ENVIRONMENT IMPACT ASSESSMENT

FOR

INTEGRATED KASHANG HYDROELECTRIC PROJECT (243 MW) OF HIMACHAL PRADESH

PREPARED BY:

HIMALAYAN FOREST RESEARCH INSTITUTE
(*Indian Council of Forestry Research & Education*)
Conifer Campus, Panthaghati
SHIMLA-171 009 (H.P.)
E-mail: dir_hfri@icfre.org

IN ASSOCIATION WITH

MANTEC CONSULTANTS PVT. LTD.
805, VISHAL BHAWAN, 95, NEHRU PLACE, NEW DELHI-110 019
PH – 011-26429294/5/6, FAX – 26842531/26463665
E-mail: envmantec@yahoo.co.in, mantec@vsnl.com

JULY 2008

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER-1

INTRODUCTION

1.1 BACKGROUND

In the past few years India has turned into a vibrant economy. With the growth of the Industrial sector and an improved quality of life, the demand for electric power is increasing day by day. Quality power is required to maintain the sustained growth of agricultural and industrial sectors, to accomplish a higher GDP and sustainable development. The electrical energy may be generated from fossil fuels, thermal power, nuclear energy, hydropower or from renewable sources like solar or wind energy. Deriving electrical energy from fossil fuels like coal is becoming increasingly unmanageable because of environmental implications. Gaseous emissions from the operation of thermal plants cause irreparable damage to the environment, contributing to climate change and global warming. The nuclear power projects are basically cost intensive and the risk element related to leakage of nuclear radiations is extremely high. The scenario of renewable resources is uncertain because the sector is still in the development stage and the cost of technology involved in renewable power generation is extremely high. So the power generated from renewable resources such as wind, solar power, bio-gas etc. cannot really take care of the demands of the booming industry.

Considering the vast and untapped potential and availability, of the hydro resources in India, the development of hydro power projects is thus required to be explored fully. Power generation from such projects is also comparatively less damaging for the environment. Though power production from hydro resources does have its environmental concerns such as large inundations, disposal of muck and rehabilitation and resettlement (R&R) problems, they can be suitably handled with appropriate plans. for e.g. the problem of muck disposal is always resolvable if the restoration of disposal areas is carried out in a scientific way. It would also be appropriate to state here that the problems related to large inundations and R&R may be tackled by going in for run-of-the-river schemes in place of large reservoir schemes as the quantum of inundation and displacement will be much less in run-of-the-river scheme projects.

- **Power Development in India**

India faces significant challenges in balancing its increased demand for energy with the need to protect its environment from further damage. Overall, India's energy production was around 8.8 quadrillion Btu (quads) in

1995. By 2010, India's energy output is expected to reach 16.4 quads, in comparison to China's total energy production, which was 11.7 quads in 1970, 35.6 quads in 1995, and is forecast to rise to 64 quads by 2010. India's rapidly growing population and exorbitant economic growth will drive energy demand growth at a projected annual rate of 4.6 percent by 2010. This is the highest incremental energy demand rate of any major country.

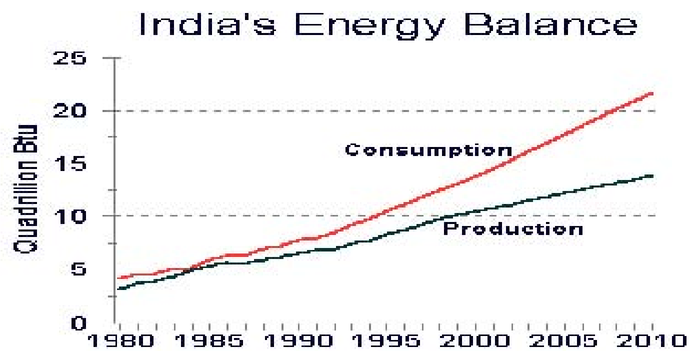


Table 1.1: The Power Supply Position from 1997-98 Onwards

Year	Energy requirement (MU)	Energy Availability (MU)	Energy shortage (MU)	Energy Shortage (%)
1997-98	424505	390330	34175	8.1
1998-99	445584	420235	25349	5.9
1999-00	480430	450594	29838	6.2
2000-01	507216	467400	39616	7.8
2001-02	522537	483350	39187	7.5
2002-03	545963	497890	48093	8.8
2003-04	559264	519396	39866	7.1
2004-05	591373	548115	43258	7.3
2005-06	466109	430408	35701	7.7

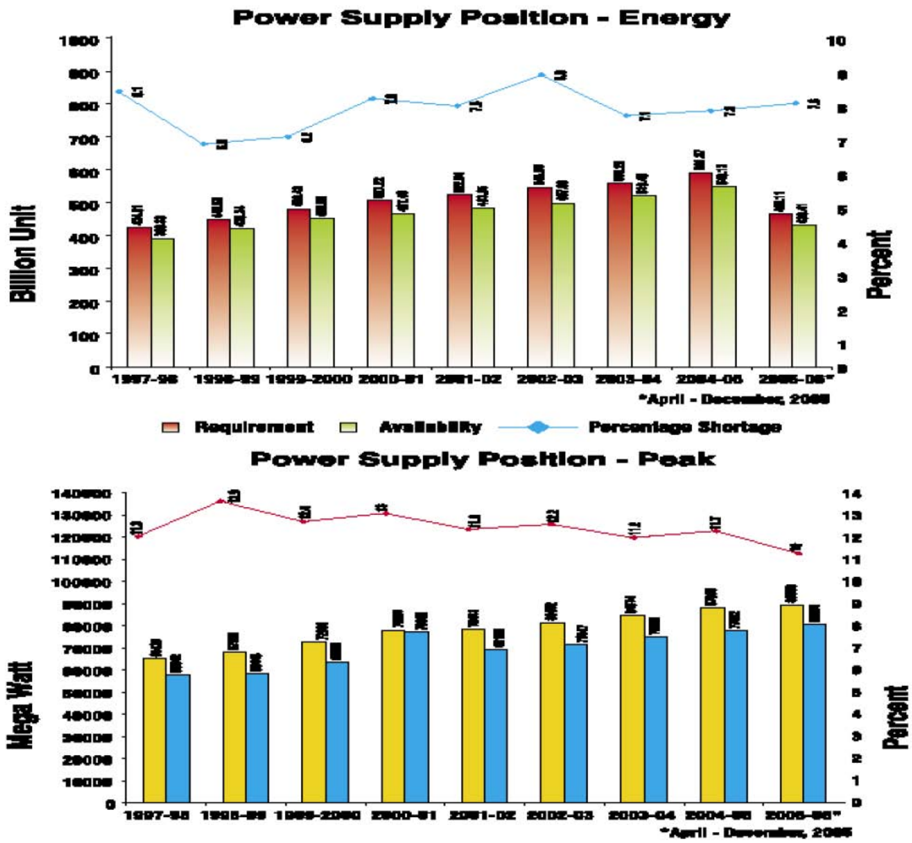


Figure 1.1: Power supply position

In power sector, all India targeted power production to meet the energy demand during the 10th five plan was 41,100 MW including 14393 MW hydro; 25417 MW Thermal and 1300 MW Nuclear), out of which 36956 MW has been achieved. But still the energy shortage remains the same and is expected to grow in near future because the production **(Table -1.1)** and the supply remains more or less the same **(Figure-1.1)** .

1.1.1 Development of Hydro-Power in India

The first hydro-electric plant in India was installed in 1897-98 at Darjeeling (installed capacity 200 KW). This was followed by a hydro-electric station (4200 KW) along the Kaveri river at Sivasamudram (Karnataka) in 1902 to supply electricity to the Kolar Gold Mine. Third hydel station was built on the Jhelum river at Mohara (4500 KW) in 1909, this was followed by hydel power stations at Shimla in 1911 (1750 kw). Another hydro power project of 48 MW capacity was constructed at Shanan near Jogindernagar in the mid twenties. The First World War gave impetus to electricity development and a number of hydel projects were started in different states of the country. After independence a number of multipurpose and river valley projects were initiated to improve power generation, notable among these were Bhakra Nangal, Hirakund, Rihand, Chambal, Tungabhadra, Koyna, Tehri etc. raising the electric generation from 2.5 billion kwh in 1950-51 to 80.6 billion kwh in 1999-2000 recording 32 times growth.

- **Hydro-Power Potential**

Geo-morphologically, India offers great sources of hydropower with well-defined regions, which are topographically favorable for the run-off river hydro development. The generation from hydel is assumed at plant load factor of 40% for the period 1999-2019. Like the Green Revolution of the past, which concentrated on Punjab and Haryana, the new "Power Revolution" is focusing on power producing states like Chhattisgarh, Himachal Pradesh and Uttarakhand which have a potential to produce nearly 50000 MW of power because of their rich natural resources. India currently generates about 83% of its electricity from conventional thermal power plants and about 14% from hydroelectric plants (mainly located in Himachal Pradesh, Uttarakhand, and the northeast). Accordingly GOI has launched a 50,000-megawatt (MW) hydroelectric initiative. Hydropower is a renewable source of energy and much cheaper as compared to thermal power

As per the assessment of CEA the country is endowed with hydro potential of 84000 MW at 60% load factor or an installed capacity of around 1,50,000 MW. The region wise hydro potential is placed in **Table 1.2**.

Table 1.2: Region wise Breakup of Hydropower Potential in the Country

Region	Potential at 60% load factor, MW	Feasible Installed Capacity, MW	Potential in billion, KWH/year	Pumped Storage Feasible Installed Capacity, MW	Small Hydro (up to 15 MW Potential), MW
Northern	30155	53405	225	13065	3180
Western	5697	8928	31.4	39684	661
Southern	10768	16446	61.8	17750	801
Eastern	5590	10965	42.5	9125	530
North Eastern	31857	58956	239.3	16900	1610
Total	**84044**	**148700**	**600**	**95524**	**6782**

It is significant to note that the country has harnessed barely 15 percent of its hydro potential whereas only about 7 percent more is under various stages of development. This leaves 78 percent hydropower potential of our rivers un-harnessed and rivers flow down to the sea unused, in the process causing severe damage through flood year after year. Data collected by Central Water Commission for the period 1953-1999 suggests that an annual of 8.113 million hectare gets floods of which 3.567 million hectares comprises of cropped area. Average damage to crops, houses, and public utilities has been estimated around Rs.1,399 crore at the year 2000 price level. The exploitable global hydropower potential is estimated around 15,000 billion units, of which India's potential counts for about 4 percent. But all the same, India ranks fifth in hydro potential. In 62 countries, hydropower share in total power output is 50 percent, in 23 countries 90 percent and in 15 countries 100 percent. But in India hydropower share is only 24 percent. It is a well-known fact that countries having a larger share of hydropower have been able to offer to their consumers significantly lower power tariffs.

- **Benefits and scope of Hydropower development**

Apart from being non-polluting and clean energy, hydropower cost of generation progressively goes down in contrast to other sources like thermal, gas, oil, etc. where the cost of fuel goes on increasing. A very significant benefit of hydropower in contrast to thermal power is the inherent ability of hydro plants for quick starting and stopping and almost instantaneous load acceptance and rejection. This makes them ideal for meeting peaking power shortage (current peaking power shortage in India is around 18 per cent). In a typical power system, it is seen that only 60 percent of the demand may be for 24 hours, the balance 40 percent arises only for six to eight hours per day. In this context, it is worth pointing out that the latest policy on hydropower development framed by the Union Government has given a thrust to ensure exploitation of the hydro potential. The policy envisages benefits to investors such as normative level for incentives, simplification of procedures and further reassurances of return on investments. It is envisaged in the policy on hydro development, that steps will be taken to accelerate hydropower development by higher budgetary allocation for the hydro sector by giving priority to languishing state sector. The policy lays a greater emphasis on the ideal hydro thermal mix, which should be in the ratio of 40:60.

1.1.2 Hydro Power Development of Himachal Pradesh

Himachal Pradesh is a mountainous state located in north of country. The state has a diverse topography high mountain ranges interspersed with deep gorges and valleys to fertile Gangetic plains in the south east. The climate varies from semi-tropical in the lower hills to semi arctic in the cold deserts of

Lahul, Spiti and Kinnaur. The altitude ranges from 350 m to 6975 m above mean sea level. Hydro Power development has been taking place in the state even before the state was granted full statehood. A small project of capacity 0.45 MW got executed by the erstwhile Raja of Chamba state in 1908 which was followed by a small project at Chamba with capacity 1.75 MW near Shimla in 1912. Another hydro power project of 48 MW capacity was constructed at Shanan near Jogindernagar in district Mandi in mid twenties. Small projects were also executed at Nogli in district Shimla and Gharola in district Chamba. The erstwhile Punjab Government in the late fifties and early sixties constructed Shansha and Billing Projects in district Lahal and Spiti. Later, Bassi HEP (60 MW) and Giri Hydro Electric Project (60 MW) were executed.

1.1.3 Hydro Power Potential of Himachal Pradesh

Himachal Pradesh is blessed with abundant water resources in its five major rivers i.e. Chenab, Ravi, Beas, Satluj and Yamuna, which emanate from western Himalayas and flow through the state. These snowfed rivers and their tributaries carry copious discharge all the year round which can be exploited for power generation. All the river basins and valleys are connected by roads, other communication network and strong base of other social infrastructure like health and education etc.

The power generation potential of the state is 20,386 MW, which is about 25% of the total hydel potential of the country, out of which only around 6150 MW stand harnessed so far. The balance potential, if harnessed expeditiously in a judicious manner, can provide adequate resources to the state to promote its developmental activities. The total power potential of the state and the basin wise power potential available in the state with the corresponding project status indicating their operation, constructional and allotment status is given in **Table 1.3**.

Table 1.3: Hydro Potential in Himachal Pradesh

Total identified hydro potential in H. P.	:	20,386 MW
1. Potential Harnessed so Far:		
i. State Sector	:	413.50 MW
ii. Central Sector	:	3829.57 MW
iii. Joint Sector	:	1500.00 MW
iv. Private Sector	:	386.00 MW
v. Under HIMURJA	:	21.20 MW
Total	**:**	**6150.27 MW**

2. Projects under Execution / Stand Allotted
   i. i. State Sector : 1219.00 MW
   ii. Central Sector : 3101.00 MW
   iii. Joint Sector : 402.00 MW
   iv. Private Sector : 1811.00 MW
   Total : 6533.00 MW

3. Projects under Consideration for Allotment : 1101.00 MW

4. Projects under HIMURJA : 750.00 MW

5. Projects Advertized in the Month of Oct. 2005 = 1767 MW – 330 MW (Projects withdrawn) : 1437.00 MW

6. Projects Advertized in the Month of Jan. 2006 : 3964.50 MW
7. Projects abandoned due to Environmental Consideration
   i. Baspa-I HEP : 210.00
   ii. Gara Gossain HEP : 25.00
   iii. Gharopa HEP : 99.00
   iv. Chamba HEP : 126.00
   Total : 450.00 MW
   Grand Total : 20,386.00 MW

Basin wise hydro potential vis-à-vis status of various major and medium projects and the potential under Himurja, is tabulated in **Table 1.4**.

Table 1.4: Basin Wise Hydro Potential of Himachal Pradesh

Sl. No.	Status of Projects	Basin (in MW)					Total
		Beas	Yamuna	Chenab	Ravi	Satluj	
1.	Under operation	1718.50	211.52	5.30	1043.50	3150.25	6129.07
2.	Under execution / stand allotted in Slate sector	261.50	266.00	-	17.00	674.50	1219.00
3.	Under execution / stand allotted in Central sector	2070.00	-	-	231.00	800.00	3101.00
4.	Under execution / stand allotted in Joint sector	-	-	-	-	402.00	402.00

5.	Under execution / stand allotted in Private sector	408.00	68.00	-	175.00	1160.00	1811.00
6.	Project advertised for allotment in Private sector	7.50	46.00	2723.00	701.50	1914.50	5392.50
7.	Project under consideration for allotment	-	-	-	-	1101.00	1101.00
8.	Projects not to be executed	124.00	-	-	126.00	210.00	460.00
9.	Projects under Himurja	4589.50	591.52	2728.30	2294.00	9412.25	20386.77
							Say 20386.00

1.1.4 Development of Hydro Power Demand in Northern Region

The Northern Region Power Grid comprising state of U. P., Uttarakhand, Rajasthan, Punjab, Haryana, Himachal Pradesh and J & K, Delhi and UT of Chandigarh has been experiencing acute power shortage during last decade and is unable to crop with rapid industrialization, urbanization and developing irrigation network. The demand for power has outstripped availability to an alarming proportion in the country as a whole though not to that extent in Northern region. Actual power supply position in the Northern region only during the year 2004-2005 has been shown in **Table 1.5**.

Table 1.5: Actual Power Supply Position in Northern Region Grid

Peak Power (MW) – July 2004				
State	**Peak Demand**	**Peak Met**	**Shortage (-) / Surplus (+)**	**Percentage**
Chandigarh	210	220	10	4.8
Delhi	3500	3500	0	0.0
Haryana	3460	2850	-610	-17.6
Himachal Pradesh	600	630	30	5.0
Jammu & Kashmir	1280	870	-410	-32.0
Punjab	5740	4660	-1080	-18.8
Rajasthan	3900	3910	10	0.3
Uttar Pradesh	6500	5300	-1200	-18.5
Uttaranchal	720	1010	290	40.3

1.1.4.1 Future Forecast

During the 10th plan period, i.e. upto the year 2006-07, 31 projects, with an aggregate installed capacity of 13280 MW were scheduled to be implemented in the Northern Region. Their status wise and sector wise break up is shown in **Table 1.6** and **Table 1.7**.

Table 1.6: Status-Wise Break-up of Implemented Project during 10the FYP

Status	No. of Projects	Total Capacity (MW)
Sanctioned and on going	11	6263.78
CEA Cleared	10	2310.32
New	10	4706.0
Total	31	13280.1

Table 1.7: Sector-wise Break-up of the proposed Capacity

Status	No. of Projects	Total Capacity (MW)
Central Sector	13	7590.0
State Sector	14	4420.1
Private Sector	4	1270.0
Total	31	13280.1

As per the studies carried out in the Central Electricity Authority, the power supply position in Northern Region as expected by the end of the 10th plan is given in **Table 1.8**.

Table 1.8: Expected Power Supply Position Northern Region by the end of 10th Plan

Energy (MU) 2006-2007				
State	**Requirement**	**Availability**	**Shortage (-) / surplus (+)**	**% Shortage or Surplus**
Chandigarh	2120	674	(-) 1446	68.2
Delhi	25672	21256	(-) 4416	17.2
Haryana	25750	17547	(-) 8204	31.9
Himachal Pradesh	5113	8800	(+) 3687	72.1
Jammu & Kashmir	9099	9948	(+) 849	9.33
Punjab	41922	31243	(-) 10679	25.5
Rajasthan	40343	26758	(-) 13583	33.7
UP & Uttaranchal	70803	54418	(-) 16385	23.1
Northern Region	220820	170644	(-) 50176	22.72

Peak Power (MU) 2006-2007				
State	**Requirement**	**Availability**	**Shortage (-) / surplus (+)**	**% Shortage or Surplus**
Chandigarh	403	105	298	73.9
Delhi	4310	3079	1231	28.6
Haryana	4899	2824	2075	42.4
Himachal Pradesh	973	1718	745	76.6
Jammu & Kashmir	1923	1821	102	5.3
Punjab	7719	5079	2640	34.2
Rajasthan	6772	4104	2668	39.4
UP & Uttaranchal	11384	9064	2320	20.4
Northern Region	38383	27794	10589	27.59

Further, as per 16th Electric Power Survey published by CEA, the requirement of electricity in the Northern Region and the country is likely to grow at the rate of 6.9% and 6.28% respectively during the 11th plan.

The power supply and demand scenario at the end of the 11th plan for the Northern Region and country as a whole considering the benefits arising out of the ongoing schemes would be as follows (source: 16th Electric Power Survey).

Table-1.9: Power Supply and Demand Scenario at the end of 11th Plan

Description	India	Northern Region	
	2006-2007	2006-2007	2011-2012
Energy Demand (MU)	719097	220820	308528
Energy Available (MU)	626621	181468	249731
Surplus / Deficit (MU)	-92476	-39352	-58797
Surplus / Deficit (%)	-12.9	-17.3	-19.05
Peak Demand (MW)	115705	35540	49674
Peak Availability (MW)	101527	29667	35073
Deficit (MW)	-14178	-5873	-1460
Surplus / Deficit (%)	-12.3	-17	-29.4

1.2 NECESSITY & JUSTIFICATION FOR IMPLEMENTING THE PROJECT

Comparing the projected growth of peak demand and anticipated increase in the generating capacity on the basis of new projects proposed and/or under construction / consideration during 10th and 11th Five Year Plans, it is evident that there is a dire need to provide additional power to the Northern Grid to meet the increasing demand of power. New schemes have to be taken up immediately and implemented to derive timely benefits. The most important source of power development in the Northern region is hydroelectric power located in Himachal Pradesh, Uttarakhand and Jammu & Kashmir.

The need for the integrated Kashang HEP, located in the Sutluj basin which stores 9412 MW power potential being 46% of the total hydro power potential of the state, has therefore been considered in context of power shortage in Northern Region. The discharge characteristics of Kashang and Kerang khads is also favourable with unique parameter i.e. the difference between the minimum and maximum discharge is less due to the orientation of their catchment whose major portion is permanent snow cover resulting into more winter discharge. Thus capability of boosting the availability of power during winter when the power demand is at its peak. Thus integrated Kashang HEP with an installed capacity of 195 MW in Kashang powerhouse and 48 MW in Kerang powerhouse presents itself an attractive scheme for statutory clearance and development.

1.3 "INTEGRATED KASHANG HEP": AN OVERVIEW

Integrated Kashang Hydroelectric Project is proposed for development using waters of Kashang and Kerang streams, right bank tributaries of river Sutlej. The project is located in Kinnaur district of Himachal Pradesh and is owned by HPPCL, Shimla. The index project location and vicinity map is shown in **Figure-1.2**.

