EXECUTIVE SUMMARY

1.0 INTRODUCTION

Directorate of Energy, Government of Himachal Pradesh had undertaken the task of conducting Cumulative Environmental Impact Assessment (CEIA) Study for Chenab river basin in Himachal Pradesh with an objective to assess the cumulative impacts of hydropower development in the basin. State Government committed to conduct the study, in response to CWPIL No 24/09 (Shukla Committee Report), before the honourable High Court of Himachal Pradesh. The study is an important part of the World Bank's DPL (Development Policy Loan) to Government of Himachal Pradesh and also to meet the obligation under Ministry of Environment Forest & Climate Change's (MoEF&CC) OM No. J-11013/1/2013-IA-I dated May 28, 2013, which requires state government's to undertake carrying capacity study of river basin within their states.

Terms of Reference (TOR) for the study were prepared by Directorate of Energy, Government of Himachal Pradesh and discussed and finalized in 55th meeting of Expert Appraisal Committee (EAC) for River Valley and Hydroelectric Projects of MoEF&CC held on 10th February, 2012. RS Envirolink Technologies Pvt. Ltd. (RSET), Gurgaon was awarded the study based on techno-commercial bidding. Contract was signed during November 2012 to complete the study in 18 months; however, due to some additional scope and limited accessibility to the area, the work got delayed and final report could be completed in November 2015. In the mean time, MoEF&CC has taken over all the river basin/carrying capacity studies being conducted by Central/State agencies and therefore, final report is submitted directly to MoEF&CC.

Initially as per the scope given by Directorate of Energy, Government of Himachal Pradesh only projects with installed capacity higher than 10 MW were taken up for assessment for the study. However later the Peer Group during its meeting asked all the projects with capacity more than 1 MW also to be included in the study. Directorate of Energy, Government of Himachal Pradesh has assessed the total potential of Chenab basin as **3510.95 MW** out of which only 6.40 MW has been commissioned so far. Sixteen Hydropower projects with **2951 MW** of total installed capacity are at various stages of development. Out of 16, 3 projects are located on Chandra River, 1 on Bhaga, 6 on Chenab (Chandrabhaga) river, 2 on Miyar Nallah, a major tributary of Chenab, 3 on Saichu Nallah, another tributary of Chenab and 1 on Lujai Nala which also is a right bank tributary of Chenab river. HIMURJA, Himachal Pradesh Energy Development Agency has identified 21 Small HEPs (less than or equal to 5 MW) with total potential of **64.45 MW** on the various tributaries of the Chenab River.

Such a large-scale development expected to take place over a period of next 10-15 years calls for assessment of environmental impacts. EIA notification of September 2006, issued under Environmental Protection Act, 1986, has the provision of evaluating the impacts of individual projects of capacities 25 MW or more by (Expert Appraisal Committee) EAC/ (State Expert Appraisal Committee) SEAC before issuing environmental clearances. However, in a situation where several projects are planned in cascade utilising the same natural resource; assessment of cumulative impacts is advisable to plan development in environmental friendly manner and to mitigate and manage the impacts comprehensively. The Chenab basin study is aimed at assessing the cumulative or aggregate ecological impact of all the HEPs planned or under execution on River Chenab in HP on aquatic fauna and flora, biodiversity of the riverine ecosystem and surrounding areas and ecological integrity. The objective also includes the optimization of hydropower and interoperation issues.

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.
- Evaluation of impacts on various facets of environment due to existing and planned development.
- Determination of environmental or ecological flows to be maintained immediately below the diversion structure of each of the hydro-electric projects (HEPs) in the basin.
- Free flowing riverine distance to be maintained between two successive projects in a cascading series in the basin.
- The entire river–regime including requirement to purify itself, maintaining aquatic biodiversity, recharging ground water, supporting livelihoods and irrigation, providing recreation, maintain sediments movements and fulfilling cultural and spiritual needs of the people in vicinity of the river shall be studied for requirement of Environmental Flows.
- The study should involve assessment of stress/load due to varied activities covering, e.g. exploitation of natural resources, industrial development, population growth which lead to varying degree of impacts on various facets of environment.

The basin study should also envisage a broad framework of environmental action plan to mitigate the adverse impacts on environment, which should be 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.
- Suggestion of institutional mechanism for strategic EIA in the river basin including evaluation of alternatives.

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

1.1 Scope of Work

The scope of work has been prescribed and defined by Directorate of Energy based on suggestions on Terms of Reference provided by EAC and same has been followed for the study. The study area covered is entire Chenab Basin in Himachal Pradesh up to the Himachal Pradesh and Jammu & Kashmir border i.e. confluence of Sansari Nalla with Chenab River and is proposed to be from Dugar HEP on main Chenab river (also known as Chandrabhaga River) to Gyspa (also spelled as Jispa) on Bhaga River and Chhatru HEP on Chandra River. The boundary of the study area starts from upstream of tailrace outfall of proposed Dugar HEP on main Chandrabhaga River and up to Bara Lacha-La (on Bhaga river) and Kunzum La (on Chandra river) in the basin.

1.2 Indus Water Treaty

The Indus Water Treaty was signed in 1960 between India and Pakistan to deal with the most complete and satisfactory utilization of the waters of Indus system of rivers comprising three eastern and three westerns rivers. The term eastern rivers means The Satluj, The Beas and The Ravi taken together while the term western rivers means The Indus, The Jhelum and The Chenab taken together. The treaty envisages the sharing of waters of the rivers Ravi, Beas, Sutlej, Jhelum and Chenab which join the Indus River on its left bank (eastern side) in Pakistan. According to this treaty, all the waters of Eastern Rivers shall be available for unrestricted use of India except as otherwise expressly provided in article such as domestic use, non-consumptive use & agricultural use as specified therein. Similarly, all the waters of Western Rivers shall be available for unrestricted use of Pakistan except as otherwise expressly provided in article such as domestic use, non-consumptive use, agricultural use & generation of hydro-electric power as specified therein. The countries agree to exchange data and co-operate in matters related to the treaty. For this purpose, treaty creates the Permanent Indus Commission, with a commissioner appointed by each country.

Chenab river is a western river and is covered as part of the treaty, therefore, treaty provisions with respect to hydropower projects development on Chenab river were kept in view while making

recommendations in the present study. None of the recommendations of the Chenab basin Study are in conflict with the provisions of Indus Water Treaty.

1.3 Study of Chenab basin in J&K

The present study covers the Chenab river in Himachal Pradesh only, which is about 260 Km long up to Sansari Nalla, thereafter it enters the state of Jammu and Kashmir. Chenab flows for another 380 Km in J&K up to Akhnoor, before entering Pakistan. In the J&K stretch, there are 23 planned hydropower projects, out which 6 are operational. For continuity of the basin study, it is proposed that the scope of present Chenab basin study should be extended to cover the stretch of Chenab river in J&K. This would ensure the coverage of entire Chenab basin in India for sustainable hydropower development.

2.0 HYDRO POWER PROJECTS IN CHENAB BASIN

Directorate of Energy, Government of Himachal Pradesh has assessed the total potential of Chenab basin as **3510.95 MW** out of which only **6.40 MW** has been commissioned so far as given below in **Table 1**. Sixteen Hydropower projects with **2951 MW** of total installed capacity are at various stages of development. Out of 16, 3 projects are located on Chandra River, 1 on Bhaga, 6 on Chenab (Chandrabhaga) river, 2 on Miyar Nallah, a major tributary of Chenab, 3 on Saichu Nallah, another tributary of Chenab and 1 on Lujai Nala which also is a right bank tributary of Chenab river. These 16 projects are listed at **Table 2** along with their Scoping/environment clearance status.

HIMURJA, Himachal Pradesh Energy Development Agency has identified 21 Small HEPs (less than or equal to 5 MW) with total potential of 64.45 MW on the various tributaries of the Chenab River; these projects are listed at **Table 3**. Recently, Directorate of Energy, Government of Himachal Pradesh has invited tenders for 13 HEPs to be developed under private sector on BOOT basis with a total installed capacity of 489.10 MW. Out of these 13 HEPs, 4 HEPs are with installed capacities greater than 50 MW and 9 HEPs are with installed capacities of less than 25 MW. Two large projects are located on main Chenab river, one on Bhaga and one on Miyar Nallah, a major right bank tributary of Chenab river. 9 small HEPs are on the various tributaries of Chenab river. These projects are listed at **Table 4**. A summary of hydropower potential of Chenab basin, distributed among 56 projects, is given in **Table 5**.

Table 1: Commissioned Projects

S. No.	Name of Project	Installed Capacity (MW)	Agency	Year of Commission
1	Thirot	4.50	HPSEB	-
2	Billing	0.40	HPSEB	-
3	Shansha	0.20	HPSEB	-
4	Killar	0.30	HPSEB	1995-96
5	Sissu	0.10	HPSEB	-
6	Sach	0.90	HPSEB	1995-96
Total		**6.40**		

HPSEB: Himachal Pradesh State Electricity Board Ltd.

(Source: Directorate of Energy, Government of Himachal Pradesh)

Table 2: Projects at Various Stage of Development

S. No	Name of Project	Capacity in MW	River	Agency	Status of Environment Clearance
1	Chhatru	126	Chandra	DCM Shriram Infrastructure Ltd	EC recommended by EAC
2	Shangling	44	Chandra	Shangling Hydro Power Pvt. Ltd.	TOR accorded by SEIAA
3	Teling	94	Chandra	Teling Hydro Power Pvt. Ltd.	TOR accorded by MoEF&CC
4	Bardang	120	Chenab	ABG Energy Himachal Pradesh Ltd.	Yet to apply for Scoping/TOR
5	Seli	400	Chenab	Seli Hydro Electric Power Co. Ltd.	EC and FC accorded by MoEF&CC
6	Reoli Dugli	430	Chenab	L&T Himachal Hydropower Ltd.	TOR accorded by MoEF&CC
7	Purthi	210	Chenab	Purthi Hydro Power Pvt. Ltd.	TOR accorded by MoEF&CC
8	Sach Khas	267	Chenab	L&T Himachal Hydropower Ltd.	EC recommended by EAC
9	Dugar	449	Chenab	Tata Power Company Ltd.	TOR accorded by MoEF&CC

S. No	Name of Project	Capacity in MW	River	Agency	Status of Environment Clearance
10	Tinget	145	Miyar	AMR-MITRA JV	Yet to apply for Scoping/TOR
11	Miyar	120	Miyar	Miyar Hydro Electric Power Co Ltd.	EC and FC accorded by MoEF&CC
12	Gyspa	300	Bhaga	HPPCL	TOR accorded by MoEF&CC
13	Chiroti Saichu	26	Saichu	HPPCL	Yet to apply for Scoping/TOR
14	Saichu	58	Saichu	HPPCL	Yet to apply for Scoping/TOR
15	Saichu Sach Khas	117	Saichu	HPPCL	Yet to apply for Scoping/TOR
16	Lujai	45	Lujai	HPPCL	Yet to apply for Scoping/TOR
Total		**2951**			

