turbidity (NTU)	3.2	2.3	3.8	2.5	1.25	1.2	1.3	0	2.1	2	1.7	1.2	2	2.1	2
Total Suspended Solids (mg/l)	6.1	5.8	4.7	3.4	3.8	3.9	3.4	1.4	3.2	3.4	2.7	2.5	2.6	1.9	1.98
pH	8.21	8.2	8.28	8.18	8.26	8.35	8.21	8.22	8.24	8.19	8.15	8.2	7.92	7.95	7.82
Electrical Conductivity (µS/cm)	125.25	100.2	106.88	93.52	81.83	90.18	115.23	95.19	106.88	113.56	98.53	105.21	85.17	88.51	103.54
Total Dissolved Solids (mg/l)	75	60	64	56	49	54	69	57	64	68	59	63	51	53	62
Total alkalinity (mg/l of CaCO3)	32	26	28	26	24	25	34	30	31	30	28	27	24	27	28
Sulphate (mg/l)	6.5	4.1	5.1	5.8	4.5	4.89	7.4	4.6	5.4	5.4	5.75	6.28	4.7	5.7	6.8
Chloride (mg/l)	9.2	9.6	8.99	6.9	6.54	6.78	8.3	5.2	8.98	8.97	6.62	7.25	5.9	6.95	8.44
Nitrates (NO3) (mg/l)	1.1	1.02	0.98	0.19	0.85	0.79	0.22	0.28	1.1	1.17	1.18	1.2	0.7	0.56	0.19
Phosphate (PO4) (mg/l)	0.02	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.001	0.02	0.01	0.01
Total Hardness (mg/l)	40.695	32.87	35.88	31.39	28.86	28.889	41.2	34.095	35.745	35.118	34.421	33.018	28.434	31.116	35.364
Calcium ions (mg/ l)	9.8	7.9	8.12	7.8	6.46	6.98	9.1	8.8	9.05	9.16	8.34	8.32	6.88	7.92	8.34
Magnesium ions (mg/l)	3.95	3.2	3.8	2.9	3.1	2.79	4.5	2.95	3.2	2.98	3.31	2.98	2.74	2.76	3.54
Sodium (mg/l)	2.9	1.8	2.2	1.89	1.98	2.8	2.8	1.21	2.8	2.9	2.11	2.13	1.4	1.67	2.23
Potassium (mg/l)	1.8	1.9	1.6	1.3	1.2	1.35	1.5	0.98	1.6	1.67	1.58	1.84	1.21	1.2	1.89
Iron (mg/l)	0.13	0.12	0.12	0.1	0.11	0.1	0.12	0.13	0.1	0.1	0.01	0.021	0.11	0.12	0.12
Cadmium (Cd) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Arsenic (As) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Mercury (Hg) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Copper (Cu) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Zinc (Zn) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total Chromium (Cr) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Manganese (Mn) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Lead (Pb) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Biological Oxygen Demand (mg/l)	0.15	0.21	0.26	0.11	0.19	0.15	1.2	0.25	0.16	0.21	0.24	0.67	0.59	0.79	1.15
Chemical Oxygen Demand (mg/l)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Coliform (MPN /100 ml)	P	P	P	P	P	A	A	A	P	P	P	P	P	P	P

Contd.

Physical / Chemical Characteristics	W16	W17	W18	W19	W20	W21	W22	W23	W24	W25	W26	W27	W28	W29	W30
Water Temperature (°C)	22.2	23.6	23.8	21.1	23.4	23.5	23.8	23.2	23.9	21.1	20.9	20.98	22.8	22.1	21.1
Dissolved Oxygen (mg/l)	7.62	7.55	7.58	7.92	7.42	7.57	7.75	7.82	7.52	7.99	7.83	7.62	7.75	7.58	7.9
Turbidity (NTU)	1.9	2.9	3.1	1.1	3.2	3.3	2.3	2.5	2.4	1.4	1.5	1.3	0.8	1.1	0.7
Total Suspended Solids (mg/l)	2	4.2	3.5	1.9	4.1	3.8	2.9	2.95	3.01	1.6	1.5	1.5	1.95	1.7	1.6
pH	7.88	7.84	8.1	8.18	7.89	7.82	7.85	7.99	7.92	8.16	8.21	8.18	8.15	8.14	8.1
Electrical Conductivity (µS/cm)	98.53	73.48	80.16	101.87	85.17	86.84	75.15	76.82	71.81	100.2	100.2	105.21	88.51	93.52	98.53
Total Dissolved Solids (mg/l)	59	44	48	61	51	52	45	46	43	60	60	63	53	56	59
Total alkalinity (mg/l of CaCO3)	26	22	24	27	24	23	21	21	19	31	32	34	25	26	32
Sulphate (mg/l)	7.12	2.7	5.64	7.12	5.2	5.45	2.4	3.9	4.7	4.1	4.3	4.2	3.6	2.9	2.78
Chloride (mg/l)	8.34	6.23	4.98	7.69	6.44	6.62	5.7	4.4	6.3	4.65	5.22	5.6	8.31	7.6	7.34
Nitrates (NO3) (mg/l)	0.21	0.38	0.42	0.21	0.19	0.22	0.28	0.29	0.3	0.19	0.26	0.3	0.26	0.3	0.19
Phosphate (PO4) (mg/l)	0.02	0.01	0.01	0.001	0.01	0.02	0.01	0.02	0.01	0.01	0.02	0.02	0.01	0.01	0.001
Total Hardness (mg/l)	34.176	25.645	26.709	33.092	28.073	28.505	24.61	23.37	25.81	28.94	30.07	32.468	30.57	30.035	33.356
Calcium ions (mg/ l)	8.98	6.65	5.78	8.12	6.67	6.81	6.4	6.56	6.88	6.82	7.6	8.1	7.8	7.75	8.16
Magnesium ions (mg/l)	2.86	2.2	2.99	3.12	2.78	2.8	2.1	1.7	2.1	2.9	2.7	2.98	2.7	2.6	3.16
Sodium (mg/l)	2.54	1.98	1.86	2.66	1.9	1.72	1.2	1.3	1.2	2.45	2.98	2.6	2.3	2.34	2.32
Potassium (mg/l)	1.66	1.32	1.42	1.56	1.21	1.21	1.1	1.1	1.1	2.1	1.89	1.94	1.6	1.6	1.27
Iron (mg/l)	0.11	0.12	0.12	0.11	0.11	0.11	0.1	0.01	0.01	0.11	0.11	0.1	0.01	0.11	0.12
Cadmium (Cd) (mg/l)	ND	<0.01	ND	<0.01	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Arsenic (As) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Mercury (Hg) (mg/l)	ND	<0.001	ND	<0.001	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Copper (Cu) (mg/l)	ND	<0.1	ND	<0.1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Zinc (Zn) (mg/l)	ND	<0.1	ND	<0.1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total Chromium (Cr) (mg/l)	ND	<0.05	ND	<0.05	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Manganese (Mn) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Lead (Pb) (mg/l)	ND	<0.1	ND	<0.1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Biological Oxygen Demand (mg/l)	0.35	0.89	0.45	1.12	1.26	1.3	0.54	0.32	0.21	0.19	0.28	0.18	0.4	0.5	0.35
Chemical Oxygen Demand (mg/l)	0	0	0	0	1.8	1.9	0	0	0	0	0	0	0	0	0
Total Coliform (MPN /100 ml)	A	P	P	P	P	P	P	P	P	P	P	P	P	P	A

Contd.

Physical / Chemical Characteristics	W31	W32	W33	W34	W35	W36	W37	W38	W39	W40	W41	W42	W43	W44	W45
Water Temperature (°C)	22.8	22.6	21.6	22.1	19.2	18.9	20.8	21.1	20.8	22.1	20.5	20.8	21.9	22.1	21.1
Dissolved Oxygen (mg/l)	7.45	7.57	7.75	7.62	7.99	8.1	8	7.87	7.75	7.55	7.76	8	7.82	8.11	7.82
Turbidity (NTU)	1.3	1.8	0.9	0.8	1.1	1.2	1.2	1.5	1.6	1.1	1.2	0.8	1.5	0.8	0.6
Total Suspended Solids (mg/l)	1.6	1.65	1.34	1.24	2.25	2.44	1.95	1.99	2.1	1.8	2.2	1.95	1.5	1.8	1.7
pH	8.21	8.02	8.2	8.21	8.25	8.21	8.16	8.19	8.18	8.19	8.42	8.18	8.28	8.14	7.92
Electrical Conductivity (µS/cm)	80.16	78.49	85.17	83.5	68.47	71.81	76.82	73.48	70.14	80.16	96.86	91.85	96.86	86.84	73.48
Total Dissolved Solids (mg/l)	48	47	51	50	41	43	46	44	42	48	58	55	58	52	44
Total alkalinity (mg/l of CaCO3)	26	25	28	27	22	23	25	23	22	26	32	30	32	28	22
Sulphate (mg/l)	2.45	2.48	2.2	2.4	2.1	2.3	2.68	2.54	2.59	2.56	3.65	3.94	4.18	3.78	3.02
Chloride (mg/l)	5.98	6.2	6.1	6.41	5.3	5.9	5.92	5.98	5.75	6.28	5.99	5.94	5.82	5.9	6
Nitrates (NO3) (mg/l)	0.18	0.19	0.28	0.18	0.19	0.12	0.16	0.19	0.12	0.16	0.2	0.18	0.14	0.21	0.24
Phosphate (PO4) (mg/l)	0.01	0.01	0.001	0.02	0.02	0.02	0.01	0.001	0.02	0.02	0.01	0.01	0.01	0.01	0.01
Total Hardness (mg/l)	25.816	26.295	27.619	28.32	22.52	24.91	27	25.637	24.135	26.601	33.323	31.786	31.502	28.695	25.586
Calcium ions (mg/ l)	6.21	6.91	7.21	7.31	5.4	5.7	6.7	6.45	6.21	6.36	7.95	7.45	7.32	6.64	6.2
Magnesium ions (mg/l)	2.51	2.2	2.34	2.45	2.2	2.6	2.5	2.32	2.1	2.61	3.28	3.21	3.22	2.95	2.46
Sodium (mg/l)	2.38	1.85	2.11	2.21	1.7	1.9	1.5	1.78	1.72	2.2	1.72	1.78	2.34	2.1	1.62
Potassium (mg/l)	1.62	1.56	1.75	1.6	1.2	1.34	1.2	1.31	1.28	1.24	1.25	1.37	1.65	1.8	1.1
Iron (mg/l)	0.11	0.11	0.1	0.11	0.1	0.12	0.11	0.11	0.11	0.12	0.11	0.1	0.11	0.1	0.11
Cadmium (Cd) (mg/l)	ND	ND	ND	ND	ND	ND	<0.01	ND	<0.01	ND	ND	ND	ND	ND	ND
Arsenic (As) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Mercury (Hg) (mg/l)	ND	ND	ND	ND	ND	ND	<0.001	ND	<0.001	ND	ND	ND	ND	ND	ND
Copper (Cu) (mg/l)	ND	ND	ND	ND	ND	ND	<0.1	ND	<0.1	ND	ND	ND	ND	ND	ND
Zinc (Zn) (mg/l)	ND	ND	ND	ND	ND	ND	<0.1	ND	<0.1	ND	ND	ND	ND	ND	ND
Total Chromium (Cr) (mg/l)	ND	ND	ND	ND	ND	ND	<0.05	ND	<0.05	ND	ND	ND	ND	ND	ND
Manganese (Mn) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Lead (Pb) (mg/l)	ND	ND	ND	ND	ND	ND	<0.1	ND	<0.1	ND	ND	ND	ND	ND	ND
Biological Oxygen Demand (mg/l)	0.3	0.7	0.9	0.85	1.15	0.26	0.98	0.87	1.25	1.2	0.2	0.28	0.3	0.26	0.24
Chemical Oxygen Demand (mg/l)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Coliform (MPN /100 ml)	P	P	P	P	P	A	P	P	P	P	A	A	P	A	A

Contd.

Physical / Chemical Characteristics	W46	W47	W48	W49	W50	W51	W52	W53	W54	W55	W56	W57	W58	W59
Water Temperature (°C)	20.7	20.6	22.4	22.2	22.8	22.4	22.9	23.1	20.9	21.9	22.6	22.1	20.6	21.7
Dissolved Oxygen (mg/l)	8.01	7.98	7.62	7.78	7.71	7.84	7.8	7.54	7.5	7.8	7.87	7.79	7.85	7.76
Turbidity (NTU)	0.8	0.6	0.6	0.9	0.95	0.6	0.8	1.1	0.7	1.1	0.9	0.7	1.1	1.2
Total Suspended Solids (mg/l)	1.55	1.85	1.52	1.82	1.77	1.58	1.96	1.85	1.35	1.22	1.65	1.49	1.9	1.78
pH	8.17	8.08	7.72	7.85	7.78	7.74	7.82	7.85	8.02	8.18	8.11	7.92	8.17	8.11
Electrical Conductivity (µS/cm)	76.82	73.48	81.83	78.49	86.84	68.47	75.15	71.81	83.5	76.82	91.85	88.51	91.85	80.16
Total Dissolved Solids (mg/l)	46	44	49	47	52	41	45	43	50	46	55	53	55	48
Total alkalinity (mg/l of CaCO3)	23	23	27	26	30	22	24.5	22.7	26	24	34	31	30.2	26
Sulphate (mg/l)	2.89	2.76	2.68	2.8	2.72	2.8	2.45	2.67	3.32	3.65	3.1	3.2	2.83	3.3
Chloride (mg/l)	5.44	6.25	4.98	5.25	5.26	4.95	4.8	5.62	4.98	5.92	3.05	3.92	4.95	5.4
Nitrates (NO3) (mg/l)	0.24	0.23	0.31	0.28	0.26	0.22	0.19	0.18	0.2	0.21	0.23	0.19	0.18	0.16
Phosphate (PO4) (mg/l)	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Total Hardness (mg/l)	25.865	25.123	26.73	26.476	29.19	23.963	25.405	25.897	27.92	26.496	27.595	27.056	27.871	26.709
Calcium ions (mg/ l)	6.41	5.9	6.1	5.9	6.1	5.6	5.57	5.98	6.33	6.4	6.2	6.05	6.54	5.78
Magnesium ions (mg/l)	2.4	2.53	2.8	2.86	3.4	2.43	2.8	2.67	2.95	2.56	2.95	2.91	2.81	2.99
Sodium (mg/l)	1.6	1.8	1.67	1.85	1.78	1.5	1.6	1.92	2.1	1.7	3.1	2.96	3.1	2.1
Potassium (mg/l)	1.23	1.31	1.23	1.3	1.45	1.2	1.2	1.21	1.21	1.3	1.98	2.56	1.45	1.3
Iron (mg/l)	0.12	0.11	0.14	0.12	0.15	0.11	0.1	0.11	0.01	0.1	0.01	0.01	0.01	0.01
Cadmium (Cd) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	<0.01	ND	<0.01
Arsenic (As) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Mercury (Hg) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	<0.001	ND	<0.001
Copper (Cu) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	<0.1	ND	<0.1
Zinc (Zn) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	<0.1	ND	<0.1
Total Chromium (Cr) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	<0.05	ND	<0.05
Manganese (Mn) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Lead (Pb) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	<0.1	ND	<0.1
Biological Oxygen Demand (mg/l)	0.32	0.25	0.26	0.22	0.27	1.04	1.21	1.75	1.43	0.95	0.38	0.86	0.72	1.1
Chemical Oxygen Demand (mg/l)	0	0	0	0	0	2.58	2.42	2.6	2.59	1.2	0	1.1	1	0
Total Coliform (MPN /100 ml)	A	P	P	P	P	A	A	P	P	P	P	A	P	P