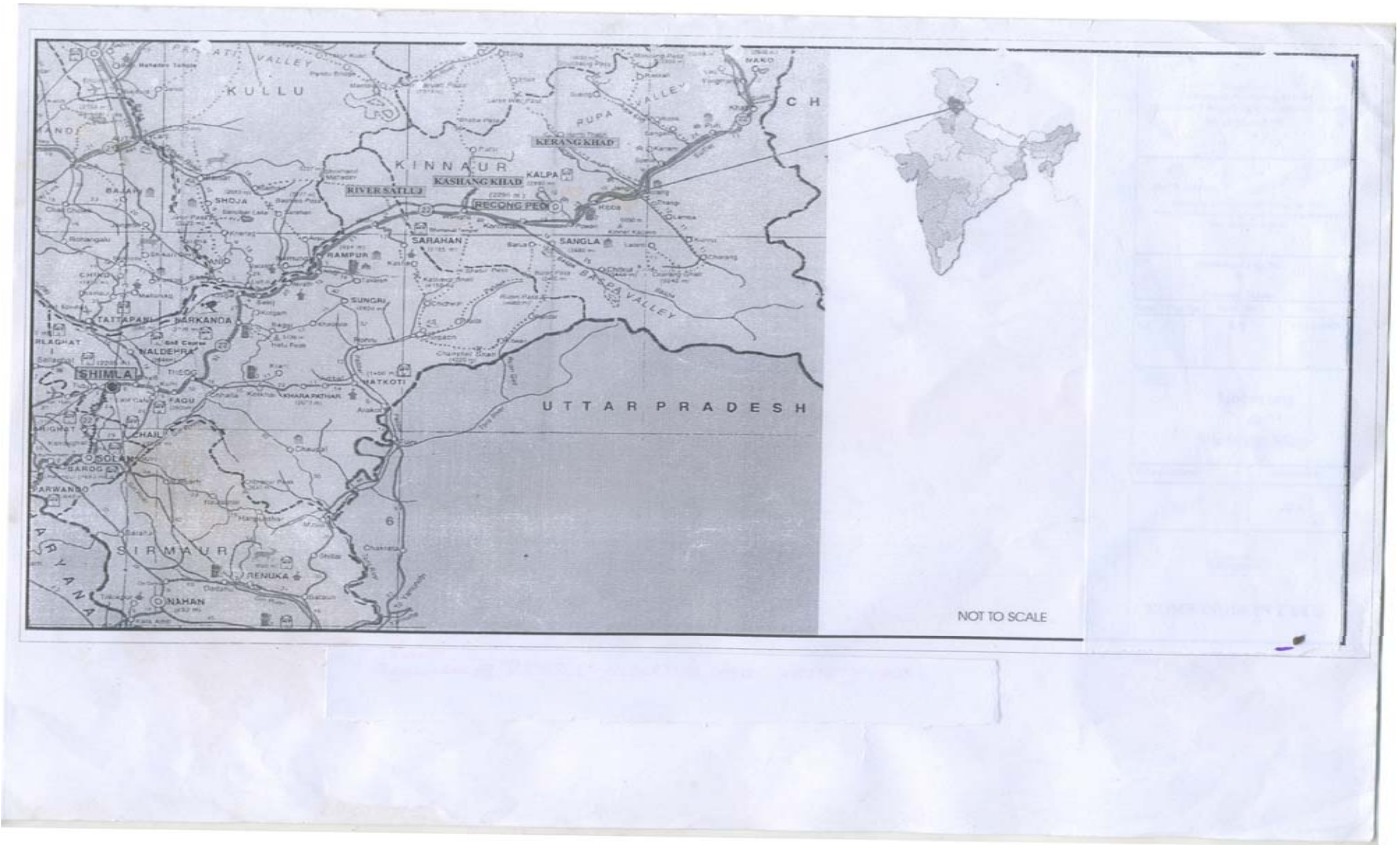


Figure1.2: Project Location and Vicinity Map

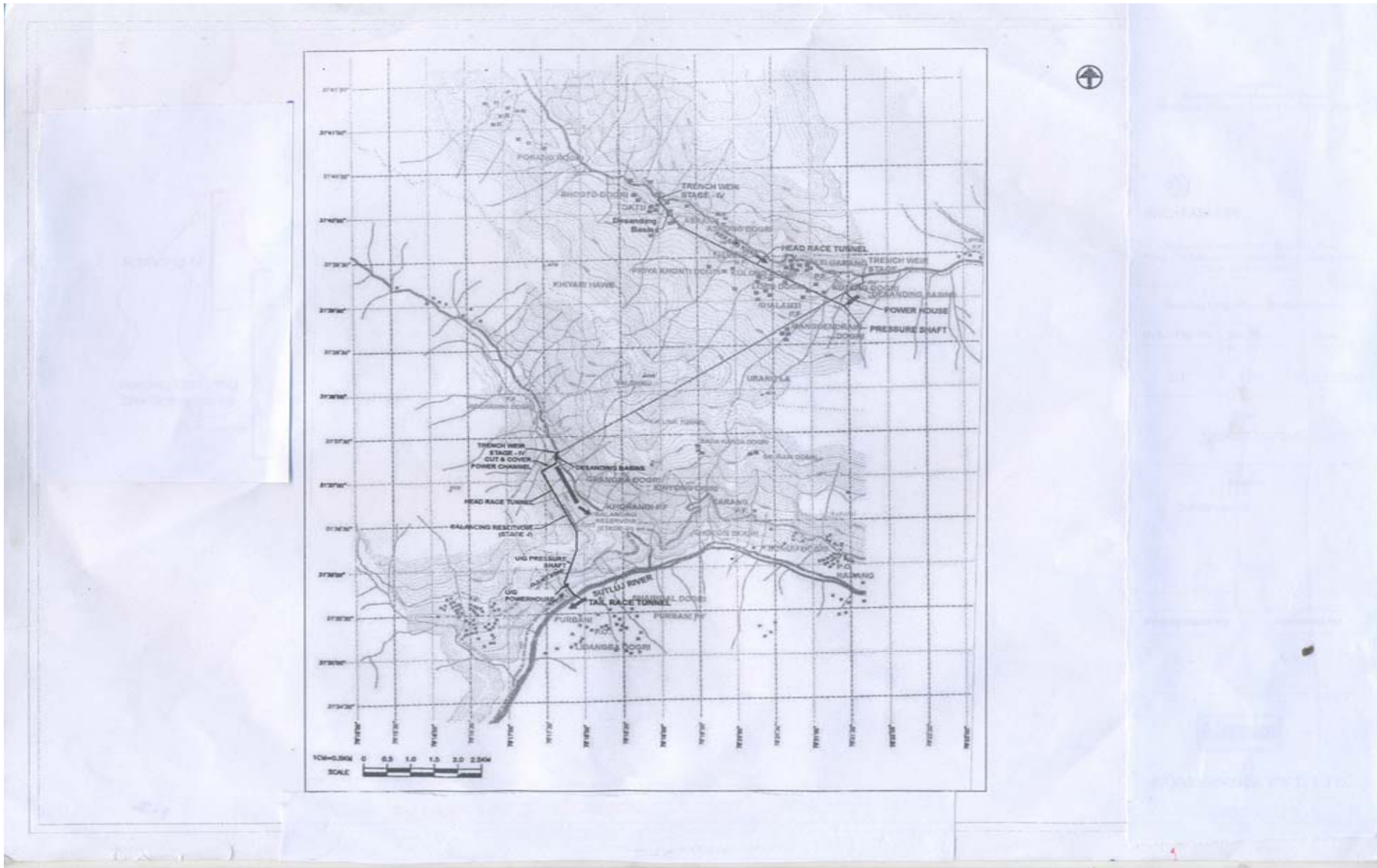


Figure 1.3: General Layout Plan

Kashang and Kerang river valleys are adjacent to each other and are separated by a high altitude ridge in the area of the project. Topographic features permit diversion of Kashang khad at an altitude of roughly 2830 m to an underground powerhouse located on the right bank of Sutlej river, developing a head of approximately 830 m. Topographic and geological features between Kerang and Kashang valleys are also conducive to diversion of Kerang khad, which has higher inflows than Kashang, into the Kashang water conductor system for significant augmentation of generating capacity at Kashang powerhouse.

1.3.1 Integration alternatives

Various alternative possibilities for integration of the two streams have been assessed. In one of the alternatives, diversion of Kerang khad is envisaged at elevation 3150 m+ to an underground powerhouse to be located on the left bank of Kashang khad near the site from where the Kashang khad is proposed for diversion. The differential head is dissipated through power generation and the tail water is channelized into Kashang water conductor for additional generation of power in Kashang powerhouse. The scheme entails working in high altitudes with logistic as well as working-season constraints and could seriously jeopardize the economic merits of the integration as its implementation schedule would be susceptible to delays.

Another integration alternative comprises of diversion of Kerang khad at a lower elevation so that the Kerang water can be brought directly to Kashang water conductor through a "Link" tunnel. Many of the logistic difficulties involved in the first alternative would be circumvented in this scheme as all work sites are easily accessible and no major infrastructure development work is involved. The Kerang water will be efficiently and expediently utilized over the high head available in Kashang scheme, resulting in significant economic benefits. Development of the power potential of the two streams as originally envisaged through Integration can be completed by exploiting the remaining head available in Kerang khad (between the lower and the upper sites) through an underground powerhouse-based scheme located on the right bank of Kerang khad.

1.3.2 The Proposed Integrated Scheme

The proposed Integrated Kashang Project comprises of four distinct stages of development:

- Stage-I, comprising of diversion of the Kashang stream, at El. 2829 m, to an underground powerhouse located on the right bank of Sutlej near Powari village, developing a head of approximately 830 m;

- Stage-II, comprising of diversion of the Kerang stream, at El. 2870 m, into an underground water conductor system leading the upstream end of Stage-I water conductor system;
- Stage-III, consisting of augmenting the generating capacity of Stage-I powerhouse using Kerang waters over the 820 m head available in Kashang Stage-I powerhouse.

- Stage-IV, comprising of more or less independent scheme harnessing the power potential of Kerang stream upstream of the diversion site of Stage-II. In this scheme, a head of approximately 300 m could be utilized to develop power in an underground powerhouse located on the right bank of Kerang khad.

A general layout plan of the Integrated Project is shown in **Figure-1.3** and aerial view is shown in **Figure-1.4**. The project would have a total installed capacity of 243 MW: 195 MW in Kashang powerhouse and 48 MW in Kerang right bank powerhouse.

1.3.3 Location and Approach

The project area is close to Rekong Peo which is around 314 km from Kalka, the nearest rail head, to which it is connected through National Highway-22. The nearest airport is at Shimla, some 224 km from Rekong Peo. The project sites are connected to Rekong Peo by road, some of which would require widening / re-grading as below

- Kashang Diversion and Head works Area: This area is connected to Rekong Peo via Pangi village. Road from Rekong Peo to Pangi is generally good and would only require some upgrading. Beyond Pangi, the road is narrow and unmetalled and requires major upgradation for use during project construction.

- Kerang Diversion and Head works Area: This area is connected to Rekong Peo via Akpa, Jangi and Lippa villages. Road from Rekong Peo to Lippa is generally good. Beyond Lippa, the road is narrow at places and unmetalled and would require upgradation for use during project construction.

- Kashang Powerhouse Area: Kashang powerhouse is located just below National Highway 22 and is easily approachable.

1.3.4 Project Features

1.3.4.1 Stage-I Scheme

Diversion weir and Intake

In Stage-I scheme, the Kashang water is diverted using a trench weir with crest at El. 2829 m. The diversion structure (channel) is 12 m wide and the trash rack is 3 m in length. The trench weir is provided with adequate upstream and downstream protection to ensure stability and safety of the structure during high flows/floods in the river. Arrangement for flushing out shingles that pass through the trash rack is provided just before the water enters the conductor system. Provision is also made to ensure that a certain minimum flow, the riparian flow (minimum required for environmental considerations), remains in the river downstream of the diversion structure.

A gated control structure is provided at the intake and is followed by a control orifice to limit intake of water into the inlet channel. Water levels in the water conductor system are further controlled through an overflow weir provided in the side wall of the inlet channel, just upstream of the desanding basins.

Desanding arrangement

A surface cut-and-cover desanding arrangement is provided using two desanding basins which could be either the vortex tube type or the hopper type. Each desanding basin is provided with isolating gate grooves on the upstream and downstream ends.

The desanding arrangement is designed to exclude particles greater than 0.2 mm in size with an efficiency of 90%. The basins are placed parallel to the river and as close as possible so that silt flushing arrangements as well as excavation quantities are optimized.

Power channel/Headrace Tunnel

Downstream of the desanding basins, a 3.5m(W) x 3.84m(H) cut-and-cover power channel is provided which is oriented towards the right bank hill slopes. As the natural ground profile slopes up towards the right bank, the channel soon encounters higher grounds which provide sufficient cover to facilitate tunneling. The power or headrace tunnel is first driven through overburden material and then through rock. The headrace tunnel is approximately 2 km long and has a 3.5 m(W)x4.115(H)m, D-shaped section (finished).

Balancing Storage

Since Kashang powerhouse is conceived as a peaking station and the diversion structure has no storage capacity, balancing storage is required to ensure guaranteed generation during peak hours. Given the topographic, geomorphological and geological features of the Kashang valley in the area of the project, a surface reservoir is not feasible. The balancing storage is therefore provided underground, by enlarging the downstream portion of the headrace tunnel.

The total balancing storage requirement for Stage-I is 54,000 m3.

Valve Chamber

A 8m(W)x15m(L)x10m(H) valve chamber housing a butterfly valve has been provided downstream of the balancing reservoir. A butterfly valve has been provided to isolate the pressure shaft and the power house complex from the water conductor in case of need.

EOT crane is provided in the valve chamber to handle the valve during maintenance and erection works. Main hook of the EOT crane would be capable of lifting 25 tonnes while auxiliary hook is designed to lift 5 tonnes.

Pressure shaft

A 2.6 m diameter pressure shaft is provided with inlet at the downstream end of the balancing reservoir. The 1220 m long inclined pressure shaft is embedded in rock and, to facilitate and expedite construction, is provided with a horizontal limb at roughly the mid height.

The pressure shaft is steel lined all along, using ASTM A517 and A537 steels.

Powerhouse Complex

The underground powerhouse complex is located on the right bank of Sutlej, near Powari village, just below National Highway 22.

The general arrangement of Kashang Stage-I and Stage-III powerhouse has been developed for three, 65 MW, vertical axis Pelton turbines. Out of these, two units will be installed in Stage I and the third unit will be installed in Stage-III, along with the implementation of Kerang-Kashang Link Scheme. The excavation required for both the Stage I and Stage III of the project would be completed within the scope of the Stage I works.

Machine Hall Cavern

The machine hall cavern is 16 m wide and 87 m long. The control room, 16m x 20 m, is located at the North end of the machine hall cavern. This locates it away from the construction work required in Stage III. The service bay and the main construction adits are located at the southern end of the machine hall.

The principle access to the machine hall is by means of the main access tunnel (MAT) which is 7 m, D-shaped.

Transformer Hall Cavern

The transformer hall cavern is 15.5m wide and 88.2 m long and is designed to house 10 single-phase transformers and the GIS equipment.

1.3.4.2 Kashang Stage-II (Kerang-Kashang Link) Scheme

Diversion weir and Intake

Stage-II diversion structure is located in a narrow valley, some 60 m below the road from Lippa to Asrang. A trench weir type diversion structure is proposed, with crest at El. 2872 m. The diversion structure (channel) is 15 m wide and the trash rack is 3 m in length. Although the Kerang trench weir is located in a portion of the river where bedrock is exposed on the abutments and is also visible in the river bed, the structure is provided with adequate upstream and downstream protection works to ensure stability and safety during high flows/floods in the river.

Arrangement for flushing out shingles that pass through the trash rack is provided just before the water enters the conductor system. Provision is also made to ensure that a certain minimum flow, the riparian flow (minimum required for environmental considerations), remains in the river downstream of the diversion structure.

A gated control structure is provided at the intake and is followed by a control orifice to limit intake of water into the inlet channel. Water levels in the water conductor system are further controlled through a siphon spillway provided in the side wall of the inlet channel, just upstream of the desanding basins.

Desanding arrangement

Since the Kerang valley is quite narrow in the area of the diversion, underground desanding arrangement is the only option. Two Du Four type desanding basins are provided.

The desanding arrangement is designed to exclude particles greater than 0.2 mm in size with an efficiency of 90%. A flushing tunnel brings the excluded sediment back to the river downstream of the diversion weir.

Kerang-Kashang Link Tunnel

Kerang-Kashang Link Tunnel extends from the downstream end of the desanding basins to the left bank of Kashang khad, where it joins a cut-and-cover channel. The latter brings the Kerang water to the Kashang water conductor system, downstream of the surface desanding basins.

The Link tunnel is about 6.5 km long and has been provided with a vertical drop some 30 m from the desanding basins. The drop is provided to account for the difference in head between the diversion elevation in Kerang and the junction point in Kashang water conductor.

The drop is provided near the upstream end of the tunnel so that the power potential of Kerang khad upstream of the Stage-II diversion site could be maximized for development in Stage-IV.

Balancing Reservoir (for the Integrated Stage-III powerhouse)

From operation considerations, additional balancing storage would be required for the Integrated Stage-III powerhouse. For the purpose of work scheduling and cost estimation, this balancing reservoir is considered as part of Stage-II civil works. The reservoir is placed parallel to the reservoir of Stage-I, near the upstream end of the pressure shaft and comprises a 10-m wide and 960 m long underground cavity, placed at 40 m from the reservoir of Stage-I scheme. A connecting tunnel is provided so that the two reservoirs work in tandem.

1.3.4.3 Kashang Stage-III Scheme

Major components of Stage-III development comprise of addition of the third 65 MW unit in Stage-I powerhouse; the water conductor system of Stage-I downstream of the junction where Kerang water enters is already sized for the design discharge of three generating units.

1.3.4.4 Kashang Stage-IV Scheme

Diversion weir and Intake

Stage-IV diversion structure is located near Toktu village. A trench weir type diversion structure is used, with crest at El. 3150 m. The diversion structure (channel) is 15 m wide and the trash rack is 3 m in length. Since the river bed slope is rather flat in this area, the crest of the weir is raised 5 m above the natural river bed level to provide/accommodate slopes required for shingle and silt flushing. The structure is provided with adequate upstream and downstream protection works to ensure stability and safety during high flows/floods in the river.

Arrangement for flushing out shingles that pass through the trash rack is provided just before the water enters the conductor system. Provision is also made to ensure that a certain minimum flow, the riparian flow (minimum required for environmental considerations), remains in the river downstream of the diversion structure.

A control orifice is provided at the upstream end of the gated intake structure to limit intake of water. Additional control is provided through an overflow type weir located just downstream of the intake structure.

Desanding arrangement

In the area of diversion works, the Kearng valley is narrow and has exposed rock abutments. Sufficient space is not available for locating the desanding arrangement on surface. Consequently, underground desanding arrangement is proposed and comprises of two Du Four type desanding basins.

The desanding arrangement is designed to exclude particles greater than 0.2 mm in size with an efficiency of 90%. A flushing tunnel brings the excluded sediment back to the river downstream of the diversion weir.

Headrace Tunnel

The headrace tunnel starts at the junction of link tunnels provided on the downstream end of the desanding basins. The tunnel is D-shaped, 3m wide by 3.15m high and is designed to target a water velocity of 2 m/s for all flow conditions; flow conditions in the tunnel would vary between full (or pressurized) flow and partial (or open channel) flow, depending on the river inflow. The tunnel is concrete lined and culminates into a surge tank.

Surge Tank

A 10 m diameter and 42 m high, open to air, surge tank is provided in this scheme as the headrace tunnel is designed as a pressure conduit and the hydraulic transient conditions necessitate a surge shaft.

Pressure Shaft/Penstock

A 2.1 m diameter, steel lined, inclined pressure shaft is provided which starts from the surge tank. Layout of the pressure shaft is governed by the location of the sure tank and the powerhouse. Both these important structure have been sited in sound geological formations, which are localized. The pressure shaft bifurcates into two unit penstocks. The steel lining is designed using ASTM A537 steel.

<u>Powerhouse Complex</u>

The underground powerhouse complex is located on the left side of the Stage-II (K-K Link) Scheme's water conductor system. This location is governed by geological considerations.

The powerhouse is designed for an installed capacity of 48 MW. Two 24 MW vertical axis Pelton turbines are proposed.

<u>Machine Hall Cavern</u>

The machine hall cavern is 16 m wide and 62.8 m long. The control room, 16m x 14.6 m, is located at one end and the service bay, along with the main construction adits, is located at the other end of the machine hall.

The principle access to the machine hall is done by means of the main access tunnel (MAT) which is 7 m, D-shaped.

<u>Transformer Hall Cavern</u>

The transformer hall cavern is 15.5m wide and 61.4 m long and is designed to house 7 single-phase transformers and the GIS equipment.

Principal access to the transformer hall is done by means of the main access tunnel which traverses the cavern. Two bus duct galleries are proposed between the machine hall cavern and the transformer hall cavern.

A cable tunnel is provided to bring high voltage cables from the GIS (located in transformer hall cavern) to the open pothead yard situated on the hill slope, adjacent to the portal of the main access tunnel.

1.4 SALIENT FEATURES OF THE PROJECT

1.4.1 Project Location

State	Himachal Pradesh, India
District	Kinnaur
Rivers	Kashang and Kerang khads (Tributaries of river Sutlej)

1.4.2 Kashang Stage-I Scheme

Hydrology

Catchment area	124 km2
Average annual inflow	196.4 mcm
Average discharge	6.3 m3/s
Specific average discharge	50.8 I/s/ km2
Minimum ecological water release in Kashang Khad	0.3 m3/s
Design flood (1 in 1000)	100 m3/s

Intake (Trench Weir)

River	Kashang
Vicinity	Dollo-Dogri Village
Latitude	31° 37′ 30″
Longitude	78° 17′ 30″
Water inlet elevation (Centerline of Trench weir Trash rack)	2829.00 m.a.s.l.
Nominal discharge	14 m3/s
Dimension of trash rack opening (L x W)	12 m x 3 m
Dimension of trash rack units (L x W)	1 m x 3.3 m
Number of trash rack units	12

Control Structure

No. of Gates	1
Type	Fixed wheel Type
- Sill elevation	2826.3 m.a.s.l.
- Dimensions (W x H)	3.0 m x 3.0 m (Clear opening)
- Design Head	4.0 m

Shingle Excluder

No. of Gates	2
Type of Gate	Slide Type
Dimension (W x H)	1.0 m x 1.2 m(Clear Opening)
Design Head	5.85 m
Length of flushing duct	80 m
Size (W x H)	1 m x 2 m

Overflow weir

Length	20 m
Crest Elevation	2827.8 m.a.s.l.
Discharging capacity	44 cumecs
Water level at maximum discharge	2828.9 m.a.s.l.