HPPCL: Himachal Pradesh Power Corporation Ltd

Table 3: Small HEPs (≤ 5 MW) of HIMURJA

S. No.	Name of Project	Capacity in MW	Agency	Status
1	Sakchum	3.00	Aukta Energy Pvt. Ltd.	TEC accorded
2	Larnettar	3.00	Aukta Energy Pvt. Ltd.	TEC accorded
3	Chhatru	2.20	Cold Dessert Hydro Power Explorers	DPR with DOE for TEC
4	Khoksar	2.00	The Chandra Valley Hydro Power Projects Co-op. Society Ltd.	Clearance Stage
5	Limphu	2.75	The Chandra Valley Hydro Power Projects Co-op. Society Ltd.	S&I in progress
6	Sissu	0.80	The Chandra Valley Hydro Power Projects Co-op. Society Ltd.	S&I in progress
7	Mooling	1.00	The Lahaul Valley Hydro Power Co-op Society	S&I in progress
8	Billing I	2.00	Green Basin Hydro Power Pvt. Ltd.	TEC accorded
9	Billing II	3.50	Shansha Hydro Power Projects Co-op Society	Clearance Stage
10	Lingar	1.70	Kirting Hydro Power	DPR with DOE for TEC
11	Shansha	4.00	Shansha Hydro Power Projects Co-op Society	Clearance Stage
12	Sansa	4.50	Bhrigu Power Pvt. Ltd.	Clearance Stage
13	Jahlma	5.00	A.C. Hydro Power	S&I in progress
14	Gilding	3.50	Jai Buhari Hydro Projects	Clearance Stage
15	Kishori	3.00	Sapt Dhara Hydro Power Pvt. Ltd.	Clearance Stage
16	Kurched	3.00	Miyar Hydro Electric Company Limited	S&I in progress
17	Tindi (Tandru)	1.40	Monal Hydro Power	DPR with DOE for TEC
18	Tindi (Harsar)	5.00	L & T Power Development Ltd.	S&I in progress
19	Ajog	5.00	Sanjay Shartri & Sky Gates Real Estate Pvt. Ltd.	Clearance Stage
20	Chho	3.50	L & T Power Development Ltd.	DPR with DOE for TEC
21	Luj	4.60	Dugar Hydro Power Limited	S&I in progress
Total		**64.45**		

Table 4: Recently Advertised Projects

S. No.	Name of Project	Capacity in MW	River/Nalla	River Bed Level at Diversion Site (m)	Elevation at Power House Site (m)
1	Patam	65.00	Miyar	±3577	±3232
2	Rashil	130.00	Chenab	±2752	±2688
3	Tandi	104.00	Chenab	±2835	±2780
4	Stingiri	98.00	Bhaga	±3000	±2854
5	Jankar	24.50	Jankar	±3367.95	±3302.36
6	Me	7.50	Me	±3121	±2693
7	Kutoi	6.20	Kutoi	±3137.72	±2879.4
8	Ur-I	5.80	Ur	±2885.86	±2658.57
9	Galwat	12.80	Galwat	±2858.11	±2112.93
10	Lower Mahal	8.00	Mahal	±2560.98	±2286.59
11	Upper Mahal	9.00	Mahal	±3201.22	±2774.39
12	Dheda	8.90	Dheda	±2712	±2484
13	Dheda-I	9.40	Dheda	±2354.6	±2114.6
TOTAL		**489.10**			

Table 5: Total Hydropower Potential of Chenab Basin

S. No.	HEP Category	No. of Projects	Total Generation Capacity (MW)
1	Commissioned HEPs	6	6.40
2	Allotted HEPs (at various stages of development)	16	2951.00
3	Small HEPs identified by HIMURJA	21	64.45
4	Recently advertised HEPs	13	489.10
Total		**56**	**3510.95**

(Source: Directorate of Energy, Government of Himachal Pradesh and HIMURJA, Himachal Pradesh Energy Development Agency)

Projects locations, for all the 56 projects are shown in **Figure 1.**

Out of total 50 planned projects in Chenab basin, only 20 projects are with installed capacity of 25 MW or more i.e. projects covered under EIA Notification for environment clearance. Out of these 20 projects, 17 projects are with installed capacity of 50 MW or greater i.e. requiring environment clearance from MoEF&CC; remaining 3 will require environment clearance from the State Level Committee. A summary of EC status of hydropower projects in Chenab basin is given below:

Status	No.	Name of Projects
Projects covered under EIA notification for Environment Clearacne	20	
Yet to be allotted	4	Rashil, Tandi, Sitingiri, Patam
Yet to apply for scoping	6	Bardang, Tinget, Chiroti Saichu, Saichu, Lujai, Saichu Sach Khas
TOR accorded by SEIAA	1	Shangling
TOR accorded by MoEF&CC	5	Teling, Reoli Dugli, Purthi, Duggar and Gyspa
EC recommended by EAC	2	Chhatru, Sach Khas
Environmental and Forest clearance accorded by MoEF&CC	2	Seli, Miyar

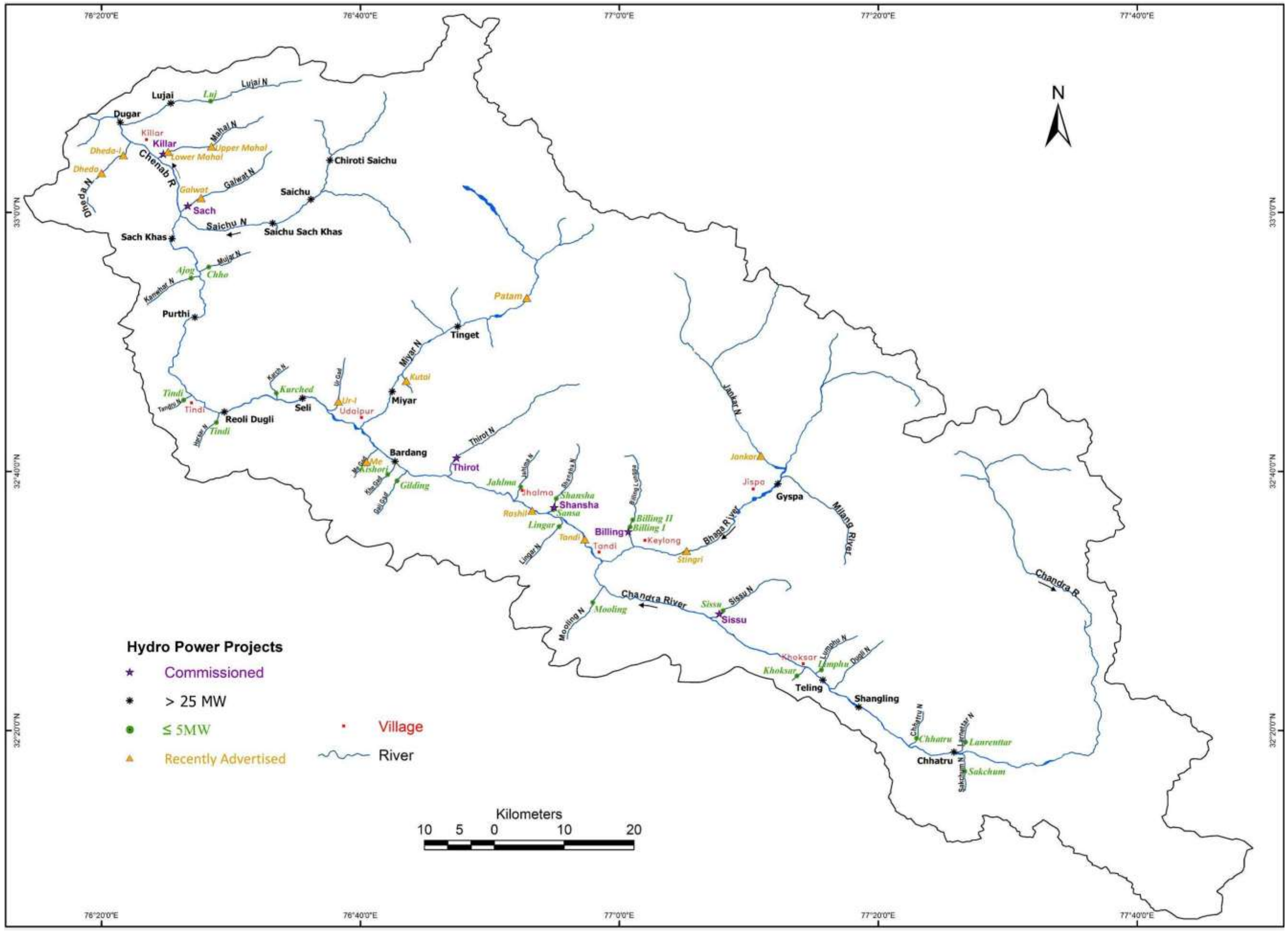

Figure 1: Planned Hydro-Development in Chenab Basin *(Source: Directorate of Energy & HIMURJA)*

3.0 BASIN CHARACTERISTICS

The Chenab river basin is part of Indus River System. The Chenab originates from ice and snow fields on the south-eastern side of the Bara-Lacha La at 6194m. The water flowing south from the pass are known as the Chandra River and those that flow north-northwest are called the Bhaga River. Chandra flows south-east to southern direction for a considerable distance and thereafter it takes western turn and flows in this direction to be joined by Bhaga River on its right bank. The Bhaga River flows around to the south joining the Chandra near village Tandi. The Chandra and Bhaga meet to form the Chenab River at Tandi. After this it is known by the name of Chandrabhaga river as well as Chenab river. However for the sake of uniformity, nomenclature of the river has been retained as Chenab river in the entire report. It leaves Himachal Pradesh near the confluence of Sansari Nala and enters Jammu & Kashmir after crossing Pangi valley.

In Jammu & Kashmir Chenab flows through Paddar area for a distance of about 56 km in Kishtwar district when it is joined by the Marua or Marusudar River on its right bank at Bhandarkot, 12 km from Kishtwar town. Further Downstream, the river flows in a southerly direction for a distance of 34 km up to Thathri and then takes a westward course. The river Chenab thereafter flows generally in a northwest direction for another 58 km till it receives a tributary Bichleri on the right bank. Afterwards, the river traverses in a westerly direction for a distance of about 50 km. In this reach a number of small streams join in, namely Chaini, Talsuen, and Ans on the right bank, Yabu Nallah, Mandial and Painthal Khad on the left bank. Downstream of Ans river confluence the river changes its direction and flows in southerly course for about 45 km up to Akhnoor where-after it enters into Sialkot district of Pakistan. It traverses a distance of 330 km up to Akhnoor where it enters Pakistan downstream of Tawi confluence. It is joined by the Jhelum River at Trimmu and then by the Ravi River at Ahmedpur Sial. It then merges with the Sutlej River near Uch Sharif, in Pakistan to form the Panjnad or the 'Five Rivers', the fifth being the Beas River which joins the Sutlej near Ferozepur in India. The Chenab then leaves India and joins Indus at Mithankot in Pakistan. The total length of the Chenab river from its origin to its confluence with India is approximately 960 km.