Table 7.5: Physico-Chemical characteristics of water at different sampling sites in the Study Area (August 2016)

Physical / Chemical Characteristics	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13	W14	W15
Water Temperature (°C)	20.6	21.1	20.4	21.8	21.2	21.9	22.3	10.2	21.6	21.7	23.6	23.5	22.3	22.6	21.5
Dissolved Oxygen (mg/l)	7.9	7.85	7.82	7.76	7.95	7.9	7.69	8.2	7.9	7.95	7.56	7.75	7.74	7.79	7.65
Turbidity (NTU)	3.1	2.2	3.9	2.2	1.3	1.25	1.28	0	1.5	1.45	1.3	1.1	1.8	2	1.4
Total Suspended Solids (mg/l)	5.9	5.4	4.5	3.3	3.6	3.6	3.5	1.5	3.5	3.2	2.6	2.2	2.4	2.1	2.2
pH	8.15	8.18	8.28	8.14	8.33	8.39	8.15	8.18	8.2	8.16	8.17	8.24	7.86	7.89	7.92
Electrical Conductivity (µS/cm)	120.24	103.54	106.88	95.19	85.17	90.18	106.88	95.19	106.88	105.21	98.53	96.86	85.17	86.84	100.2
Total Dissolved Solids (mg/l)	72	62	64	57	51	54	64	57	64	63	59	58	51	52	60
Total alkalinity (mg/l of CaCO3)	32	29	27	28	26	27	34	31	30	29	29	27	25	25	27
Sulphate (mg/l)	6.9	5.1	5.6	5.7	4.8	5.2	7.6	4.9	5.25	5.4	5.9	6.6	5.2	5.7	6.9
Chloride (mg/l)	9.6	9.8	9.2	7.2	6.6	7.1	8.9	5.8	9.1	9	6.9	7.3	6.8	6.95	8.4
Nitrates (NO3) (mg/l)	1.4	1.2	1.1	0.15	0.1	0.11	0.23	0.67	1.1	1.25	1.21	1.22	0.9	0.6	0.32
Phosphate (PO4) (mg/l)	0.01	0.01	0.02	0.01	0.001	0.01	0.02	0.02	0.01	0.02	0.01	0.01	0.02	0.02	0.01
Total Hardness (mg/l)	41.31	33.69	35.46	31.71	30.12	30.87	42.61	34.96	37.39	33.91	33.87	33.18	29.89	31.73	35.18
Calcium ions (mg/ l)	9.8	7.9	7.95	7.6	6.8	7.1	9.5	8.9	9.38	9.3	8.3	8.35	7.2	8.1	8.25
Magnesium ions (mg/l)	4.1	3.4	3.8	3.1	3.2	3.2	4.6	3.1	3.4	2.6	3.2	3	2.9	2.8	3.55
Sodium (mg/l)	2.7	2.6	2.2	1.9	1.9	2.3	2.7	1.2	2.9	2.9	2.3	2.4	1.8	1.6	2.45
Potassium (mg/l)	1.9	1.8	1.4	1.3	1.2	1.4	1.6	0.9	1.77	1.8	1.75	1.92	1.3	1.15	1.95
Iron (mg/l)	0.12	0.13	0.12	0.11	0.12	0.11	0.14	0.18	0.12	0.1	0.1	0.01	0.12	0.1	0.11
Cadmium (Cd) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Arsenic (As) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Mercury (Hg) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Copper (Cu) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Zinc (Zn) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total Chromium (Cr) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Manganese (Mn) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Lead (Pb) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Biological Oxygen Demand (mg/l)	0.11	0.2	0.2	0.1	0.2	0.2	0.1	0.28	0.18	0.23	0.22	0.76	0.95	0.86	1
Chemical Oxygen Demand (mg/l)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Coliform (MPN /100 ml)	P	P	P	P	P	A	A	A	P	P	P	P	P	P	P

Contd.

Physical / Chemical Characteristics	W16	W17	W18	W19	W20	W21	W22	W23	W24	W25	W26	W27	W28	W29	W30
Water Temperature (°C)	21.3	23.6	23.4	20.8	23.1	23.7	23.5	23.1	23.8	20.7	20.8	20.85	22.6	21.7	20.6
Dissolved Oxygen (mg/l)	7.6	7.53	7.58	7.95	7.42	7.59	7.75	7.82	7.6	7.9	7.85	7.65	7.75	7.72	7.85
Turbidity (NTU)	1.6	3.2	3.4	0.9	3.2	3.3	2.2	2.5	2.4	1.3	1.2	1.1	0.3	0.5	0.2
Total Suspended Solids (mg/l)	2.1	4.3	3.5	2.1	4.2	4	3.1	2.9	3	1.9	1.6	1.4	1.9	1.8	1.7
pH	7.82	7.9	8.05	8.21	7.97	7.99	7.98	8.1	7.99	8.1	8.15	8.2	8.1	8.16	8.05
Electrical Conductivity (µS/cm)	98.53	81.83	78.49	101.87	83.5	86.84	80.16	76.82	71.81	93.52	100.2	105.21	88.51	90.18	95.19
Total Dissolved Solids (mg/l)	59	49	47	61	50	52	48	46	43	56	60	63	53	54	57
Total alkalinity (mg/l of CaCO3)	26	22	23	28	23	24	22	23	21	31	32	34	26	27	31
Sulphate (mg/l)	7.2	6.1	5.78	7.1	5.29	5.45	4.6	3.8	4.1	4.1	4.25	4.32	3.45	3.1	2.9
Chloride (mg/l)	8.6	6.4	5.25	7.95	6.45	6.8	5.7	4.45	5.3	4.9	5.3	5.4	8.25	7.6	7.5
Nitrates (NO3) (mg/l)	0.41	0.56	0.92	0.23	0.33	0.25	0.42	0.54	0.66	0.32	0.49	0.36	0.38	0.51	0.25
Phosphate (PO4) (mg/l)	0.001	0.02	0.02	0.02	0.01	0.02	0.01	0.02	0.02	0.01	0.001	0.001	0.01	0.01	0.001
Total Hardness (mg/l)	33.86	27.41	26.60	33.95	27.25	29.68	24.86	25.11	24.92	29.08	30.73	32.96	31.39	30.48	33.62
Calcium ions (mg/ l)	8.95	6.7	5.8	8.33	6.8	6.95	6.5	6.6	6.82	6.94	7.8	8.1	7.8	7.6	8.2
Magnesium ions (mg/l)	2.8	2.6	2.95	3.2	2.5	3	2.1	2.1	1.92	2.86	2.74	3.1	2.9	2.8	3.2
Sodium (mg/l)	2.45	1.9	1.95	2.9	1.92	1.7	1.15	1.4	1.25	2.38	2.15	2.8	2.2	2.45	2.35
Potassium (mg/l)	1.6	1.4	1.5	1.8	1.3	1.25	1.22	1.1	1.15	1.94	2.18	1.9	1.5	1.58	1.32
Iron (mg/l)	0.14	0.13	0.12	0.13	0.11	0.11	0.1	0.01	0.1	0.12	0.12	0.1	0.1	0.12	0.12
Cadmium (Cd) (mg/l)	ND	<0.01	ND	<0.01	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Arsenic (As) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Mercury (Hg) (mg/l)	ND	<0.001	ND	<0.001	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Copper (Cu) (mg/l)	ND	<0.1	ND	<0.1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Zinc (Zn) (mg/l)	ND	<0.1	ND	<0.1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total Chromium (Cr) (mg/l)	ND	<0.05	ND	<0.05	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Manganese (Mn) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Lead (Pb) (mg/l)	ND	<0.1	ND	<0.1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Biological Oxygen Demand (mg/l)	0.24	1	0.67	1.1	0.9	0.9	0.2	0.2	0.1	0.2	0.2	0.1	0.28	0.18	0.23
Chemical Oxygen Demand (mg/l)	0	0	0	0	1.7	1.9	0	0	0	0	0	0	0	0	0
Total Coliform (MPN /100 ml)	A	P	P	P	P	P	P	P	P	P	P	P	P	P	A

Contd.

Physical / Chemical Characteristics	W31	W32	W33	W34	W35	W36	W37	W38	W39	W40	W41	W42	W43	W44	W45
Water Temperature (°C)	22.6	22.3	21.4	22.5	18.6	18.4	20.5	20.7	20.4	21.8	20.2	20.3	21.7	21.6	20.5
Dissolved Oxygen (mg/l)	7.42	7.62	7.74	7.65	8.05	8.1	8	7.95	7.9	7.52	7.75	7.99	7.9	8.1	7.82
Turbidity (NTU)	0.8	1.5	0.2	0.3	0.1	0.2	1.1	1.2	1.1	0.8	0.7	0.2	0.8	0.3	0.1
Total Suspended Solids (mg/l)	1.4	1.5	1.4	1.2	2.2	2.3	2.1	1.9	2	1.9	2.1	1.9	1.6	1.7	1.8
pH	8.17	7.98	8.2	8.27	8.17	8.2	8.25	8.3	8.2	8.21	8.54	8.21	8.35	8.19	7.9
Electrical Conductivity (µS/cm)	80.16	81.83	85.17	85.17	70.14	71.81	76.82	80.16	75.15	81.83	98.53	91.85	96.86	88.51	80.16
Total Dissolved Solids (mg/l)	48	49	51	51	42	43	46	48	45	49	59	55	58	53	48
Total alkalinity (mg/l of CaCO3)	26	25	28	28	23	22	25	26	24	25	32	30	31	29	26
Sulphate (mg/l)	2.8	2.7	2.3	2.6	2.1	2.5	2.75	2.1	2.6	2.66	3.6	4.1	4.2	3.78	3.2
Chloride (mg/l)	5.9	6.4	6	6.45	5.4	5.9	5.96	6.1	5.75	6.32	6.1	5.9	5.78	5.95	6.18
Nitrates (NO3) (mg/l)	0.31	0.27	0.25	0.19	0.18	0.21	0.18	0.19	0.21	0.19	0.24	0.18	0.16	0.21	0.28
Phosphate (PO4) (mg/l)	0.001	0.001	0.02	0.01	0.01	0.01	0.01	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Total Hardness (mg/l)	27.07	28.00	27.84	28.39	23.43	24.34	26.16	27.66	25.13	27.89	33.45	31.62	31.85	29.97	27.99
Calcium ions (mg/ l)	6.4	7.1	7.2	7.5	5.6	5.8	6.2	6.8	6.28	6.4	8.1	7.4	7.41	7.15	6.72
Magnesium ions (mg/l)	2.7	2.5	2.4	2.35	2.3	2.4	2.6	2.6	2.3	2.9	3.22	3.2	3.25	2.95	2.73
Sodium (mg/l)	2.35	1.98	2.2	2.1	1.9	1.95	1.8	2.1	1.8	2.2	1.82	1.9	1.95	1.92	1.8
Potassium (mg/l)	1.68	1.52	1.84	1.69	1.3	1.4	1.4	1.5	1.4	1.4	1.26	1.3	1.5	1.5	1.2
Iron (mg/l)	0.11	0.11	0.1	0.11	0.12	0.18	0.13	0.11	0.12	0.12	0.11	0.14	0.11	0.16	0.11
Cadmium (Cd) (mg/l)	ND	ND	ND	ND	ND	ND	<0.01	ND	<0.01	ND	ND	ND	ND	ND	ND
Arsenic (As) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Mercury (Hg) (mg/l)	ND	ND	ND	ND	ND	ND	<0.001	ND	<0.001	ND	ND	ND	ND	ND	ND
Copper (Cu) (mg/l)	ND	ND	ND	ND	ND	ND	<0.1	ND	<0.1	ND	ND	ND	ND	ND	ND
Zinc (Zn) (mg/l)	ND	ND	ND	ND	ND	ND	<0.1	ND	<0.1	ND	ND	ND	ND	ND	ND
Total Chromium (Cr) (mg/l)	ND	ND	ND	ND	ND	ND	<0.05	ND	<0.05	ND	ND	ND	ND	ND	ND
Manganese (Mn) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Lead (Pb) (mg/l)	ND	ND	ND	ND	ND	ND	<0.1	ND	<0.1	ND	ND	ND	ND	ND	ND
Biological Oxygen Demand (mg/l)	0.22	0.76	0.95	0.86	1	0.24	1	0.67	1.1	1	0.11	0.2	0.2	0.1	0.2
Chemical Oxygen Demand (mg/l)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Coliform (MPN /100 ml)	P	P	P	P	P	A	P	P	P	P	A	A	P	A	A

Contd.

Physical / Chemical Characteristics	**W46**	**W47**	**W48**	**W49**	**W50**	**W51**	**W52**	**W53**	**W54**	**W55**	**W56**	**W57**	**W58**	**W59**
Water Temperature (°C)	20.3	20.1	22.3	22.4	22.6	22.8	22.5	22.1	22.6	21.3	22.2	21.9	20.1	21.2
Dissolved Oxygen (mg/l)	8	7.9	7.75	7.72	7.69	7.85	7.8	7.61	7.59	7.75	7.89	7.75	7.85	7.69
Turbidity (NTU)	0.2	0.2	0.4	0.5	0.5	0.2	0.3	0.4	0.2	0.6	0.3	0.21	0.3	0.2
Total Suspended Solids (mg/l)	1.6	1.9	1.6	1.9	1.68	1.69	1.89	1.9	1.4	1.25	1.76	1.56	1.5	1.9
pH	8.13	8.15	7.85	7.9	7.82	7.81	7.76	7.79	8.1	8.21	8.15	7.89	8.26	8.19
Electrical Conductivity (µS/cm)	83.5	75.15	83.5	85.17	86.84	73.48	75.15	73.48	83.5	81.83	93.52	86.84	91.85	80.16
Total Dissolved Solids (mg/l)	50	45	50	51	52	44	45	44	50	49	56	52	55	48
Total alkalinity (mg/l of CaCO3)	26	24	26	27	29	24	25	23	26	25	34	30	31	26
Sulphate (mg/l)	3.2	2.6	3.1	2.75	3.1	2.8	2.54	2.34	3.3	3.6	3.4	3.2	2.9	3.3
Chloride (mg/l)	5.75	6.2	5.5	5.22	5.3	4.9	5.1	5.35	5.1	6	3.4	3.9	4.5	5.9
Nitrates (NO3) (mg/l)	0.36	0.42	0.38	0.32	0.27	0.23	0.21	0.1	0.15	0.13	0.16	0.11	0.12	0.1
Phosphate (PO4) (mg/l)	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.001
Total Hardness (mg/l)	27.44	25.75	27.34	26.94	28.91	25.41	25.07	25.32	28.59	27.62	28.77	28.09	27.11	27.46
Calcium ions (mg/ l)	6.94	6.2	6.05	6.1	6.15	5.9	5.6	5.7	6.35	6.7	6.26	6.15	6.25	6.13
Magnesium ions (mg/l)	2.46	2.5	2.98	2.85	3.3	2.6	2.7	2.7	3.1	2.65	3.2	3.1	2.8	2.96
Sodium (mg/l)	1.95	1.7	1.7	1.8	1.8	1.45	1.82	1.9	1.7	1.73	3.4	2.95	3.1	1.95
Potassium (mg/l)	1.26	1.3	1.2	1.25	1.4	1.2	1.25	1.4	1.35	1.32	1.95	1.48	1.5	1.2
Iron (mg/l)	0.17	0.16	0.14	0.15	0.16	0.12	0.1	0.19	0.1	0.01	0.12	0.01	0.1	0.11
Cadmium (Cd) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	<0.01	ND	<0.01
Arsenic (As) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Mercury (Hg) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	<0.001	ND	<0.001
Copper (Cu) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	<0.1	ND	<0.1
Zinc (Zn) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	<0.1	ND	<0.1
Total Chromium (Cr) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	<0.05	ND	<0.05
Manganese (Mn) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Lead (Pb) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	<0.1	ND	<0.1
Biological Oxygen Demand (mg/l)	0.2	0.1	0.28	0.18	0.23	1.5	1.7	1.6	1.9	1	0.24	1	0.67	1.1
Chemical Oxygen Demand (mg/l)	0	0	0	0	0	2.8	2.4	2.5	2.55	1.2	1.1	1.6	1.05	1.88
Total Coliform (MPN /100 ml)	A	P	P	P	P	A	A	P	P	P	P	A	P	P