Desanding Arrangement

Number of Basins	2
Type	Hopper or Vortex Tube type
Size (L x H x W)	67.2 m x 7.9 m x 9.6 m (Hopper type) 52 m x 7.8 m x 1.1 m (Vortex Tube type)
Nominal discharge through each chamber	6.6 m3/s
Size of Particle to be removed	0.2 mm

Inlet Gate for De-sanding Arrangement

No. of Gates	1
Type	Slide Type
Sill elevation 2825.82 m	
Dimensions (H x W)	1.75 m x 2.69 m (Clear opening)
Design Head	3.1 m

Outlet Gate for De-sanding Arrangement

No. of Gates	1
Type	Slide Type
Sill elevation	2824.77 m
Dimensions (H x W)	2.00 m x 4.31 m (Clear opening)
Design Head	4.13 m

Flushing System

Type	Circular openings in Hopper bottom or Central flushing channel in Vortex Tube type
Openings (in Hopper type)	
No. and size	7, 140/120 mm
Discharge from each chamber	0.86 m3/s

Headrace Tunnel

Excavated Shape	D- Shaped
Finished Size (W x H)	3.5 m x 4.115 m
Length	2 km
Velocity for nominal discharge	2.0 m/s
Slope	1 in 900
Nominal discharge	11.45 m3/s
Lining type	Cement Concrete Lining
Thickness	200 mm

Balancing Reservoir

Capacity	54000 m3
Size (W x H) ,D-Shaped	10 m x 13/15 m (H)
Bed Slope	1 in 90
Length	204 m

Adit to Balancing Reservoir

Size (W x H) ,D-Shaped	6.5 m x 7.25 m
Length	250 m

Connecting Tunnel Between Balancing Reservoir of Stage-I and Stage-III

Size (W x H), D-shaped	3.5 x 4.115 m
Length	40 m (10 m in Stage-I)
Bed Elevation	2814.2 m.a.s.l.

Pressure Shaft

Type	Underground, Steel lined
Quality of steel	ASTM-A537, ASTM-A517
Thickness of liner	16 to 45 mm
Number of pressure shaft	1
Total Length	1400 m
Internal Diameter	2.6 m
Velocity for normal discharge	3.45 m/s
Nominal discharge	18.3 m3/s

Valve Chamber

Size of cavern	8m x 10m x 15 m

Butterfly Valve

Number	1
Axis Elevation	2809.90 m a.s.l
Diameter	2.6 m
Design Head	17.85 m

Unit Penstocks

Number	3 (1 for stage III)
Internal diameter	1.5 m

Powerhouse

Main Access Tunnel	
Shape	D-Shaped
Size (W x H)	7 m x 7 m
Length	174 m
Type of Turbine	Pelton
Number of units	2 + 1 (for Stage-III)
Turbine setting elevation	1999.2 m a.s.l
Rated discharge per unit	9.15 m3/s
Turbine speed	600 rpm
Max. / Min. gross head	828 / 818 m
Rated head	821 m
Installed capacity per unit	65 MW

Main Inlet valve	
Type	Spherical
Number	3
Axis elevation	1999.2 m.a.s.l
Diameter of valve	1.5 m
Design Head (Static + Water hammer)	908 m
Generator	
Type	Suspended type
Number	2 + 1 (for Stage-III)
Nominal speed	600 rpm
Voltage / Frequency	11 Kv/50 Hz
Load factor (CosØ)	0.9
Powerhouse Cavern	
Dimensions (L x W x H)	87 m x 16 m x 29.9 m
Turbine Pit Elevation	1992.6 m.a.s.l
Crown Elevation	2022.50 m.a.s.l
Crane Rail Elevation	2016.15 m.a.s.l
Erection Bay Elevation	2008.0 m.a.s.l
Capacity of EOT Crane	100/10 T
Bus Duct Tunnel	
Shape	D-Shaped
Size (H x W)	5 m x 5.5 m
No.	2 + 1 (Stage-III)
Transformer Hall Cavern	
Dimensions (L x W x H)	88.2 m x 15.5 m x 23.6 m
Transformer type	OFWF
Number	6 + 3 (Stage-III) + 1 (Spare)
Unit Capacity	26.5 MVA
Voltage ratio	11 Kv/ (220/√3) Kv
Cable Tunnel	
Shape	D- Shaped
Size (H x W)	5 m x 6 m
Length	125 m
EOT Crane Capacity (GIS Hall)	5 T
Tailrace Tunnel	
Number	3 Combined into One (1 for Stage-III)
Length	342 m (combined)

Shape	D-Shaped
Size (W x H)	3.4 m x 4 m (Units 1 and 3) 5 m x 6 m (Unit 2)
Slope	1 in 220
Nominal discharge	18.3 m3/s
Outlet sill elevation	1992.0 m.a.s.l
Pothead Yard	
Type	Out door
Area (L x W)	60 m x 30 m
Estimated Cost (Indian Rupees)	
Civil works	288.79 Crores
E & M works	246.50 Crores
Total basic cost (excluding transmission line cost)	535.29 Crores
Cost of Transmission Works (included in DPR as per information supplied by H.P.S.E.B.)	
a) LILO of Bhaba-Kunihar Line	27.00 Crores
b) Shunt capacitors to the extent of 75% of the installed capacity	2.40 Crores
c) Project Share towards development of composite evacuation plan	37.36 Crores
Total	66.76 Crores
Construction Period	
Construction Period	4 Years
Power Benefits	
90% dep. Energy	245.8 GWh
Completion cost of the Project	
(1) Project cost (excluding Transmission)	
Basic Cost of Project including LADA	543.32 Crores
Escalation during construction period	69.29 Crores
Interest during construction & Financing Charges	91.12 Crores
Total – Generation works	703.73 Crores
Cost per MW installed	5.41 Crores
LADA provision	9.19 Crores
(b) Project cost (including Transmission)	
Basic Cost of Project including LADA	543.32 Crores
Transmission works	66.76 Crores
Escalation during construction period	77.08 Crores

Interest during construction & Financing Charges	98.38 Crores
Total – Generation and Transmission works	785.54 Crores
Cost per MW installed	6.04 Crores
LADA provision	9.19 Crores

Financial Aspects

Cost of generation (Average for 35 years per kWh at power house bus bars, including IDC) during 90% dependable year	Rs. 3.71 / kWh
Cost of generation (Average for 35 years per kWh at purchase center, including IDC) during 90% dependable year	Rs. 4.30 / kWh

1.4.3 Kashang Stage-II (Kerang-Kashang Link) and Stage-III Schemes

Hydrology for Kerang Trench Weir

Catchment area	400 km2
Average annual inflow	440 mcm
Average discharge	14 m3/s
Specific average discharge	35 I/s/ km2
Minimum ecological water release in Kerang Khad	0.65 m3/s
Design flood (1 in 1000)	315 m3/s

Intake (Trench Weir)

River	Kerang
Location	Near Lippa Village
Latitude	31^0 39′ 21.3″
Longitude	78^0 21′ 36.4″
Water inlet elevation (Centerline of Trench weir Trash rack)	2872.00 m.a.s.l
Nominal discharge	22 m3/s
Dimension of trash rack opening (L x W)	15 m x 3 m
Dimension of trash rack units (L x W)	1 m x 3.3 m
Number of trash rack units	15

Control Structure

No. of Gates	1
Type	Fixed Wheel Type
- Sill elevation	2868.6 m
- Dimensions (H x W)	3.0 m x 2.65 m (Clear Opening)
- Design Head	5.2 m

Shingle Excluder

No. of Gates	2
Type of Gate	Slide Type
Dimension (W x H)	1.5 m x 1.5 m (Clear Opening)
Design Head	7.17 m
Length of flushing duct	52 m
Size (W x H)	1.5 m x 2 m

Siphon Spillway

Length	3.5 m
Discharging capacity	7 cumecs

Adit For Desanding Basin

Shape	D-Shaped
Size (W x H)	5 m x 6 m
Length	220 m

Desanding Arrangement

Number of Basins	2
Size (L x H x W)	140 m x 8.35 m x 9.0 m
Type	Dufour type
Nominal discharge through each basin	10.5 m3/s
Size of Particle to be removed	0.2 mm

Inlet Gate for De-sanding Arrangement

No. of Gates	1
Type	Slide Type
Sill elevation	2867.50 m
Dimensions (H x W)	3.0 m x 2.65 m (Clear opening)
Design Head	4.0 m

Outlet Gate for De-sanding Arrangement

No. of Gates	1
Type	Slide Type
Sill elevation	2866.87 m
Dimensions (H x W)	3.00 m x 2.65 m (Clear opening)
Design Head	4.63 m

Flushing System

Type	Flushing duct with holes in the top slab
Size	500 mm wide x

	300 to 1200 mm high
Discharge per basin	1.35 m3/s
No. of holes	Alt.-I 37 (1 of 270 mm dia and 36 of 60 mm dia) Alt-II 23 (1 of 270 mm dia and 22 of 75 mm dia)

Flushing Tunnel

Size (W x H)	1.5 m x 2.0 m
Length	235 m

Link Tunnel

Excavated Shape	D- Shaped
Finished Size (W x H)	3.5 x 4.5 m
Length	6300 m
Velocity for nominal discharge	2.13 m/s
Slope	1 in 1025
Nominal discharge	18.3 m3/s
Lining type	Cement Concrete Lining
Thickness	200 mm

Estimated Cost (Indian Rupees)

Civil works	274.28 Crores
E & M works	97.50 Crores
Total basic cost (excluding transmission line cost)	371.78 Crores

Cost of Transmission Works (included in DPR as per information supplied by H.P.S.E.B.)

a) Shunt capacitors to the extent of 75% of the installed capacity	1.20 Crores
b) Project Share towards development of composite evacuation plan	18.68 Crores
Total	19.88 Crores

Construction Period

Construction Period	4 Years

Power Benefits

90% dep. Energy	735.2 GWh

Completion cost of the Project

(1) Project cost (excluding Transmission)

Basic Cost of Project including LADA	377.36 Crores
Escalation during construction period	88.74 Crores

Interest during construction & Financing Charges	59.27 Crores
Total – Generation works	525.37 Crores
Cost per MW installed (Stage-I + K-K Link & Stage-III)	6.32 Crores
LADA provision (K-K Link & Stage-III)	6.99 Crores

(b) Project cost (including Transmission)

Basic Cost of Project including LADA	377.36 Crores
Transmission works	19.88 Crores
Escalation during construction period	94.24 Crores
Interest during construction & Financing Charges	61.95 Crores
Total – Generation works and Transmission works	553.43 Crores
Cost per MW installed (Stage-I + K-K Link & Stage-III)	6.86 Crores
LADA provision (K-K Link & Stage-III)	6.99 Crores

Financial Aspects

Cost of generation (Average for 35 years per kWh at power house bus bars, including IDC) during 90% dependable year (Stage-I + K-K Link & Stage-III)	Rs. 2.20 / kWh
Cost of generation (Average for 35 years per kWh at purchase center, including IDC) during 90% dependable year (Stage-I + K-K Link & Stage-III)	Rs. 2.47 / kWh

1.4.4 Kashang Stage-IV Scheme

Hydrology

Catchment area	374 km2
Average annual inflow	413 mcm
Average discharge	13.1 m3/s
Specific average discharge	35 l/s/ km2
Minimum ecological water release in Kashang Khad	0.6 m3/s
Design flood (1 in 1000)	300 m3/s

Intake (Trench Weir)

River	Kerang
Vicinity	Toktu Village
Latitude	31º 40′ 12″
Longitude	78º 19′ 01″
Water inlet elevation (Centerline of Trench weir Trash rack)	3155.00 m.a.s.l.
Nominal discharge	22 m3/s
Dimension of trash rack opening (L x W)	15 m x 3 m
Dimension of trash rack units (L x W)	1 m x 3.3 m
Number of trash rack units	15

Control Structure	
No. of Gates	1
Type	Fixed wheel Type
- Sill elevation	3152.2 m.a.s.l.
- Dimensions (W x H)	3.0 m x 2.65 m (Clear Opening)
- Design Head	4.56 m
Shingle Excluder	
No. of Gates	2
Type of Gate	Slide Type
Dimension (H x W)	1.5 m x 1.5 m
Design Head	6.53 m
Length of flushing duct	280 m
Size (W x H)	1.5 m x 2 m
Overflow weir	
Length	16 m
Crest El.	3154.22 m.a.s.l.
Discharging capacity	32 cumecs
Water level at maximum discharge	3155.22 m.a.s.l.
Desanding Arrangement	
Number of Basins	2
Size (L x H x W)	140 m x 9 m x 9.35 m
Type	Dufour type
Nominal discharge through each chamber	10.65 m3/s
Size of Particle to be removed	0.2 mm
Inlet Gate for De-sanding Arrangement	
No. of Gates	1
Type	Slide Type
Sill elevation	3150.41 m
Dimensions (H x W)	3.0 m x 2.65 m (Clear opening)
Design Head	4.81 m
Outlet Gate for De-sanding Arrangement	
No. of Gates	1
Type	Slide Type
Sill elevation	3149.01 m
Dimensions (H x W)	3.00 m x 3.15 m (Clear opening)
Max. Head	6.21 m

Flushing System

Type	Flushing duct with holes in the top slab
Size	Alt-I 500mm (w) x 300 to 1200mm (H) (1 of 270 and 36 of 60mm dia) Alt-II 500mm (w) x 300 to 1200mm (H) (1 of 270 and 22 of 75mm dia)
Discharge per chamber	1.40 m3/s

Headrace Tunnel

Tunnel	
Excavated Shape	D- Shaped
Finished Size (W x H)	3 m x 3.15 m
Length	5 km
Velocity for nominal discharge	2.1 m/s
Slope	1 in 1000
Nominal discharge	18.5 m3/s
Lining type	Cement Concrete Lining
Thickness	200 mm

Surge Tank

Type	Surface
Diameter	10 m
Max upsurge level	El 2867.00

Pressure Shaft

Type	Underground, Steel lined
Quality of steel	ASTM-A537
Thickness of liner	16 to 25 mm
Number	1
Total Length	375 m
Internal Diameter	2.1 m
Velocity for normal discharge	5.34 m/s
Nominal discharge	18.5 m3/s

Unit Penstocks

Number	2
Internal diameter	1.5 m
Length	50 m

Powerhouse	
Main Access Tunnel	
Shape	D-Shaped
Size (W x H)	7 m x 7 m
Length	500 m
Type of Turbine	Pelton
Number of units	2
Turbine setting elevation	2844.3 m a.s.l
Rated discharge per unit	9.25 m3/s
Turbine speed	375 rpm
Rated head	300 m
Installed capacity per unit	24 MW
Main Inlet valve	
Type	Spherical
Number	2
Axis elevation	2844.3 m.a.s.l
Diameter	1.5 m
Design Head (Static + Water hammer)	323 m
Generator	
Type	Suspended type
Number	2
Nominal speed	375 rpm
Voltage / Frequency	11 kV/ /50 Hz
Power factor (CosØ)	0.9
Powerhouse Cavern	
Dimensions (L x W x H)	62.8 m x 16 m x 29.2 m
Turbine Pit Elevation	2837.60 m.a.s.l
Crown Elevation	2866.8 m.a.s.l
Crane Rail Elevation	2860.65 m.a.s.l
Erection Bay Elevation	2852.5 m.a.s.l
Capacity of EOT Crane	70/10 MT
Bus Duct Tunnel	
Shape	D-Shaped
Size (H x W)	5 m x 5.5 m
No.	2
Transformer Hall Cavern	
Dimensions (L x W x H)	61.4 m x 15.5 m x 23.6 m
Transformer type	OFWF

Number	7 (One spare)
Unit Capacity	9.5 MVA
Voltage ratio	11 kV/ (220/√3) kV
EOT Crane Capacity (GIS Hall)	5 MT

Tailrace Tunnel

Number	2 Combined into One
Length	100 m (combined)
Shape	D-Shaped
Size (W x H)	2.5 m x 3.2 m (for Units) 3.2 m x 3.2 m for combined
Slope	1 in 600
Nominal discharge	18.5 m3/s
Outlet sill elevation	2837.43 m.a.s.l

Pothead Yard

Type	Out door
Area (L x W)	40 m x 20 m

Estimated Cost (Indian Rupees)

Civil works	186.87 Crores
E & M works	108.50 Crores
Total basic cost (excluding transmission line cost)	295.37 Crores

Cost of Transmission Works (included in DPR as per information supplied by H.P.S.E.B.)

a) D/c line to Kashang-	6.41 Crores
b) Terminal bays for D/c line between Stage-I and Stage-IV (installed at Stage-I powerhouse)	7.00 Crores
c) Shunt capacitors to the extent of 75% of the installed capacity	0.94 Crores
d) Project Share towards development of composite evacuation plan	13.79 Crores
Total	28.13 Crores

Construction Period

Construction Period	4 Years

Power Benefits

90% dep. Energy	178.0 GWh

Completion cost of the Project

(a) Project cost (excluding Transmission)

Basic cost of Project including LADA	299.80 Crores
Escalation during construction period	94.11 Crores
Interest during construction & Financing Charges	53.84 Crores
Total - Generation works	447.75 Crores
Cost per MW installed	9.33 Crores
LADA provision	5.91 Crores

(b) Project cost (including Transmission)

Basic cost of Project including LADA	299.80 Crores
Transmission works	28.13 Crores
Escalation during construction period	103.35 Crores
Interest during construction & Financing Charges	58.33 Crores
Total - Generation and Transmission works	489.61 Crores
Cost per MW installed	10.20 Crores
LADA provision	5.91 Crores

Financial Aspects

Cost of generation (Average for 35 years per kWh at power house bus bars, including IDC) during 90% dependable year	Rs. 3.26 / kWh
Cost of generation (Average for 35 years per kWh at purchase center, including IDC) during 90% dependable year	Rs. 3.66 / kWh

1.5 POLICY, LEGAL AND ADMINISTRATIVE FRAMEWORK

The emerging environmental scenario calls for requisite attention on conservation and proper use of natural resources and also development without destruction. There is a need to integrate the environmental consequences of the development activities and planning suitable mitigation measures in order to ensure sustainable development in the region. The environmental considerations in any development process have become a necessity for achieving sustainable development. To achieve these goals, the Ministry of Environment & Forests, Govt. of India has enacted Acts, Legislations, Guidelines and Standards from time to time.

The regulation of environmental acts, legislation, guidelines and standards is the responsibility of different government agencies. The principal environmental regulatory agency in India is the Ministry of Environment & Forests, New Delhi. MoEF formulates environmental policies and accords environmental clearances for different projects. The important environmental legislations in India are given in **Table 1.10**.

Table 1.10: Key Environmental Legislations

Name	Scope and Objective	Key Areas	Operational Agencies / Key Players
Water (Prevention and Control of Pollution) Act, 1974, 1988	To provide for the prevention and control of water pollution and enhancing the quality of water	Control sewage and industrial effluent discharges	Central and State Pollution Control Boards
Air (Prevention and Control of Pollution) Act, 1981, 1987	To provide for the prevention and control of air pollution	Controls emissions of air pollutants	Central and State Pollution Control Board
Forest (Conservation) Act, 1980, 1988	To consolidate acquisition of common property such as forests, halt India's rapid deforestation and resulting environmental degradation	Regulates access to natural resources, state has a monopoly right over land, categories forests, restriction on de-reservation and using forest for non forest purpose	State Government and Central Government
Wildlife (Protection) Act, 1972, 1993	To protect wildlife	Creates protected areas (national parks / sanctuaries) categories of wildlife which are protected	Wildlife Advisory Boards, Central zoo Authorities
Environment (Protection) Act, 1986	To provide for the protection and improvement of environment	An umbrella legislation, supplements pollution laws	Central government nodal agency, MoEF can delegate powers to state departments of environment
National Policy on R & R, 2007	Resettlement and rehabilitation of project affected people	Social issues	Central Government
EIA Notification 14th September 2006	Environmental Impact Assessment	Environmental Protection	Project Developer, State and Central Government

As per MoEF notification dated 14th September 2006, construction of new project or activities or the expansion or modernization of existing projects or activities listed in the schedule to the notification shall be undertaken in any part of India only after the prior environmental clearance from the Central Government in the Ministry of Environment and Forests, New Delhi for matters falling under Category 'A' in the schedule and at state level the State Environment Impact Assessment Authority (SEIAA) for matters falling under Category 'B' in the said schedule, the latter duly constituted by the Central Government under sub-section (3) of section 3 of the said act.

The integrated Kashang HEP having 243 MW generation is a river valley project falling under project category with threshold limit "A". The project is an integration of earlier Kashang HEP (66 MW) on stream of the same name and antoher HEP on Kerang Khad. The integrated project has four stages with erstwhile Kashang HEP (66 MW) as Stage-I, the MoEF had already accorded EC for stage-I project on 15-11-2002. However, in view of integration with other stages of development making total proposed generation 243 MW, fresh environmental clearance is being sought.

1.6 SCOPING OF THE PROJECT

In consonance with the provision under section-6 of the MoEF notification, dated 14th September 2006, the project proponent viz., HPPCL moved to the MoEF an application in the prescribed Form-1 duly filled along with a copy of the DPR of the project. In view of the project classified as Category 'A' project the first step required in the environment clearance process is 'Scoping' by which the Expert Appraisal Committee of the MoEF determine detailed and comprehensive Terms of Reference (ToR) addressing all relevant environmental concerns for the preparation of an Environmental Impact Assessment (EIA) Report with respect to the project for which prior environmental clearance is sought.

The Expert Appraisal Committee at its meeting held on November 14, 2007, while setting out the ToR proposed for environmental impact assessment studies and preparation of EMP for the Integrated Kashang HEP, took note of the fact that the integrated project interalia includes the erstwhile Kashang HEP (66 MW) as Stage-I to which EC was accorded on 15-11-2002. The EAC, therefore, desired that CAT plan of the erstwhile Kashang HEP (now Stage-I) be incorporated as such in the new EMP for the integrated project and previous EIA and Ecological Assessment Reports, literature and relevant existing data available be used and conflated to prepare fresh elaborate EIA report covering further field monitoring over two more seasons (Post-monsoon and Winter). The MoEF vide letter J-12011/81/2007-IAI dated 12-12-2007 accorded clearance for pre-construction activities in the proposed sites along with determination of "Terms of Reference" (ToR) for preparation of EIA report which has been appended as Annexure-I to this report.

1.7 Compliance of ToR

The EIA/EMP report has been prepared in conformity to all the issues brought out in the detailed ToR issued by the MoEF vide letter dated 12-12-2007. The brief issues involved and their reference of compliance have been provided in Table-1.11.