Total catchment area of Chenab river in Himachal Pradesh is 7878 sq km and its length in the study area is about 260 km.

4.0 BIODIVERSITY PROFILE OF CHENAB BASIN

4.1 Terrestrial Ecology

4.1.1 Forest Types and cover

Forests constitue only 1.64% of the basin and majority of the area under non-forest is comprised of barren land, snow, glaceirs and ice-fields.

The forests in the Chenab basin are under the administrative control of Lahaul and Pangi Forest Divisions of Himachal Pradesh State Forest Department with headquarter at Keylong and Killar, respectively. Lahaul Forest Division is comprised of four Forest Ranges viz. Keylong, Pattan, Udaipur and Tandi while Pangi Forest Division is comprised of KIllar, Sach and Purthi Ranges. Sach Forest Range also includes Sechu Tuan Wildlife Sanctuary.

Major forest types as per the 'A Revised Survey of The Forest Types of India' classification of Champion and Seth (1968) have been described in the following paragraphs.

GROUP	FOREST TYPE	
13	**HIMALAYAN DRY TEMPERATE FORESTS**	
	C1	Dry broadleaved and coniferous forest
	C2	Dry temperate coniferous forest
	C2a	Neoza pine forest (*Pinus gerardiana*)
	C2b	Dry deodar forest
	C2/DS1	Pohu Scrub (*Parrotiopsis jacquemontiana*)
	C3	West Himalayan dry temperate deciduous forest

	C4	West Himalayan high-level dry blue pine forest (*Pinus wallichiana*)
	C4	West Himalayan dry juniper forest
14	**SUB-ALPINE FORESTS**	
	C1a	West Himalayan sub-alpine high level fir forest
	C1b	West Himalayan birch/fir forest
15	**MOIST ALPINE SCRUB**	
	C1	Birch-Rhododendron scrub forest
	C3	Alpine pastures
16	**DRY ALPINE SCRUB**	
	C1	Dry alpine scrub

4.1.2 Floristics

In all 1418 plant species including lichens are reported from the basin. Among higher plants Angiosperms are represented by 1345 species of 471 genera belonging to 90 families, Gymnosperms by 20 species belonging to 4 families and Pteridophytes by 10 species belonging to 6 families. Bryophytes are comprised of 16 species belonging to 9 families while Lichens have 27 species belonging to 14 familes were recorded (**see Table 6**).

Table 6: Summary of number plants species documented in Chenab basin

VASCULAR PLANTS				
Group	**Angiosperms**	**Gymnosperms**	**Pteridophytes**	**Total**
Species	1345	20	10	1375
Families	90	4	6	100
LOWER PLANTS				
Group	**Bryophytes**	**Lichens**		
Species	16	27		**43**
Families	9	14		**23**

4.1.3 Dominant Plant Groups in Chenab Basin

Amongst all flowering plant families Asteraceae is the most dominant family in the basin being represented by 166 species followed by Poaceae with 153 species, Rosaceae with 86 species and Fabaceae with 60 species. The predominance of Asteraceae, Poaceae, Rosaceae and Fabaceae is indicative of presence of large areas with gentle slopes near the snow line as large percentage (about 88%) of area in the basin lies above 3800m while nearly 10% of the area lies between 2800m and 3800m where most of the alpine meadows are located. These alpine meadows and scrubs predominantly habour elements of these four families.

Threatened & Endemic Plant Species

Nayar and Sastry (1987-1990) have reported 23 species of rare and endangered plant species from Himachal Pradesh. In Chenab basin there are 13 plant species that are either 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), there are 57 species of plants in Himachal Pradesh under various threat categories. Out of these 43 species are found in Chenab basin. According to H.J. Chowdhery, 1999 45 species are different threat categories. However according to IUCN only 82 species have been assessed for their conservation status globally and most of them are listed in 'Least Concern' category and only 2 are in VU category, one in Near Threatened and 2 are listed as Data Deficient.

Endemic Plant Species

In order to understand the floristic importance of Chenab basin an exercise was undertaken to enumerate plant species which are endemic to Himalaya and occur in the basin. A list of plant species endemic to Himalaya has been presented in the report 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 reportedly found in Chenab basin. 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 (Chaoudhery, 1999) 56 species are reported from Chenab basin. Four species viz. *Crucihimalaya axillaris*, *Pseudomertensia lahulensis*, *Meconopsis bikramii* and *Ranunculus bikramii* are reported only from Lahaul & Spiti district.

Medicinal Plants

The occurrence of large number species of medicinal plants in the area indicates that its environmental conditions, particularly shady moist and forest habitats, are suitable for the growth and development of such species. The available data and information available on occurrence of medicinal plants in Pangi as well as Lahaul regions has been compiled and also listed of their usage by locals for different medicinal purposes, plant part/s being used viz. roots, rhizomes, tubers, inflorescences, fruits and seeds, etc. This has been done in view of dwindling their populations due to over-exploitation which coupled with poor regeneration may lead to their extirpation from their habitats. Total 524 species belonging to 72 families have been documented so far. Out of these 428 are herbs, 27 are trees, 66 shrubs or undershrubs and 3 climbers

4.1.4 Faunal Elements

The Chenab basin habours unique faunal diversity. Some of the prominent wild animals and birds are Ibex (*Capra ibex*), Bharal (*Pseudois nayaur*), Snow Leopard (*Panthera uncia*), Musk Deer (*Moschus chrysogaster*), Ghoral (*Nemorhaedus goral*), Himalayan Marmot (*Marmota bobak*), Wild Yak (*Bos grunniens*), Himalayan Snow Pigeon (*Columba leuconota*), Northwestern Crow (*Corvus caurinus*), Chukor (*Alectoris chukar*), Bar-headed Goose (*Anser indicus*), Snow Pigeon (*Columba leuconota*) and Himalayan Snow Cock (*Tetraogallus himalayensis*).

Mammals

In Chenab basin, according to information and data collected from different sources 32 species of mammals belonging to 13 families are found. An account of observations made during the field surveys is given in the following paragraph.

In the basin at the lower reaches like Killar village and Dugar HE project area Himalayan Shrew is common. The bat species were recorded from Pattan and Sissu areas of Chenab basin (Uttam *et al.*, 2011). Like other areas of Himalaya Rhesus Macaque is not very common in the valley. The field investigations also could not confirm its presence along the road sides and settlement areas; however, its presence in the surroundings of Dugar H.E. Project was confirmed by local people. *Canis aureus* (Jackal) and *Canis lupus* (Wolf) are common species of Chenab valley. These species are found from lower reaches up to 3000m levation. *Canis aureus* was spotted in the surroundings of Dugar and Sach Khas projects. Yellow-throated Marten and Himalayan Weasel are commonly found species in the basin. These species are found in open forested area. Yellow-throated Marten was spotted in the project area of Reoli Dugli HE project during the field investigation. Pale Weasel is restricted to upper reaches of Chenab basin. Its habitat is alpine scrubs. During the surveys Pale Weasel was sighted in the vicinity of Khoksar HE project.

Among the bear family Black Bear is also found in the basin. It is found up to 3500m and descends down to 1500 m during winters. Black Bear was spotted in the vicinity of Sach Khas HE project while a carcass of it was spotted lying along the river bank near Rashil village. Brown Bear is reportedly found above 2500 m in the basin and its habitat is dense coniferous forests in Pangi. Felidae comprises of three species namely Common leopard, Snow leopard and Lynx. Common Leopard is generally spotted at lower reaches and is reportedly found in and around Tindi while Lynx and Snow leopard are restricted to higher altitudes only in the basin.

Among the Artiodactyla, Sambar and Barking Deer are found in lower reaches of the basin. These species habitat is dense coniferous forests. The calls of Barking Deer were recorded from forest area of Lujai nallah. Musk deer is found above 3000 m in the catchment. Generally its habit is sub alpine region of the basin. In the family Bovidae Ibex, Himalayan tahr, Tibetal Gazelle, Argali and Blue Sheep are reported from Chenab basin. These species are restricted above 3000 m and roam around sub-alpine and alpine areas. Family Sciuridae is represented by Long-tailed Marmot, which confined to upper reaches (in the catchment of

Khoksar and Chhatru HE projects). In the family Muridae High Mountain Vole and Wooly Hare are found in upper reaches (common in the catchment area of Khoksar and Chhatru projects) while House Rat is very common in the basin. Family Ochotonidae is represented by two species (Ladak Pika and Royle's Pika). Both species are common and were spotted in the catchment areas of Khoksar and Chhatru HE projects.

Majority of the species (19) reportedly found in the Chenab basin are categorized under 'Least Concern' category as per IUCN Redlist. Two species i.e. *Uncia uncia* and *Moschus chrysogaster* are listed as Endangered in IUCN Redlist. Six species are under 'Near Threatened' category, while three species i.e. *Ursus thibetanus, Cervus unicolor* and *Capricornis sumatraensis* are under 'Vulnerable' category. As per Wildlife (Protection) Act, 1972, 11 species are Schedule I species while 9 are Schedule-II species. Most of the threatened and Schedule I species viz. *Ursus thibetanus*, *U. arctos*, *Uncia uncia*, *Lynx lynx*, *Moschus chrysogaster*, *Capra sibirica*, *Hemitragus jemlahicus* and *Pseudois nayaur* are distributed in upper reaches.

Avifauna

An inventory of the birds reportedly found in the Chenab basin was prepared based upon literature survey and field surveys. According to it **147 species** of birds belonging to **43 families have been recorded**. It includes all those species also which were recorded in point sampling as well as normal sighting. However during the field **surveys 61 species of birds belonging to 26 families** were recorded from the study area. Nearly 42.5% of the total bird species are widespread residents followed by sparse residents (24.5%). Only two species *Carduelis carduelis* (Gold finch) and *Luscinia pectoralis* (Himalayan rubythroat) are vagrant and irregular visitors in this basin.

Only one bird species (*Tragopan melanocephalus*) reported from the basin is listed as Vulnerable in IUCN Redlis and five species are listed as Schedule-I species viz. *Lophophorus impejanus, Tragopan melanocephalus, Tetraogallus tibetanus, Accipiter badius* and *Accipiter nisus*. Rest of all the species are 'Least Concern' category of IUCN and Scheduled IV of WPA.

Herpetofauna

The diversity of herpetofauna in Chenab basin is not vey high which may be due to comparatively drier conditions and low temperartures prevailing in majority of area. ZSI publication (Mehta, 2005) has not mentioned any herpetofaunal species from Lahaul and Spiti area. However, the lower areas of Chenab basin under Chamba district harbour few species of reptiles and amphibians. During the field surveys 3 species namely *Bufo viridis* (from Dugar village), *Agama tuberculata* (from Tindi and Sach Khas) and *Scincella himalayanum* (from Thirot) were spotted in the basin.