Table 7.6: Physico-Chemical characteristics of water at different sampling sites in the Study Area (September 2016)

Physical / Chemical Characteristics	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13	W14	W15
Water Temperature (°C)	19.2	20	19.3	21.2	20.4	21.1	22	9.8	19	19.1	22.4	20.8	21.3	22.1	19.2
Dissolved Oxygen (mg/l)	8	7.9	7.9	7.8	8.1	8	7.8	8.4	8.1	8.1	7.6	7.8	7.76	7.82	7.9
Turbidity (NTU)	3	2	4	2.1	1.2	1.3	1.2	0	1.1	1.2	1.2	0.5	1.7	1.95	1.2
Total Suspended Solids (mg/l)	6	5.3	4.8	3.2	3.5	3.7	3.4	1.2	3.4	3.5	2.3	2.1	2.3	1.56	1.8
pH	8.2	8.14	8.32	8.1	8.34	8.4	8.11	8.14	8.19	8.21	8.2	8.22	7.91	7.94	7.98
Electrical Conductivity (µS/cm)	116.9	106.88	101.87	98.53	75.15	80.16	110.22	100.2	113.56	108.55	93.52	101.87	81.83	78.49	96.86
Total Dissolved Solids (mg/l)	70	64	61	59	45	48	66	60	68	65	56	61	49	47	58
Total alkalinity (mg/l of CaCO3)	29	26	24	24	21	22	32	27	28	27	26	25	22	22	25
Sulphate (mg/l)	6.8	4.1	5.3	5.5	4.2	4.7	7.3	4.1	4.9	5.1	5.7	6.2	4.6	5.1	6.7
Chloride (mg/l)	9.4	9.4	8.9	6.4	6.3	6.67	8.5	5.3	8.9	8.7	6.5	7.1	6.4	6.7	8.32
Nitrates (NO3) (mg/l)	1.2	1.1	0.95	0.11	0.98	0.85	0.19	0.22	1.22	1.21	1.11	1.1	0.56	0.48	0.12
Phosphate (PO4) (mg/l)	0.001	0.001	0.002	0.001	0.001	0.002	0.001	<.001	0.001	0.001	0.01	0.001	0.002	0.002	0.001
Total Hardness (mg/l)	39.58	31.46	34.67	29.82	27.39	28.23	41.95	33.64	36.37	33	33.21	32.39	28.73	29.59	34.44
Calcium ions (mg/ l)	9.6	7.5	7.8	7.5	6.2	6.7	9.4	8.7	9.3	9.1	8.2	8.2	6.9	7.9	8.2
Magnesium ions (mg/l)	3.8	3.1	3.7	2.7	2.9	2.8	4.5	2.9	3.2	2.5	3.1	2.9	2.8	2.4	3.4
Sodium (mg/l)	2.6	2.5	2.1	1.8	1.8	2.1	2.6	1.1	2.8	2.7	2.1	2.32	1.2	1.5	2.1
Potassium (mg/l)	1.8	1.7	1.3	1.2	1.1	1.3	1.4	0.7	1.6	1.7	1.63	1.89	1.1	1.05	1.8
Iron (mg/l)	0.15	0.14	0.11	0.11	0.11	0.12	0.13	0.22	0.1	0.1	0.01	0.021	0.11	0.12	0.11
Cadmium (Cd) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Arsenic (As) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Mercury (Hg) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Copper (Cu) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Zinc (Zn) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total Chromium (Cr) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Manganese (Mn) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Lead (Pb) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Biological Oxygen Demand (mg/l)	0.14	0.26	0.23	0.15	0.21	0.25	0.18	0.26	0.27	0.22	0.18	0.89	1.1	0.95	1.2
Chemical Oxygen Demand (mg/l)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Coliform (MPN /100 ml)	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A

Contd.

Physical / Chemical Characteristics	W16	W17	W18	W19	W20	W21	W22	W23	W24	W25	W26	W27	W28	W29	W30
Water Temperature (°C)	20.4	23	22.2	19.5	22.4	23.6	23.1	22.9	23.4	19.5	19.8	20.1	22	20.6	19.5
Dissolved Oxygen (mg/l)	7.6	7.5	7.6	8.1	7.4	7.6	7.8	7.9	7.5	8.1	7.9	7.6	7.8	7.6	8
Turbidity (NTU)	1.8	3.2	3.4	0.3	3.4	3.2	2.1	2.4	2.3	1.2	1.1	0.8	0	0	0
Total Suspended Solids (mg/l)	2.1	4.4	3.7	1.5	4.5	4.2	3.2	2.8	3.1	1.5	1.3	1.2	2	1.3	1.5
pH	7.94	7.88	7.99	8.17	8.03	8.02	8.05	8	8	8.11	8.19	8.17	8.15	8.19	8.1
Electrical Conductivity (µS/cm)	91.85	70.14	73.48	98.53	80.16	83.5	78.49	73.48	75.15	96.86	103.54	108.55	78.49	85.17	91.85
Total Dissolved Solids (mg/l)	55	42	44	59	48	50	47	44	45	58	62	65	47	51	55
Total alkalinity (mg/l of CaCO3)	23	18	20	26	20	22	18	19	17	29	30	32	22	24	29
Sulphate (mg/l)	6.95	5.6	5.6	6.9	5.1	5.2	4.1	3.5	4.3	3.9	4.1	4	3.2	2.8	2.6
Chloride (mg/l)	8.12	6.1	5.1	7.8	6.3	6.5	5.6	4.2	6.1	4.8	5.1	5.3	8.2	7.5	7.2
Nitrates (NO3) (mg/l)	0.18	0.45	0.58	0.14	0.12	0.11	0.24	0.31	0.35	0.11	0.21	0.28	0.21	0.28	0.11
Phosphate (PO4) (mg/l)	0.001	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.01	0.01	0.001
Total Hardness (mg/l)	33.32	24.36	25.73	34.44	25.68	28.07	23.54	22.56	23.72	28.48	29.41	31.89	28.5	28.59	32.96
Calcium ions (mg/ l)	8.9	6.3	5.7	8.2	6.5	6.8	6.3	6.4	6.7	6.8	7.5	8	7.3	7.5	8.1
Magnesium ions (mg/l)	2.7	2.1	2.8	3.4	2.3	2.7	1.9	1.6	1.7	2.8	2.6	2.9	2.5	2.4	3.1
Sodium (mg/l)	2.4	1.8	1.9	2.6	1.87	1.6	1.1	1.2	1.15	2.4	2.9	2.5	2.1	2.3	2.2
Potassium (mg/l)	1.5	1.2	1.3	1.4	1.12	1.1	1.02	1.05	1.1	1.9	2.01	1.8	1.4	1.5	1.2
Iron (mg/l)	0.13	0.12	0.12	0.13	0.11	0.11	0.01	0.01	0.01	0.11	0.11	0.1	0.01	0.11	0.12
Cadmium (Cd) (mg/l)	ND	<0.01	ND	<0.01	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Arsenic (As) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Mercury (Hg) (mg/l)	ND	<0.001	ND	<0.001	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Copper (Cu) (mg/l)	ND	<0.1	ND	<0.1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Zinc (Zn) (mg/l)	ND	<0.1	ND	<0.1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total Chromium (Cr) (mg/l)	ND	<0.05	ND	<0.05	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Manganese (Mn) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Lead (Pb) (mg/l)	ND	<0.1	ND	<0.1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Biological Oxygen Demand (mg/l)	0.56	0.98	0.78	1.2	0.95	0.86	0.28	0.3	0.18	0.26	0.25	0.18	0.21	0.25	0.27
Chemical Oxygen Demand (mg/l)	0	0	0	0	1.6	1.8	0	0	0	0	0	0	0	0	0
Total Coliform (MPN /100 ml)	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A

Contd.

Physical / Chemical Characteristics	W31	W32	W33	W34	W35	W36	W37	W38	W39	W40	W41	W42	W43	W44	W45
Water Temperature (°C)	22.1	21.4	20.1	21.2	15.6	15.3	17.8	18.2	18	21.2	19.2	19.6	20.7	21.2	19.2
Dissolved Oxygen (mg/l)	7.4	7.6	7.8	7.7	8.2	8.3	8.1	8	7.9	7.5	7.8	8.1	7.9	8.21	7.89
Turbidity (NTU)	0	1.1	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Suspended Solids (mg/l)	1.1	1.4	1.2	1.1	2.1	2.2	1.9	1.8	1.9	1.6	2.1	1.8	1.3	1.45	1.5
pH	8.16	8.01	8.2	8.27	8.17	8.2	8.25	8.3	8.2	8.21	8.54	8.21	8.35	8.19	7.9
Electrical Conductivity (µS/cm)	73.48	71.81	80.16	78.49	63.46	65.13	65.13	66.8	68.47	86.84	108.55	98.53	93.52	83.5	83.5
Total Dissolved Solids (mg/l)	44	43	48	47	38	39	39	40	41	52	65	59	56	50	50
Total alkalinity (mg/l of CaCO3)	23	22	26	25	19	20	23	20	21	24	30	29	30	27	24
Sulphate (mg/l)	2.3	2.4	2.1	2.3	1.9	2.1	2.6	2.4	2.5	2.5	3.5	3.8	4.1	3.65	3.1
Chloride (mg/l)	5.8	6.1	5.9	6.3	5.3	5.7	5.8	5.9	5.7	6.2	5.9	5.8	5.76	5.8	6.1
Nitrates (NO3) (mg/l)	0.12	0.13	0.11	0.16	0.11	0.12	0.11	0.12	0.11	0.13	0.15	0.12	0.11	0.18	0.2
Phosphate (PO4) (mg/l)	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.01	0.01	0.01	0.01	0.01
Total Hardness (mg/l)	25.09	25.61	26.77	27.391	21.86	23.18	23.86	24.52	23.475	26	32.46	30.96	30.94	28.324	26.51
Calcium ions (mg/ l)	6.1	6.8	7.1	7.25	5.3	5.5	6.1	6.2	6.11	6.3	7.9	7.3	7.21	6.59	6.34
Magnesium ions (mg/l)	2.4	2.1	2.2	2.26	2.1	2.3	2.1	2.2	2	2.5	3.1	3.1	3.15	2.89	2.6
Sodium (mg/l)	2.3	1.9	2.1	2.15	1.6	1.7	1.4	1.6	1.6	2.1	1.68	1.7	1.9	1.87	1.7
Potassium (mg/l)	1.5	1.4	1.7	1.5	1.1	1.2	1.1	1.2	1.2	1.1	1.17	1.25	1.54	1.43	1.05
Iron (mg/l)	0.11	0.11	0.1	0.11	0.1	0.12	0.11	0.11	0.11	0.12	0.11	0.1	0.11	0.12	0.11
Cadmium (Cd) (mg/l)	ND	ND	ND	ND	ND	ND	<0.01	ND	<0.01	ND	ND	ND	ND	ND	ND
Arsenic (As) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Mercury (Hg) (mg/l)	ND	ND	ND	ND	ND	ND	<0.001	ND	<0.001	ND	ND	ND	ND	ND	ND
Copper (Cu) (mg/l)	ND	ND	ND	ND	ND	ND	<0.1	ND	<0.1	ND	ND	ND	ND	ND	ND
Zinc (Zn) (mg/l)	ND	ND	ND	ND	ND	ND	<0.1	ND	<0.1	ND	ND	ND	ND	ND	ND
Total Chromium (Cr) (mg/l)	ND	ND	ND	ND	ND	ND	<0.05	ND	<0.05	ND	ND	ND	ND	ND	ND
Manganese (Mn) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Lead (Pb) (mg/l)	ND	ND	ND	ND	ND	ND	<0.1	ND	<0.1	ND	ND	ND	ND	ND	ND
Biological Oxygen Demand (mg/l)	0.28	0.89	1.1	0.95	1.1	0.4	1.09	0.85	1.02	0.95	0.19	0.25	0.22	0.16	0.28
Chemical Oxygen Demand (mg/l)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Coliform (MPN /100 ml)	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A

Contd.