Table-1.11: Compliance of Terms of Reference

Sl. No.	Issues Covered in ToR	Reference of Compliance in EIA/EMP
1.	Baseline Studies	
i.	Area falling within 10 km radius of the project should be studied in detail, while a larger radius for catchment area treatment based on catchment of Kerang stream	Para 3.1 (EIA)
ii.	CAT plan for the erstwhile Kashang HEP (now stage-I) would be incorporated as such in the new EMP for the integrated project	Para 1.8 (EMP)
iii.	Further field monitoring spans for EIA will be over to more seasons	Para 2.1 field monitoring was carried out for winter and pre-monsoon season during March 2008 to July 2008
2 (A)	Land Environment	
i.	Assessment of land use pattern in catchment using remote sensing data	Figure 3.10 (EIA)
ii.	Identification of critically and severely eroded sub-watershed in the catchment	Figure 1.12 (EMP)
iii.	Assessment of silt yield and prediction of impact in the proposed CAT plan	Para 1.6.3 and Table 1.6 (EMP)
iv.	Delineation of plans for restoration of silt contributing sites with use of biological and engineering measures under CAT plan	Para 1.8, 1.9, 1.10 and 1.11 (EMP)
v.	Delineation of compensatory afforestation measures	Chapter 3 (EMP)
vi.	Land requirement for project shall be spelt	Para 3.12 (EIA)
2(B)	Geology	
(i)	The geological status of the project area will be studied from existing literature and field observation	Para 3.4 (EIA) Para 3.5 (EIA) Para 3.6 (EIA)
(ii)	The project area will be classified for seismic zones and detailed data on various earthquake along with intensity that have occurred in the area in the past shall be reported	Para 3.7 (EIA) Figure 3.5
3.	Soils	
	Soils samples from various locations in the catchment area and periphery of project components shall be analyzed	Para 3.8 (EIA) Table 3.4 (EIA) Fig. 3.7 (EIA)
4.	Water Environment	
(i)	Study of regional hydrology	Para 4.1 and 4.2 (EIA)
(ii)	Possible siltation in the underground balancing reservoir and recommendation on appropriate watershed management practice	Para 4.3.2 and its sub-para (EIA)
(iii)	Prediction of changes in water quality due to project including impact due to water diversion at trench weir sites, upstream and downstream of these site	Para 8.4 (EIA) Para 4.4 (EIA)

(iv)	Map showing the distance of affected stretches of stream from diversion point to the point of their confluence with river Satluj.	Figure 4.1 (EIA) Figure 4.2 (EIA) Para 4.2.2 (EIA) Para 4.2.3 (EIA)
(v)	Environmental flow requirement to be established with details of streams joining the affected **ren..**	Para 4.4 (EIA) Fig 4.1 & 4.2 (EIA)
(vi)	All major water sources in the diversion and surrounding areas to be identified. Current and future water use for irrigation, industrial and domestic activities etc. will be established	Para 4.4 (EIA) Table 4.5 & 4.6 (EIA)
(vii)	The quality of surface and ground water in the project area will be established with respect to physico chemical characteristics and major sources of pollution will also be identified.	Para 4.5 (EIA) Table 4.8 & 4.9 (EIA)
(viii)	The historical data on monthly water discharge and lean season flow of river at trench weir sites will be provided	Para 4.3 (EIA) Table 4.3 & 4.4 (EIA) Figure 4.4 through 4.7 (EIA) Table 4.7 (EIA)
(ix)	Current rate of sedimentation and rate of sedimentation expected of the implementation of CAT plan	Para 4.3.2
5.	Meteorology	
	Climatological conditions of the site will be described with respect to wind speed and direction, temperature, humidity and rainfall	Para 3.2 (EIA) and its sub-paras
6.	Air Quality	
	Ambient air quality near major construction sites will be established with respect to SO_2, NOx, SPM and RPM	Para 5.2 (EIA) Table 5.3 through 5.9 (EIA)
7.	Noise Environment	
	Noise monitoring at a maximum of 5 locations near major construction sites will be undertaken during the two proposed seasons of further studies	Para 5.3 (EIA) Table 5.11 & 5.12 (EIA)
8.	Biological Environment Terrestrial Ecology	
(i)	Collection of information on flora and fauna including rare and endangered species	
(ii)	Identification of forests type and density in catchment and project area, bio-diversity and importance value index of the dominant vegetation	
(iii)	Collection of data on wildlife (including Avifauna) feeding area in catchment and project area	
(iv)	Prediction of impact on forest due to water diversion assessment of changes in flora in the project area	
(v)	Flora and fauna will be listed under various threat categories	
(vi)	Impact of project of flora and fauna will be established in the EIA	
(vii)	Map of the project area will be provided vis-à-vis the Lippa-Asrang Wild Life Sanctuary and EMP would include a management plan for wildlife also	

9.	Aquatic Ecology	
(i)	Assessment of biotic resources with special reference to primary productivity, zooplankton, benthos and fishes in impact area	
(ii)	Identification of fish habitats, monitoring of resident and migratory fishes	
(iii)	Population densities and diversities of phytoplankton, zooplankton and fish be estimated	
(iv)	The aquatic ecosystem be discussed with respect to phytoplankton, zooplankton, macro-invertibrates, fishes and their breeding habitats for time and locations	
(v)	Rare and endangered species be identified and discussed	
10.	Socio-Economic and Cultural Environment	
(i)	Demographic and socio-economic characteristics of human settlements in the project area be established with respect to population, number of houses, gender ratio, educational pattern, religious beliefs, family structure, occupational pattern, sources of livelihood, economic opportunities	
(ii)	Identification of the approximate number of homesteads and project affected families due to land acquisition for the project. The perception of the local population, NGOs and the project affected families about the project should also be determined through survey	
(iii)	Assessment of information relating to tourism, monuments/ sites of cultural, historical, religious, archaeological or recreational importance	Para 3.13 (EIA)
(iv)	Prediction of disruption in social life due to relocation of human settlements, roads and assessment of rehabilitation requirements	
(v)	Prediction of anticipated health problems due to vector borne diseases induced by water impoundment	Para 9.2 (EMP)
(vi)	Prediction of health problems related to changes in population density and distribution of immigrant construction workers	Para 9.2 (EMP)
11.	Public Health	
	Baseline health status and disease pattern will be established through socio-economic survey as well as government hospital records. Any specific environmental parameters responsible for deteriorating health of the population shall be indicated	Para 9.1 and 9.2 (EMP) Table 9.2 (EMP)
12.	Impact Assessment	
	The impact on each discipline of environment due to construction and operation of the project be identified and assessed quantitatively, as far as possible. The impact will include both positive and negative impacts and the discipline which require mitigation measures should be specified. Both the short term and long term impacts on sensitive areas, if any, such as habitat of endangered species of wildlife or plants, sites/ monuments and cultural importance be established.	Chapter 8 (EIA)

13	Environmental Management Plan	
	Management plan should be formulated to minimize potential adverse environmental impacts. The key components of the EMP may have following activities / sub plans.	
(i)	Inventorization of water sources in the project area for baseline and comparison for changes if any due to project activities	Para 8.2.5 (EIA)
(ii)	Inventorization of buildings in the project area for the same reason as above	Para 8.2.2. (EIA)
(iii)	Development of green belt and afforestation around the project components	Chapter 4 (EMP)
(iv)	Sewage disposal / management measures	DPR and Chapter II (EMP)
(v)	Management of MSW	Chapter 11 (EMP)
(vi)	Wild life management plan / ecological conservation and management plan	Chapter 5 (EMP)
(vii)	Catchment area treatment plan by identifying critically and severely degraded areas in the catchment	Chapter 1 (EMP)
(viii)	Muck management plan	Chapter 6 (EMP)
(ix)	Compensatory afforestation	Chapter 3 (EMP)
(x)	Quarry and mining area reclamation / rehabilitation plan	Chapter 7 (EMP)
(xi)	Green belt development	Chapter 4 (EMP)
(x)	R & R Plan as per National Rehabilitation Policy, 2007.	Chapter 2 (EMP)
(xi)	Human health management	Chapter 9 (EMP)
(xii)	Disaster management plan	Chapter 13 (EMP)
(xiii)	Post study monitoring plan	Chapter 14 (EMP)

1.8 CDM Initiatives

The total installed capacity of all the four stages of the Integrated Kashang HEP is 243 MW and it would generate 1659 Gwh energy annually on 90% dependability. In no hydro power project scenario, in order to generate this power by thermal power plant, considering specific fuel (coal) consumption as 1.06 kg/KWh, about 1.76 million tones of coal would be required annually. Thus with the implementation of Integrated Kashang HEP a saving of equal amount of coal i.e. 1.76 million tones/year shall accrue which implies a direct benefit to the tune of Rs. 5280 million per year assuming the rate of coal of plant of Rs. 300/ton. In addition to this, there shall be reduction in Greenhouse Gas (Carbon dioxide) emission, if a thermal power plant were established. The emission of carbon dioxide depends on quality of coal, combustion characteristics and excess air available in the combustion. Assuming about 997 gm/KWh emission factor for CO_2 genration (based on CPCB Study) about 1.65 million tones of CO_2 will be emitted from 243 MW coal fired thermal power plant for generating 1659 Gwh power.

Thus with the implementation of the proposed HEP equal amount of carbon emission will be eliminated. Besides this the pollution load caused by other major pollutants like NOx and SO_2 shall be reduced annually to the tune of 450 tons and 6500 tons respectively. Thus in consonance with the stipulation of the Himachal Pradesh Hydro-power Policy, 2006, the project will help in reduction of emission of "Green House Gases" and thus qualify for carbon credits at the global carbon market run under the UN Framework Convention on Climate Changes, known as the Clean Development Mechanism Sale of such equivalent carbon credits by the project proponent on account of development of project shall be through competitive process in order to derive maximum benefits

CHAPTER 2

METHODOLOGY

2.1 INTRODUCTION

The EIA study includes the study of various baseline parameters of environment viz. land, water, air, noise, flora, fauna and socio-economics. Integration of these parameters gives an overall perception of positive and negative impacts due to construction of a hydroelectric project, if any. For overall prediction of impacts, the Study Area was considered 10 km radius from center of K-K link tunnel integrating Stage-I with Stage-II & III and covering all consequential project component viz. intake structures of Stage-I (Dolo Dogri), Stage-II (Lappo), Stage-IV (Tortu), underground power houses of Stage-I and Stage-IV and TRT discharging into river Satluj along with free drainage catchment of Kashang and Kerang Khads above the trench weir sites. It is worth mentioning here that the Stage-I, Stage-II & IV of the integrated project, are the only HEP in Kashang and Kerang Khad respectively and there is no other HEP in the downstream or upstream reach of Stage-I and IV intake points except for Stage IV which is also a part of integrated scheme. There is also no submergence area in view of diversion of flow through vertical drop trench weirs. In view of baseline studies already made with respect to EIA studies earlier carried out and with respect to which (Stage-I) clearance was accorded on 15-11-2002, further baseline study was carried out for winter and pre-monsoon seasons during March 2008 to July 2008 as contained in para 4.1 of the TOR set out by the MoEF vide letter No. J-12011/81/2007-1A.1 dated 12-12-2007.

2.2 PHYSICAL ENVIRONMENT STUDY

The Digital Satellite data IRS P6 LISS-III (Gen:22 November 2007, Path 96, Row 48) was acquired from NRSA and evaluated on ERDAS Imagine Software. The standard False Colour Composite (FCC) was generated by assigning blue, green and red colours to visible green, visible red and near infrared bands respectively. Expressing image pixel addresses in terms of a map coordinate base is often referred to as geo-coding. As various thematic layers were to be overlaid for this project, all the layers were geo-referenced to real world coordinates. The 1:50,000 scale toposheets (53 I/1, I/2, I/5 and I/6) of the free/directly draining catchment area were used for the purpose of geo-referencing. A large number of GCPs were selected for reasonably accurate geo-referencing/geo-coding. A map projection system (real world) was also defined.

Histogram of the scene under study has been generated to check the range of special values present in the scene. In order to use total grey level range and to optimize the contrast, the actual grey level ranges of three bands were linearly stretched independently. The zoomed images were studied wherever necessary. The interpretation key necessary for identifying different features has been developed systematically on the basis of image characteristics and associated elements viz. shape, size, shadow, pattern, color/tone, texture, association, location and available ground truth. Among these characteristics shape, size, shadow and pattern and basically dependent on the scale of the image whereas the color/tone and texture depend upon the brightness, contrast and resolution of the image. Various land units were identified, delineated and the map was validated.

Detailed field survey was conducted for study of soil characteristics of erosion prone areas and landslides in the catchment area. The vulnerable and problematic areas were identified in different physiographic zones in the entire catchment area. The data was generated on physiography, landuse/landcover, lithology, structure, drainage pattern, slope characteristics, landslides/slips etc. These data sets were used for preparation of the thematic maps, calculation of sediment yield index and Erosion Intensity Units in the catchment area according to the following procedures.

2.2.1 Landuse – Landcover Classification

- Prior to ground truthing, the satellite data was classified using unsupervised classification technique. Further after collecting ground truth details maximum likelihood classification based on supervised classification method was used with remote sensing image data.

- After the supervised classification procedure, a landuse map was prepared which the team at field verified, and errors or omissions were identified.

- A reclassification of the landuse categories implementing the details and corrections, if any, was done. The reclassification output was used for the preparation of the final landuse classification map. This map after due verification was then composed and printed, as desired.

2.2.2 Slope

- Slope is a measure of change in the value of altitudes over distance, which can be expressed in degrees or as a percent .The first step in generation of slope map is to create surface using the elevation values stored in the form of contours or points. Surface is a representation of geographic information as a set of continuous data in which the map features are not spatially discrete, i.e., between any two locations, there are no clear or well defined breaks between possible values of the map features. Models built from regularly or irregularly spaced sample points on the surface can represent the surface.

- Slope map of the study area was prepared using the elevation information for the area from contour heights. Toposheets of the scale 1:50,000 were collected for the entire free/directly draining catchment area. These toposheets were then manually pasted together to form a seamless mosaic of the area and the catchment boundary for the proposed project was marked on them.

- After marking the study area, all the contours on the toposheet were digitized. The output of the digitization procedure was the contours as well as points contours in the form of x, y and z points (x, y location and their elevation). All this information was in real world coordinates (latitude, longitude and height in meter above sea level).

- A Digital Terrain Model (DTM) of the area was then prepared, which was used to derive a slope map. The slope was divided in classes of slope percentages.

2.2.3 Soil

- Based on a 3-tier approach (Landform analysis, field survey and laboratory investigation) soil resource map of study area has been prepared.

- The results were superimposed with the soil map of Himachal Pradesh (Regional) prepared by National Bureau of Soil Survey and Landuse Planning (NBSS and LUP), Nagpur.

- The taxonomy of soils are used as per USDA system of soil classification.

- The soil map as prepared was then brought into GIS environment and used along with ERDAS Imagine Software as base map of further analysis.

2.3 AIR, NOISE AND WATER ENVIRONMENT STUDY

2.3.1 Air Quality Assessment

The number of sampling at each station was done for two consecutive days. The baseline data of ambient air environment is generated for the mentioned parameters as given below.

1. Suspended Particulate Matter (SPM)
2. Respirable Suspended Particulate Matter (RSPM)
3. Sulphur dioxide (SO2)
4. Nitrogen oxide (NOx)

Methodology (Air Monitoring)

The air pollution analysis techniques include the evaluation of the following:

1. Suspended Particulate Matter (SPM) and RSPM
2. Sulphur dioxide (SO_2)
3. Nitrogen oxide (NO_2)

In regard to the techniques for collection of sample of particulate matter, the "Respirable Dust Sampler Envirotech Model APM 460 BL" was used for air monitoring. The dust particulate matter was collected on filter paper (size GF/A20.3x25.4 cm) and dust cup and the gaseous pollutants were collected simultaneously by a known volume of air through a number of bubblers of different flow rate through appropriate solution for absorbing different gases. The collected sample when analyzed according to standard method for different pollutants for samples in air was collected in glass impinges by displacement of distilled water.

Theory of Respirable Dust Sampler (RDS)

The principle involved in Suspended Particulate Matter (SPM) sampling method is that the particles are filtered from known volume of an air sample by a suction apparatus and the particle are deposited on a filter paper. Generally the gaseous pollutants in air are made to react with liquid absorbing media at atmospheric temperature and pressure when air is bubbled through the absorbing solution in the impinger. RD sampler measures only the concentration of SPM and Gases in the ambient air.

Calculation

For particulate matter

SPM or RSPM ($\mu g/m^3$) weight of filter paper after sampling – initial weight of filter paper x 10% volume of air.

For gaseous pollutants

SO_2 ($\mu g/m^3$) = (A – A0 x 103) x B / Va x Volume of sample

Where, A = Sample Absorbance, A0 = Reagent blank Absorbance and Va = Volume of Air Sample in liters.

2.3.2 Sound Level Measurement

The sound level was measured by sound level meter RS 232 (digital Instrument). It consists of the following major section.

1. The Sensor or Microphone

The sensor is a high precision electrode condenser microphone, which must be protected from physical abuse, dirt, oil, water or ingress of any such substance.

2. The Control Panel

The control panel comprises of the:-

1. Recorder for the maximum level of sound and minimum level of sound
2. Range selector
3. Auto and manual rest switches
4. Hold on max and min level

3. The Range Selector

These switches can be used for selecting the relevant range of the sound level.

Methodology

The calibrated and charged sound level meter is adjusted for slow time response. The sound level was measured at different sites and maximum and minimum level of sound was recorded for the particular site and then average was calculated which gave the final readings. Readings were taken in each division of north, south, east and west around each source and at various distances and the maximum minimum for particular hours were recorded.

Sources

The major sources of air pollutants in the project area are vehicular traffic, blasting (during road construction at present), dust arising from local and village road, forest fire and domestic fuel burning.

2.3.3 Water Quality Assessment

The baseline data for water quality assessment was done based on the parameters given below.

1. General survey of the Kashang and Kerang khads 1 km upstream of proposed weir sites up to confluence with river Sutlej.
2. Selection of spots for water sampling and collection of aquatic organisms.
3. Distribution and population density of macro-zoo benthos in Kashang and Kerang khads.

4. Periodical monitoring of physical, chemical and biological characteristics of river water.
5. Estimation of coliform (MPN) and E. Coli organisms in river water.
6. Importance of water quality on existing aquatic fauna in mountain rivers.

2.3.3.1 Water Quality Analysis

Eight sites were selected for water sampling and collection of aquatic organism. The selection of sites was done considering the location of different project components, junction of streams and river course, spots of high water velocity and some of the stagnated pools along with the areas having human interference. The sampling was carried out for two seasons keeping the frequency of observation once in 30 days time. The limnological parameters were recorded mainly following the standard methods described by Welch (1948), CSIR (1974). Mackereth *et.al.* (1978) and APHA, AWWA, WPCF (1995) as following:

Parameters Instrumentation

Ambient temperature	: Digithermometer (stainless steel sensor probe)
Transparency	: Seehi dise method (Weleh 1948)
Water velocity	: EMCON digi current meter
Turbidity	: Nephelometer
Total Dissolved Solids	: Titration method
pH	: Digi pH meter (HANNA)
Alkalinity, Acidity, Chlorides, Silicates, DO, Free CO2, Zn, Si, Fe and Nutrients (Phosphorus, Sulphates)	: Aquamerck / Aquaquant kits
Total Ca and Mg Hardness – EDTA	: Titrametric methods (Natrajan and Jhingran 1988)
Inorganic phosphates	: Colorimetric Methods
BOD	: Titration
E-Coli and Total Coliform	: Macconkey broth

2.3.3.2 Aquatic Environment

Data on existing aquatic environmental conditions in and around proposed project has been generated as per following:

- Biological characteristics of river water.
- Inventorization of phytobenthos and Zoobenthos
- Estimation of coliform organisms.
- Present status of riverine fish fauna: Identification of obligate fish species.
- Their Migratory pattern, diseases, feeding and breeding grounds.

Evaluation of Phytobenthos

Samples of periphyton were obtained by scraping off 3 cm^2 area of the boulders and preserving it in 1 ml of Lugol's solution. The upper surface of boulders was scraped with the help of sharp razor. Three replicates were obtained and integrated. Thus the total area sampled amounted to 9 cm^2. Sedgewick-Rafter cell counts (APHA 1992) were made and density was recorded as cell m m^2. For qualitative studies the keys of Trivedy and Goel (1984) and Ward and Whipple (1959) were being used for identifying the filametous and non-filamentous algae.

However, for identifying diatoms, permanent mounts were prepared and identified. For computing abundance (as %) 300-400 diatom cells were identified in each sample (with BX-40).

Evaluation of Benthic Macro-Invertebrates

Benthic macro-invertebrates were collected from the designated sampling sites in river Kashang and Kerang using surber's square foot sampler (Welch, 1948) adopting random sampling device. All collected specimens were preserved in 8% formalin solution and identified upto the generic level with the aid of keys given by Usinger (1950), Ward and Whipple (1959), Needham and Needham (1962), Macan (1979), Tonapi (1980) and Edington and Hildrew (1995). The density of benthic macroinvertebrates was expressed as unit per meter square (unit/m2).

Benthic macroinvertebrates were sampled from an area of one ft^2. All the stones of the area were collected in a bucket with as little disturbance as possible and washed thoroughly. Three replicates were obtained and integrated. The sampleswere sieved and preserved in 70% alcohol for further analysis. The benthic macroinverterbrates could be identified upto order/family/genus level with the help of keys given by Edmondson (1959) and Pennak (1953). Counts of the identified organisms were made in each sample and density was recorded as individual's m-2. The spatial variations in community structure were recorded by computing percentage abundance.

Evaluation of Total Coliform

To assess the quality of water in terms of pathogenic and parasitic organisms, the use of indicator system has been thought to be best method. The coliform organisms are considered to be the best indicators of pathogenic organisms. The standard test for the estimation of number of coliform group had been carried out generally by multiple tube dilution technique which gave most probable number (MPN) of bacteria. A selective medium was used to develop only coliform bacteria. Coliform ferments lactose and produce acid and gas which could be detected by uplifting of Durham's tube by vision. MPN was not an actual enumeration of coliform bacteria but merely an index of the probable.

Culture Media

A. Mac Conkey Broth : For Presumptive Test of Coliform

Peptone 20 g.
Lactose 10 g.
Sodium chloride 5 g.
Bile salt 5 g. (may be replaced by sodium taurocholate or sodium taurogly – chocholate)
Distilled water 1000 ml.

B. EC Medium: This medium is used for the test of presence of coliform group of fecal origin.

Tryptose or trypton	: 20 g.
Lactose	: 5 g.
Bile salt mixture	: 1.5 g.
Bile salt No. 3	
Dipotassium hydrogenphosphate	: 4 g. KH2PO4
Potassium dihydrogen phosphate	: 1.5 g. KH2PO4
Sodium chloride	: 5 g.
Distilled water	: 1 lit.

C. Buffered Dilution Water: To prepare stock phosphate buffer solution 34 g of potassium dihydrogen phosphate is to be dissolved in 500 ml distilled water at pH 7.2 with 1N NaOH and be diluted in 1 lit with distilled water. 1.25 ml stock phosphate buffer solution will be added to 1 lit distilled water. Dispense in amounts that will provide 9 ml in 150 x 25 mm test tubes sterilized autoclave at 121 °C for 15 min.

Calculation: Coliform density was determined by using a standard MPN Table. The density was given against various +ve tube combinations. Expression of Results: It was convenient to express the results of the examination of replicate tubes and dilution in terms of the Most Probable Number (MPN). In usual practice the results were expressed in terms of MPN index/100 ml of various combinations of +ve and -ve results generally given in most of the microbiological manuals.

Fecal Coliform (MPN) procedure: For separation of coliform organisms of fecal origin from that of non fecal, elevated temperature tests had been used. Gas formation in subculture of the +ve tubes from presumptive tests of coliform in EC medium at 44.5 ±0.2 0C for 24 hrs gave the + ve test of fecal coliform.

<u>Total Count:</u> Total bacterial count is indicative of the presence of chemosynthetic heterotrophic group of bacteria (Exotic) and is often performed in conjunction with total coliform (MPN) in waters. The test is not differential between pathogens and indicator organisms but is considered affirmative to population.