Butterflies

Despite harsh climatic conditions and scarciry of vegetation especially in Lahaul region contary to expectations the diversity of butterflies in Chenab basin is very good unlike low diversity of herpetofauna which again can be attributed to low temperatures. In the literature though very little information is available on occurence of the butterflies in Chenab basin, an attempt was made to document the same and according to this 47 species are reportedly found in the basin. These belong to 4 families out of which Lycaenidae and Nymphaliadae the largest families with 15 species each.

Except for one species (*Pontia daplidice moorei*) none of the species reported from the basin have not been assessed yet by IUCN Redlist criterion. In the schedule list of WPA (1972) three species *Parnassius delphius* (Banded Apollo), *Parnassius stoliczkanus* (Ladakh Banded Apollo) and *Calinaga budha* (The Freak) are kept under Schedule I. In addition 4 are Schedule II species viz. *Aporia nabellica, Baltia butleri butleri, Colias eogene* and *Parnassius charltonius.*

4.1.5 Protected Areas

There are two protected areas in Chenab basin viz. Sechu Tuan Nalla Wildlife sanctuary and Chandratal Wildlife Sanctuary. Chandratal WLS is located in the upper region of Chenab i.e. near source region of Chandra river comprised of Chandra Taal – a glacial lake with an area of about 38.56 sq km. Sechu Tuan

Nalla Wildlife Sanctuary is located in Pangi valley comrising the catchent of Sechu Tuan Nala with an area of 216.27 sq km. There is Inderkilla National Park adjacent to Chenab basin which follows the ridge dividing Chenab and Beas basins near Rohtang Pass. Upper catchment of Chenab river comprised of Bhaga sub-zone and Uadipur Sub-zone is to be included in the proposed Cold Desert Biosphere Reserve.

No project falls within 10 km radius of Chandra Taal Wildlife Sanctuary whereas 10 projects or part of their project components fall within 10 km radius of Sechu Tuan Nalla Wildlife Sanctuary. Similarly part of components of 3 projects viz. Teling, Shangling and Chhatru HEPs also fall within 10 radius of Inderkilla National Park.

4.2 Aquatic Ecology

4.2.1 Physico-Chemical Water Quality

Analysis of river water quality in Chenab basin based upon WQI is given in the following paragraphs.

In order to assess the physico-chemical water quality of Chenab river and its tributary streams WQI was calculated. WQI in general varies from 80 to 93 which indicates that water quality is Good to Excellent. At number of sampling sites WQI was more than 90 most of time indicating excellent water quality.

4.2.2 Biological Water Quality

Phytoplankton

In all total 29 species of phytoplankton were recorded from the sampling sites during different seasons from Chenab river during the entire study period. While 20 species were recorded during in pre-monsoon sampling, only 16 species were recorded during monsoon and maximum number (28) was recorded in post-monsoon season. Most common species which are found at almost all the sites are *Achnanthidium exilis, Achnanthidium affinis, Achnanthidium hauckiana, Cymbella ventricosa, Gomphonema olivaceum, Gomphonema gracile, Gomphonema parvulum* and *Reimeria sinuata* are found most of the sampling sites during the study period.

During pre-monsoon season density of phytoplankton (no. of individuals/l) ranged from 10 in (S9 – Miyar HEP and to 42 at S1 (Dugar HEP dam site). It ranged from 2 to 29 indiv/l in monsoon and from 8 to 135 indiv/l in post-monsoon.

The Shannon-Weiner Diversity index of phytoplankton species in Chenab river and its tributaries varied from 1.01 to 2.42 in pre-monsoon, 0.58 to 1.54 in monsoon and 1.64 to 2.41 in post-monsoon.

According to Evenness Index values computed during different periods at all the sampling locations in most of the phytobenthos species were more or less evenly distributed in different seasons.

Phytobenthos

In all total 46 species of phytobenthos were recorded from the study area in different seasons (Bacillariophyceae – 29 species and Fragilariophyceae – 17 species). In pre-monsoon 25 species were recorded, in monsoon 20 species and in post-monsoon period 42 species were recorded. Among phytobenthos also most common species are *Achnanthidium minutissima, Achnanthidium affinis, Cymbella ventricosa, Gomphonema olivaceum* and *Reimeria sinuata* found at most of the sampling sites in all sampling seasons season.

Phytobenthos density as expected was highest during post-monsoon as compared to the other seasons and it ranged between 23 and 584 cells/cm^2 in this period.

Zooplankton

Zooplankton in the Chenab river are represented by 14 species belonging to protozoa, rotifers and crustacean (cladoceran and copepods). Among protozoans *Arcella crenulata, Peridinium cinctum,*

Ceratium furca and *Vorticella* were observed at most of the sites. Among Crustaceans *Bosmina longirostris* and *Daphnia pulax* of order Cladoceran werefound, whereas Copepods was represented by *Cyclops glacialis* and *C. scutifer* were recorded.

The density of zooplankton was highest (no. of individuals/l) from 2 to 86 during post-monsoon season, followed by pre-monsoon 2 to 28**.** Lowest number of species were recorded during monsoon when only 9 species were recorded. The density also ranged from low of 2 to 18 no. of individuals/l and at site S17-Chhatru dam site no zooplankton were found.

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 13 species falling under 4 orders belonging to 10 families like Heptageniidae, Baetidae, Hydroptilidae, Hydropsychidae, Perlodidae, Chironomidae, Ephemerellidae, Tipulidae, Elmidae and Simuliidae. *Cinygmula* was the most abundant genus and was recorded from most of the sampling sites in all the seasons followed by *Baetis, Isoperla* and *Chironomus* recorded from Chenab river and its tributaries in different seasons. In general number of species were higher at lower altitudes and no macro-invertebrates were recorded from three sites located at high altitudes like S15 – S17 i.e. dam sites of Gondhala, Khoksar and Chhatru HEPs.

The density of macro-invertebrates varied from season to season. Macro-invertebrates' density as expected was highest during post-monsoon as compared to the other seasons and it ranged between 127 and 2584 individuals/l in this period. Density during pre-monsoon varied from 192 to 1670 individuals/m^2 and was highest at S1 and S2 – dam site of Dugar HEP and in Dheda nala near Dugar HEP site and lowest at Gyspa HEP dam site (S14). Density during monsoon months was recorded between 33 and 554 individuals/ m^2.

Water Quality Assessment

The Macro-invertebrates are one of the indicators of water quality of freshwater streams. The water quality assessment of Chenab river was assessed by calculating BMWP and ASPT values which are an indicative of river water quality.

BMWP score, calculated during pre-monsson season varied from 24 to 58, during monsoon varied from 19 to 71 and in post- monsoon varied from 24 to 51. Therefore, on an average, water quality of Chenab river is poor to moderate and some where good throughout the study area.

During pre monsoon and monsoon season macro invertebrates were not found at most of the sites when the velocity of water is high. BMWP score calculated nil at most of the sites during pre monsoon, monsoon and post monsoon season and highest 71 was recorded during monsoon sampling. However in general the average BMWP scores during monsoon were good as it ranged from 19 to 71 and pre-monsoon it ranged 24 to 58. In the Monsoon season when the velocity of water is very high BMWP score was calculated range from 19-71.

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. A higher ASPT at various locations indicate good water quality and few places it was moderate. The ASPT score varied from 5.1 to 10.2.

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. Likewise BMWP scores, a higher ASPT indicate better water quality. The ASPT score varied from 3.68 to 10.0.

The average ASPT scores during different seasons followed the pattern of BMWP scores.

4.3 Fish and Fisheries

Chenab basin is bestowed with rich water resources in the form of rivers, rivulets and lakes, but high potential of water bodies does not reflect in the ichthiyofauna. Almost negligible presence of fish can be attributed to harsh climatic conditions like extremely low temperatures. In a publication by ZSI (2010-2011) there are no records of fishes even from from Pangi valley. During the present surveys also no fish species could be recorded from any of the stretch of Chenab right from 2000 m to 3500 m elevation. The local people also confirm the absence of fish fauna from Chenab basin in Himachal Pradesh. Mehta and Uniyal (2005) mentioned only two species viz. *Diptychus maculatus* (Cyprinidae) and *Triplophysa stoliczkae* (Cobitidae) from Lahaul and Spiti district, where Chandra Bhaga and Spiti rivers are main drainages. Interviews with the local people confirmed that *Salmo trutta fario* (Brown trout) had been introduced in Sissu lake some time back, therefore occasional fries or small fishes can be seen in area around Sissu and Trilokinath and it is presumed that populations of brown trout were not maintained which has led to almost vanishing of even Brown trout from Chenab river. Only very rarely one can catch Brown trout and therefore the remains of it may still be seen sometimes in Chenab river. Other species which are anticipated to inhabit this basin in Himachal Pradesh are *Boti geto* because it inhabits the water of cold desert of Kinnaur, however even that could not be found despite extensive efforts made during surveys.

In July 2013, discussions were held with State Fisheries Department of Himachal Pradesh at Bilaspur to discuss the fish and fisheries issues/resources of Chenab basin in Himachal Pradesh. The various issues like fish composition, introduction of fish in Chenab basin, probability of the presence of fish species in the rivers of basin and secondary literature available for Chenab basin were discussed with Director& Warden, State Fisheries Department, Bilaspur. It was conveyed that the infrastructure available in Lahaul & Spit districts of Himachal Pradesh for exploration of fish and fisheries resources are negligible as compared to other districts of Himachal Pradesh, which is related to harsh climatic conditions. Also, other organizations, institutions etc except Zoological Survey of India (ZSI) are not active in their fishery research activities in this area. Thus, no comprehensive secondary data on the fish and fisheries of Chenab basin was available with state Fisheries Department and other sources. ZSI (2005) reported only two species from entire Lahaul & Spiti district but their locations were not specified. A need of a comprehensive survey on the ichthyofauna of the basin was highlighted.

4.4 Biodiversity Values in Sub-Basins

The Lahaul region has been be further sub-divided into Chandra, Bhaga and Udaipur sub-zones. Chandra and Bhaga sub-zones areas comprised of their respective catchment areas upstream of confluence of two river near Tandi and is characterized by predominantly arid climatic conditions, while Udaipur sub-zone is characterized by arid to semi-arid conditions.

Chandra sub-zone

Chandra sub-zone is home to around 597 plant species including 4 species of gymnosperms, and 2 species of pteridophytes and 11 species of bryophytes. The vast tracts of herbaceous vegetation that comes up on areas exposed by ice/snow melting are home to number of Rare, Endangered and Threatened (RET) species which are of high medicinal value and also harbours some of the grasses which are of high nutritive value. Though according to Red Data Book by BSI only 5 RET species are found in this sub-zone, however according to an assessment made by FRLHT 22 species are reported from this sub-zone which have been assessed as Threatened Medicinal Plants of Himachal Pradesh and listed as Critically Endangered (9 species), Endangered (8 species), Vulnerable (3 species) and Near Threatened. Similarly 21 species have been listed as Threatened plant species by Choudhery, 1999 (BSI Assessment). However according to IUCN Redlist of Globally threatened criteria only 32 species have been assessed so far and have been listed in 'Least Concern' category and rest of the species have yet not been assessed by IUCN Redlist criteria.