Physical / Chemical Characteristics	W46	W47	W48	W49	W50	W51	W52	W53	W54	W55	W56	W57	W58	W59
Water Temperature (°C)	18.9	18.6	21.5	21.1	21.6	21.8	21.6	21.9	20.5	19.8	20.1	20.4	18.9	19.6
Dissolved Oxygen (mg/l)	8.1	8	7.68	7.8	7.75	7.98	7.85	7.59	7.54	7.85	7.92	7.83	7.98	7.85
Turbidity (NTU)	0	0	0.3	0.4	0.4	0.1	0.15	0.21	0	0.2	0.1	0.12	0	0
Total Suspended Solids (mg/l)	1.35	1.8	1.5	1.6	1.55	1.42	1.56	1.75	1.2	1.1	1.6	1.21	2.6	1.8
pH	8.13	8.15	7.85	7.9	7.82	7.81	7.76	7.79	8.1	8.21	8.15	7.89	8.22	8.15
Electrical Conductivity (µS/cm)	88.51	78.49	80.16	81.83	85.17	63.46	68.47	70.14	80.16	83.5	88.51	81.83	90.18	75.15
Total Dissolved Solids (mg/l)	53	47	48	49	51	38	41	42	48	50	53	49	54	45
Total alkalinity (mg/l of CaCO3)	25	21	26	26	28	20	22	20	24	23	32	28	28	24
Sulphate (mg/l)	3	2.6	2.8	2.6	2.65	2.7	2.3	2.5	3.2	3.54	3.18	3.1	2.65	3.2
Chloride (mg/l)	5.6	6.15	5.21	5.1	5.16	4.8	4.9	5.3	4.9	5.85	3.2	3.8	4.8	5.2
Nitrates (NO3) (mg/l)	0.21	0.19	0.26	0.22	0.21	0.14	0.12	0.1	0.15	0.13	0.16	0.11	0.12	0.01
Phosphate (PO4) (mg/l)	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.001
Total Hardness (mg/l)	26.208	23.715	26.64	26.023	28.075	22.93	24.285	24.414	27.39	25.34	28.217	26.535	26.57	25.924
Calcium ions (mg/ l)	6.58	5.55	5.9	5.85	5.9	5.4	5.45	5.6	6.2	6.2	6.17	5.94	6.2	5.63
Magnesium ions (mg/l)	2.38	2.4	2.9	2.78	3.25	2.3	2.6	2.54	2.9	2.4	3.12	2.85	2.7	2.89
Sodium (mg/l)	1.85	1.58	1.6	1.7	1.65	1.4	1.7	1.84	1.55	1.6	3.2	2.89	2.85	1.82
Potassium (mg/l)	1.15	1.2	1.12	1.2	1.25	1.1	1.17	1.1	1.19	1.21	1.9	1.43	1.32	1.1
Iron (mg/l)	0.12	0.11	0.14	0.12	0.15	0.11	0.1	0.11	0.01	0.01	0.01	0.01	0.01	0.01
Cadmium (Cd) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	<0.01	ND	<0.01
Arsenic (As) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Mercury (Hg) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	<0.001	ND	<0.001
Copper (Cu) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	<0.1	ND	<0.1
Zinc (Zn) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	<0.1	ND	<0.1
Total Chromium (Cr) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	<0.05	ND	<0.05
Manganese (Mn) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Lead (Pb) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	<0.1	ND	<0.1
Biological Oxygen Demand (mg/l)	0.29	0.34	0.31	0.21	0.26	1.2	1.35	1.95	1.32	1.1	0.6	1.1	0.8	1.2
Chemical Oxygen Demand (mg/l)	0	0	0	0	0	2.3	2.1	2.8	2.5	1.8	0	1.9	1.5	1.1
Total Coliform (MPN /100 ml)	A	A	A	A	A	A	A	A	A	A	A	A	A	A

Table 7.7: Physico-Chemical characteristics of water at different sampling sites in the Study Area (October 2016)

Physical / Chemical Characteristics	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13	W14	W15
Water Temperature (°C)	17.1	17	17.4	18.1	18	19.1	19.6	7.1	17.5	17.2	20.1	18.2	19.2	19.5	18.1
Dissolved Oxygen (mg/l)	8.2	8.1	8	7.9	8.2	8.1	8	8.6	8.2	8.1	7.9	8	7.8	7.8	7.85
Turbidity (NTU)	1.1	1.1	1.5	1.2	0	0.2	0.4	0	1	1.1	0.8	0.2	1.5	1.82	0.5
Total Suspended Solids (mg/l)	5.3	5.2	4.5	3	3.1	2.2	2.7	1.5	3.2	3.3	2.1	2	2.1	1.8	1.2
pH	8.24	8.21	8.28	8.13	8.3	8.35	8.18	8.2	8.2	8.17	8.16	8.21	7.7	7.8	7.87
Electrical Conductivity (µS/cm)	103.54	95.19	91.85	88.51	80.16	83.5	106.88	95.19	103.54	100.2	91.85	95.19	83.5	85.17	93.52
Total Dissolved Solids (mg/l)	62	57	55	53	48	50	64	57	62	60	55	57	50	51	56
Total alkalinity (mg/l of CaCO3)	28	26	26	24	22	23	30	29	28	27	29	23	24	25	23
Sulphate (mg/l)	5.3	4.8	4.9	5.1	4.6	4.8	7.1	3.9	4.5	4.9	5.2	5.9	4.3	4.8	6.2
Chloride (mg/l)	8.2	8.3	8.4	7.5	7.1	6.9	8.2	5.1	8.1	8.2	6.1	6.8	6.1	6.3	7.9
Nitrates (NO3) (mg/l)	1.05	1.02	0.91	0.12	0.82	0.89	0.15	0.19	1.1	1.1	0.9	0.89	0.54	0.51	0.25
Phosphate (PO4) (mg/l)	0.001	0.001	0.002	0.001	0.001	0.002	0.001	<.001	0.001	0.001	0.01	0.001	0.002	0.002	0.001
Total Hardness (mg/l)	36.76	33.62	34.83	30.89	28.46	28.14	39.97	33.96	34.87	33.89	32.14	29.25	30.46	29.66	32.46
Calcium ions (mg/ l)	8.8	8.2	7.7	7.6	6.3	6.5	9.1	8.5	8.7	8.8	8.1	7.6	7.1	7.6	7.9
Magnesium ions (mg/l)	3.6	3.2	3.8	2.9	3.1	2.9	4.2	3.1	3.2	2.9	2.9	2.5	3.1	2.6	3.1
Sodium (mg/l)	2.2	2.4	2.2	2.1	2	1.9	2.2	1.2	2.3	2.4	2	2.1	1.4	1.7	2.2
Potassium (mg/l)	1.9	1.8	1.6	1.5	1.4	1.1	1.2	0.8	1.5	1.4	1.45	1.6	1.1	1	1.1
Iron (mg/l)	0.13	0.12	0.11	0.11	0.11	0.11	0.13	0.22	0.1	0.1	0.01	0.021	0.11	0.12	0.11
Cadmium (Cd) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Arsenic (As) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Mercury (Hg) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Copper (Cu) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Zinc (Zn) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total Chromium (Cr) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Manganese (Mn) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Lead (Pb) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Biological Oxygen Demand (mg/l)	0.11	0.2	0.2	0.1	0.2	0.2	0.1	0.28	0.18	0.23	0.22	0.76	0.95	0.86	1
Chemical Oxygen Demand (mg/l)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Coliform (MPN /100 ml)	P	P	P	P	P	A	A	A	P	P	P	P	P	P	P

Contd.

Physical / Chemical Characteristics	W16	W17	W18	W19	W20	W21	W22	W23	W24	W25	W26	W27	W28	W29	W30
Water Temperature (°C)	19	20	19.2	18.2	20.1	20.5	20.4	20.2	21.2	17.2	18.1	18.2	21.1	20.1	19.1
Dissolved Oxygen (mg/l)	7.8	7.7	7.85	8.15	7.36	7.75	7.85	7.92	7.8	8.2	8.1	8	8.1	7.9	8.2
Turbidity (NTU)	1.1	2.9	2.9	0	3.2	2.1	2.2	2.1	2.1	1	0.5	0.4	0	0	0
Total Suspended Solids (mg/l)	1.7	4.1	3.8	1.7	4.1	3.5	3	2.5	2.6	1.6	1.4	1.3	2.1	1.2	1.4
pH	7.9	7.87	8	8.11	7.85	7.9	8	8.15	8.1	8.15	8.16	8.19	8.11	8.2	8.1
Electrical Conductivity (µS/cm)	86.84	71.81	75.15	93.52	83.5	88.51	83.5	80.16	75.15	91.85	105.21	106.88	85.17	90.18	88.51
Total Dissolved Solids (mg/l)	52	43	45	56	50	53	50	48	45	55	63	64	51	54	53
Total alkalinity (mg/l of CaCO3)	21	19	21	24	22	24	19	21	19	28	29	30	24	25	28
Sulphate (mg/l)	6.5	5.4	5.7	6.2	5.6	5.8	5.3	4.2	4.8	4.1	4.3	4.3	3.8	3.2	2.9
Chloride (mg/l)	7.9	5.7	5.4	6.6	6.1	6.1	5.7	4.9	5.7	4.5	5.5	5.4	7.8	7.9	7.5
Nitrates (NO3) (mg/l)	0.15	0.34	0.43	0.12	0.12	0.12	0.21	0.21	0.28	0.11	0.12	0.18	0.22	0.21	0.16
Phosphate (PO4) (mg/l)	0.001	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.01	0.01	0.001
Total Hardness (mg/l)	31.66	24.93	27.14	32.71	28.07	29.14	25.27	24.13	24.61	27.91	30.152	32.255	29.82	29.955	32.202
Calcium ions (mg/ l)	8.4	6.2	6.1	8	6.8	6.9	6.5	6.7	6.4	6.9	7.6	7.9	7.5	7.8	7.6
Magnesium ions (mg/l)	2.6	2.3	2.9	3.1	2.7	2.9	2.2	1.8	2.1	2.6	2.72	3.05	2.7	2.55	3.22
Sodium (mg/l)	2.2	1.5	1.2	2.2	1.9	1.7	1.4	1.5	1.2	2.1	2.75	2.6	2.34	2.5	2.45
Potassium (mg/l)	1.2	1	0.9	1.2	1.1	1.2	1	1.1	1.23	1.5	2.1	1.9	1.6	1.7	1.5
Iron (mg/l)	0.13	0.12	0.12	0.13	0.11	0.11	0.01	0.01	0.01	0.11	0.11	0.1	0.01	0.11	0.12
Cadmium (Cd) (mg/l)	ND	<0.01	ND	<0.01	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Arsenic (As) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Mercury (Hg) (mg/l)	ND	<0.001	ND	<0.001	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Copper (Cu) (mg/l)	ND	<0.1	ND	<0.1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Zinc (Zn) (mg/l)	ND	<0.1	ND	<0.1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total Chromium (Cr) (mg/l)	ND	<0.05	ND	<0.05	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Manganese (Mn) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Lead (Pb) (mg/l)	ND	<0.1	ND	<0.1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Biological Oxygen Demand (mg/l)	0.24	1	0.67	1.1	0.7	0.8	0.2	0.2	0.1	0.2	0.2	0.1	0.28	0.18	0.23
Chemical Oxygen Demand (mg/l)	0	0	0	0	1.7	1.9	0	0	0	0	0	0	0	0	0
Total Coliform (MPN /100 ml)	A	P	P	P	P	P	P	P	P	P	P	P	P	P	A

Contd.

Physical / Chemical Characteristics	W31	W32	W33	W34	W35	W36	W37	W38	W39	W40	W41	W42	W43	W44	W45
Water Temperature (°C)	21.2	20.2	19.1	19.2	15.2	15.1	16.8	17.2	17.7	20.4	18.4	18.3	19.4	20.3	18.1
Dissolved Oxygen (mg/l)	7.6	7.8	7.85	7.8	8.22	8.35	8.18	8.2	7.75	7.6	7.85	8.15	7.95	8.15	7.9
Turbidity (NTU)	0	0.6	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Suspended Solids (mg/l)	1.2	1.3	1.4	1.4	2.2	2.1	1.6	1.7	1.8	2.1	2.2	1.9	1.5	1.6	1.5
pH	8.16	7.99	8.12	8.25	8.21	8.25	8.19	8.27	8.22	8.21	8.48	8.2	8.31	8.24	8.1
Electrical Conductivity (µS/cm)	80.16	81.83	86.84	85.17	70.14	76.82	73.48	75.15	66.8	81.83	100.2	95.19	91.85	90.18	93.52
Total Dissolved Solids (mg/l)	48	49	52	51	42	46	44	45	40	49	60	57	55	54	56
Total alkalinity (mg/l of CaCO3)	25	23	28	27	22	24	22	23	20	27	30	29	30	30	25
Sulphate (mg/l)	2.7	2.8	2.4	2.6	2.1	2.5	2.9	2.8	2.9	2.9	3.5	3.3	4.1	4.1	3.8
Chloride (mg/l)	6.2	6.4	6.3	6.6	6.1	6.1	6.5	6.2	5.95	6.4	6.3	6.56	6.1	6.2	6.2
Nitrates (NO3) (mg/l)	0.18	0.11	0.1	0.12	0.09	0.1	0.15	0.13	0.1	0.12	0.11	0.08	0.13	0.15	0.21
Phosphate (PO4) (mg/l)	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.01	0.01	0.01	0.01	0.01
Total Hardness (mg/l)	27.07	26.77	27.885	28.012	24.75	25.91	24.77	25.84	24.11	25.84	31.89	30.849	31.05	29.97	28.07
Calcium ions (mg/ l)	6.4	7.1	7.3	7.4	5.8	6.1	6.3	6.4	6.2	6.4	8	7.6	7.5	7.15	6.8
Magnesium ions (mg/l)	2.7	2.2	2.35	2.32	2.5	2.6	2.2	2.4	2.1	2.4	2.9	2.89	3	2.95	2.7
Sodium (mg/l)	2.5	2.1	2.2	2.3	1.9	2.1	1.8	1.9	1.8	2	1.7	1.8	2.1	1.9	1.8
Potassium (mg/l)	1.6	1.5	1.8	1.6	1.4	1.3	1.2	1.3	1.28	1.25	1.21	1.35	1.5	1.4	1.2
Iron (mg/l)	0.11	0.11	0.1	0.11	0.1	0.12	0.11	0.11	0.11	0.12	0.11	0.1	0.11	0.12	0.11
Cadmium (Cd) (mg/l)	ND	ND	ND	ND	ND	ND	<0.01	ND	<0.01	ND	ND	ND	ND	ND	ND
Arsenic (As) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Mercury (Hg) (mg/l)	ND	ND	ND	ND	ND	ND	<0.001	ND	<0.001	ND	ND	ND	ND	ND	ND
Copper (Cu) (mg/l)	ND	ND	ND	ND	ND	ND	<0.1	ND	<0.1	ND	ND	ND	ND	ND	ND
Zinc (Zn) (mg/l)	ND	ND	ND	ND	ND	ND	<0.1	ND	<0.1	ND	ND	ND	ND	ND	ND
Total Chromium (Cr) (mg/l)	ND	ND	ND	ND	ND	ND	<0.05	ND	<0.05	ND	ND	ND	ND	ND	ND
Manganese (Mn) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Lead (Pb) (mg/l)	ND	ND	ND	ND	ND	ND	<0.1	ND	<0.1	ND	ND	ND	ND	ND	ND
Biological Oxygen Demand (mg/l)	0.22	0.76	0.95	0.86	1	0.24	1	0.67	1.1	1	0.11	0.2	0.2	0.1	0.2
Chemical Oxygen Demand (mg/l)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Coliform (MPN /100 ml)	P	P	P	P	P	A	P	P	P	P	A	A	P	A	A

Contd.