Total count was often performed to assess:

1. Progress of self-purification in rivers, ponds and lakes in time and space.
2. Efficiency of bacterial removal during storage and treatment processes.
3. Ascertaining quality in general.

Culture Media
Nutrient Agar
Beef extract 3 g.
Peptone 5 g.
Agar 15 g.

2.4 BIOLOGICAL ENVIRONMENT

2.4.1 Floral Study

The present report on the plants of project area is based on extensive field survey of the area. The seasonal study has been conducted between February 2008 to July 2008, for two different seasons covering winter and pre-monsoon season. The plant species were identified with the help of Botany Division, FRI, Dehradun.

Besides the collection of plant species, information was also collected on the vernacular names and uses of plants made by local inhabitants.

2.4.1.1 Phytosociology

A nested quadrates technique was used for sampling the vegetation. The size and number of quadrates needed were determined using the species area curve (Mishra, 1968) and the running mean method (Kershaw, 1973). Summarization of previously used methods and recommendations led to the use of more than often (10 x10 m) quadrates laid out for sampling the tree stratum and 1x1m quadrates for herbs, grasses and seedlings of tree species less than 1.3 cm dbh (diameter at breast height) at different altitudinal gradients using GPS. However, for examining the shrub species 3x3m sample plots were laid out. The enumeration of the vegetation in each of the quadrate was done by measuring dbh individually in case of woody vegetation and collar diameter in case of herbs and grasses, with the help of tree caliper and electronic digital caliper. In case of grasses and sedges, each erect shoot is considered to a plant tiller and the enumeration was done by laying 1x1m quadrates at random, further subdivided into 10x10 cm segments.

Four such segments selected at random were analyzed from each quadrate by counting the tillers individually. The method used was that of Singh and Yadava (1974).

The vegetation data collected for phytosociological information was quantitatively analyzed for density, frequency and abundance according to Curtis and McIntosh (1950). The relative values of frequency, density and dominance of all the species were summed up to represent Importance Value Index (IVI). The following are the formulae to derive frequency, density, dominance, IVI etc.

$$\text{Frequency} = \frac{\text{Total number of quadrats in which species occurred}}{\text{Total number of quadrats studied}}$$

$$\text{Abundance} = \frac{\text{Total number of individuals of species in all quadrats}}{\text{Total number of quadrats in which species occurred}}$$

$$\text{Density} = \frac{\text{Total number of individuals of a species}}{\text{Total number of quadrats studied}}$$

IVI = Relative frequency + Relative dominance (basal area) + Relative density

$$\text{Relative Frequency} = \frac{\text{Frequency of the species}}{\text{Total frequency of all species}} \times 100$$

$$\text{Relative Density} = \frac{\text{Density of the species}}{\text{Total density of all species}} \times 100$$

$$\text{Relative Dominance} = \frac{\text{Dominance of the species}}{\text{Total dominance of all species}} \times 100$$

$$\text{Relative Abundance} = \frac{\text{Abundance of the species}}{\text{Total abundance of all species}} \times 100$$

2.4.1.2 Diversity of The Forest Vegetation

The tree species diversity for each stand in different forest types was determined using Shannon Wiener information function (Shannon and Wiener, 1963), which is:

$$H = -\sum_{i=1}^{s} (Ni/N) \ln (Ni/N)$$

Where, Ni is the total number of individuals of species i and N is the total number of all species in a stand.

2.4.1.3 Concentration of dominance

Concentration of dominance (Cd) was measured by Simpson Index (Simpson, 1949):

s

$$C = \sum_{i=1} (Ni/N)^2$$

Where, Ni and N were the same as for Shannon Wiener information function. This index ranges from one, if all the individuals belong to one species, to (1/s) if they are equally divided among species (S).

2.4.2 Faunal Study

Ground surveys were carried out by trekking the impact zone for identification of important animal groups such as butterflies (insects), birds, mammals, reptiles, and some fishes inhabiting the area, along the riverbanks, adjoining forest on the slopes, nallahs, hill top and agricultural fields.

- For sampling butterflies the standard 'Pollard Walk' methodology was used by recording all the species that were encountered while trekking along the foot trails between these two sites, daily. Voucher specimens of species were collected by means of a butterfly net for only those species that could not identified in the field besides photographing them for the same purpose. Sampling was done for 1 hour in a stretch on each transect (n = 4).
- For sampling birds 'point sampling' along the fixed transects (foot trails) was carried out to record all the species of birds observed with the help of binoculars; field guides and photography for 1 hour on each transect (n=4).
- For sampling mammals, 'direct count on open width (20m) transect' was used on the same transects (n=4) for 1 hour in each transect. Besides, information on recent sightings/records of mammals by the villagers and locals was also collected from these areas.
- 'Reptiles' mainly lizards were sampled by 'direct count on open width transects' (n = 4) for 1 hour in each transect.
- Seasonal variation in species diversity of different groups of animals (butterflies and birds) were evaluated using Shannon-diversity Index (***H'***) to know the season of peak diversity in the area amongst the two seasons i.e. winter and pre-monsoon studied.

  $H' = -\Sigma N$
  1 Pi In Pi

  (from species 1 to n; n= total number of species)
  Where **Pi** is the proportion of the individual species in the total population.

2.4.2.1 Aquatic Fauna

Evaluation of Aquatic Fauna

An extensive survey of Kashang and Kerang khads 1 km upstream of trench weir and up to confluence with river Satluj was made during February 2008 to July 2008 in two seasons, with the intention to examine aquatic animal species such as fishes, insects, arthropods, amphibians, snakes, water-birds, otters etc.

2.5 SOCIOECONOMIC STUDY

The data on socio economic and dependency aspects were collected in two stages. The first stage involved a rapid assessment of the study area in order to obtain an overall perspective of the villages that were located in the project area. The second stage of data collection was done in the villages which are going to be directly affected by acquisition of land for construction of project. A sampling frame for survey area was initially devised and as per this the villages going to be affected due to project construction were surveyed. These villages fall in District Kinnaur. Data collection from secondary sources has also been made to validate some of the information and to supplement the data on demographic aspects.

Secondary information was collected from different government and non government offices. The data collected mainly was of secondary nature and involved information regarding access to facilities such as PHC's, schools, bus services, LPG distribution centers, type of roads, livestock information, land utilization, demographic profile of the villages, location and distribution of villages with respect to Project.

2.5.1 Socioeconomic survey of project affected villages

Based on the formats devised for conducting socioeconomic survey information on socioeconomics of the affected families was collected by undertaking door to door survey. In his regard three types of questionnaire were devised (Annexure 9- 11), as per the following details:

- Close-ended structured questionnaire for Rapid village survey
- Close-ended structured questionnaire for household survey
- Close and open ended questionnaire for psychology/attitude evaluation.

Under the rapid village survey studies information on overall demography, infrastructure, availability of natural resources, livestock status etc. were evaluated by analyzing the records of village panchayats and from the local villagers. This study has provided a definite insight in analyzing the overall socioeconomic status of the villages.

While conducting the household survey the population of affected families was interviewed by conducting door to door survey to collect information on:

demographic structure of the households (information on family size, age and sex of the family members), number of people in working age group (18 to 60 years), division of labour, level of literacy, occupation, size of land holding, livestock holding and crops grown. In addition to this dependency of the families on forests for fuel wood, timber, fodder etc., and, loss to movable-immovable assets were also collected. Data were collected on quantity of fuel wood, timber and types of Non Timber Forest Produces (NTFP) collected, consumed and sold each year and its contribution to the family's annual income.

In order to gather information on public perception of the proposed project the attitude/psychology survey was carried out which depicts the prevailing awareness and acceptance/no-acceptance about the project. Total number of families fully or partially affected by the project, approached for collecting socioeconomic data. All the families present in the villages during the study period were interviewed and based on the availability, information on families those had migrated to other places were collected from their relatives and neighbors.

Data Analysis
SPSS 11.5 software was used for data processing. Descriptive statistics (frequency, percentages) were used to summarize the data.

2.6 SECONDARY SOURCES OF DATA

Metrological department	: Climatic data
Survey of India	: Topo sheet
National Remote Sensing Agency	: Satellite Data
Forest Survey of India	: Forest cover
Botanical Survey of India	: Floral characteristics/vegetation of Kashang Valley
Zoological Survey of India	: Distribution of fauna in Kashang valley and identification key.
Revenue Department	: Land data / population statistics

CHAPTER-3

PHYSICAL ENVIRONMENT

3.1 INTRODUCTION

The Integrated Kashang Hydroelectric Project (243 MW) has been conceptualized for harnessing waters of Kashang and Kerang streams, the right bank tributaries of River Satluj. Topographic and geological features between Kerang and Kashang valleys, which are contiguous, are conducive to diversion of Kerang Khad having higher inflows than Kashang, into Kasahang underground water conductor system for significant augmentation of generating capacity at an underground power house located on the right bank of Satluj near Powari village, developing a head of approximately 830 m. The integrated Kashang HEP encompasses four distinct stages of development viz. Stage I, II, III & IV, the first three being closely interlinked in terms of component configuration and their connectivity whereas Stage-IV is an absolute scheme harnessing the power potential of Kerang stream upstream of the diversion site of Stage-II. Therefore, the catchment area of Kashang Khad upto Stage-I trench weir and Kerang stream up to Stage-II trench weir site, measuring 124.03 sq. km. and 400.04 sq. km. and also the area covered within the 10 km radius circle from the mid of integrating link tunnel covering all components of project constitute the study area for evaluating the land environment which was assessed in the light of its climate, basin characteristics, topography, slopes, geology, seismicity, soil, sedimentation and land use/land cover etc.

3.2 CLIMATE

The study area falls in temperate climate zone having winters from November to April and summer from May to October. It is typical of the Himalayan range to have strong variations with elevation exposure to the sun and shelter effect from bordering ranges. The winter season is a little extended by virtue of elevation of the area. The summer season includes the rainy season. The bulk of annual precipitation falls from late June to late September, with moisture originating from the Bay of Bengal. Some precipitation originating from the West occurs during the dry season. At the diversion sites of the project, where elevation is near 3000 m, dry season temperatures are close to or below freezing point and precipitation occurs as snow from December to early March. At the power house site near Powari, where the elevation is close to 2000 m ±, freezing temperature and snowfall rarely occur. The higher parts of the study area remain snow covered long into the summer months and areas above 4200 m are permanently covered by glaciers.

Once pollutants are discharged in the atmosphere, the meteorological factors play an important role in transport, dispersion and diffusion with the environment. Since these factors show wide fluctuations with time, it felt necessary and desirable as part of this EIA study, to collect meteorological data during 2007-2008 at nearest IMD station viz. Kalpa which is the nearest observatory to the project site. The climatological data is presented in **Table 3.1**. The principal determinants of weather and climatic conditions in the region include:-

1. Altitude and its physiographic completing.
2. Direction of the ridges and location on the windward and leeward sides.
3. Degree of slope and its aspect
4. Intensity of forest cover and
5. Proximity to water bodies and glaciers.

Table 3.1: Average Air Temperature, Rainfall, Relative Humidity and Mean Wind Speed data of IMD Kalpa for the period 2007-2008

Month	Air Temperature Average		Relative Humidity		Mean wind Speed	Prevailing Wind Direction
	Highest in the month	Lowest in the month	Average (at 8:30)	Average (at 17:30)	Average	
	ºC	ºC	%	%	Kmph	
JAN	10.4	-13.2	76.29	67.61	3.20	NE
FEB	13.0	-10.0	61.92	56.01	4.20	NE
MAR	17.4	-2.8	43.06	35.83	4.30	NW
APR	22.0	-1.8	52.73	43.96	4.50	NE
MAY	25.2	2.1	54.48	51.29	3.70	NE
JUN	27.3	5.0	67.36	50.66	4.40	SW
JUL	26.0	8.9	87.83	69.77	2.70	SW
AUG	25.0	9.1	88.96	74.03	1.30	SW
SEP	26.0	4.0	78.16	67.35	1.20	SE
OCT	22.0	0.0	52.25	46.35	1.03	SE
NOV	20.0	-2.0	42.40	33.06	2.60	NE
DEC	13.6	-8.6	64.35	43.51	3.20	NW

3.2.1 Precipitation

The climate of Satluj valley shows a gradual alteration from the heavy monsoon of the outer Himalayas to the arid Tibetan type with a winter snowfall and practically no summer rains. The monsoon clouds advancing from the plains of India are combed out by the outer ranges of the Himalayas, where most of the monsoon rains occur, so that inner valleys though get a good deal of cloud but no steady precipitation. The snowfall is also heavier in the Himalayas than it is on the Tibetan plateau, but the zone of heavy snowfall includes the whole of Kinnaur district and it is only beyond the Tibetan border and up in Spiti valley that the snowfall shows any marked decline. Precipitation in the catchment of Kashang and Kerang rivulets occurs mostly in the form of snow which can be described as moderate to heavy depending upon the altitude. Average annual precipitation is of the order of 350-450 mm. The precipitation data observed at Meteorological Observatory at Kalpa (El. 2770 m.) and shown in **Table 3.2** reveals that annual average rainfall at Kalpa is only 320 m, while annual average snowfall is approximately 437 cm. This trend of less rainfall and more snowfall only strengthens with increasing altitude. Accordingly, the trench weir sties of Stage-I, II and IV being at El. 2829 m., 2872 m. and 3155 m above msl respectively receive less rainfall and more snowfall in a year.

Table 3.2: Monthly and Annual Average Rainfall / Snowfall at Kalpa

Month	Rainfall, mm	Snowfall, cm
January	0	100
February	1	68
March	20	201
April	61	8
May	41	0
June	41	0
July	31	0
August	53	0
September	36	0
October	32	0
November	2	17
December	2	43
Total	**320**	**437**

3.2.2 Temperature

It is expected that the temperature will be further lowered at the trench weir sites due to higher altitudes viz. El 2820 m, 2872 m and 3155 m above msl for Stage-I, II and IV schemes respectively. The temperature falls below 0^0C during the cold season extending from November (-2^0C) to April (-1.8^0C) with the lowest recorded during the year in January (-13.2^0C). The maximum temperature during these months ranges between 10.4^0C and 22.0^0C. In the summer months, temperature is highest during June (27.3^0C) and minimum temperature is (2.1^0C).

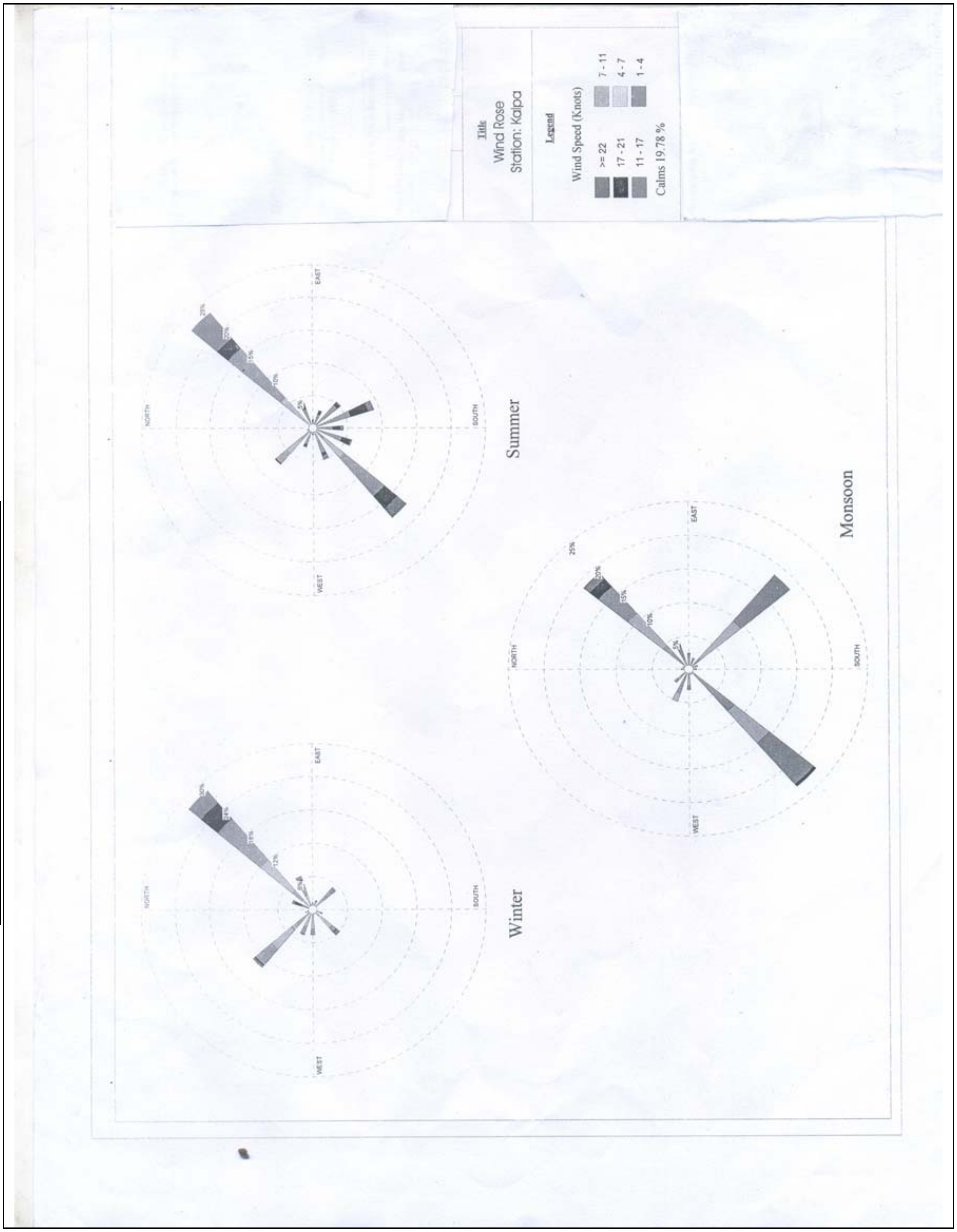
3.2.3 Relative Humidity

The monthly mean relative humidity data (0830 and 1730 hrs.) observed at IMD station Kalpa which is very near to the study area have already been depicted in **Table-3.1**. The data shows that relative humidity varies from 42.40 % to 88.96%. The month of March is observed to have the lowest humidity whereas the maximum humidity is observed during month of August.

3.2.4 Wind Speed / Direction

The nearest meteorological station to the project site where wind is recorded is at Kalpa. The predominant wind direction is mainly observed to be North-Easterly as is evident in the prepared wind rose diagram **Figure-3.1**. During clear weather i.e. in winter the winds are often found to be North-Westerly. However, the wind pattern in mountainous regions varies in different valleys owing to the topography of the land.

Figure-3.1: Wind Rose Diagram



3.3 PHYSIOGRAPHY

The district Kinnaur (H. P.), wherein the project lies, is located between latitudes 31^{0}05′50″ N to 32^{0}05′15″ N and longitude of 77^{0}00′45″ E to 79^{0}00′45″ E. The district is bounded by Tibet (China) to the east, district Shimla in the West and Southwest, State of Uttarakhand to the south, Lahul and Spiti district to the north and Kullu district in the north-western fringe. It has a total geographical area of 6401 sq. km. Satluj river divides the district into two parts. In its traverse the Sutluj river crosses three more or less parallel mountain ranges viz. Zasker Mountain. The Great Himalayas and the Dhauldhar ranges. Between three mountain ranges lie the subsidiary valleys of varying dimensions from the narrow glens and ravines of Tidong and Kerang streams to sizeable valleys of Spiti and Baspa rivers.

The significant tributary streams and rivers that flow into river Satluj from south or along its left bank are successively the Tidong, Hogis, Gymthing, Baspa, Duling, Sholding and Manglad etc. Likewise those entering from the north or its right bank are Spiti river, Ropa, Kerang, Kashang, Pangi, Choling, Bhabha, Sorang, Kut and Ganwi streams. Zasker range, height up to El. 7026 m. above msl, is the eastern most range of Himachal Pradesh and separates Spiti and Kinnaur from Tibet (China) and constitutes International Boundary between India and Tibet (China). The project area falls in Upper Himalayan zone. Kashang and Kerang streams are two right bank tributaries of Satluj river with catchment area aligned approximately North-West. The topography of the study area is of steep to extremely steep hills. Both of these are typically hilly rivulets mostly fed by snow melt from large glacial bodies present in substantially sizeable chunk of their catchment areas. These rivulet also have typical step pools bed configuration and have steep bed gradient with bed made up of big boulders and exposed bed rock at places and they flow in successive hydraulic falls with pool length varying from 5 to 20 meters and the height varying from 0.3 m to 3 m. There is glacial flow in the upper reaches of both streams. The valley slopes are prone to landslide at several places but are generally stable. At some location open mixed type forests / grassland pastures are also observed. The elevation of project site varies between El 3155 m (trench weir site of Stage-IV) at Toktu) and El. 2000 m above msl (power house site at Powari). The satellite imagery of sub watershed Kashang and Kerang showing the topography are presented in **Figure 3.2** and **Figure 3.3**. The digitized terrain map of the free draining catchment is depicted in **Figure-3.4**.