Of 182 species endemic to Himalaya 79 species are found here and out of 84 species which are endemic to Himachal Pradesh 29 are found in this sub-zone. In addition of 4 species that are endemic only to Lahaul & Spiti area i.e. *Crucihimalaya axillaris, Meconopsis bikramii* and *Ranunculus bikramii* are found in this sub-zone. Percentage of species endemic to Himalaya is nearly 13.23% of all species reported from the sub-zone.

The unique landscape of Lahaul & Spiti area harbours vast variety of plant species of high medicinal importance. Chandra sub-zone also harbours around 181 species and FRLHT has already listed 21 of them under different threatened categories. In addition 4 medicinally important species are endemic only to Himachal Pradesh viz. *Lagotis kunawurensis* (Rohtang), *Ranunculus diffuses* (Rohtang), *Tanacetum himachalensis* (Khoksar) and *Thalictrum reniforme* (Mooling).

The faunal element of this sub-zone is comprised of high altitude mammals like ibex, brown bear, tahr, blue sheep, musk deer, fox, marmot and snow leopard. The abundance of mammals in this sub-zone is less as most of the area is above tree line and vast tracts are either barren rockyland or covered with glaciers and ice fields. However the area harbours good avi-faunal diversity as nearly 51 species of birds have been reported from this sub-zone and during the field surveys also 19 species were sighted. They were predominantly sighted near brooks, Chandra Taal, and wherever the annuals come up during summer after melting of snow. Two species i.e. *Accipiter badius* and *Tetraogallus tibetanus* are Schedule-I species. However all species are listed under 'Least Concern' catergory of IUCN Redlist.

Chandra river in this sub-zone is devoid of any fish as the water temperature go below zero and is very little vegetation. Aquatic microflora and fauna is very poor in the river and during the sampling no Macro-invertebrates were found. Even populations of phyotobenthos and zooplankton also are very poor. Only in a pool in Chandra river near Sissu sometimes small fries of fish can be seen wherein Rainbow trout was introduced by Fisheries department sometimes back. Fish populations however are not able to sustain and finding fish is extremely rare in the river even in Sissu lake. This mainly is because that environmental characteristics of Chandra is not suitable for survival, growth and propagation of trouts.

Bhaga sub-zone

Bhaga sub-zone is home to around 522 plant species including 5 species of gymnosperms, and 2 species of pteridophytes and 7 species of bryophytes. There are number of Rare, Endangered and Threatened (RET) species which are of high medicinal value and grasses which are of high nutritive value. In Red Data Book by BSI, 8 RET species are reported from this sub-zone, but FRLHT has listed 17 species from this sub-zone which have been assessed as Threatened Medicinal Plants of Himachal Pradesh and listed as Critically Endangered (8 species), Endangered (5 species), Vulnerable (2 species) and Near Threatened (2 species). Similarly 24 species have been listed as Threatened plant species by Choudhery, 1999 (BSI Assessment). However, according to IUCN Redlist of Globally threatened criteria only 30 species have been assessed so far and have been listed in 'Least Concern' category and rest of the species have yet not been assessed by IUCN Redlist criteria.

Of 182 species endemic to Himalaya 81 species are found here and out of 84 species which are endemic to Himachal Pradesh 27 are found in this sub-zone. In addition of 2 species that are endemic only to Lahaul & Spiti area i.e. *Crucihimalaya axillaris* and *Ranunculus bikramii* are found in this sub-zone. Percentage of species endemic to Himalaya is nearly 16.09% of all species reported from the sub-zone.

The unique landscape of Lahaul & Spiti area harbours vast variety of plant species of high medicinal importance. Bhaga sub-zone also harbours around 198 species and FRLHT has listed 15 of them under different threat categories. In addition 6 medicinally important species are endemic only to Himachal Pradesh and W Himalaya viz. *Erophila verna* (Kenlung), *Ferula jaeschkeana* (Gemur), *Heracleum thomsonii* (Keylong), *Lagotis kunawurensis* (Stingiri), *Thalictrum reniforme* (Keylong) and *Scrophularia koelzii*.

The fauna of this sub-zone is similar to Chandra sub-zone and is comprised of high altitude mammals like ibex, brown bear, tahr, blue sheep, musk deer, fox, marmot and snow leopard. The abundance of mammals in this sub-zone is less as most of the area is above tree line and vast tracts are either barren rockyland or covered with glaciers and ice fields. From this area 33 species of birds have been reported and during the field surveys also 6 species were sighted. They were predominantly sighted near brooks, river banks, and meadows. Three species i.e. *Accipiter badius*, *Tetraogallus tibetanus* and *Tragopan melanocephalus* are Schedule-I species. However all but one species are listed under 'Least Concern' catergory of IUCN Redlist. *Tragopan melanocephalus* is under Vulnerable category of IUCN.

Similar to Chandra river Bhaga river also is devoid of any fish. Aquatic microflora and fauna is very poor in the river and during the sampling species diversity of Macro-invertebrates was quite low. Even populations of phyotobenthos and zooplankton also are very poor. Though no fish were landed during surveys however according to local inhabitants occassionally fish is seen near Gyspa as Rainbow trout was introduced by Fisheries department. Fish populations however are not able to sustain and finding fish is extremely rare. This is mainly because of the fact that environmental characteristics of Bhaga river like Chandra also is not suitable for survival, growth and propagation of trouts.

Udaipur sub-zone

In Udaipur sub-zone reportedly 573 plant species including 12 species of gymnosperms, and 11 species of pteridophytes and 19 species of bryophytes. There is much more vegetation in this sub-zone as described earlier. This sub-zone also is home to number of Rare, Endangered and Threatened (RET) species. According to Red Data Book by BSI there are 8 RET species. These is one species under Endangered category i.e. *Saussurea costus*, two species under Rare category - *Cypripedium cordigerum* and *Eremurus himalaicus* and four under Vulerable category - *Acer caesium, Aconitum ferox, Aconitum heterophyllum* and *Allium stracheyi*. However according to an assessment made by FRLHT there are 25 species which have been assessed as Threatened Medicinal Plants of Himachal Pradesh and listed as Critically Endangered (10 species), Endangered (11 species), Vulnerable (3 species) and one Near Threatened. According to Choudhery, 1999 (BSI Assessment) there are 16 species that are Threatened. However according to IUCN Redlist of Globally threatened criteria only 36 species have been assessed so far and 2 have been listed as Vulberable viz. *Cypripedium cordigerum* and *Ulmus wallichiana*, *Juglans regia* has been listed as Near Threatened while rest of the species have been listed in 'Least Concern' category.

Of 182 species endemic to Himalaya 76 species are found here and out of 84 species endemic to Himachal Pradesh and Western Himalaya 10 are found in this sub-zone. One species endemic to Himachal only i.e. *Lagotis kunawurensis* is also found in this sub-zone.

The unique landscape of Lahaul & Spiti area harbours vast variety of plant species of high medicinal importance. It harbours around 272 species and FRLHT has listed 24 of them under different threatened categories with 8 are under Critically Endangered category, 12 are in Endangered category and 3 in Vulnerable category. Five such species are endemic to Himalaya. *Allium stracheyi, Gentiana kurroo, Meconopsis aculeata, Picrorhiza kurroa* and *Dactylorhiza hatagirea* are found near Trilokinath area, *Lilium polyphyllum* in Ratoli area, *Aconitum violaceum* in Miyar valley, *Valeriana jatamansi* near Tindi area.

The faunal elements of this sub-zone is comprised of mammals like Ibex, Himalayan brown bear, Black bear, tahr, Bharal/Blue sheep, Musk deer, Goral, Fox, Marmot and Snow leopard. The area harbours good avi-faunal diversity as 80 species of birds have been reported from this sub-zone though during the field surveys only 18 species were sighted. Birds were predominantly sighted in forested areas, near villages and settlements, agricultutral fields and glaciers. *Lophophorus impejanus* is a Schedule-I species while rest of them are Schedule-IV species. White-naped Tit (*Machlolophus nuchalis*) is listed as Vulnerable species under IUCN Redlist while rest of them are under 'Least Concern' catergory. Majority of them are resident species and only a few them are summer visitors or vagrants.

Chenab river in this sub-zone also is devoid of any fish though according to locals it is found near Trilokinath area. Aquatic microflora and fauna is including phytoplankton, phytobenthos and Macro-invertebrates were better represented than Chandra and Bhaga sub-zones. The small fries of trout reportedly found by locals might have been the residual surviving population of trout which are introduced by Directorate of Fisheries in Sissu lake. Fish populations however are not able to sustain and finding fish is extremely rare in the river.

Pangi sub-zone

Pangi sub-zone is home to around 629 flowering plant species including 14 species of gymnosperms, and 10 species of pteridophytes and 16 species of bryophytes. There are number of Rare, Endangered and Threatened (RET) species which are of high medicinal value. In Red Data Book by BSI, 8 RET species are

reported from this sub-zone, but FRLHT has listed 36 species from this sub-zone which have been assessed as Threatened Medicinal Plants of Himachal Pradesh and listed as Critically Endangered (13 species), Endangered (16 species), Vulnerable (5 species) and Near Threatened (2 species). Similarly 26 species have been listed as Threatened plant species by Choudhery, 1999 (BSI Assessment). However, according to IUCN Redlist of Globally threatened criteria only 34 species have been assessed so far. Only one species i.e. *Ulmus wallichiana* is listed as Vulnerable, *Juglans regia* as Near Threatened and *Astragalus leucocephalus* and *Eclipta prostrata* as Data Deficient have been listed whereas rest of species are list in 'Least Concern' category and rest of the species have yet not been assessed by IUCN Redlist criteria.

Of 182 species endemic to Himalaya 93 species are found here and out of 84 species which are endemic to Himachal Pradesh 10 are found in this sub-zone. Percentage of species endemic to Himalaya is nearly 51% of all species reported from the sub-zone.
The landscape of Pangi area harbours vast variety of plant species of high medicinal importance. It harbours around 380 species and FRLHT has listed 36 of them under different threat categories. In addition 8 medicinally important species are endemic only to Himachal Pradesh and W. Himalaya viz. *Aconitum heterophyllum* (Hudan, Sural), *Allium stracheyi, Berberis aristata, Dactylorhiza hatagirea, Meconopsis aculeata, Picrorhiza kurroa, Rheum spiciforme* and *Selinum vaginatum.*

The fauna of this sub-zone is similar to Udaipur sub-zone and is comprised of high altitude mammals like ibex, brown bear, tahr, blue sheep, musk deer, fox, marmot and snow leopard. The abundance of mammals in this sub-zone is highest in the area and accordingly an area of 390.29 sq km has been demarcated as Sechu Tuan Nalla Wildlife sanctuary comprising the catchment of Saichu Nala. From this area 59 species of birds have been reported and during the field surveys also 26 species were sighted. They were predominantly sighted near brooks, river banks, and meadows. Only one species i.e. *Lophophorus impejanus* is a Schedule-I species. Most of the species are listed under 'Least Concern' catergory of IUCN Redlist.