Physical / Chemical Characteristics	**W46**	**W47**	**W48**	**W49**	**W50**	**W51**	**W52**	**W53**	**W54**	**W55**	**W56**	**W57**	**W58**	**W59**
Water Temperature (°C)	18.2	17.9	19.2	19.3	19.4	19.5	19.2	19.7	18.9	18.2	18.7	18.9	17.5	18.2
Dissolved Oxygen (mg/l)	8.15	8.12	7.75	7.84	7.79	8.1	7.9	7.6	7.65	7.9	8	7.9	8.1	7.9
Turbidity (NTU)	0	0	0.4	0.3	0.3	0.2	0.15	0.3	0	0.2	0.1	0.1	0	0
Total Suspended Solids (mg/l)	1.4	1.6	1.7	1.7	1.6	1.5	1.6	1.8	1.4	1.2	1.7	1.3	2.5	2.1
pH	8.15	8.11	7.93	7.95	7.91	7.86	7.82	7.85	8.12	8.25	8.11	7.92	8.2	8.14
Electrical Conductivity (µS/cm)	85.17	76.82	80.16	80.16	90.18	70.14	73.48	70.14	78.49	90.18	95.19	86.84	90.18	81.83
Total Dissolved Solids (mg/l)	51	46	48	48	54	42	44	42	47	54	57	52	54	49
Total alkalinity (mg/l of CaCO3)	27	24	27	27	29	22	24	22	25	24	31	29	30	26
Sulphate (mg/l)	3.5	2.9	3.2	2.9	3.1	3.2	2.9	2.8	3.4	3.6	3.4	3.5	3.2	3.5
Chloride (mg/l)	5.2	6.4	5.8	5.52	5.59	5.2	5.16	5.89	5.45	6.2	4.1	4.3	5.2	5.4
Nitrates (NO3) (mg/l)	0.22	0.18	0.21	0.18	0.19	0.17	0.1	0.11	0.18	0.12	0.15	0.14	0.11	0.12
Phosphate (PO4) (mg/l)	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.001
Total Hardness (mg/l)	27.5	25.91	28.05	27.365	29.54	24.34	25.32	25.615	28.3	27.164	29.075	27.365	27.492	27.468
Calcium ions (mg/ l)	6.9	6.1	6.3	6.19	6.24	5.8	5.7	5.9	6.4	6.7	6.3	6.19	6.29	6.1
Magnesium ions (mg/l)	2.5	2.6	3	2.9	3.4	2.4	2.7	2.65	3	2.54	3.25	2.9	2.87	2.98
Sodium (mg/l)	1.9	1.6	1.8	1.9	1.8	1.5	1.7	1.9	1.7	1.7	2.8	2.95	2.94	2.1
Potassium (mg/l)	1.4	1.3	1.25	1.32	1.35	1.2	1.25	1.26	1.3	1.4	1.69	1.59	1.6	1.3
Iron (mg/l)	0.12	0.11	0.14	0.12	0.15	0.11	0.1	0.11	0.01	0.01	0.01	0.01	0.01	0.01
Cadmium (Cd) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	<0.01	ND	<0.01
Arsenic (As) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Mercury (Hg) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	<0.001	ND	<0.001
Copper (Cu) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	<0.1	ND	<0.1
Zinc (Zn) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	<0.1	ND	<0.1
Total Chromium (Cr) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	<0.05	ND	<0.05
Manganese (Mn) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Lead (Pb) (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	<0.1	ND	<0.1
Biological Oxygen Demand (mg/l)	0.2	0.1	0.28	0.18	0.23	1.5	1.7	1.3	1.5	1	0.24	1	0.67	1.1
Chemical Oxygen Demand (mg/l)	0	0	0	0	0	2.2	2.3	2.9	2.8	0	0	0	0	0
Total Coliform (MPN /100 ml)	A	P	P	P	P	A	A	P	P	P	P	A	P	P

Note: W1 to W59 shows sampling Sites

Site Code	**W1**	**W2**	**W3**	**W4**	**W5**	**W6**	**W7**	**W8**	**W9**	**W10**	**W11**	**W12**	**W13**	**W14**	**W15**
Sampling Sites	Malana I	Malana I	Tosh	Patikari	Allain Duhangan	Allain Duhangan	Sarbari-II	Beas Kund	Malana II	Malana II	Neogal	Uhl -II	Binwa Khad	Baner Khad	Gaj Khad
Site Code	**W16**	**W17**	**W18**	**W19**	**W20**	**W21**	**W22**	**W23**	**W24**	**W25**	**W26**	**W27**	**W28**	**W29**	**W30**
Sampling Sites	Khauli	Larji	Larji	Uhl-I (Shanan)	Pong Dam	Pong Dam	Beas Satluj Link	Beas Satluj Link	Beas Satluj Link	Parbati III	Parbati III	Parbati III	Baner II	Fozal	Lambadug
Site Code	**W31**	**W32**	**W33**	**W34**	**W35**	**W36**	**W37**	**W38**	**W39**	**W40**	**W41**	**W42**	**W43**	**W44**	**W45**
Sampling Sites	Lower Uhl	Baragao n	Uhl III	Uhl III	Sainj HEP	Sainj HEP	Parbati II	Parbati II	Parbati II	Uhl	Sarsadi II	Palchan Bhang	Uhl Khad	Bhang	Balargha
Site Code	**W46**	**W47**	**W48**	**W49**	**W50**	**W51**	**W52**	**W53**	**W54**	**W55**	**W56**	**W57**	**W58**	**W59**	**-**
Sampling Sites	Sharni	Sarsadi	Nakhthan HEP	Nakhtha n HEP	Nakhthan HEP	Thana Plaun	Thana Plaun	Triveni Mahadev	Dhaulasidh	Parbati	Hurla-I	Kilhi-Bahl	Malana III	Jobrie	-

Annexure - VIII

No MPP-F(2)-16/2008
Government of Himachal Pradesh,
Department of MPP and Power.

From

The Principal Secretary (Power) to the
Government of Himachal Pradesh.

To

1. The Principal Secretary (NES) to the
Government of Himachal Pradesh,
Shimla-171002.
2. The Chairman,
H.P. State Electricity Board,
Vidyut Bhawan, Shimla-171004.
3. The Chief Executive Officer,
HIMURJA< Urja Bhawan,
Kasumpti, Shimla-171009.

Dated : Shimla-2, the 29 January, 2009.

Subject :- Policy regarding ensuring minimum flow of water in Hydro Electric Projects.

Sir,

It is intimated that the aforesaid issue was under consideration of State Government for some time past. The State Government has recently decided that the minimum flow of water in Hydro Electric Projects will henceforth be regulated as under:-

"The Company, if ROR Project shall ensure minimum flow of 15% water immediately downstream of the diversion structure of the Project throughout the year. For the purpose of determination of minimum discharge, the average discharge in the lean months i.e. from December to February shall be considered. This minimum discharge is required keeping in mind the serious concerns of the State Government on account of its fragile ecology & environment and also to address issues concerning riparian rights drinking water, health aquatic life, wild life, fisheries, silt and even to honour the sensitive religious issues like cremation and other religious rites etc. on the river banks However, the companies are at liberty to install mini hydel projects to harness such water for their captive use for their utilities.

M(P)
30.1

CE (P&M)

CE (Contracts)

/823/W/TEC

SE(W)TEC) for further necessary action pl.

systems and colonies, subject to prior approval of the State Government".

In the light of aforesaid Policy decision, you are, requested to modify this clause in draft MOUs/PIAs/IAs etc. This Policy change will come into immediate effect and will apply to all the power producers, in the spirit of the Hydro Power Policy-2006.

This Policy change may also be brought to the notice of the all power producers.

Yours faithfully

29/1/2009

Special Secretary (Power) to the
Government of Himachal Pradesh.

BEFORE THE NATIONAL GREEN TRIBUNAL,
PRINCIPAL BENCH, NEW DELHI

Original Application No. 498 of 2015
(M.A. No. 628/2016)

IN THE MATTER OF:

Pushp Saini Vs. Ministry of Environment, Forest & Climate Change & Ors.

CORAM : HON'BLE MR. JUSTICE SWATANTER KUMAR, CHAIRPERSON
HON'BLE MR. JUSTICE RAGHUVENDRA S. RATHORE, JUDICIAL MEMBER
HON'BLE MR. BIKRAM SINGH SAJWAN, EXPERT MEMBER

Present:	**Applicant:**	
		Ms. Shibani Ghosh, Adv. for Intervenor
	Respondent No. 1 :	**Mr. Divya Prakash Pande , Adv.**
	Respondent Nos. 15&26:	**Mr. Mukesh Verma, Adv.**
		Mr. Nishe Rajen Shonker and Ms. Anu K. Joy, Advs. for State of Kerala
	Respondent No. 19:	**Ms. K. Enatoli Sema, Adv. For Nagaland SPCB and Mr. Amith J, Adv.,**
	Respondent No. 22:	**Mr. Shiv Mangal Sharma, AAG, Mr. Saurabh Rajpal, Adv., and Mr. Adhiraj Singh, Adv. for State of Rajasthan**
		Respondent Nos. 28&29: Mr. Nikhil Nayyar, Adv., Ms. Smriti Shah, Advs. for APPCB & TSPCB
		Mr. G.M. Kawoosa, Adv. and Ms. Palak Mittal, Adv. for State of J&K
		Mr. Guntur Prabhakar, Mr. Pramod Kumar and Mr. Gautam Prakhakar, Advs. for State of AP
		Mr. Devraj Ashok, Adv. for State of Karnataka
		Mr. A.K. Panda and Mr. M. Paikaray, Advs. for SPCB, Odisha
	Respondent No. 37:	**Mr. Atul Jha, Adv. For State of Chhattisgarh**
		Mr. Ranjan Mukherjee and Ms. Aprajita Mukherjee, Advs. For State of Meghalaya
		Mr. Raja Chatterjee and Mr. Chanchal Kumar Ganguly, Advs., Mr. Piyush Sachdev, Adv. for State of WB
		Mr. Aruna Mathura, Mr. Avneesh Arputham, Ms. Simran Jeet and Ms. Anuradha Arputham, Advs. For State of Sikkim
		Mr. Edward Belho, Mr. K. Luikang Michael and Mr. Hoineithiam, Advs. for State of Nagaland
		Ms. Yogmaya Agnihotra, Adv. for CECB
		Ms. Priyanka Sinha, Adv. for State of Jharkhand
		Mr. Anil Shrivastav, Mr. Rituraj Biswas and Ms. Sujaya Bardhan, Advs. for State of Arunachal Pradesh
		Mr. Tayenjam Momo Singh, Adv. for Meghalaya SPCB
		Mr. Sapam Biswajit Meitei and Mr. Naresh Kumar Gaur, Advs. for MPCB
		Mr. Gopal Singh, Mr. Rituraj Biswas, Advs. for State of Tripura
		Mr. Dhruv Pal and Mr. Himanshu Pal, Advs. for State of Gujarat & GSPCB
		Mr. Ajay Marwah, Adv. for HPSPCB
		Mr. Gautam Singh, Adv. for Mr. Shoeab Alam, Adv. for State of Bihar
		Mr. R. Rakesh Sharma, Adv. For State of Tamil Nadu & TN Pollution Control Board
		Mr. Rajul Shrivastav, Adv. for MPPCB
		Mr. V.K. Shukla, Adv. and Ms. Vijay Laxmi, Adv. for State of MP
		Mr. Amrit Agarwal and Ms. Asha N. Basu, Advs. for WBPCB

Mr. Ravin Dubey, Adv.
Mr. Utkarsh Sharma, Adv. for State of UP
Mr. Gaurav M. Liberhan, AAG, State of Punjab
Mr. Jogy Scaria, Adv., Mr. Reegan S. Bal and Ms. Beena Victor, Advs. for Kerala State Pollution Control Board
Mr. Shuvodeep Roy, Adv. and Mr. Sayooj Mohandas M., Adv. for State of Assam and ASPCB
Mr. Rajkumar, Adv. for Central Pollution Control Board
Mr. Anil Grover, AAG, Mr. Rahul Khurana, Mr. Sandeep Yadav and Mr. Mishal Vij, Advs. for HSPCB
Mr. Naginder Benipal, Adv. for PPCB
Mr. B.V. Niren, Adv. and Mr. Vinayak Gupta, Adv.

	Date and Remarks	**Orders of the Tribunal**
	Item No. 21 **August 09, 2017** **sn**	The Learned Counsel appearing for Ministry of Environment, Forest and Climate Change submits that the Ministry has already completed river basin study of 6 river basins i.e. Siang River Basin, Twang River Basin, Bichom River Basin, Subansiri River Basin, Dibang River Basin and Lohit River Basin and upon study the Ministry has recommended the minimum flow of the river to be 18% of the average of lean season flow of the river. However, in some of the cases, it has stated to be even 20%. The Tribunal in the recent Judgment pronounced on river Ganga had directed 20% minimum environment flow to be maintained from Haridwar onwards on the basis of the average lean season flow. In light of the above and the clear stand being taken by the Ministry, we direct that all the rivers in the Country shall maintain minimum 15 % to 20% of the average lean season flow of that river. However, whichever State is unable to adhere to this average percentage, in that event we grant liberty to that State Government to move the Secretary, Ministry of Environment, Forest and Climate Change who shall in

	Item No. 21 **August 09, 2017** **sn**	consultation with the Ministry of Water Resources examine such a representation and if it is desirable to fix any lower percentage than the percentage aforestated, then it will pass appropriate order. The order should be reasoned and thereafter it would be left to the discretion of the State concerned to follow the directions of the Ministry in accordance with law. We also grant liberty to the Applicant to move the Ministry of Environment, Forest and Climate Change if it has material with them in respect of any river of the country, which should have minimum environment flow in excess of 20%. If such representation is moved the same shall be disposed of by the Committee headed by Secretary in the Ministry of Environment, Forest and Climate Change in accordance with law. With the above direction, Original Application No. 498 of 2015 stands disposed of without any order as to cost. **M.A. No. 628 of 2016** This Application does not survive for consideration as the main Application itself stands disposed of. Thus, M.A. No. 628 of 2016 stands disposed of accordingly. ……………………………………,CP (Swatanter Kumar) ……………………………………,JM (Raghuvendra S. Rathore) ……………………………………,EM (Bikram Singh Sajwan)

Minutes of the 13th Meeting of the Expert Appraisal Committee for River Valley & Hydroelectric Projects held on 27.04.2018 at Narmada Meeting Hall, Ground Floor, Jal Wing, Indira Paryavaran Bhawan, Jor Bagh Road, New Delhi–3.

The 13th meeting of the re-constituted EAC for River Valley & Hydroelectric Projects was held on 27.04.2018 with the Chairmanship Dr. S.K. Jain in the Ministry of Environment, Forest & Climate Change at Narmada Meeting Hall, Ground Floor, Jal Wing, Indira Paryavaran Bhawan, Jor Bagh Road, New Delhi. The following members were present:

1.	Dr. S.K. Jain	-	Chairman
2.	Shri Sharvan Kumar	-	Representative of CEA
3.	Dr. J.A. Johnson	-	Representative of WII
4.	Shri N.N. Rai	-	Representative of CWC
5.	Dr. S.R. Yadav	-	Member
6.	Dr. D.M. More	-	Member
7.	Dr. J.P. Shukla	-	Member
8.	Dr. T.P. Singh	-	Member
9.	Dr. (Mrs.) Poonam Kumria	-	Member
10.	Dr. S. Kerketta	-	Member Secretary

Dr. A.K. Sahoo, Shri Chetan Pandit, Dr. R. Vasudeva, Dr. Vijay Kumar and Dr. Govind Chakrapani could not present due to pre-occupation. The deliberations held and the decisions taken are as under:

Item No. 13.0 Confirmation of minutes of 12th EAC meeting.

The Minutes of the 12th EAC (River Valley & Hydroelectric Projects) meeting held on 27.03.2018 were confirmed.

Item No. 13.1 CIA and CCS of Beas River Basin – reconsideration and presentation of Draft Final Report before the EAC

The Consultant, IRSET, Gurgaon has presented the draft Final report of CIA and CCS of Beas River Basin and *inter-alia* provided the following:

The CIA&CCS of Beas basin study's report was presented with special focus on the issues of post EAC's visit to the study area covering the issues raised during the visit. Site visit was conducted during April 12-14, 2018 to Parbati valley, Beas river up to Solang valley including Allain and Duhangan tributaries, Sainj valley and Tirthan valley. Detailed discussions were held during the visit based on the observations made by the Sub-committee of the EAC and following major issues were flagged:

1) Protected areas in the basin with status of declaration of ESZ along with marking on the map
2) Environment flow assessment for all the projects
3) Justification for projects recommended to be dropped

Consultant has discussed each point in detailed and have informed the Committee that they have updated the status of ESZ for all the protected areas in the Beas basin report. There are 10 Wildlife Sanctuaries and 3 National Parks in the basin. Indrakilla National Park ESZ has been declared by final notification, whereas remaining two national parks and 10 ESZ are in draft notification stage as listed below:

S. No.	Protected Areas	Area km²	Status of ESZ Notification
	Wildlife Sanctuaries		
1	Dhauladhar Wildlife Sanctuary	982.86	Draft Notification
2	Kanawar Wildlife Sanctuary	107.29	Draft Notification
3	Khokhan Wildlife Sanctuary	14.94	Draft Notification
4	Manali Wildlife Sanctuary	29.00	Draft Notification
5	Sainj Wildlife Sanctuary	90.00	Draft Notification
6	Pong Dam Lake Wildlife Sanctuary	207.59	Draft Notification
7	Tirthan Wildlife Sanctuary	61.00	Draft Notification
8	Shikari Devi Wildlife Sanctuary	29.94	Draft Notification
9	Nargu Wildlife Sanctuary	132.37	Draft Notification
10	Kais Wildlife Sanctuary	12.61	Draft Notification
	National Parks		
11	Great Himalayan National Park Conservation Area (GHNPCA)	1615.40	Draft Notification
12	Khirganga National Park	710.00	Draft Notification
13	Indrakilla National Park	104.00	Final Notification

Environmental flow assessment has been discussed in detail. Consultant informed that there are 50 hydropower projects in the Beas river basin with installed capacity of more than 5 MW, out of which 18 projects have installed capacity of 25 MW or more. These 18 projects have been assessed for modelling study. Small projects (less than 25 MW IC) could not be subjected to modelling study and recommendations for these projects are made based on standard guidelines of EAC/MoEF&CC.