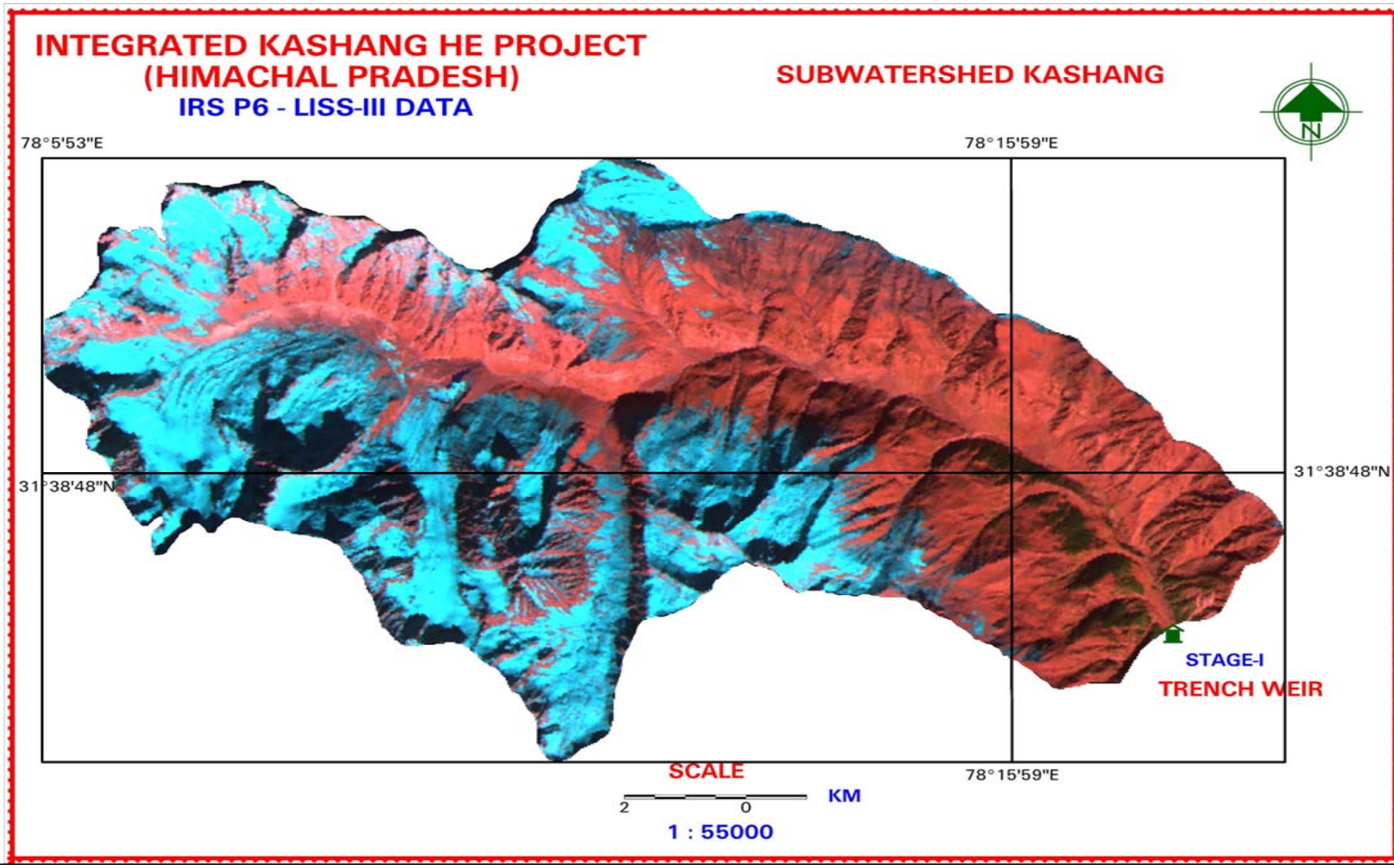


Figure 3.2: Satellite Imagery of Sub-watershed – kashang

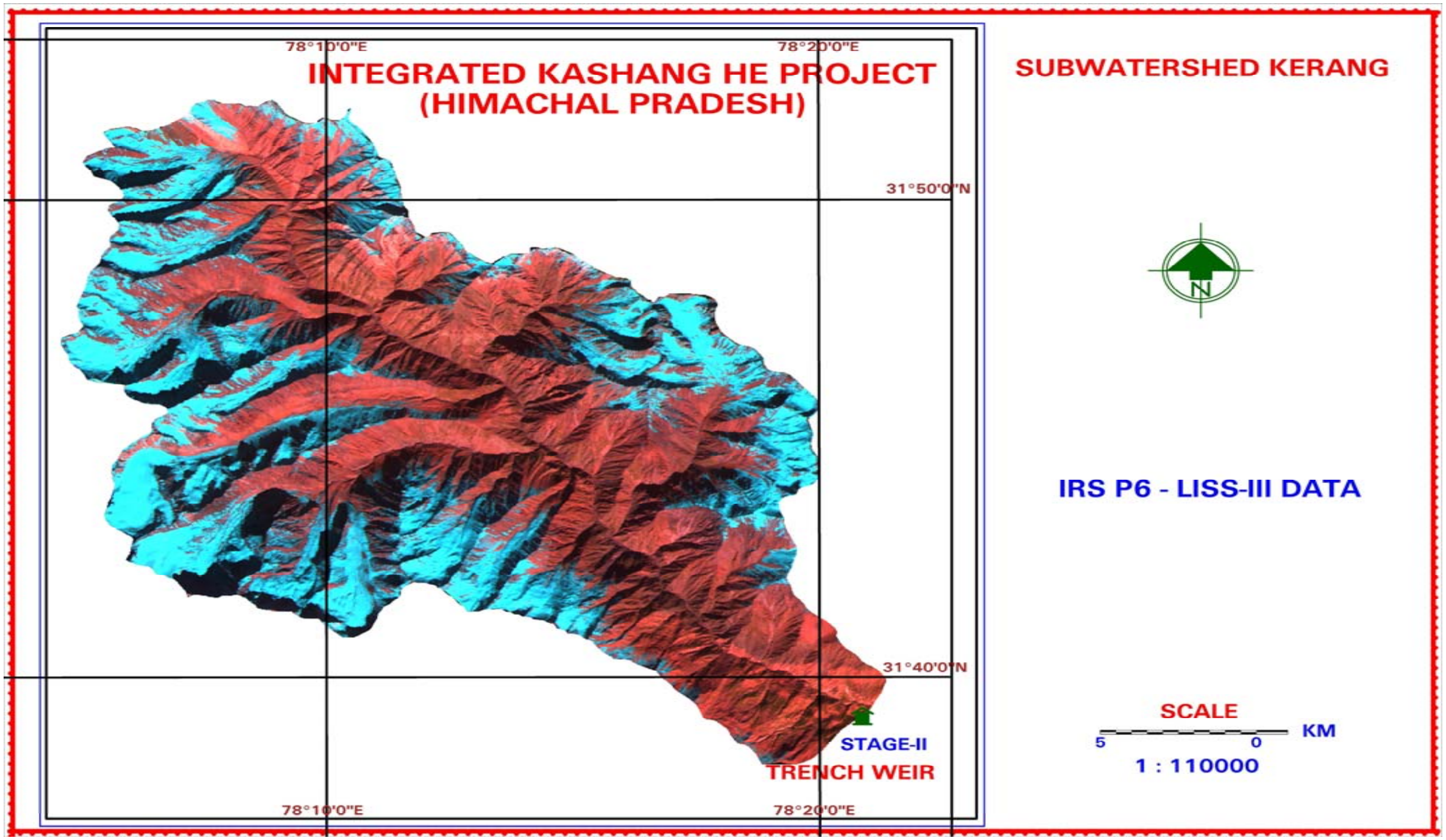


Figure 3.3: Satellite Imagery of Sub-watershed - kerang

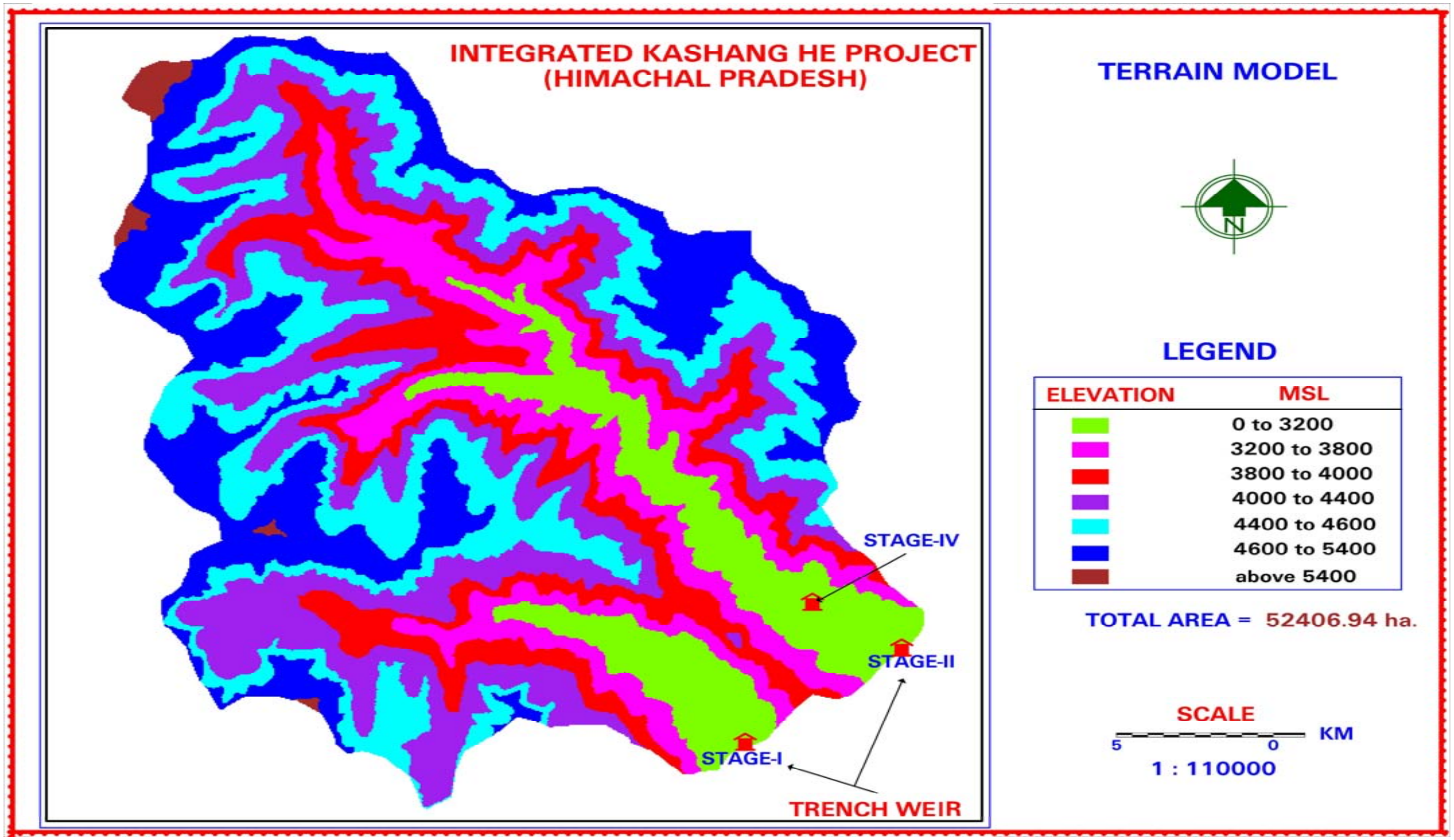


Figure-3.4: Digitized Terrain Map of Free Draining Catchment

3.4 REGIONAL GEOLOGY

The Integrated Kashang Hydroelectric Project (243 MW) is located in the Higher Himalayas. The area exposes high grade metamorphic rocks belonging to Vaikrita group of middle to late Proterozoic age consisting of felspathic gneiss, quartzite, high grade schist and migmatites. These rocks are exposed in an arcuate pattern and rest over Jutogh, Salkhala and Rampur group of rocks along Vaikrita thrust. The Jutogh group, Salkhala group and Rampur group have also thrusted contact. These rocks are intruded by Rakcham and Nako granites.

The litho-stratigraphic sequence of various rock formations of the project area, as exposed from east to west, is given in table and supplemented by data from other geological maps and publications. The formations are largely non-fossiliferous metasediments, as a result of which difficulty has been experienced in establishing chronological succession and correlation of various litho units, especially due to the presence of complex tectonic structures including large scale thrusting and long distance translation along thrust zones. Various proposals concerning order of superposition, including marking of various thrusts, have been put forward to suit a particular geological model. Sometimes, formations show a conformable sequence of rocks at the location of the thrust, with uniformity of strike and dip of formation. The thrust zones are normally associated with large scale sheared rocks which is not observed along Vaikrita thrust in the area.

Five thrusts namely Karcham, Salkhala, Jutogh, Vaikrita/Main Central Thrust (MCT) and the Tethian thrusts have been marked on the basis of regional geological mapping. The latter remains questionable, however it may extend across the Kerang-Kashang Link tunnel or otherwise bifurcate towards the east and daylight in the Kerang khad at the trench weir of Stage-II (Kerang-Kashang Link) Scheme.

Table-3.3: Geological Succession of Rocks from East to West in the Satluj Valley, Rampur-Kalpa Area

Formation	Lithology	Group
East		
Haimanta formation	Metamorphose Sandstone. Quartzite interbedded Biotite schist	Haimanta
Thethyan Thrust		
Shiasu	Sillimanite, kyanite bearing schist and gneiss, calc silicate and migmatites (central crystallines)	Vaikrita
Morang		
Kharo		
MCT/Vaikrita Thrust		

Formation	Lithology	Group
	Pale white to grey quartzite, amphibolite, subordinate schist, locally carbonaceous quartz mica schist, garnetiferous schist, phyllite and amphibolite	Jutogh
Jutogh Thrust		
Kullu Formation	Garnet biotitic schist, quartzite and gneiss	
Ghar Formation	Augen & streaky biotitic gneiss	
Kamarada Formation	Carbonaceous (locally) graphitic schist, quartzite and limestone	Salkhala
Salkhala Thrust		
	Quartzite-interstratified basic flows and chlorite phyllite	Rampur
	Jeori Wangtoo Gneiss	Jeori-Wangtoo gneissic complex
West		
Glacial Debris		Sub recent

3.4.1 Litho Tectonic Units

Haimanta Group

The Haimanta Group of rocks may extend to the north upto the Kerang-Kashang Link tunnel.

Vaikrita Group (Central Crystallines)

The Vaikrita Group of rocks extends towards northeast along Satluj and Spiti valleys up to Shipkila and Sumdo. The rocks of Vaikrita Group have been divided into three formations, i.e. Kharo, Morang and Shiasu. The rocks belonging to Kharo formations are exposed extensively in the area around Kashang project site, whereas those belonging to other formations are encountered further towards north and northeast.

Kharo formation is restricted to the west of Rakcham granites and is well exposed along Kupa-Rakcham, Shongtong-Kharo-Khadra and Powari-Kalpa road sections. These are best exposed in Kharo section (Shongtong-Khandra) along NH-22. The rocks of Kharo formation tectonically overlie the Jutogh, Salkhala and Rampur groups. The gneissic rocks of Kharo formation are argillaceous towards the base, felspathic towards the middle and migmatised towards the upper part, along the contact with Rakcham granite. The basal part, which is exposed near Shongtong, is mainly schistose with profuse development of Kyanite. Here, Sillimanite makes its first appearance as minute needles. The schistose rocks are interbanded with dark grey quartzites. The overlying gneisses contain quartz, sericitised plagioclase and potash feldspar, bioltite and kyanite.

Towards the upper part, i.e. in Thopan-Kharo-Khadra section, the gneisses develop migmatitic character with increase of granitic material. There is marked recrystalization of biotite, making the migmatites metasomatic. Folding and dilation structures leading to bonding are frequent. Localised concentrations of hornblende around quartz lenses are common. Small bands of schist and quartzite are ubiquitous in these gneisses. It has been postulated that the basal Kharo formation may in fact represent the felspathised and migmatised deeper parts of the overlying Morang formation. The regional geological map indicates that the area has undergone at least four phases of deformation, of which the last two are represented by NW-SE and NE-SW trending mesoscopic folds. The axis of NE-SW trending regional Satluj Shiasu Shipila Anticline is located on the left bank of Satluj in the area under study.

3.4.2 Other Geological Formations

Glacial Deposits

Extensive deposits of glacial material are present in Kashang and Kerang khads in the valley portion. The material generally consists of un-assorted rock blocks of various dimensions along with sandy micaceous and clayey material. These deposits form good lands for cultivation and habitation.

Recent Fluvial Deposits

Fluvial deposits of recent period occur in the form of terraces along the Satluj river banks and consist of sub-rounded to rounded boulders of various sizes composed of quartzite, gneiss, amphibolite embedded in sandy matrix. These terraces form gently sloping ground about 5-10 m above the river bed and provide space for camps, villages etc.

Sand bars and channel bars occur in about a kilometre length of the river in the 100-150 m wide Satluj bed upstream of Choling khad confluence. This wide river bed has been developed due to formation of an impoundment caused by blockade of the river Satluj by old Urni slide. This material is being quarried for coarse and fine aggregate. This source shows partial annual replenishment.

3.5 STRUCTURAL DETAILS

Thrusts

Three thrusts, namely Salkhala, Jutogh and MCT, are located about 9 km downstream, and further, of the Kashang Stage-I powerhouse located on the right bank of Satluj river. These thrusts have a general N-S trend and dip on upstream side i.e. easterly. These thrust zones do not show large scale shearing in rocks and do not form any topographic expression.

The integrated Kashang Hydroelectric Project lies in the thrusted gneissic rocks of Vaikrita Group of middle to late Proterozoic age.

Salkhala Thrust

The Salkhala thrust sheet overlies the Rampur group of rocks. This thrust sheet has been delineated in the field by its cross-cutting relationship. Any distinct topographic expression of the thrust and marked shearing of rocks is not seen on the right bank of Satluj at Karcham, where it is supposed to be dipping at 450 easterly or upstream of Satluj.

Jutogh Thrust

The Jutogh thrust is marked at the confluence of the Baspa river with the Satluj, having an easterly dip on the right bank of Satluj river. At this place, hard and intact rock is present forming well marked hill slopes; presence of crushed rock zones is not seen. The rock profile does not show any topographic depression along the supposed thrust. Formations show consistency in the amount of dip and strike direction on both sides of the thrust point.

The Jutogh thrust is supposed to follow Baspa river for some distance and climb up on the left bank of Baspa river. Indications of carbonaceous schist are seen at places on the left bank of Baspa river about 1 to 1.2 km upstream of its confluence with the river Satluj.

Vaikrita Thrust/Main Central Thrust (MCT)

MCT, which is the most important tectonic structure within Himalayan belt, is located about 10 km upstream of Karcham. The observations made in the area have indicated presence of sound rock forming cliff faces and absence of any crushed rock zone along the thrust.

This thrust has, however, been delineated by sharp break in metamorphic grade i.e. presence of kyanite/sillimanite minerals. The formations show isoclinal recumbent folds in Vaikrita group of rocks which are well exposed on the cliff formed on the right bank of river Satluj near Shongtong bridge, indicating over-thrusting movement. The dip of MCT/Vaikrita thrust is parallel to foliations, i.e. 250 – 300 in N300 E direction near Shongtong bridge. The complex recumbent folding is characteristic of Vaikrita group of rocks. The MCT is an important tectonic feature having its regional trend parallel to Himalayan axis and has been identified in the entire stretch of Himalaya, although there is some controversy about its location in Himachal Pradesh.

<u>Faults</u>

Choling Fault

A fault trending almost N-S along the Choling Khad, located to the west of the project, has been marked on the basis of regional geological mapping. The existence of this fault, called Choling fault, could not be identified in the field as large part of the Choling khad near the confluence with Satluj river on the right bank is covered by extensive glacial debris.

On the left bank, distinct evidence of shearing could, however, be deciphered.

<u>Kaurik Fault</u>

Kaurik fault is a well known fault located to the east of the project, having a general N-S to N200E – S200W trend and dip of 800 towards west to near vertical. Hayden, in the year 1904. first mapped this fault from Kaurik in the north to Kalang Dogri in the south over a distance of about 40 km. This was later extended up to the right bank of Satluj river near Morang. It brings the Lipak formation to about against the Precambrian Salkhalas and the lower most Haimanta group of rocks in the area.

3.6 GEOLOGY OF PROPOSED STRUCTURES

The geology of each of the components of all the proposed four stage of the Integrated Kashang HEP, as contained in the DPR (SNC-LAVALIN-2007) of the project, is being brought out in brief in the following paragraphs.

3.6.1 Geology of Kashang Stage I & Stage III Scheme

3.6.1.1 Kashang Trench Weir Site

The Kashang weir is proposed to be located in a 200 m wide and about 1.0 km long gentle sloping valley portion of Keshang Khad, at an altitude of 2830 m ±. The project has been investigated by GSI during 1997-98 as well as HPSEB. The weir site area is mainly occupied by thick (more than 40-50m) glacial deposit. The left bank, at the weir axis, forms a steep slope occupied by foliated gneiss, while the right flank consists of gentle slope of the cultivated fields on fluvio-glacial deposits. Migmatitic gneiss is exposed at about 130m from the weir site forming the hill ranges on the right flank.

High-grade metamorphic rocks, basically migmatitic gneiss and quartz-muscovite gneiss belonging to the Kharo formation of the Vaikrita group, prevail in the project area. The rocks are of Middle to Late Proterozoic age. At the weir axis, oriented N62ºE, on the left bank, the Steep rock is occupied by gneisses dipping 40º-50º in N25ºE direction (into the hills). The right bank valley portion at the weir axis consists of cultivated fields over the glacial deposits

3.6.1.2 Sedimentation Chamber Site

Arrangement for sediment removal has been planned on the right bank of Kashang Khad on the sloping terraces. The desilting arrangement is connected by a cut-and-cover section of the intake channel. These structures fall in overburden consisting of fluvio-glacial deposit composed of sub-rounded boulders and gravels embedded in sand-silt matrix. Exploratory bore hole drilled to a depth of 39m near the downstream end of the proposed desending basin reveals over burden material comprising of cobbles, gravels, boulders of gneiss and quartzite with some sand.

3.6.1.3 Headrace Tunnel and Balancing Reservoir

The upstream portion of the headrace, after the Surface Sedimentation arrangement located on the right bank of Kashang Khad, lies in the overburden (fluvio glacial deposits) consisting of boulders embedded in sand and silt forming the sloping terraces. A certain length approx 150m-170m of the headrace, just downstream of the Sedimentation Chamber, would be constructed as cut-and-cover section. Once the headrace reaches an area where depth of overburden is adequate for tunneling, soft ground tunneling will be resorted to. The alignment will pass under the nallah bed in the overburden area for a distance of 50m to 100m. However, at tunnel grade, El 2824m, competent bed rock is expected. A 60m deep drill hole carried out above the road level, near the alignment, shows rocks at El 2825.11m Sporadic rock outcrop, at around EL 2880 m, has been observed in the nallah bed, indicating that the bedrock consisting of migmatitic gneisses, will be encountered at the headrace invert at El. 2824m. The headrace tunnel, after entering into the bedrock, will have, in general, a rock cover varying from 5m in the initial reaches to about 150-250m near the balancing reservoir. No major stream cuts are present across the tunnel alignment, only dry gullys are present having steep gradient above the road, snow moves along these gullys during winter.

No major shear zone is expected to be encountered along the headrace alignment, however few foliation shears 0.5m to 1m thick, may be encountered. Since Kashang Khad is a deep drainage valley and no perennial stream or spring is present above the road to Pangi village, problems related to water seepage during tunneling are expected to be minimal moist to dripping condition which are usually met, are expected with insignificant discharge. Chances of encountering hot water in HRT are remote as no thermal spring is reported/present in the area.

3.6.1.4 End of Balancing Reservoir

The downstream end of the balancing reservoir (intake of the penstocks) is located about 100m above the road from Pangi to weir site. The area is occupied by migmatitic gneisses with wide open joints on the surface. The foliation dips 40/N15^{o}E i.e. into the hill. Near vertical joints i.e. 80^{o} are the most prominent set at spacing of 1.5m to 2m with continuity of 10m or more. The other joint set is 40^{o}/N^{o}E, at spacing 70cm and continuity 10m. Opening of the joints at surface is due to freeze and thaw action during winter but the joints are expected to be tight at depth.