Similar to other parts of Chenab river the river is devoid of any fish in this sub-zone also. It is the only stretch of Chenab river where aquatic microflora and fauna is present in moderate numbers and diversity of Macro-invertebrates also was highset among all sub-zones. In this stetch also no fish could be landed despite extensive experimental fishing done during surveys. It is reported that Rainbow trout was introduced by Fisheries department near Shaur village however fishe populations are not able to sustain grow in the area though riverine profile seems to conducive for the sustenance of trouts at least. Even Zoological Survey of India have not been able to establish the presence of fish in Pangi area.

5.0 ENVIRONMENTAL FLOWS

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.

For assessment of environmental flow focus is 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.

In this study analysis, different methodologies like hydraulic rating methodologies, habitat simulations or micro-habitat modeling methodologies along with desktop methods based on hydrological data like Environmental Management Class (EMC), etc. have been explored. The primary reason for exploring these methods is objectivity of the methodology, availability of data including surveyed river cross-sections and limited timeframe available for the study. Absence of fish in Chenab River is also a determining factor in exploring desktop methods based on hydrological data like Environmental Management Class (EMC). Main

reasons for not exploring Hydrological Index Methods is that though these provide a relatively rapid, non-resource intensive, but give low resolution estimate of environmental flows. Building Block Method (BBM) is also not being recommended 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 Chenab basin study, the major stakeholder is only riverine ecology. Hence adopting such rigorous exercise is neither needed nor practical within a limited time frame and resources.

Due to peculiarity of seasons and flow pattern in the study catchment (except Miyar catchment), Environmental flow regime has been 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 November to April.
(b) Season II: It is considered as high flow season influenced by snow-melt. It covers the months from June to September.
(c) Season III: This season is considered as intermediate flow period, covers the months of May and October.

However, for Miyar catchment, Environmental flow regime has been 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 typically covers the months from October to April.
(b) Season II: It is considered as high flow season influenced by snow-melt. It covers the months from June to August.
(c) Season III: This season is considered as intermediate flow period, covers the months of September and May.

The most critical reach for assessing release of environmental flow is immediately downstream of diversion structure till first significant tributary meets river. To assess environmental flow requirements, a flow simulation study has been carried out using one dimensional mathematical model MIKE 11 developed by Danish Hydraulic Institute of Denmark.

There are 20 major hydro projects (installed capacity $\geq$25 MW) planned in the Chenab river basin. None of the projects have started construction; many of the projects are at various stages of survey and investigation and quite a few of projects have yet to start the survey and investigation work as well; and therefore data availability of such projects is very limited. Out of these, simulation modeling has been carried out for 10 projects based on data availability and to ensure the coverage of projects on Chenab and its major tributaries.

Out of the full year flow series (90% DY), three average values have been calculated for all three seasons as explained above.

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 10 projects. Various key parameters for establishing habitat requirement have been calculated which include water depth, flow velocity and top width of waterway.

Initial few km or the length up to which first major tributary meets the river is considered critical as for the rest of the stretch tributaries will add to the environment flow released from the diversion structure. Keeping this in view, 8-10 cross sections were taken immediate downstream of the diversion structure for each project and used in the modelling exercise. These sections have been represented in MIKE 11 model set up.

5.1 Environment Flow Assessment in different seasons

Keeping in view that about 50% of pre-project depth and width should be retained in the intermediate stretch in post project scenario in different seasons/flow periods, recommendation for environment flow release for different projects is summarised below.

Project	Low Flow Period (Nov-Apr)[1]		High Flow Period (June-Sept)[2]		Intermediate (Oct and May)[3]	
	Recommended release (cumec)	% of Average Discharge of Low Flow period in 90% DY	Recommended release (cumec)	% of Average Discharge of High Flow Period in 90% DY	Recommended release (cumec)	% of Average Discharge of Intermediate Period in 90% DY
Chhatru	3.13	25	24.78	20	13.33	25
Shangling	4.06	25	22.81	15	8.08	20
Teling	3.49	20	32.73	20	8.70	20
Bardang	9.88	20	72.48	20	20.38	20
Seli	7.41	15	86.41	20	25.57	20
Reoli Dugli	15.93	25	89.36	20	33.05	25
Sach Khas	17.05	25	95.64	20	35.38	25
Dugar	20.26	25	113.57	20	42.01	25
Miyar*	0.87	15	17.52	20	7.08	15
Gyspa	1.73	30	17.82	20	3.91	25

**1,2,3: For Miyar HEP, low flow period is October to April, High Flow period is June to August and Intermediate Flow period is May and September*

For remaining 10 projects, where specific environment flow assessment study could not be carried due to data deficiency, following recommendations should be considered.

Rashil	In the absence of any specific data for Rashil HEP, environment flow assessment could not be made. It is an immediate upstream project of Bardang HEP, therefore same environment flow recommendation should be applicable to this project till such time a specific study is made as per the criteria discussed in this chapter. Environment flow release requirement for Rashil should be at least 20% of average flow of lean period (November to April), 20% of average flow of peak period (June to September) and 20% of average flow of intermediate period (October and May) to be release in corresponding period. Percentages are based on 90% dependable year discharge data approved by CWC.
Tandi	In the absence of any specific data for Tandi HEP, environment flow assessment could not be made. It is an immediate upstream project of Rashil HEP, therefore same environment flow recommendation should be applicable to this project till such time a specific study is made as per the criteria discussed in this chapter. Environment flow release requirement for Tandi HEP should be at least 20% of average flow of lean period (November to April), 20% of average flow of peak period (June to September) and 20% of average flow of intermediate period (October and May) to be release in corresponding period. Percentages are based on 90% dependable year discharge data approved by CWC.
Purthi	Purthi HEP is a tailrace development scheme linked to Reoli Dugli HEP. Tailrace discharge of Reoli Dugli HEP will be diverted to the powerhouse of Purthi HEP, however, environment flow released from Reoli Dugli HEP along with the contribution of the intermediate catchment downstream of Reoli Dugli diversion will not be diverted and shall be available for intermediate stretch of Purthi. This will be augmented by 20% untapped release from Reoli Dugli tailrace at all the time.
Tinget	In the absence of any specific data for Tinget HEP, environment flow assessment could not be made. It is an immediate upstream project of Miyar HEP, therefore same environment flow recommendation should be applicable to this project till such time a specific study is made as per the criteria discussed in this chapter. Environment flow release requirement for Tinget HEP should be at least 20% of average flow of lean period (October to April), 20% of average flow of peak period (June to August) and 20% of average flow of intermediate period (September and May) to be released in corresponding period. Percentages are based on 90% dependable year discharge data approved by CWC.

Patam	In the absence of any specific data for Patam HEP, environment flow assessment could not be made. It is an immediate upstream project of Tinget HEP, therefore same environment flow recommendation should be applicable to this project till such time a specific study is made as per the criteria discussed in this chapter. Environment flow release requirement for Patam HEP should be at least 20% of average flow of lean period (October to April), 20% of average flow of peak period (June to August) and 20% of average flow of intermediate period (September and May) to be released in corresponding period. Percentages are based on 90% dependable year discharge data approved by CWC.
Stingiri	In the absence of any specific data for Sitingiri HEP, environment flow assessment could not be made. It is an immediate Downstream project of Gyspa HEP, therefore same environment flow recommendation should be applicable to this project till such time a specific study is made as per the criteria discussed in this chapter. Environment flow release requirement for Sitingiri HEP should be at least 25% of average flow of lean period (November to April), 20% of average flow of peak period (June to September) and 25% of average flow of intermediate period (October and May) to be released in corresponding period. Percentages are based on 90% dependable year discharge data approved by CWC.
Chiroti Saichu	In the absence of any specific data for Chiroti Saichu HEP, environment flow assessment could not be made. Till such time a specific study is made as per the criteria discussed in this chapter, environment flow release requirement for Chiroti Saichu HEP should be at least 20% of average flow of lean period (November to April), 30% of average flow of peak period (June to September) and 25% of average flow of intermediate period (September and May) to be released during corresponding months. Percentages are based on 90% dependable year discharge data approved by CWC.
Saichu	In the absence of any specific data for Saichu HEP, environment flow assessment could not be made. Till such time a specific study is made as per the criteria discussed in this chapter, environment flow release requirement for Saichu HEP should be at least 20% of average flow of lean period (November to April), 30% of average flow of peak period (June to September) and 25% of average flow of intermediate period (September and May) to be released during corresponding months. Percentages are based on 90% dependable year discharge data approved by CWC.
Saichu Sach Khas	In the absence of any specific data for Saichu Sach Khas HEP, environment flow assessment could not be made. Till such time a specific study is made as per the criteria discussed in this chapter, environment flow release requirement for Saichu Sach Khas HEP should be at least 20% of average flow of lean period (November to April), 30% of average flow of peak period (June to September) and 25% of average flow of intermediate period (September and May) to be released during corresponding months. Percentages are based on 90% dependable year discharge data approved by CWC.
Lujai	In the absence of any specific data for Lujai HEP, environment flow assessment could not be made. Till such time a specific study is made as per the criteria discussed in this chapter, environment flow release requirement for Lujai HEP should be at least 20% of average flow of lean period (November to April), 30% of average flow of peak period (June to September) and 25% of average flow of intermediate period (September and May) to be released during corresponding months. Percentages are based on 90% dependable year discharge data approved by CWC.

Consolidated environment flow release recommendations for all the 20 projects in Chenab basin with installed capacity of 25 MW or higher is given at **Table 7** below in terms of percentages of average values of corresponding period based on 10 daily discharge series of 90% dependable year.

Table 7: Project-wise Recommendations for Environment Flow Release

Project	% of Average Discharge of Low Flow Period in 90% DY	% of Average Discharge of High Flow Period in 90% DY	% of Average Discharge of Intermediate Period in 90% DY
Chhatru	25	20	25
Shangling	25	15	20
Teling	20	20	20
Tandi	20	20	20
Rashil	20	20	20
Bardang	20	20	20
Seli	15	20	20
Reoli Dugli	25	20	25
Purthi	Environment flow released fro Reoli Dugli along with contribution of intermedite cathcment and 20% untapped release from Reoli Dugli tailrace at all the time.		
Sach Khas	25	20	25
Dugar	25	20	25
Miyar*	15	20	15

Project	% of Average Discharge of Low Flow Period in 90% DY	% of Average Discharge of High Flow Period in 90% DY	% of Average Discharge of Intermediate Period in 90% DY
Tinget	20	20	20
Patam	20	20	20
Gyspa	30	20	25
Stingiri	25	20	25
Chiroti Saichu	20	30	25
Saichu	20	30	25
Saichu Sach Khas	20	30	25
Lujai	20	30	25

6.0 STAKEHOLDERS PUBLIC CONSULTATIONS MEETINGS

In order to have complete transparency in the process of Cumulative Environment Impact Assessment Study, the Directorate of Energy (DoE) organized the Stakeholders public consultation meetings to apprise various stakeholders about the purpose of on-going Cumulative Environment Impact Assessment (CEIA) study of entire Chenab basin within Himachal Pradesh, progress made till date and to gather the inputs of stakeholders for basin level hydropower planning and management.