Out of 18 projects subjected to environmental flow assessment by habitat simulation and hydraulic modeling, 10 are already commissioned, 3 are under construction and 5 are under different stages of survey & investigations. Area downstream of Pong dam is outside the study area and Uhl II (Basi) is tailrace development of Uhl I without any additional diversion; therefore, no environmental flow is recommended for these projects. For each of the remaining 16 projects, based on modelling exercise, environmental flows have been recommended in the range of 20-25% in lean season; 15-30% in peak season and 15-25% in other seasons. EAC deliberated on the subject in detail, especially keeping in view that many of the projects are operational for a very long time and presently they are releasing EFs as per the state government norms of 15% of lean season average. EAC decided that the matter will be discussed with the state government before making recommendations.

Major recommendations of the report were also discussed in details.

1. Following four projects falling in protected areas, were recommended for dropping by EAC:

S. No.	Name of Project	Capacity (MW)	Developer	Status	Reasons for Dropping
1	Jobrie	12	Green Infra Limited	Under S&I	Located within Inderkilla National Park
2	Manalsu	21.9		Yet to be allotted	Located within Manali Wildlife Sanctuary

3	Bujling	20	Sai Engineering Foundation	Recently Allotted	Located within Dhauladhar Wildlife Sanctuary
4	Makori	20.8	Sai Engineering Foundation	Recently Allotted	Located within Dhauladhar Wildlife Sanctuary

2. Two proposed projects, viz. Palchan Bhang and Bhang HEPs, both of installed capacity of 9 MW are allotted in the same river reach. Palchan Bhang HEP levels are 2246m to 2035m and Bhang HEP levels are 2240m to 2104m. Due to conflicts in level only one project is possible. Therefore, it is recommended that state government may take a decision on which project to proceed with and sort out the matter with private developers.

3. A yet to be allotted 7 MW project named Seri Rawala, is proposed with diversion weirs on Seri and Rawala nallas at an altitude of about 3000 m. The area is characterized by moist alpine scrub and is very rich in biodiversity. The project is recommended for dropping. EAC discussed the matter and accepted the recommendation.

4. Consultant discussed another proposed project viz. Raison HEP (18 MW) located on main Beas river, upstream of Kullu, along the National Highway between Kullu and Manali. The stretch along with tributaries has several trout fishing sites. EAC flagged the matter for discussion with State Government.

5. Consultant informed that four projects, namely, Parbati (12 MW), Sharni (9.6 MW), Sarsadi (9.6 MW) and Sarsadi-II (9 MW) with total capacity of 40.20 MW are proposed on Parbati river in cascade. Projects are allotted and are under survey and investigation stage. Total length of Parbati river from confluence of Malana Nallah to confluence with Beas river is about 15 km, out which 13 km will be affected by these four projects. These projects are not meeting the EAC/MoEF&CC norm of at least one km free flowing stretch between two projects.

   Parbati river is rich in fish fauna and trout is known to migrate upstream in Parbati river; Kasol is an important trout fishing site upstream of these projects. Fish fauna of the sub-basin is comprised of 20 species comprised mainly of *Amblyceps mangois, Sperata aor, Botia dario, Crossocheilus latius, Garra gotyla, Labeo pangusia, Puntius chola, Schizothorax richardsonii* and *Systomus sarana.* The consultant recommended that all four projects should be dropped to keep this important stretch free from development. EAC deliberated the issue in detail and discussed and flagged it for further discussion.

6. The proposed Nakthan HE project is located on the boundary of Khirganga National Park. Draft notification declaring ESZ of Great Himalayan National Park Conservation Area (Khirganga National Park is a part) was issued on 25th July 2016; the matter was discussed in Expert Committee Meeting held on 27th February 2017 where it was recommended for finalization subject to certain corrections in coordinates. The project falls within the ESZ as it is just touching the boundary of the National Park, ESZ is about 1.8 km wide on this part of the park. Entire catchment of Nakthan constitutes Khirganga National

Park and is home to important wildlife and number of RET plant species. At present the matter related to diversion of Tosh Nalla for Nakthan is sub-judice and EAC has taken a note of it during the discussion in 91st meeting held on 8-9th February 2016. EAC deferred the appraisal till the time the matter is settled in court. It is also recommended that whenever the project is considered by EAC for appraisal after court order, it will be ensured that all the project components and pondage, up to the tip of submergence should be outside the ESZ of Great Himalayan National Park Conservation Area. A wildlife management plan should be prepared and approved by Chief Wildlife Warden for the construction of the project ensuring enough safeguard to protect the wildlife in the region.

It was suggested that MoEF&CC will discuss the report with state government of Himachal Pradesh and thereafter the final report will be discussed in EAC again for final appraisal and recommendation. The EAC ***deferred the proposal*** for reconsideration in a subsequent meeting.

Table – E-flow details

Name of Project	River (Affected Stretch)	Recommended E-flow as % of average discharge in 90% DY			Recommended E-flow cumec		
		Lean Season (Dec-Mar)	Peak Season (June-Sept)	Other Months (Oct, Nov, Apr and May)	Lean Season (Dec-Mar)	Peak Season (June-Sept)	Other Months (Oct, Nov, Apr and May)
Beas Satluj Link	Beas River (25 km)	20	15	15	14.25	64.72	25.74
Parbati-III	Sainj River (13.7 km)	20	15	15	1.51	8.46	2.83
Allain Duhangan	Allain (9.2 km)	20	15	15	0.42	2.43	0.85
	Duhangan (5 km)	20	15	20	0.15	0.96	0.4
Larji	Beas River (5.65 Km)	20	15	15	11.42	64.06	21.45
Uhl-I	Uhl River (40 km)	20	15	15	0.44	2.37	1.11
Malana-II	Malana Nalla (5.2 km)	20	15	15	0.43	2.94	1.1
Sainj	Sainj River (9 km)	20	15	15	0.71	3.34	1.61
Malana-I	Malana Nalla (2.32 km)	20	15	15	0.49	3.32	1.24
Parbati-II	*Parbati River (5.28 km)*	*20*	*15*	*15*	*2.99*	*16.3*	*3.79*
	Jigrai Nalla (0.8 km)	*20*	*30*	*25*	*0.2*	*1.16*	*0.54*
	Jiva Nalla (8.2 km)	*20*	*30*	*25*	*1.19*	*6.2*	*2.53*
	Hurla Nalla (12 km)	*20*	*30*	*25*	*0.57*	*3.12*	*1.28*
Lambadug	*Lambadug (6.3 Km)*	*20*	*15*	*15*	*0.25*	*1.28*	*0.6*
*Uhl III**	*Rana Khad*	*20*	*30*	*25*			
	Neri Khad						
Nakhtan	Toss (4.4 km)	25	20	20	0.93	5.24	1.99
	Parbati (8.9 km)	25	20	20	1.42	7.84	2.94
Thana Plaun	Beas River (12.7 km)	20	15	15	5.05	46.62	11.64

Triveni Mahadev	Beas River (5.5 km)	20	15	15	5.62	54.05	14.49
	Binwa Khad (3.2 km)	20	15	15	0.93	4.6	1.5
Malana-III	Malana Nalla (3.35 km)	20	15	15	0.34	2.32	0.95
Dhaulasidh	Beas River (37 km)	20	30	25	7.11	90.79	7.87

Item No. 13.2: Lugu Pahar Pumped Storage Project (1500 MW) in Bokaro District of Jharkhand by M/s Damodar Valley Corporation - for TOR -File No. J-12011/10/2018-IA.I (R), Proposal No. IA/JH/RIV/73970/2018

The project proponent has submitted this proposal online on 04.04.2018 for grant of fresh Terms of Reference to the Project for preparation of EIA/EMP report. The project proponent made a detailed presentation of the project along with the Consultant, WAPCOS, Gurgaon and *inter-alia*, provided the following information:

The Lugu Pahar Pumped Storage Project (1500 MW) is located near Lugu village in Bokaro District of Jharkhand comprises of 2 reservoirs i.e. one at lower elevation and another one at upper elevation. The difference of water levels of the reservoirs will represent the effective head of the project. The water conductor system will connect the 2 reservoirs through an underground powerhouse. During peaking hours power will be generated by releasing the water of upper reservoir through conductor, turbines and generator installed at powerhouse to lower reservoir. The project envisages construction of 2 dams i.e. 104.5 m high rock-fill upper dam across Kairo Jhama Nallah to provide a storage of 10.8 MCM with full reservoir level at 640 m & MDDL at 630 m and 31.5 m high rock-fill lower dam across Bokaro Nallah to provide a live storage of 11.5 MCM with full reservoir level at 269 m & MDDL at 262 m.

The total land requirement is about 496 ha. Out of which, 430 ha is forest land and remaining 66 ha is government land. The total submergence is about 318 ha (upper reservoir – 202 ha + lower reservoir – 116 ha). About 24 villages are coming under submergence due to proposed scheme. Total cost of the project is Rs.4303.48crores.

The project was considered by EAC and after detailed deliberations and considering all the facts of the project as presented by the PP, the EAC recommended for grant of scoping/TOR clearance for the proposed project with the following additional conditions along with the standard ToR:

i. Three (3) season's data should be collected for the entire project.
ii. As there are two reservoirs proposed for the pumped water storage project, details of district located may be identified for conducting Public Hearing.
iii. Two dams are being constructed to divert water to store. E-flow requirement will be studied as per the existing norms i.e. Minimum environmental flow release should be 20% of average of four lean months of lean period and 20-30% of flows during non-lean and non-monsoon period corresponding to 90% dependable year. The cumulative environmental flow releases including spillage during the monsoon period should be about 30% of the cumulative inflows during the monsoon periods corresponding to 90% dependable year.
iv. Land requirement if any, for the project shall be suitably compensated in accordance with the law of the land with the prevailing guidelines. Private land shall be acquired as per provision of Right to Fair Compensation and Transparency in Land acquisition, Rehabilitation and Resettlement Act, 2013.

Minutes of the 15th Meeting of the Expert Appraisal Committee for River Valley & Hydroelectric Projects held on 28.06.2018 at Teesta Meeting Hall, 1st Floor, Vayu Wing, Indira Paryavaran Bhawan, Jor Bagh Road, New Delhi–3.

The 15th meeting of the re-constituted EAC for River Valley & Hydroelectric Projects was held on 28.06.2018 with the Chairmanship Dr. S.K. Jain in the Ministry of Environment, Forest & Climate Change at Teesta Meeting Hall, 1st Floor, Vayu Wing, Indira Paryavaran Bhawan, Jor Bagh Road, New Delhi. The following members were present:

1.	Dr. S.K. Jain	-	Chairman
2.	Shri Sharvan Kumar	-	Representative of CEA
3.	Shri N.N. Rai	-	Representative of CWC
4.	Dr. A.K. Sahoo	-	Representative of CIFRI
5.	Shri Chetan Pandit	-	Member
6.	Dr. D.M. More	-	Member
7.	Dr. T.P. Singh	-	Member
8.	Dr. S. Kerketta	-	Member Secretary

Dr. J.A. Johnson, Dr. Vijay Kumar, Prof. S.R. Yadav, Dr.(Mrs.) Poonam Kumria, Dr. J.P. Shukla, Dr. R. Vasudeva and Dr. Govind Chakrapani could not present due to pre-occupation. The deliberations held and the decisions taken are as under:

Item No. 15.0 Confirmation of minutes of 14th EAC meeting.

The Minutes of the 14th EAC (River Valley & Hydroelectric Projects) meeting held on 28.05.2018 were confirmed.

Item No. 15.1 Cumulative Impact Assessment and Carrying Capacity Study of Beas River Basin, Himachal Pradesh - Re-consideration of the Study Report before the EAC

The recommendations of the CIA & CCS report of Beas River Basin along with the site visit report of the Sub committee of EAC was deliberated in the 13th EAC meeting held on 27.04.2018, subsequent to this, Directorate of Energy, Government of Himachal Pradesh had requested to attend the EAC meeting for submissions of their comments on the recommendations of Beas River Basin Study on behalf of state of Himachal Pradesh. The Ministry agreed the request. And accordingly, two Officials of the Directorate of Energy, Govt. of H.P attended the 15th EAC meeting and *inter-alia,* made a detailed presentation on the recommendation of the study report.

EAC deliberated on all the issues. Project wise deliberation and the recommendation of the EAC is as follows:

1. **Jobire HEP (12 MW)** – The project has been recommended for dropping as some of project its components falls in Inderkilla Wildlife Sanctuary. Govt. of H.P. mentioned that some of the project's components are on the boundary of the protected area and sought some time to redefine/revisit so that no component would fall within the protected area.

   EAC deliberated on the matter and asked the H.P. Govt. representative to revise the project proposal so that it would completely fall outside the protected area and also the ESZ boundary. It was agreed that H.P. Govt. would approach MoEF&CC within 2 months with revised project details along with a certificate from Chief Wildlife Warden that all components of the revised project are located outside the protected area and ESZ.

2. **Manalsu HEP (21.9 MW) –** The project has been recommended for dropping as the project falls in Manali Wildlife Sanctuary. Govt. of H.P. agreed to it and confirmed that the project shall not be allotted.

3. **Bujling HEP (20 MW) –** The project has been recommended for dropping as some of project its components fall in Dhauladhar Wildlife Sanctuary. Govt. of H.P. mentioned that some of the project's components are on the boundary of the protected area and sought some time to redefine/revisit so that no component would fall within the protected area.

   EAC deliberated on the matter and asked the H.P. Govt. representative to revise the project proposal so that it would completely fall outside the protected area and also the ESZ boundary. It was agreed that H.P. Govt. would approach MoEF&CC within 2 months with revised project details along with a certificate from Chief Wildlife Warden that all components of the revised project are located outside the protected area and ESZ.

4. **Makori HEP (20.8 MW) -** The project has been recommended for dropping as the project falls in Dhauladhar Wildlife Sanctuary. Govt. of H.P. agreed to it and confirmed that the project shall be cancelled.