3.6.1.5 Pressure Shaft Alignment

The penstock slopes, about one kilometre long, is approachable by three roads, NH-22 around El.2075m, by old HT road at El.2412m and by road from Pangi to weir site at El 2825m +. The ground slope along the rock outcrops are seen as a few patches of shallow overburden, especially above NH-22, where the ground profile is gentle. The gneisses, that occupy the penstock slope present a foliation, dipping into the hill. These have been further classified as (i) thinly foliated gneisses, (ii) porphyroblastic gneisses, (iii) migmatitic gneisses and (iv) schistose gneisses. The thinly foliated gneisses occupy the powerhouse area and the area just above NH-22. Very hard porphyroblastic gneisses occur both below and above HT road crossing the penstock alignment forming the steep rock profile. The migmatitic gneisses are above the road from Pangi to weir site at El 2825 m+. These are hard and fresh.

3.6.1.6 Powerhouse Complex

The under ground powerhouse of Kashang (Stage – I) project is located on the right bank of Satluj river below NH-22, opposite Pawari village. Thinly foliated gneiss dipping 35^{o}-40^{o}/N40^{o}E direction are exposed along the NH and below upto Satluj river, with patches of overburden consisting of river borne material. The underground powerhouse cavern is proposed to be 210m inside the hill, with crown at EL 2015m, under a rock cover of about 200m. The geological investigation (exploratory drifts) reveal that rock mass at powerhouse cavern area is characterized by thinly foliated gneisses (central crystallines) with pegmatite and quartz veins. The foliation dip is 32^{o}/N 41^{o}E direction. A shear seam, about 2m thick with 20-30 cm thick gouge has been encountered near the junction of the approach adit with cross drift.

3.6.1.7 Transformer Hall Cavern

Transfer hall cavern has been proposed about 25 m from powerhouse cavern towards Satluj. The transformer hall cavern is located under a rock cover of about 175m. A drift of 60m length at RD 151m from the approach adit reveals that rock conditions similar to powerhouse drift have been existent. In general the rock mass seems to be in fair category.

3.6.2 Kashang Stage II (Kerang-Kashang Link) Scheme.

The Kashang Stage-II Scheme consists of a trench weir across Kerang Khad at El.2870m, an intake tunnel, two desilting chambers with 9m diameter and 120M length each and free flowing Link tunnel carrying water to Kashang water Conductor System for generation at Kashang Powerhouse.

3.6.2.1 Trench Weir Site

The proposed trench weir site is located at the beginning of a narrow gorge of width varying from 5m to 10m. The left bank forms a steep high cliff consisting of open jointed, blocky granitic gneisses, which has also resulted into debris accumulation at bottom reaches of slope. The right bank consists of more gentle slopes occupied by moraines under lain by granitic gneisses outcrop at lower elevation.

3.6.2.2 Underground Desilting Chambers and Flushing Tunnel.

Two underground desilting chambers of about 120m in length and 9m in width and 10m in height aligned in N60ºE-S60ºW direction have been proposed upstream of trench weir site on the right bank of Kerang Khad. The chamber in the initial reaches (d/s side) would have a ground cover of about 80m while in the end reach (U/S Side) the ground cover is expected to be around 160m. The rock is mostly granitic gneiss with some bands of mica schists. The proposed flushing tunnel alignment outlet portal falls in the narrow gorge portion where the gneiss are exposed for a height of 5 to 10m.

3.6.2.3 Kerang-Kashang Link Tunnel

The proposed Kerang-Kashang link tunnel shall cross a mountain ridge separating the two valleys. Outcrops are observed on the right bank of Kerang Khad and they consist of massive granitic gneiss. However, in genral, the right bank is covered by boulders and glacial deposits to a large extent. On the other side of mountain ridge, the left bank of Kashang valley is very steep and consists of massive granite, at higher elevation, that cover schistose gneiss and Kyanaite gneiss (Vaikria group)

3.6.3 Kashang Stage-IV Scheme

3.6.3.1 Intake Area

The proposed trench weir is located about 400 m u/s of Toktu village on Kerang Khad. In that area, the rock consists of mainly grantic gneiss. At the trench weir site, the left bank forms a steep slope with mostly vertical joints. The foliation is near vertical to 80^0 towards north. Joints are open and sparsely located. The right bank has a more gentle slope, partially covered with shallow overburden and consisting of detached gneiss blocks with fines.

3.6.3.2 Headrace Tunnel

The proposed tunnel alignment area is mostly occupied by the granitic gneiss with mica schist bands. In the lower part of the right bank of Kerang khad slope, thick moraine deposits, cultivated terraces on moraines and rock boulders are observed. Near the Kerang Khad level on the right bank a number of gneiss rock outcrops are seen.

3.6.3.3 Powerhouse Area

The underground powerhouse shall be located near the tunnel intake after the desilting chambers of Kerang-Kashang link scheme. Out of two alternate alignment, the hill side power house alignment has been preferred at it passes mostly in exposed rock and also the powerhouse cavity area lies in exposed rock.

3.7 SEISMICITY

As per BIS:1893:2002, the project area lies in an active seismic zone-iv of the Seismic Zoning map of India **Figure 3.5** indicating severe seismic intensity in the area.

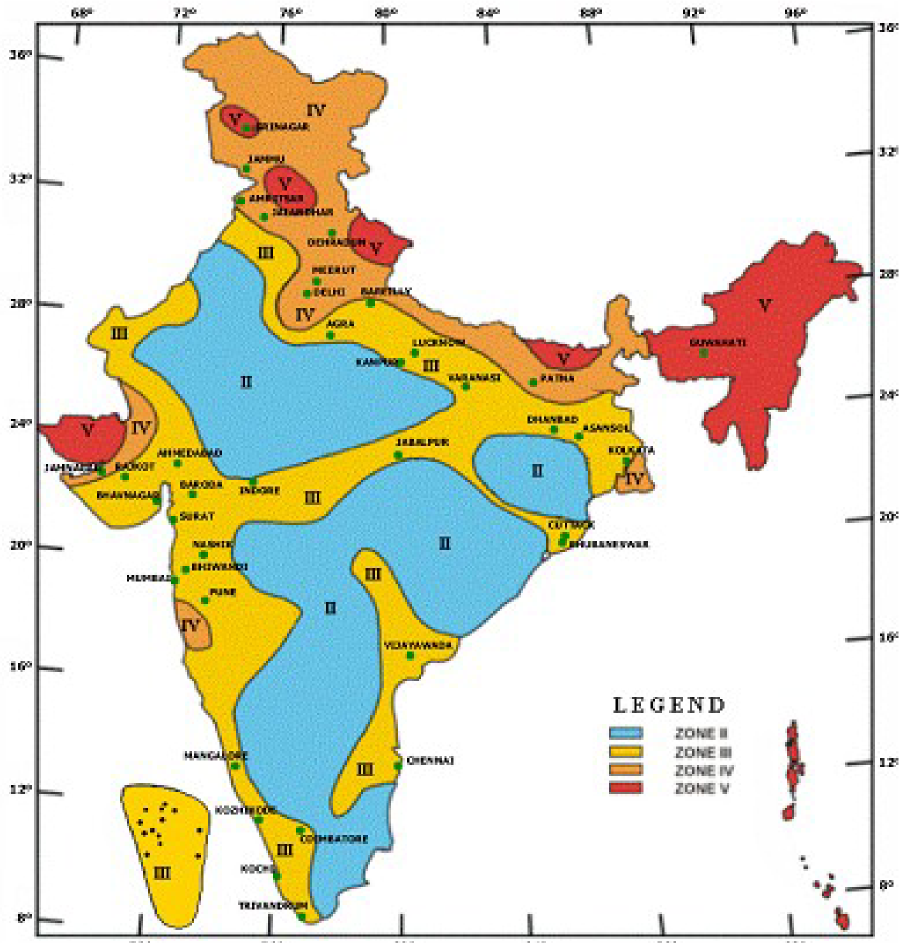


Figure-3.5: Seismic Zoning Map of India

Available data on seismicity, within a radius of 150 km of the project, shows that earthquakes having magnitude greater than 5.0 on the Richter scale, occur at frequent intervals. Important seismic events which have taken place within a radius of 200 km. from the project area, in the past 150 years, have caused significant damage, include the 1905 Kangra Quake (magnitude 8+), the 1908 Kullu Quake (magnitude 6.0), the 1945 and 1947 Chamba Quakes (magnitude 6.5 and 6.6), the 1975 Kinnaur quake (magnitude 6.8), the 1991 Uttarkashi earthquake (magnitude 6.6) and the 1999 Chamoli earthquake (magnitude 6.8).

3.8 SOIL CHARACTERISTICS (PHYSICAL / PHYSIO-CHEMICAL)

The soil in the area belongs to soils of Greater Himalayas. The soil of summit and ridge tops and glacier valleys are shallow, excessively drained, sandy skeltial soil with severe erosion. Taxonomically such soils belong to suborder – Orthents, Great group – Cryorthents and sub group – Lithic Cryorthents.

The soil of side/ exposed slope belong to sub group Typic Cryorthents and are medium deep (50-100 cm) excessively drained, loamy skeltial, calcareous soil on very steep slopes with loamy surface, severe erosion. At some places the soils belong to sub group Lithic Cryorthents and one shallow, coarse loamy calcareous soils on steep slopes with loamy surface associated with severe erosion and strong stoniness. The fluvial valley extend to some distance in Kerang Khad shows loamy skeltial soil belonging to Typic – Eutrochrepts sub group. These soils are medium deep (50-100 cm), mesic, loamy skeltial on very gentle slopes with loamy surface and has moderate erosion. The soil samples have been collected from five locations for testing soil quality in project. The soil map of the area is presented in **Figure 3.6** and the soil distribution is presented in **Table 3.4**. The location of soil sampling station is depicted in **Figure 3.7** and the location details show in **Table 3.5**.

Table 3.4: Soil Class of study area

(10 Km radius from dam site and free draining catchments)

Sl. No.	Landuse Category	Area in Sq. Km.	Area in %
1.	Sandy skeltial soil	6875.50	9.44
2.	Rock outcrops and valley glaciers	2959.07	4.06
3.	Rock outcrops/ glaciers associated with loamy skeltial calcareous soil	12544.22	17.22
4.	Rock outcrops associated with loamy skeltial soil	6833.46	9.38
5.	Rock outcrop associated with loamy skeltial calcareous soil	30310.28	41.62
6.	Rock outcrops associated with coarse loamy calcareous soil	9286.07	12.76
7.	Very deep sandy soil with moderate erosivity	675.12	0.01
8.	Very deep coarse loamy soil	3356.22	4.61
		72839.94	100%

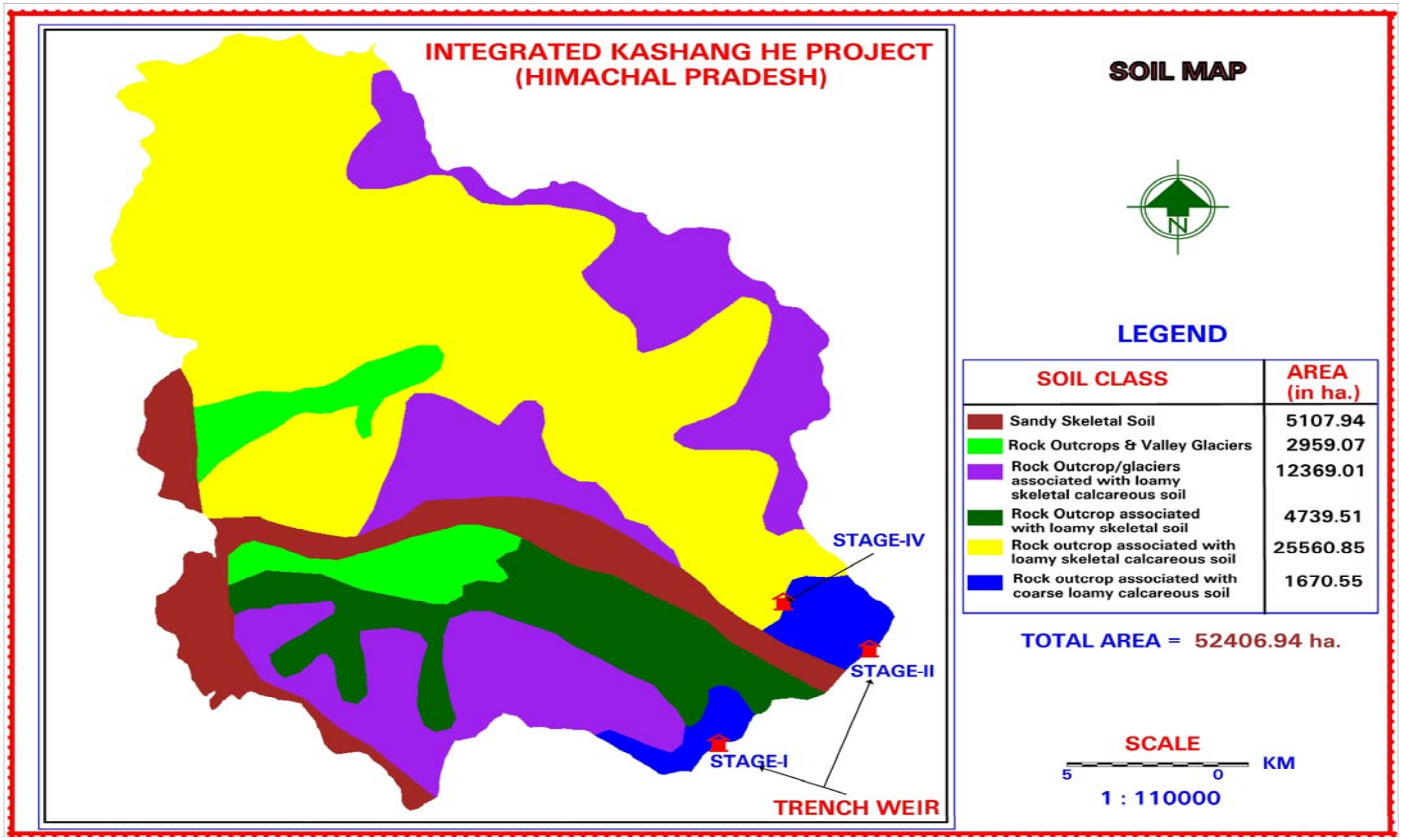


Figure 3.6: Soil Map of the Area

Table 3.5: Location of Soil Quality Monitoring Stations.

Station Code	Station Name	Location with respect to Trench Weir Site		Description
		Distance (Km)	Direction	
S-1	Pangi	03	SW	Ag. Land
S-2	Lipa	10	NNE	Ag. Land
S-3	Lapo	07	NE	Forest land
S-4	Lipa	10	NNE	Barren Land
S-5	Rarang	06	E	Forest Land

The analysis results of soil sample collected at site during winter are presented in **Table 3.6** & **Table 3.7** and for pre-monsoon in **Table 3.8 & 3.9**.

Table 3.6: Physical Characteristics of Soil in the Study Area

Code	Location Name	Texture	Texture Results			Bulk Density. gm/cc	Porosity
			% Sand	% Silt	% Clay		
SQ1	Pangi	Loamy sand	73	21	06	1.50	18
SQ2	Lipa	Loamy sand	76	18	06	1.30	20
SQ3	Lapo	Loamy sand	80	14	06	1.60	18
SQ4	Lipa	Loamy sand	74	20	06	1.25	21
SQ5	Rarang	Sandy	86	08	06	1.22	22

Table 3.7: Chemical Characteristics of Soil in the Study Area

Code	Location	pH	Conductivity, µmhos/cm	N, mg/100 g.	P, mg/100 g.	K, mg/100 g.	SAR	Moisture Content, %
SQ1	Pangi	7.91	141	144.0	36.2	03	1.50	8.70
SQ2	Lipa	7.80	390	148.0	38.4	07	1.40	12.10
SQ3	Lapo	8.03	235	142.0	22.2	04	1.30	8.50
SQ4	Lipa	8.10	290	52.0	10.6	ND	1.70	6.20
SQ5	Rarang	8.50	181	125.0	28.4	02	1.80	8.60

The result of the soil analysis shows that the soil is slightly basic in nature having pH varies from 7.80 to 8.50. The texture of the soil varies from sandy to sandy loam having predominantly sand. The moisture content of the soil varies from 6.20 to 12.10% and sodium absorption ration varies from 1.30 to 1.80. The micro nutrients are found in all the samples.

Table 3.8: Physical Characteristics of Soil in the Study Area

Code	Location Name	Texture	Texture Results			Bulk Density. gmcc	Porosity
			% Sand	% Silt	% Clay		
SQ1	Pangi	Loamy sand	74	19	07	1.50	17
SQ2	Lipa	Loamy sand	77	16	07	1.40	16
SQ3	Lapo	Loamy sand	82	12	08	1.60	17
SQ4	Lipa	Loamy sand	75	17	08	1.30	18
SQ5	Rarang	Sandy	83	10	07	1.20	20

Table 3.9: Chemical Characteristics of Soil in the Study Area

Code	Location	pH	Conductivity, µmhos/cm	N, mg/100 g.	P, mg/100 g.	K, mg/100 g.	SAR	Moisture Content, %
SQ1	Pangi	8.00	148	150.0	38.2	04	1.60	9.20
SQ2	Lipa	7.80	394	154.0	39.4	06	1.40	12.10
SQ3	Lapo	8.10	236	164.0	24.2	05	1.30	10.4
SQ4	Lipa	7.90	292	48.0	10.4	ND	1.80	6.50
SQ5	Rarang	8.40	190	112.0	30.2	02	1.80	10.60

The result of the soil analysis shows that the soil is slightly basic in nature having pH varies from 7.80 to 8.40. The texture of the soil varies from sandy to sandy loam having predominantly sand. The moisture content of the soil varies from 6.50 to 12.10% and sodium absorption ration varies from 1.30 to 1.80. The micro nutrients are found in all the samples

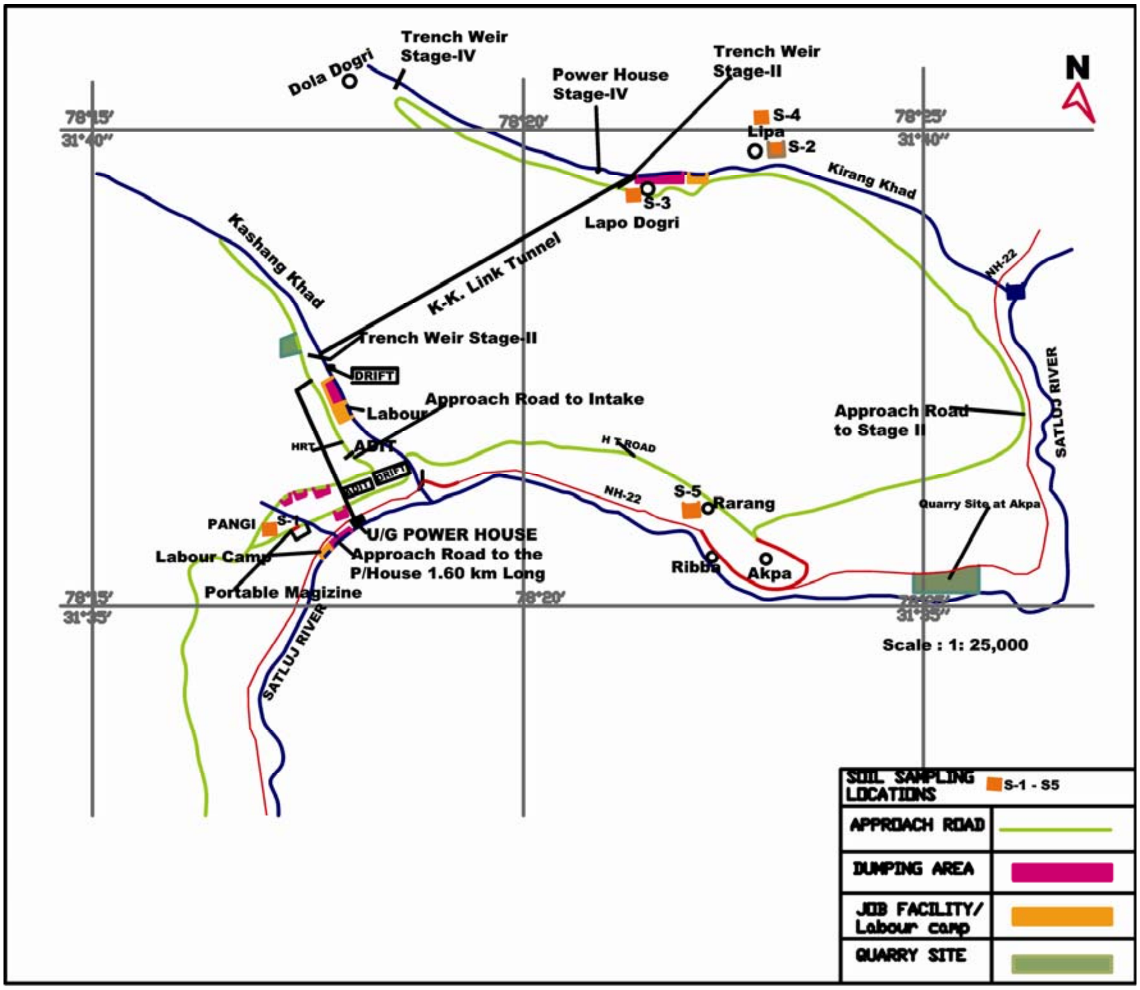


FIGURE 3.7 SOIL SAMPLING LOCATIONS

The analysis results of soil sample collected at site during monsoon and post monsoon are presented in ……..

3.9 SLOPE

In a mountainous topography the slope plays major role in controlling the sediment / soil movement with water and the soil retention. The land use capability is a direct function of slope, which signifies the change in the value of elevation over a distance and is expressed either in degree or in percentage. The slope in catchment area is exhibited in **Figure 3.8** and enumerated in **Table 3.10**. The aspect map of study area is shown in **Figure 3.9**.

Table 3.10: Slope Classes for Free Draining Catchments Area.

S. No.	Sub Watershed / Micro Watershed Code	Slope										
		0-35%		35-45%		45-55%		55-80%		>80%		Total (Area in Sq km)
		Area	%	Area	%	Area	%	Area	%	Area	%	
Kashang												
1.	1A2C5(1)	53.26	61.32	14.57	16.78	11.48	13.22	5.39	6.21	2.15	2.47	86.85
2.	1A2C5(2)	14.67	39.46	13.37	35.96	7.18	19.31	1.82	4.90	0.14	0.37	37.18
Total Sub-watershed (Kashang)		67.93	54.77	27.94	22.53	18.66	15.05	7.21	2.81	2.29	1.84	124.03
Kerang												
1.	1A2C5(3)	139.97	47.36	102.31	34.62	42.39	14.34	5.02	1.70	5.86	1.98	295.55
2	1A2C5(4)	36.15	34.60	37.48	35.87	24.25	23.21	5.60	5.36	1.01	0.96	104.49
Total Sub-watershed (Kerang)		176.12	44.03	139.79	34.94	66.64	16.66	10.62	2.65	6.87	1.72	400.04
Grand Total		244.05	46.57	167.73	32.00	85.30	16.28	17.83	3.40	9.16	1.75	524.07

3.10 LAND USE / LAND COVER

The Modern technique of Satellite Remote sensing facilitates such type of studies. The inaccessibility to the region in diverse weather conditions, requirement of synoptic coverage at various locations, and the computer adaptability for land use classification makes the digital image processing and remote sensing an inevitable tool. As already stated under physiography that the catchment area is characterized by steep hills and deep valleys, the dominating classes are dense forest, open forest, waste land, agriculture & settlement patches and some degraded forest. The land use pattern of study area is exhibited in **Figure 3.10** and enumerated in **Table 3.11**.