Three such public consultation meetings were conducted on 28th, 29th and 31st October 2014 at Keylong, Udaipur and Killar (Pangi) respectively with a view to cover all the areas with concentration of planned hydropower projects. Target audience included general public, public representatives, hydropower developers of the basin and government officers of various departments. The members of Peer Group formed by State Government to monitor and steer CEIA study and officers of various concerned departments also participated in these meetings.

The status of the report was presented and the purpose and importance of this study was explained along with various aspects of hydro power development in the basin. The officers of Department of Energy also discussed the Hydro Power Policy of the State. Except for the stakeholders meetings of Keylong, the rest of meeting were held in peaceful and supportive manner. In Keylong, "Jispa Bandh Jankalyan Sangharsh Samiti" have strongly opposed the development of Gyspa HEP and boycotted the meeting.

6.1 Stakeholders Inputs Received During The Meetings

Inputs received during the stakeholders public consultations meetings have been summarised below.

6.1.1 Inputs from Keylong Meeting

- Secretary of the Janjatiya Kalyan Samiti, Lahaul-Spiti and Jispa Bandh Jankalyan Sangharsh Samiti strongly opposed the development of hydro power projects especially Gyspa HEP and asserted to keep the valley free from potential destruction as caused by power projects in Kinnaur.
- All the stakeholders were against Gyspa HEP as it involves submergence of villages. They showed/expressed their support to small hydro-electric projects instead.
- Public demanded for declaration of area above 7000 ft as Eco Sensitive Zones and to be recommended as no project zone.
- No storage dams to be constructed as per Indus Water Treaty. Large dams also result in creation of large submergence, loss of flora, change in micro climate, emission of carbon di oxide/greenhouse gases etc.
- No HEPs should come up near sliding zone, sensitive zone, and glacier or avalanche prone zones.
- People were apprehensive and expressed insecurity due to large number of migration of labours and other staff especially during construction phases of the projects.
- It was pointed out that all HEPs in Lahaul & Spiti district should have clearance or NOC from MoD, Ministry of External Affairs, Ministry of Home Affairs, Ministry of Scheduled Tribes etc.
- It was emphasized that impacts of dam construction should be clearly spelt out in individual EIAs.
- It was pointed out by locals that impacts of HEPs on agricultural land and cash crops should be clearly spelt out in the EIA study.

- It was highlighted by people that an RTI application has revealed that due to HEPs in Kinnaur valley there has been reduction in water availability by 60 to 70%. This issue may be explored in the study.
- There was a demand by locals that TBM should be used instead of blasting.
- Mini or Micro HEPs, Solar power should be given priority and large projects should be dealt with extra caution.

6.1.2 Inputs from Udaipur Meeting

- People highlighted that there will be loss of forest land as well as agricultural land due to project related activities. There is a provision in law to adequately compensate for loss of forests as well as agriculture land but problem occurs when there are squatters or encroachers. A mechanism for such landless inhabitants needs to be spelt out.
- There was a concern among locals that due to submergence, chances of landslides will increase, therefore, proper treatment measures should be taken up prior to filling of reservoirs.
- Several speakers stressed about the presence of fishes around Udaipur area especially below Triloknath.
- People opposed the submergence of Mini Manali area and loss of large number of trees which have been estimated by them around 60000 and loss of around 10000 trees near Jhalma. According to them the FRLs of projects causing these losses should be decreased to save this pristine area.
- It was pointed out by locals that there could be a change in climatic conditions due to freezing during winter months especially for upstream projects (Chhatru, Shangling, Teling etc). This impact needs to be studied and addressed.
- It was demanded that cascade development of hydro projects on the river should be critically examined and some area/stretches should be declared as no project zone.
- All glaciers and glacier lakes are required to be studied as these glaciers especially on adjacent hill slopes might break down due to blasting and may move downwards.
- Almost all the nallas in the basin are avalanche or glacier prone and during season the water levels in all the nallas increase and many a times avalanches/glaciers slide down and reach river. Once the projects are constructed and reservoirs are filled up, there could be a movement of avalanches along nallas directly draining into the reservoir, which may cause high waves in the reservoir and also possibly damage head works thus creating a disaster like situation. Such impacts need to be studied and adequate management plan needs to be formulated to avoid such disaster like situation.
- R&R policy of HPPCL related to compensation to people left with less than 2 biswa of land after land acquisition to be studied and may be proposed/adopted in all projects.
- While according NOCs for stone crushers, quarry sites etc, gram panchayats should also be involved and NOCs must be signed for stone crushers, quarry sites etc by Gram panchayats also to avoid any possibility of fraudulent practices. MoU with gram panchayat should also be signed.
- There was a concern that blasting during project construction activities may damage house/property of local inhabitants. Hence videography of houses prior to construction should be taken up so that if there is such damage/claim, exact estimation of such losses can be estimated and proper compensation can be worked out.
- Scheme for employment and their documentation of HPPCL to be studied for institutional mechanism.
- It was demanded by locals that scheme for works less than worth 5 lakhs should be awarded to local contractor.
- Scheme of HPPCL for work experience to youth should be studied and should be included/adopted in all projects.

6.1.3 Inputs from Killar Meeting

- It was demanded by local inhabitants that a comprehensive study on folds and faults should be undertaken at the time of preparation of project reports and impact on them due to construction activities or reservoir filling needs to be evaluated and addressed.
- A detailed study of RET, medicinal, flora and fauna prevalent in the study area needs to be carried out so that it can serve as a baseline and reference for any impact assessment due to project related activities.

Inputs received from stakeholders meetings have been reviewed and relevant issues considered while making the final recommendations.

7.0 CUMULATIVE IMPACT ASSESSMENT

The objective of cumulative environment impact assessment is to assess stress/ load due to hydropower development in the basin and envisage a broad framework of environmental action plan to mitigate the adverse impacts.

7.1 Impacts on Terrestrial Ecology

Cumulative impacts on terrestrial ecology have been discussed under the following heads:

- Impacts due to reservoir formation
- Impact due to changed flow consitions
- Landsceape fragmentation
- Direct forest cover loss
- Forest cover loss due to nibbling effect
- Impact of Spatial and Temporal crowding
- Impact on Ecological Values
- Impacts on Wildlife
- Impact on RET & Endemic Species
- Loss of Riparian Habitats

7.2 Impacts on Aquatic Ecology

The impacts on aquatic ecology can happen in following ways:

- Reduced flows in downstream stretches
- Altered flow regime in different flow periods viz. high flow, low flow and intermediate periods
- Discontinuity of river flow i.e. conversion of free flowing river into alternating small stretches of free flowing lotic ecosystem to lentic ecosystems of reservoirs and deprived stretches of river (run-of-the-river with long head race tunnels).
- Submergence
    - Alteration of river system from lotic to lentic environment
    - Loss of forest land
    - Alteration of landscape/aesthetics of area
- Alteration of river flow pattern downstream resulting due to variation in energy generation requirements in different periods.
    - Alteration of local ecosystem/ increased moisture conditions
    - Health risks/Increased incidence/ proneness to unknown diseases
    - Downstream flooding due to sudden peaking

As discussed above, planned 11 projects on main Chenab river will affect **117.76** km of the river length; **41.04 km** will be converted to reservoirs and **76.72 km** will be travelling through tunnels leading to significant alteration of free flowing riverine ecosystem of Chenab river.

Projects proposed on Chandra/Chenab are affecting more than 49m river length per MW. Shangling and Teling HEPs in the upper stretch of Chandra will affect 116m and 132m of river length per MW. Along Bhaga 120m of river stretch per MW is being affected by Stingiri HEP. Patam HEP on Miyar Nala will affect 134m of river stretch per MW. More than 246m and 106m of Saichu Nala, an imporatant tributary of Chenab in lower stretches, are being affected by Chiroti and Saichu Sach Khas HEPs.

Cumulative impacts on aquatic ecology have been discussed under the following heads:

- Impacts of damning of river
- Imapct of cascade of projects
    - Dissruption of river continuum
    - Importance of free flowing river/loss of free flowing river stretches

- Impact of projects on river continuum
- Impact on fisheries
- Impact on tributaries/alteration of free flow of river & lateral habitat connectivity

8.0 CONCLUSIONS AND RECOMMENDATIONS

Recommendations are made, keeping in view the outcome of the study as per scope of work, and are discussed in the ensuing text.

8.1 Recommendations for projects requiring prior EC

There are twenty projects with proposed installed capacity of 25 MW or more. These are spread in all the fur sub-zones for which a brief description is given in ensuing text.

Every sub zone is unique and has its own valued ecosystem components. For impact ranking of proposed HEPs in Chenab basin, ecosystem components viz. Forest cover, Floristic Diversity, Faunal diversity, biodiversity richness and aquatic ecology have been used. Ranking values have given on a scale of 10, where the sub zone with the highest value gets a value of 10 and others sub-zones have been given proportionate value calculated mathematically. Only exception is aquatic ecology, where absent gets zero, low gets 5 and moderate 7.5. VEC Values (sub zone wise) are taken for the project in that sub zone and are given 50% weightage. Remaining 50% is given to project specifc impacts.

Projects impacts have been valued based on following components:

1. Located within the protected area or in vicinity of protected areas
2. Located in pristine or undisturbed area
3. River length affected by project per MW of installed capacity
4. Forest area affected by project per MW of installed capacity
5. Social un-acceptance of project based on local inputs gathered during stakeholder consultation

Projects located within protected area are given a value of 10; projects within eco-sensitive zone but outside the boundary of protected area are given a value of 5 and for projects outside the eco-sensitive zone a value of zero is given. One exception was made for, Saichu Sach Khas, which is just outside the protected area therefore a value of 8 is given. For pristine or undisturbed area assessment, projects within the protected areas or otherwise completely undisturbed areas get a value of 10 and other projects get proportionately lower value; based on the inputs from the project area information derived from field surveys to these project locations. River length affected by project per MW of installed capacity has been calculated for each project and the highest value gets a value of 10 and remaining projects have been given proportionate value calculated mathematically. Land requirement for each project is available for only 11 projects out of 20. Further, project wise forestland requirement is not available for all the projects. Therefore, this criterion could not be used in the impact ranking. Social un-acceptance rankig is based on stakeholders consultation where Gyspa was strongly opposed by the locals and therefore a value of 10 is given to Gyspa. Stingiri HEP was not in the list at the time of stakeholders meeting, however, the same value is given to Stingiri as all the reasons on which Gyspa is being opposed are applicable to Stingiri HEP as well. Only other project, which was opposed by locals is Seli HEP, where they have not demanded the scrapping of the project but lowering of FRL to avoid submergence of Mini Manali, a local tourist spot. Therefore, Seli has been given 5 and all other projects have been given zero.

Based on the project ranking and detailed impact assessment, the following recommedations are made.