5. **Palchan Bhang HEP (9 MW) and Bhang HEP (9 MW)–** Beas basin study has recommended that Palchan Bhang HEP levels are 2,246 m to 2,035 m and Bhang HEP levels are 2,240 m to 2,104 m. Due to conflicts in level only one project was possible. Govt. of H.P clarified that these are two parallel schemes, one on Kothi Khad, a tributary of river Beas and another on Beas river and there is no level conflicts between these two schemes. EAC discussed the matter and recommended that both the schemes can be developed, as they are independent schemes. Govt. of H.P was requested to submit a location map showing the layouts of both the projects components and levels.

6. **Seri Rawela (7 MW) –** The Project has been recommended for dropping as the project is located at an elevation of 3000m in an area, which is characterized by moist alpine scrub and the area is rich in biodiversity.

Govt. of H.P submitted that the project may be allowed with stringent conditions to conserve the Biodiversity, and ensured that all the necessary measures shall be adopted in designing of the project, during construction of the project and also after commissioning. EAC deliberated the concerns in detail and concluded that as the project is in near vicinity of Rohtang tunnel portal, Small HEP be taken up, with adequate precautions to minimize adverse impacts on biodiversity.

7. **Raison HEP (18 MW) –** Beas RBS has flagged this project for detailed deliberations. The project is proposed on the Beas river, upstream of Kullu, along the Kullu – Manali National Highway. The river stretch along with tributaries has several trout fishing sites, besides there was lot of constructional activities are in progress for widening of the NH.

   Govt. of H.P. submitted that this project is proposed to be developed as a model project by using the head attained by the meandering of Beas river stretch at Raison. The technology to be adopted for the construction of this HEP with flexible weir option will have the least impacts in comparison to what has been anticipated in the report. The concept and proposal of the project have already been appreciated by the experts in the fields.

   EAC deliberated on the issue in detail and considering the new technology, recommended this project for development.

8. **Four projects on Parbati River viz. Parbati HEP (12 MW), Sharni HEP (9.6 MW), Sarasadi HEP (9.60 MW) & Sarasadi-II HEP (9 MW) –** Beas RBS has flagged these projects, proposed on Parbati river in cascade in about 15 km of river stretch without any significant inter-project free flow stretch. Further, this river stretch is rich in fish fauna and trout is known to migrate upstream in Parbati river along this stretch from Beas. Development of this stretch would hamper trout movements and also during construction phase the road to Manikaran Sahib will be severely affected. Govt. of H.P. has submitted that they will redefine the projects to ensure the minimum free flowing river stretch is maintained between projects in cascade and shall also ensure fish movement by provisions of well-designed fish ladders. Further Sharni HEP (9.6 MW) and Sarasadi HEP (9.6 MW) are proposed to be dropped. It was also submitted that project construction will be taken up in phased manner.

   EAC recommended that Govt. of H.P. may redefine these projects by ensuring minimum 1 km of free flowing river stretch between FRL and TWL of projects in cascade. E-flows have to be provided as per the norms and the impact on the river should be minimum. Revised project configurations be submitted within 2 months and the same shall be deliberated in EAC.

9. **Nakhtan HEP (460 MW) –** Beas RBS has flagged the project as the proposed project is located on the boundary of Khirganga National Park and falls within the ESZ boundary of Great Himalayan National Park Conservation Area (Khirganga National Park is a part). Further, the matter related to diversion of Tosh Nalla for Nakthan HEP is sub-judice.

Govt. of H.P., requested that the recommendations on above two aspects may be left for the stage of individual EC of this project.

EAC noted the concerns raised and concluded that it is a legal requirement to keep the project components outside the ESZ. Further, the court order with respect to diversion of Tosh Nalla will be binding on project developer. Therefore, once the matters are resolved, a fresh look will be taken at the project at that point of time.

10. **Environment Flow Release Recommendations** – With respect to environment flow release recommendations of all the projects viz., operational, under construction and proposed as made in Beas river basin study report; GoHP has submitted that project specific e-flow release with respect to 8 operational projects and 3 under construction projects should not be considered. These Hydro Electric Projects are bound by GoHP Notification dated 09.09.2005 regarding release of e-flow which states that "threshold value of not less than 15% of the minimum inflow observed in lean season to the main river water body whose water is being harnessed by the project" shall be the quantum of minimum flow of water to be released and maintained immediately down stream of the diversion structure of existing and upcoming hydel projects. The same has also been incorporated in the respective agreements executed for these HEPs and accordingly the e-flow is being maintained and monitored through Himachal Pradesh State Pollution Control Board. However, few developers like Bhakra Beas Management Board, Punjab State Power Corp. Ltd., etc. were not following the notification and have moved to the Hon'ble NGT. Now as per 9th August, 2017 orders of Hon'ble NGT, all theses HEPs have been directed to maintain e-flow @ 15-20% of the average lean seasons flow of a particular river. GoHP requested that let the e-flow release be as per NGT order rather than as per the basin study report because implementation of recommendation of basin study report on operational and under construction project would be a challenge for the state and developers can again take the legal recourse.

    EAC noted the issue and asked Govt. of H.P. to make a comparative statement within 2 months for all under construction and operational projects about the e-flow and energy generation under all the three scenarios viz. present release, release as per NGT order and release as per basin study report. The matter will be again deliberated in EAC on receipt of this information.

    E-flow release recommendation of 3 proposed projects viz. Thana Plaun (191 MW), Triveni Mahadev (96 MW) and Malana-III (30 MW) HEPs has been accepted by the state government.

    E-flow release recommendation with respect to Dhaulasidh HEP (66 MW), may require revision as the 90% dependable year as per the approved DPR and as taken in Beas river basin study appears to be different. EAC opined that the results be re-examined and submitted.

GoHP also requested that e-flow release requirement with respect to Nakhtan HEP should not be fixed at this stage because based on court order and ESZ boundary resolution, project components will undergo certain changes. Based on final project components, a fresh e-flow requirement study will be undertaken and presented along with the EIA report at the time of environment clearance. EAC agreed with the submission.

Beas RBS shall be deliberated after receiving the requisite information from Govt. of H.P. after two months.

Item No. 15.2 Head Regulator and Indo-Nepal Link Canal at village Sailanigoth, Tanakpur, district Champavat, Uttarakhand by M/s NHPC Ltd – for Scoping/TOR. (File No. J-12011/53/2018-IA.I(R) & Online No. IA/UK/RIV/75334/1993)

Project Proponent submitted online application on 08.06.2018 for amendment of Environmental Clearance for the above mentioned project and *inter alia,* presented the following information:

i. The proposed head regulator (35 m length) and Indo-Nepal link canal (1.15 km length) on the left bank of Mahakali River (Sharda river) and Tanakpur Barrage will transport the water of about 28.35 cumecs (1000 cusecs) and 8.5 cumecs (300 cusecs) during wet season and dry season, respectively to Nepal for irrigation purpose. The command area for which water is supplied is in Nepal.
ii. The water of 28.35 cumecs (wet season) and 8.5 cumecs (dry season) is to be supplied to Nepal as per the Mahakali Treaty, a bilateral agreement between Nepal and India which was entered in 1996.
iii. As a part of the Mahakali Treaty, India is obliged to supply 70 MU per annum of energy generated from Tanakpur Power Station to Nepal, to construct a head regulator near the left under sluice of the Tanakpur Barrage and to construct waterways of required capacity up to India-Nepal Border for supplying 28.35 cumecs and 8.5 cumecs of water during dry and wet seasons, respectively.
iv. The main component of the proposed project includes inlet waterway (11.25 m), approach channel (31.0 m), Head regulator (35.0 m), canal (1.15 km) and cross drainage work (23.0 m width).
v. Total land required for the proposed waterway is 38 ha (including 26 ha of stone quarry area, Reserve Forest) which is a forestland. Proposal for Forest Clearance is in progress which will be submitted to the State Forest Department.
vi. The quarry area is proposed downstream of Tanakpur Barrage for which 26 ha of Reserve Forestland is to be acquired. In case, Uttarakhand Forest Corporation gives permission to lift construction materials from the river bed, the forestland of 26 ha Reserve Forestland proposed for quarry sites may not be diverted in future.

Minutes of the 19th Meeting of the Expert Appraisal Committee for River Valley & Hydroelectric Projects held on 26.10.2018 at Teesta Meeting Hall, FirstFloor, Vayu Wing, Indira Paryavaran Bhawan, Jor Bagh Road, New Delhi–3.

The 19th meeting of the re-constituted EAC for River Valley & Hydroelectric Projects was held on 26.10.2018 with the Chairmanship Dr. S.K. Jain in the Ministry of Environment, Forest & Climate Change at Teesta Meeting Hall, FirstFloor, Vayu Wing, Indira Paryavaran Bhawan, Jor Bagh Road, New Delhi–3. The following members were present:

1.	Dr. S.K. Jain	-	Chairman
2.	Shri Sharvan Kumar	-	Representative of CEA
3.	Shri N.N. Rai	-	Representative of CWC
4.	Dr. A.K. Sahoo	-	Representative of CIFRI
5.	Dr. Vijay Kumar	-	Representative of IMD
6.	Shri T.P. Singh	-	Member
7.	Dr. D.M. More	-	Member
8.	Dr. J.P. Shukla	-	Member
9.	Prof. Govind Chakrapani	-	Member
10.	Prof. S.K. Kohli	-	Member
11.	Dr. S. Kerketta	-	Member Secretary

Shri Chetan Pandit, Prof. S.R. Yadav, Dr. J.A. Johnson and Dr. (Mrs.) Poonam Kumria could not be present due to pre-occupation.

The deliberations held and the decisions taken are as under:

Item No. 19.0 Confirmation of minutes of 18th EAC meeting.

The Minutes of the 18th EAC (River Valley & Hydroelectric Projects) meeting held on 27.09.2018 were confirmed.

Item No. 19.1 Koshi-Mechi Intrastate Link Project (Construction of Canal of 76.20 km long) on the existing barrage beyond existing Eastern Koshi Main Canal (41.30 km) for irrigation purpose under Koshi-Mechi Intrastate Link Project in the State of Bihar. Discussion on the site visit of the Sub-committee (File No.J-12011/22/2016-IA.I& Online No.IA/BR/RIV/57622/2016)

The site visit report of the Sub-committee was deliberated in detail; Chairman of the Sub-committee briefed the main observations/ recommendations to the EAC. A copy of the site visit report is annexed as **Annexure-I**. The following are the recommendations for the project:

1. There appears to be no problem from the design and construction point of view in taking up of the works of canal system in the extended portion. The activity seems to be conventional one.

command of the farmers. The area at places was seen water logged. This will take care of water requirement of perennial crops like banana, sugarcane and so on. With this background in the days to come the system could be converted to perennial one.

10. In the extended command, about 20% area has been proposed to be developed under micro irrigation system. It is basically for enhancing the productivity and quality of the agri-produce, in addition, it saves plenty of water. More and more area canbe planned to be brought under micro irrigation in the days to come and water could be saved. The water stored in the secondary storages in the command, use of groundwater and also the water saved in micro irrigation could help to transform the entire command into a perennial farming. Additional area from the Mahananda basin (left over as un-irrigated) could also be brought under irrigation with the help of the increased water availability as explained above. The land holding in this area is very small and therefore, it will be very much necessary to support farmers with irrigation facility.
11. The project involves remodeling of existing EKMC upto R.D. 41.30 km and construction of new canal upto RD 117.50 km.The discharge of canal will increase from present 425 cumecs to 573 cumecs.This will also involve remodeling of existing structure like canal siphons and head regulators of the branch canal, distributaries with cross regulators and escapes. PP (WRD, Govt. of Bihar) shall submit their programme to undertake such remodeling work.
12. The maintenance of canal needs improvement. Particular attention should immediately be given in head reaches where the canal needs proper re-sectioning as well as proper dumping of excavated silt with landscaping wherever.
13. Water quality particularly variation of water temp., DO, pH, TS and alkalinity, Phosphate, Nitrate, Silicates and Carbon (soil) at the site of joining of Kosi with Mechi (Upstream and downstream of joining point). E.coli data to be provided.
14. Fish species available upstream and downstream of joining point in Mechi river to be provided.
15. Possibility of fish pass in the Kosi canal (if possible) for efficient migration of Tor sp. to be explored.
16. Inventorization of fish species available in the Kosi canal to be revisited.

After detailed deliberations as per the presentation including the facts presented by the Sub-committee,the Committee agreed on all the suggestionsmade by the Sub-committee and opined that let the PP submitall the information as per the site visit report and then the **proposal will be again reconsidered for recommendation of grant of EC in the subsequent EAC meeting.**

Item No. 19.2 Cumulative Impact Assessment and Carrying Capacity Study of Beas River Basin, Himachal Pradesh - Re-consideration of the Study Report before the EAC

The Directorate of Energy, Government of Himachal Pradesh hadmade a presentation in the 15th EAC meeting and discussed their response to the recommendations of Beas Basin Study. EAC deliberated in detail and sought further information from Directorate of Energy to which they have responded vide their letter dated 23.10.2018 and made presentation before EAC. As per the presentation including the facts presented by the Director of Energy, **the Committee** discussed each project as given below:

1. **Jobrie HEP (12 MW)** - Beas Basin Study has recommended this project for dropping as the project falls in Inderkilla Wildlife Sanctuary. EAC has taken a note of it and accepted the recommendation of the study in its13thEAC meeting. GoHP has claimed that some of the projects components are on the boundary of the protected areaand they need some more time to ascertain that all project components should fall outside the protected area. GoHP submitted that Jobri Nalla is falling within the wildlife sanctuary and therefore they are not diverting the water of Jobri Nalla. Whereas another diversion of the project in on Allan Nalla, which is outside the protected area and therefore, they should be allowed to utilize the water of Allan Nalla for developing an HEP with reduced capacity of 6 MW. As up to 2 MW projects are permitted in the Eco-Sensitive Zone.GoHP may be allowed to develop an HEP of 2 MW IC in ESZ of Inderkilla WLS on Jobrie Nalla. **EAC accepted the GoHP request** with regard to Jobrie HEP.

2. **Manalsu HEP (21.9 MW)–**In the 13th EAC meeting held on 28.06.2018, the Consultant informed that Manalsu HEP (21.9 MW) is a newly identified and yet to be allotted project. It is a run-of-the river scheme utilizing the water of Manalsu Nallah which is a tributary of River Beas in Kullu district of Himachal Pradesh. The Project envisages a diversion weir with HFL at El 2500 m proposed to be constructed to divert water of Manalsu Nallah to a2.8 km long water conductor system to carry a design discharge of 6.2 cumecs to the power house with TWL at El 2100 m, located on left bank of stream to generate an estimated annual energy 87 Gwh utilizing a gross head of 400m. Based on the above information, the basin study report has mapped the location of proposed Manalsu HEP and found it to be falling within the Manali WLS. Accordingly, the project was recommended for dropping. This recommendation was accepted by the EAC and also by the State Government of Himachal Pradesh.

   However, the Member Secretary informed that a representation from a prospective developer has been received. The representation was discussed in the meeting and the Member Secretary informed the major project features viz., the powerhouse, forebay, penstock, switchyard and transmission lines will be located outside the sanctuary area. It involves an intake in a deep gorge and an underground tunnel of 2.5 km which will be excavated from one end that is out of the WLS boundary. No adit is proposed in between the tunneling excavation, ensuring no interference with the Sanctuary. However, the representation is silent on the locations of the dam/ barrage/diversion structure and the intake structure to HRT.EAC noted that as per the RBS report, the diversion structure, intake structure, etc.were falling within the Manali Wildlife Sanctuary. Further, it was clarified that the underground component (tunnelling, etc.) of the project is a part of forestland and Manali WLS and accordingly as per the guidelines permissions underForest (Conservation) Act, 1980 and Wildlife (Protection) Act, 1972 to be obtained.

After detailed deliberation, it has been decided that let the State Govt. shall submit the details of the locations of the project features of the Manalsu HEP *vis-a-vis* the boundary of the Manali WLS for further consideration of the EAC.

3. **Bujling HEP (20 MW) -**Beas Basin Study has recommended this project for dropping as the project falls in Dhauladhar Wildlife Sanctuary. GoHP was asked to re-plan the project to ensure that revised project should be completely outside the protected area as well as proposed eco-sensitive zone. GoHP has requested more time, as the ESZ of Dhauladhar Wildlife Sanctuary has not been finalized as yet. EAC accepted the request and observed that basin study should record that all the components of revised Bujling project should be outside the protected area as well as ESZ.

4. **Makori HEP (20.8 MW) -** Beas Basin Study has recommended this project for dropping as the project falls in Dhauladhar Wildlife Sanctuary. EAC has taken a note of it and accepted the recommendation in 13th meeting. GoHP agreed with the recommendation of the report and confirmed that the allotment of project will be cancelled.

5. **Palchan Bhang HEP (9 MW) and Bhang HEP (9 MW) -** Beas basin study has recommended that Palchan Bhang HEP is located at 2246m to2035m and Bhang HEP levels are2240m to2104m. Due to conflicts in levels, only one project is possible. However, GoHP has mentioned that these are two parallel schemes, one on Kothi Khad, a tributary of river Beas and another on Beas river and there is no level conflicts between these two schemes. Therefore, as such GoHP may be allowed to go ahead with both the schemes.EAC discussed the matter and concluded that if there is no level conflict, both the schemes can be developed, as they are independent schemes. EAC asked the GoHP to submit a clear location map showing the layouts of both the projects components and levels.GoHP presenteda map.However, it was not very clear. EAC asked the GoHP to submit a clear location map produced by a GIS showing contours in the region. This map may be included in the basin study report.

6. **Four projects on Parbati River viz.Parbati HEP (12 MW), Sharni HEP (9.6 MW), Sarsadi HEP (9.60 MW) & Sarsadi-II HEP (9 MW) –** Beas basin study has flagged these projects as these projects are proposed on Parbati river in Cascade in about 15 km of river stretch without any significant inter project free flow stretch. Further this river stretch is rich in fish fauna and trout is known to migrate upstream in Parbati riverfrom Beas along this stretch. Development of this stretch would hamper trout's movementsand also during construction phase the road to Manikaran Sahib will be severely affected. GoHP has submitted that they will redefine the projects to ensure the free flowing river stretch is maintained between projects in cascade and shall also ensure fish movement by provisions of well-designed fish passages. Further location of fish passages should be studied well to ensure proper migration of the fish species.In addition, a

member urged that the breeding grounds of trouts must be identified in the proposed river stretch and conservation of these sites should be ensured. The client also confirmed that project construction will be taken up in phased manner. EAC accepted the submission and recommended that GoHP will redefine these projects by ensuring minimum 1 km of free flowing river stretch between FRL and TWL of projects in cascade. GoHP presented that they have revised the project configurations and now only two projects are being planned on this stretch to ensure adequate free stretch between these two projects.

7. **Nakhtan HEP (460 MW) –** Beas Basin study has flagged the project on two counts viz. the proposed Nakthan HE project is located on the boundary of Khirganga National Park and falls within the proposed notification declaring ESZ of Great Himalayan National Park Conservation Area (Khirganga National Park is a part). The project falls within the proposedESZ as it is just touching the boundary of the National Park, ESZ is about 1.8 km wide on this part of the park. Second, the matter related to diversion of Tosh Nalla for Nakthan HEP is sub-judice. Therefore, report recommended that whenever the project is considered by EAC for appraisal after court order, it is to ensure that all the project components and pondage, up to the tip of submergence should be well outside the ESZ of Great Himalayan National Park Conservation Area.

   GoHP submitted that an out of court settlement is being done with the developer of Tosh project under which Nakhtan HEPs Tosh diversion will be dropped altogether. Instead, capacity of the existing projects on Tosh will be increased as follows:

   Tosh I HEP from 10 MW to 20 MW
   Tosh II HEP from 5 MW to 25 MW
   Tosh III HEP from 5 MW to 25 MW

   EAC asked the GoHP to provide the details of revised capacities of projects alongwith agreement on Tosh projects so that they can be included in the basin study report.

8. **Kanda Pattan HEP** - GoHP submitted that a new project has been conceived in Beas basin and it was earlier not covered in the study. This falls between Thana Plaun HEP and Triveni Mahadev HEP and will have an installed capacity of about 40 MW. EAC asked the GoHP to provide the details so that they can be appropriately included in the basin study report.

9. **Environment Flow Release Recommendations**

   EAC noted that regarding environment flow recommendations, GoHP was asked to submit the energy calculation and tariff loss for existing/under construction projects where environment flow has been recommended to be increased from the present releases. GoHP has submitted calculations for 4 operational projects only and remaining data is yet to be submitted. EAC noted that data submitted is not legible and incomplete and therefore asked GoHP to provide full detail as requested for all the projects which are under construction and under operation.

Recommendations of e-flows release of Dhaulasidh HEP

In earlier meeting, EAC asked consultant to review the E-flow release recommendation with respect to Dhaulasidh HEP (66 MW), because 90% dependable year as per the approved DPR and as taken in Beas basin study appears to be different. Consultant presented that the recommendation was reviewed and 90% DY is not found to be different in basin study from that of EIA study/DPR of Dhaulasidh HEP. Difference is in seasons, how they were considered in EIA study and in basin study and data was re-examined to re-represent the seasons as –

- Monsoon – June to September
- Lean Season – November to April
- Other Months – May and October

This has resulted in slight change in the recommendation and the revised e-flows recommendation for Dhaulasidh HEP are:

- Monsoon (June to September) – 30% (90.80 cumecs)
- Lean Season (November to April) – 20% (6.24 cumecs)
- Other Months (May and October) – 20% (8.30 cumecs)

Being a dam toe powerhouse based project, e-flows can be released from the turbines as long as continuity of release can be maintained. EAC accepted the revised e-flow recommendation for Dhaulasidh HEP.

Item No. 19.3 Eastern Rajasthan Canal Project (ERCP) at Sawai Madhopur, Rajasthan by M/s ACE WR Zone Jaipur, Rajasthan- reg. Fresh ToR (File No.J-12011/23/2018-IA.I(R)& online No.IA/RJ/RIV/80561/2018)

The project proponent made a detailed presentation of the project and *inter-alia* provided the following information:

The project envisages construction of 6 barrages and 1 dam, viz. Kunnu barrage on river Kunnu, Ramgarh barrage on river Kul, Mahalpur barrage on river Parbati, Navnera barrage on river Kalisindh. Mez barrage on river Mez and Dongri dam on river Banas to provide irrigation facility in 2,02,500 ha of land in Dholpur (72,500 ha) and Sawai Madhopur (1,30,000 ha) Districts of Rajasthan with an irrigation intensity of 120%. About 2.81 crores population will be provided drinking water facility. About 80,000 ha of command area in 13 districts will be stabilized. Total length of the water conductor system is about 1268 km consisting of gravity canal, pumping main and tunnels. The main canal from proposed Dongri dam in Sawai Madhopur Command area is located at a distance of 1 km from Ranthambhore Wildlife Sanctuary. Total submergence of forest area is about 9081.40 ha, out of which 3,703 ha is

Minutes of the 20th Meeting of the Expert Appraisal Committee for River Valley & Hydroelectric Projects held on 27.11.2018 at Teesta Meeting Hall, First Floor, Vayu Wing, Indira Paryavaran Bhawan, Jor Bagh Road, New Delhi–3.

The 20th meeting of the re-constituted EAC for River Valley & Hydroelectric Projects was held on 27.11.2018 with the Chairmanship (Acting) Dr. D.K. More in the Ministry of Environment, Forest & Climate Change at Teesta Meeting Hall, First Floor, Vayu Wing, Indira Paryavaran Bhawan, Jor Bagh Road, New Delhi–3. The following members were present:

1.	Dr. D.M. More	-	Chairman (Acting)
2.	Shri Sharvan Kumar	-	Representative of CEA
3.	Shri N.N. Rai	-	Representative of CWC
4.	Dr. J.A. Johnson	-	Representative of WII
5.	Shri T.P. Singh	-	Member
6.	Prof. S.R. Yadav	-	Member
7.	Dr. S. Kerketta	-	Member Secretary

Dr. S.K. Jain, Shri Chetan Pandit, Dr. A.K. Sahoo, Dr. Vijay Kumar, Prof. S.K. Kohli and Dr. (Mrs.) Poonam Kumria could not be present due to pre-occupation.

The deliberations held and the decisions taken are as under:

Item No. 20.0 Confirmation of minutes of 19th EAC meeting.

The Minutes of the 19th EAC (River Valley & Hydroelectric Projects) meeting held on 26.10.2018 were confirmed.

Item No. 20.1 Cumulative Impact Assessment and Carrying Capacity Study of Beas River Basin, Himachal Pradesh-Reconsideration of the study report before the EAC

Further to discussion on Cumulative Impact Assessment and Carrying Capacity Study of Beas River Basin, Himachal Pradesh in 19th EAC meeting, where Directorate of Energy, Government of Himachal Pradesh had made a presentation on the pending concerns of EAC. EAC deliberated in detailed and sought further information from Directorate of Energy to which they made presentation before EAC on the pending issues. As per the presentation including the facts presented by the Director of Energy, the Committee discussed the following:

Jobrie HEP (12 MW) – Govt. of Himachal Pradesh (GoHP) confirmed that as recommended by EAC, the HEPs will be developed as per the applicable norms and restrictions of project development in protected areas and Eco-sensitive Zones.

Manalsu HEP (21.9 MW) - A newly identified project falls within Manali WLS and was therefore recommended for dropping. However, on representation by the PP, EAC had asked State Govt. to submit the details of the locations of the project features of the Manalsu HEP *vis-a-vis* the boundary of the Manali WLS for further consideration of the EAC. Government of Himachal Pradesh submitted that diversion structure as well as part of tunnel falls within the Manali WLS while the rest of the components including powerhouse is outside the WLS. The project envisages a drop type trench weir structure in the protected area thus involves minimum construction in the protected area. GoHP further submitted that it will be ensured that while executing the construction of intake structure, utmost care will be exercised to avoid any infringement to wildlife, etc. under any circumstances.

The matter was discussed in detailed by the EAC. It was deliberated that generally during the basin studies, consideration of overall impact of development of HEPs in the entire basin is taken and, projects falling in protected areas are out rightly dropped and therefore, Manalsu HEP was also recommended to be dropped and was accepted by EAC & Govt. of H.P. It was further discussed that while the project is considered on the request of the state government, the project will require wildlife clearance. It has been opined that let the matter be discussed in the State Board of Wildlife whether the portion of the project coming in the WLS be permissible activities and accordingly Wildlife Clearance be obtained from the Standing Committee on National Board of Wildlife. Accordingly, it has been opined that let the project be placed before the NBWL for its viability.

Bujling HEP (20 MW) – GoHP has submitted that they have accepted the recommendation that all the components of revised Bujling project should be outside the protected area as well as ESZ and it will be finalized after the final notification of ESZ of Dhauladhar WLS is notified.

Makori HEP (20.8 MW) - GoHP agreed with the recommendation of the report and confirmed that the allotment of project will be cancelled.

Palchan Bhang HEP (9 MW) and Bhang HEP (9 MW) - EAC asked the GoHP to submit a clear location map produced by a GIS showing contours in the region. GoHP has submitted the map as required for inclusion in the basin study report.

Four projects on Parbati River viz. Parbati HEP (12 MW), Sharni HEP (9.6 MW), Sarsadi HEP (9.60 MW) and Sarsadi-II HEP (9 MW) – GoHP presented that they have revised the project configurations and now only two projects are being planned on this stretch to ensure adequate free stretch between these two projects. As per the revised schemes, HEP I is 15 MW with a trench weir across Parbati river at around 600 m downstream of confluence of Baladi Nallah with Parbati river at Elevation of 1365 m and powerhouse on right bank at elevation of 1273 m. HEP II will be 20 MW with a diversion barrage across Parbati river downstream of HPPWD RCC bridge at elevation of 1245 m where the good rock is available on right bank. Powerhouse at elevation of 1135 m on right bank opposite to the village Jachani. This arrangement will ensure a minimum of 1 km of free flowing river stretch between FRL and TWL of projects in cascade manner. Once, all the information are provided for both the projects, the e-flow, etc. will be recalculated again and included in the River Basin Study.

Nakhtan HEP (460 MW) – GoHP submitted that an out of court settlement is being worked out, under which Nakhtan will not have diversion of Tosh Nalla. Diversion of Nakthan project will be only on Parbati river where it should fall outside the boundary of Khirganga National Park as well as ESZ of Great Himalayan National Park Conservation Area (Khirganga National Park is a part). Based on the final project configuration, it will be considered by the EAC during environment clearance process.

Tosh Nalla will have independent schemes as:

Tosh I HEP (20 MW), presently 10 MW from 2280 m to 2480 m.

Tosh II HEP (25 MW), new project from 2490 m to 2690 m.

Tosh III HEP (32 MW), new project from 2700 m to 2960 m.

EAC discussed the matter and concluded that there is no objection to development of such schemes as long as at least 1 km free flow river stretch is available between FRL and TWL of projects in cascade and the projects on Tosh as well as on Parbati remain outside the ESZ of Khirganga National Park.

Kanda Pattan HEP - GoHP submitted that a new project, Kanda Patan HEP has been conceived in Beas basin which was not included in the study. The scheme will maintain the required riparian distance of about 1 to 1.5 km from TWL of upstream project and FRL of downstream project. The diversion site is proposed at around 600 m upstream of Neri bridge on Dharampur-Jogindernagar Road and powerhouse on the right bank at around 11 km downstream of the diversion site. EAC discussed the matter and concluded that the scheme can be considered in the basin study as long as the minimum of 1 km distance of free flow stretch is ensured from FRL of downstream project and TWL of upstream project.

E-Flow:

Based on the observation of EAC, GoHP has now worked out energy loss calculations due to implementation of environment flow recommendations by existing and under construction projects. GoHP has also submitted that some of the older projects do not comply even to the state government norms and are also not complying with NGT's order applicable to all rivers in the country for release of minimum environment flow by HEPs. GoHP requested EAC not to recommend environment flow as assessed in the basin study report for existing and under construction projects and they should be allowed to continue to follow the state government/NGT guidelines, which are comparable.

EAC deliberated the matter in detailed and concluded that environment flow in basin study has been worked out taking basin as a whole and irrespective of the fact whether there exists a project or a project is under construction or a project is proposed in future. It is based on scientific study and such recommendation should remain independent of the legal issues involved in implementation. Therefore, environment flow recommendation as per basin study should be applicable to all projects irrespective of their status of implementation. If GoHP finds it difficult to implement, GoHP can approach NGT or central government and deal with the matter separately.

EAC finally concluded all the discussions on Beas River Basin study and directed the Consultant to update/finalize the basin study report, keeping in view the matter discussed and recorded in various EAC meetings. The final Beas RBS report shall be placed again in the EAC meeting/s for finalization of the various recommendations therein.

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