Project recommended for Perclusion

6 proposed HEPs totalling 509 MW are recommended to be precluded. Out of these 6 projects, two HEPs viz. Patam and Stingiri are yet to be allotted. Three HEPs viz. Chiroti Saichu, Saichu and Saichu Sach Khas are with HPPCL, however, no work has started till to date; not even scoping clearance is applied. One (Tinget HEP) is with a private developer, M/s AMR Mitra JV, however, no work started not even scoping clearance is applied in this case as well.

Following is the list of 6 projects recommended for preclusion:

S. No.	Project	Remarks
1	Chiroti Saichu (26 MW)	Falls within Sechu Tuan Nalla Wildlife Sanctuary
2	Saichu (58 MW)	Falls within Sechu Tuan Nalla Wildlife Sanctuary
3	Saichu Sach Khas (117 MW)	Falls just outside Sechu Tuan Nalla Wildlife Sanctuary Sechu Tuan Nalla Wildlife Sanctuary, is spread along the entire upper catchment of Saichu Nala. It has dense to very dense forest cover, which harbours rich diversity of flora, mammalian species and avifauna. Further, Saichu Nala confluences with Chenab between Dugar and Sach Khas HEPs, where 10 Km of Chenab river (between FRL of Dugar and TWL of Sach Khas HEPs) is flowing free. From the proposed Tandi HEP to Sach Khas, about 90 Km of Chenab river will either flow through tunnels or become reservoir except for 1-2 Km of the free flowing river stretch between projects in cascade. This 10 Km stretch between Sach Khas and Dugar is the longest free flowing river stretch in this section. Saichu Nala flowing from the protected area, meeting Chenab river in this free stretch provides excellent lateral connectivity ensuring habitat continuity. This lateral connectivity will ensure that tributary stream funnel important materials like detritus and nutrients into mainstem habitats captured from the surrounding landscape and carry them by gravity downstream providing additional resources for invertebrates in the main stem, which is important even if the fish is absent at present. Keeping this in view, it is recommended to keep Sechu Nala free from development and therefore all three proposed projects on Saichu Nala viz. Saichu Sach Khas, Saichu and Chiroti Saichu are recommended to be precluded.
4	Tinget (145 MW)	Miyar catchment in the upstream reaches, where Tinget HEP is planned, harbours rich biodiversity, is pristine area, with no habitation. Therefore, to preserve the natural ecosystem it is recommended to drop Tinget HEP.
5	Stingiri (98 MW)	Stingiri HEP is recommended for preclusion from development; with a view to make about 12 Km of affected Bhaga stretch free. Further, it is expected that local will have similar concerns about Stingiri HEP as it would also affect agriculture fields in the region. The project was not part of the report at the time of stakeholder's consultation held during October 2014 and has been included at a later date.
6	Patam (65 MW)	Miyar catchment in the upstream reaches, where Patam HEP is planned, harbours rich biodiversity, is pristine area, with no habitation. Therefore, to preserve the natural ecosystem it is recommended to drop Tinget HEP.

Project specific recommendation for sustainable development of hydropower potential of Chenab basin:

Chhatru, Shangling and Teling HEPs:

- The proposed HRT of Chhatru HEP is 10.48 Km long; Shangling HEP is 2.63 Km long and that of Teling HEP is 11.09 Km long. Blasting for long tunnelling activities in geologically fragile terrain will lead to serious impacts. Further, the area especially the higher slopes in the project area constitute the habitat of Snow leopard, Ibex and Blue sheep; which will get impacted due to blasting activities. These 3 projects are located in geologically fragile and ecologically sensitive terrain; conventional blasting can lead to serious impacts in such terrains and therefore it is recommended that 3 projects viz. Chhatru, Teling and Shangling HEPs should carry out a detailed feasibility and viability study on use of TBM/mechanized drilling for various tunneling works required during project construction and identify the most viable option. Such study should be vetted by Central Electricity Authority/Central Water Commission/GSI. Objective of such study should be to have minimum disturbance/impact to the surrounding areas.

- Labour colonies during construction period of Chhatru, Shangling and Teling HEPs need to be planned and managed in a manner to completely avoid cutting of local shrubs for fuel wood and space heating. Developer needs to take extra care by ensuring supply of adequate quantity of fuel to avoid disturbance to delicately balanced cold desert ecosystem.

Gyspa HEP

- HPPCL, Developer for Gyspa HEP and the state government has to make proactive efforts to open up the dialogue with locals and map all their concerns, at an early stage. It is important to amicably settle the local concerns with adequate compensation, wherever needed or project modification as the case may be, to start working on this storage scheme. Due to local resistance the project has not made any significant progress in last 4 years and same status may linger on for years to come.

Tandi, Rashil and Bardang HEPs:

- While finalizing the schemes, free flow river stretch should be planned in a manner that for Tandi and Rashil as independent schemes (Alternative 2) of present configuration – 1.82 Km of free flow stretch should be maintained between TWL of Tandi and FRL of Rashil HEP. Similarly for Rashil and Bardang, a free flow river stretch of 2.5 Km should be maintained between TWL of Rashil and FRL of Bardang and another 2.5 Km of free flow river between TWL of Bardang and FRL of Seli HEP. If Tandi and Rashil HEPs, are to be combined as a single scheme or two schemes in tandem, free flow stretch downstream of combined scheme i.e. from TWL of combined scheme to FRL of Bardang HEP should be at least 3 Km.

Miyar HEP

- Miyar HE project has been accorded Environmental Clearance by MoEF&CC vide its letter dated July 30, 2012. Project has also been accorded Stage I forest clearance. Project can be developed in the present form without any modification/change of parameters. Developer should expedite completion of pre-construction activities and start of construction work.

Seli HEP:

- Environment and forest clearance has already been recommended for Seli HEP. Locals have raised the issue of submergence of Mini Manali area and felling of large number of trees in this area during stakeholder consultation meetings. The matter was reviewed in detail and it was found that while issuing "in principle" approval for diversion of 276.1875 ha of forest land for Seli HEP vide letter dated July 01, 2013, MoEF&CC's has imposed that trees available between FRL -4m shall not be felled. Further, DFO report also mentions that 11516 trees will remain standing being in a strip of 4m between EL 2606m (FRL) and EL 2602m (FRL-4m). Our team has walked through the entire Mini Manali area from river bed to road level with GPS and Camera and have observed that tree concertation and large girth size trees are mainly on the higher elevation towards the road. Marking of the levels can also be observed on the ground. Trees will not be felled in Mini Manli area above 2602 m elevation. Therefore, locals claim that large number of trees will be felled in Mini Manali area is not found to be correct. However, since the area is coming under submergence local picnic spot may not survive. Therefore, we recommend that instead of dropping the FRL, developer should settle the issue of Mini Manali submergence amicable with affected local population. Developer can consider protecting the area with tetrapods, concrete blocks/retaining wall, etc.

Reoli Dugli, Sach Khas and Dugar HEPs

- These projects are located in well forested area of otherwise scanty forested landscape of Chenab basin and are rich in biological wealth with large sized trees. Projects can be developed in the present form without any modification/change of parameters. Specific issues should be addressed in the EIA report with mitigation and management plan.

Purthi HEP:

- Purthi HEP has been recently considered for scoping clearance based on the revised scheme, where concerns about long river stretch getting affected due to it being a tailrace development scheme have been addressed. Untapped 20% release of Reoli Dugli tailrace release at all times and 1 Km free flow stretch that of Sach Khas will mitigate the impacts to a certain extent. At present the project is planned on left bank, which is inaccessible and harbours undisturbed continuous belt of forest area.

The project proponent should explore during the survey and investigation the possibility of shifting the project to right bank to avoid fragmentation of undisturbed forest area on the left bank.

Lujai HEP:

- Lujai HEP's powerhouse is planned at 2044.5 m (C/L of the units), whereas Dugar HEP, which is a downstream project on Chenab is planned with FRL at 2114 m. Submergence of Dugar will extend along Lujai Nala and the present planned powerhouse will fall in submergence area. Therefore, HPPCL, the developer for Lujai HEP, need to revise the levels of Lujai HEP in order to ensure one kilometer of free flowing river stretch of the Lujai Nala from FRL of Dugar HEP.

Environment Flow Release Recommendations:

Environment flow release requirement worked out based on modelling studies for 10 projects with installed capacity of > 25 MW where data was available and recommendation as per the table below are made for implementation.

Project	Low Flow Period (Nov-Apr)[1]		High Flow Period (June-Sept)[2]		Intermediate (Oct and May)[3]	
	Recommended release (cumec)	% of Average Discharge of Low Flow period in 90% DY	Recommended release (cumec)	% of Average Discharge of High Flow Period in 90% DY	Recommended release (cumec)	% of Average Discharge of Intermediate Period in 90% DY
Chhatru	3.13	25	24.78	20	13.33	25
Shangling	4.06	25	22.81	15	8.08	20
Teling	3.49	20	32.73	20	8.70	20
Bardang	9.88	20	72.48	20	20.38	20
Seli	7.41	15	86.41	20	25.57	20
Reoli Dugli	15.93	25	89.36	20	33.05	25
Sach Khas	17.05	25	95.64	20	35.38	25
Dugar	20.26	25	113.57	20	42.01	25
Miyar	0.87	15	17.52	20	7.08	20
Gyspa	1.73	30	17.82	20	3.91	25

**1,2,3: For Miyar HEP, low flow period is October to April, High Flow period is June to August and Intermediate Flow period is May and September*

1. To meet the environment flow requirement for the intermediate stretch of Purthi HEP, environment flow released from Reoli Dugli dam will be passed to the Purthi stretch without diversion along with the contribution of the intermediate catchment downstream of diversion Reoli Dugli. This will be augmented by 20% untapped release from Reoli Dugli tailrace at all the time.

2. Environment flow release requirement for remaining 3 projects with installed capacity of > 25 MW where specific environment flow assessment study could not be carried due to data deficiency, recommendations are made based on assessment of other project on same river. Such projects are recommended to follow the recommendations as tabulated below, till such time a detailed modelling study is carried out satisfying the criteria set in **Chapter 9** for environment flow assessment for projects in Chenab basin. Out of such study at that time can be discussed in EAC/SEAC with respect to the findings of this study and final release requirement is recommended.

Project	% of Average Discharge of Low Flow Period in 90% DY	% of Average Discharge of High Flow Period in 90% DY	% of Average Discharge of Intermediate Period in 90% DY
Tandi	20	20	20
Rashil	20	20	20
Lujai	20	30	25

8.2 Recommendations for smaller projects

Impacts of the smaller projects have been studied based on the available data and none of the project has been found to contribute substantially to cumulative impacts, as compared to some of the larger projects in critical locations, therefore, they none of them has been recommended for preclusion. Impacts of the smaller projects are generally found to be local and will be more pronounced during construction phase. Another issue, which has come up during the study with respect to smaller HEPs is that water diversion may impact local water need for agriculture. Such impacts will also be site specific and can be mitigated with local discussion and consent.