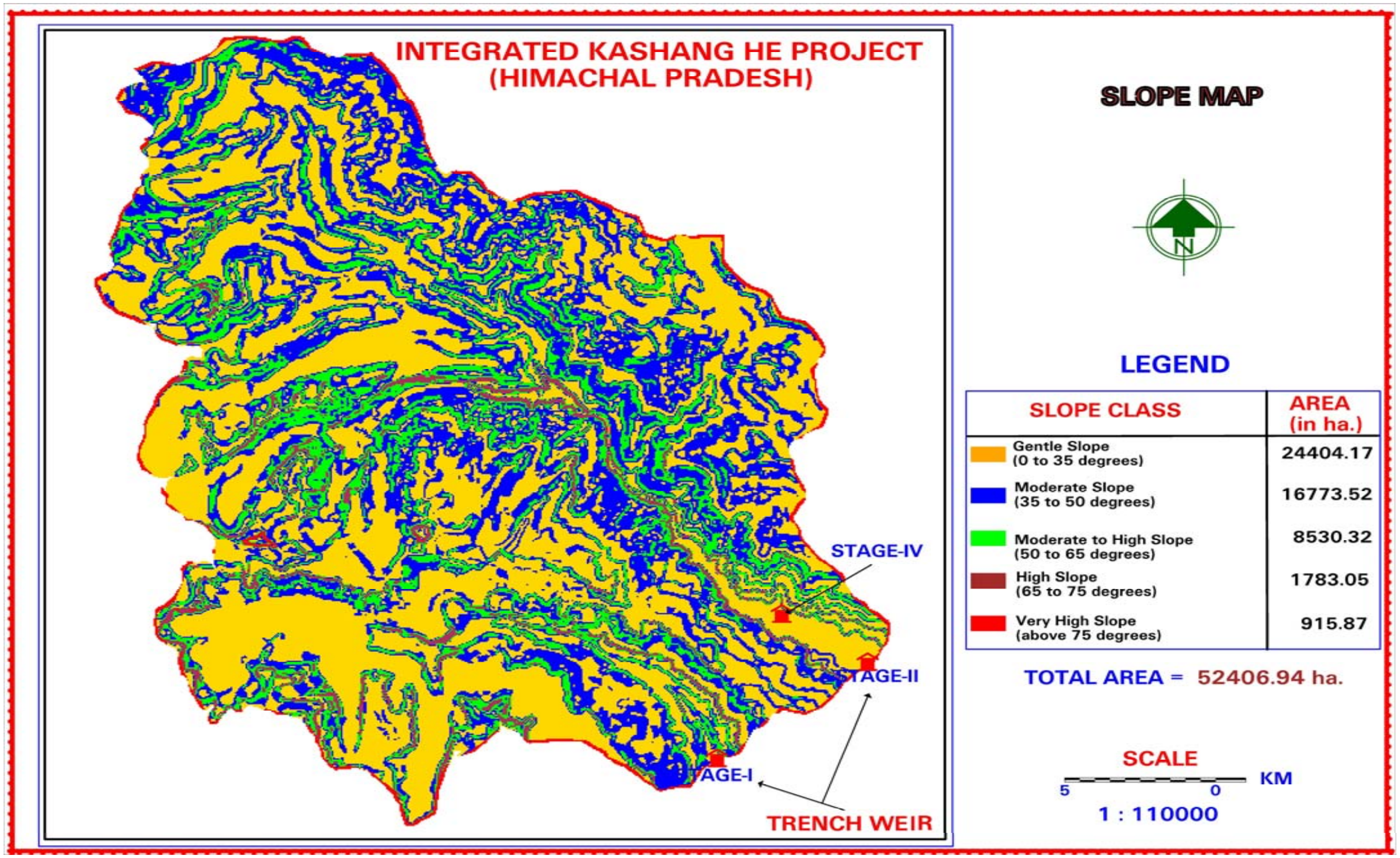


Figure 3.8: Slope Map of the Catchment Area

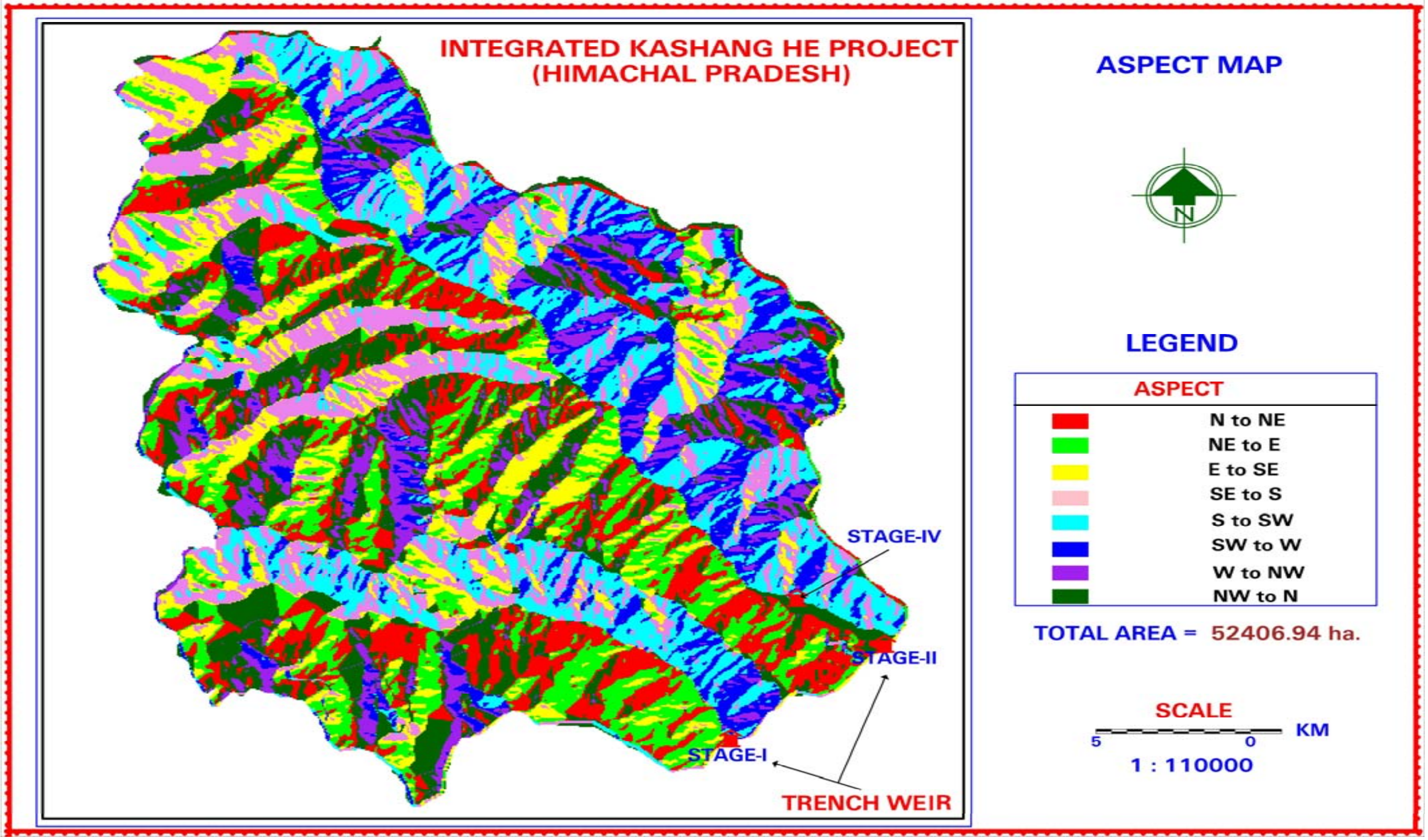


Figure 3.9: Aspect Map of the Catchment Area

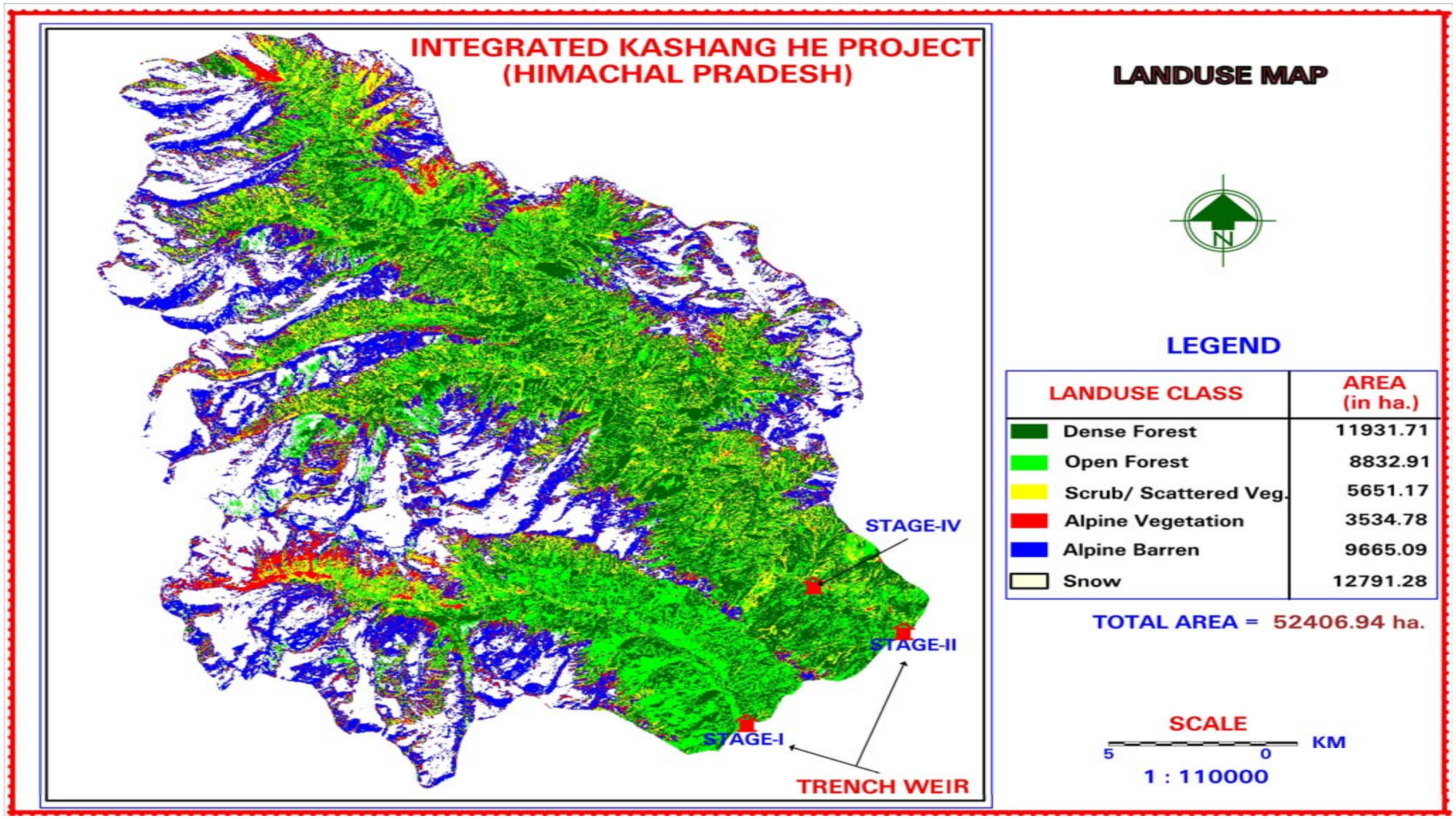


Figure 3.10: Land Use Pattern of the Study Area

Table 3.11: Land Use Details of Study Area

Sl. No.	Land Use Category	Area in Sq Km	% Area
1.	Dense Forest	21167.99	29.00
2.	Open Forest	16703.12	23.00
3.	Scrub/ Scattered Vegetation	8286.29	11.50
4.	Alpine Vegetation	3873.84	5.00
5.	Alpine Barren	9886.49	13.50
6.	Snow	12922.21	18.00

3.11 PRESENCE Of ECONOMICALLY IMPORTANT MINERAL DEPOSIT

No major occurrence of economic deposit has been found in the reservoir area.

3.12 TOTAL LAND REQUIREMENT

Overall land requirement of the project is 85.7356 ha out of which forest and private land is 61.889 ha and 23.8357 respectively. The project shall not submerge any land per se. The project component wise break up of land is given in **Table 3.12**.

Table 3.12: Land Requirement of Submergence and Project Component Area

S No	Description	Private area (ha)	Forest area(ha)	Total area (ha)
	Stage-1			
1	Quarry Site near intake	-	3.2558	3.2558
2	Approach road to Quarry site near Intake (1400m)	-	0.6801	0.6801
3	Approach road to Intake up to HRT 95200m)	0.49789	3.5508	4.0497
4	Intake Site, Power Channel, Sedimentation tank, balancing reservoir.	0.4309	1.2777	4.7086
5	Approach road to Surge shaft and drift at surge shaft (400m)	-	0.4175	0.4175
6	Approach road to Penstock Adit/Drift (3200m)	-	2.8044	2.8044
7	Approach road to Power House (2200m)	-	1.5990	1.5990
8	Power House area	-	0.2115	0.2115

9	Quarry site near Akpa	-	3.7340	3.7340
10	Dumping yard	9.9465	1.1834	11.1299
11	Pangi Khas colony and intake road	1.6100	-	1.610
	Total Stage-I	**15.4863**	**18.7142**	**34.2005**
	Stage-II			
1	Trench weir, Protals of Adits	-	1.8496	1.8496
2	Road ti intake	-	1.2000	1.2000
3	Dumping area No.1	-	2.3695	2.3695
4	Stone crusher near Kashang Khad	-	0.1748	0.1748
5	HRT outlet Portal	-	0.1920	0.1920
6	Colony site at Lappo	0.4441	-	0.4441
7	Inlet tunnel at Lappo	-	0.0540	0.0540
8	Desanding chamber at Lappo	-	0.8550	0.8550
9	Head Race Tunnel	-	3.1275	3.1275
10	Adits	-	0.6160	0.6160
11	Flushing tunnel		0.0720	0.0720
	Total Stage-II	**0.4441**	**10.5104**	**10.9545**
	Stage-III			
1	Material Stacking yard	-	2.6503	2.6503
2	Dumping area of Powerhouse i.e. D2, D3 and D11	-	1.2702	1.2702
3	Dumping area D-4 at Kashang Khad	-	0.4936	0.4926
4	Dumping area at Pangi-Intake road i.e. D-5, D-6 and D-7	-	0.7666	0.7666
5	Dumping area at old H.T. Road i.e. D-8	-	0.7000	0.7000
6	Job facilities at old HT Road	-	0.3000	0.3000
7	Portal of adit to balancing reservoir	-	0.0256	0.0256
8	Colony Site at Dakhao (Reckong Peo)	2.9053	-	2.9052
9	Balancing reservoir	-	0.9690	0.9690
	Total Stage-III	2.9053	7.1753	10.0806
	Total Stage II and III	303494	17.6857	21.0351
	Total Stage-IV	5.0000	25.5000	30.5000
	Ground Total Stage I, II, III and IV	23.8957	61.8999	85.7356

3.13 ARCHAEOLOGICAL / RELIGIOUS / HISTORICAL MONUMENTS.

It has been observed during field reconnaissance survey and also review of secondary/published information that no archeological monument of national importance either lies in the project area or the study area. There is also no structure of National Heritage in the area exists within 10 km radius from the proposed project. However one famous Budhist Temple exists at Kalpa and is about 15 km from intake of Stage-I. Another Budhist Temple of fame exists at Jangi but is again 14 km from the nearest intake point of Stage-II at Lappo. Thus no immediate impact is anticipated on these religious structures.

3.14 SENSITIVE/PROTECTED AREAS

The study area also covers parts of Lippa-Asrang Wildlife Sanctuary area. The project area however lies outside the core and buffer zone of Sanctuary. The Sanctuary boundary lies only 500 m Upstream of the diversion site at El. 3150 of Kashang IV Scheme at Village Toktu. The Kerang Khad, also Known as Taiti Garang prior to flowing out of the Sanctuary, marks northeastern boundary of the Sanctuary. The Sanctuary is situated in Morang Sub-division of Tribal belt of Kinnaur district. The sanctuary extends over an area of 30.89 sq. km and represents the typical flora and faunas of temperate to alpine region. The area comprises high altitude alpine pastures and belongs to the cold desert region. The sanctuary has been established to project the endangered species as Snow Leopard, Ibex, Blue Sheep and Snow Cock. The sanctuary is under the management of the Sarahan Wildlife Division.

CHAPTER-4

WATER ENVIRONMENT

4.1 INTRODUCTION

The project area interacts with only three surface water bodies viz. Kashang Khad, Kerang Khad and River Sutlej. Therefore, in order to conduct EIA studies of the Integrated Kashang HEP, baseline data pertaining to water environment of the proposed project was carried out evaluating the basin characteristics, drainage pattern, hydrology. The existing physio-chemical and bacteriological parameters were also analyzed for this stream/river water at different sites.

4.2 BASIN CHARACTERISTICS OF KASHANG & KERANG VALLEYS

In the wake of the fact that the Integrated Kashang HEP, has been conceptualized by harnessing stream waters of Kashang and Kerang Khads flowing in the two contiguous valleys separated by a ridge, the basin characteristics of each of these valleys is described.

4.2.1 Basin Characteristics of Kashang Valley

The Kashang Khad, which is a right bank tributary of River Satluj, originates from glaciers located in the permanent snow zone and is thus perennial in nature. The catchment area above the diversion site of Stage-I is 124.03 sq. km. out of which 30.96 sq. km. is under glaciers and permanent snow zone. The river flows for 18 km. from its origin before falling down a vertical height, known as Kasang fall and meets river Satluj near village Powari. The river bed has rocks and pebbles while large boulders present all along the stream offer resistance to stream flow. The water in the stream flows with a high velocity and gets heavily churned and remains turbulent throughout its course. The intake point of Stage-I is only 4 km. from confluence with riever Satluj. The L-section of Kashang Khad up to its confluence with river Sutlej is presented in **Figure 4.1**, which shows that neither any stream of consequence nor any canal/drinking scheme is tapped from Khad d/s of trench weir site. However, one FIS named as Jangi Phase-II which off takes about 4 km upstream of trench weir site is under construction.

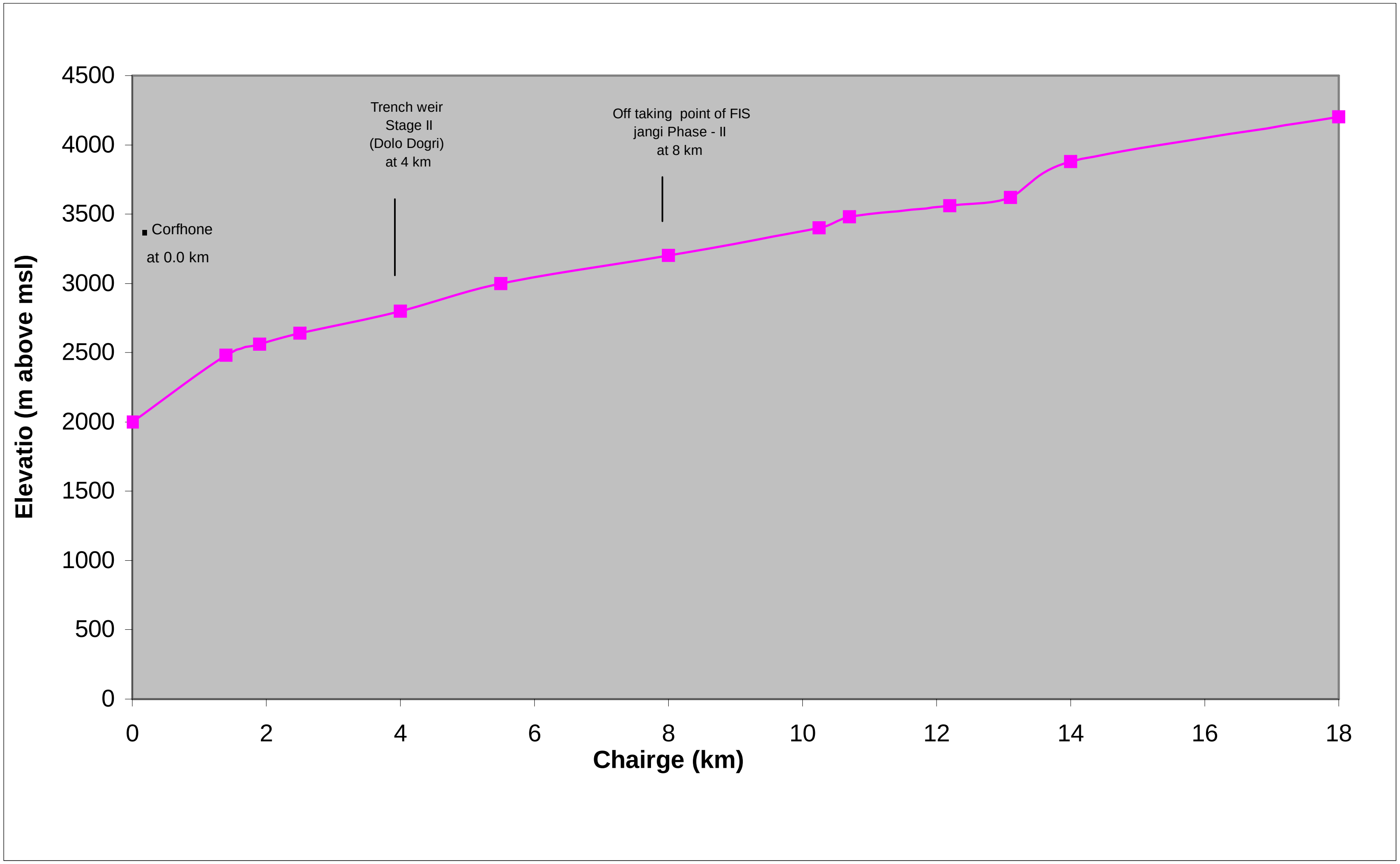


Figure 4.1: L-Section of Kashang Khad up to its Confluence with river Satluj

4.2.2 Basin Characteristics of Kerang Valley

Kerang Khad, which is a right bank tributary of river Sutlej, originates from glaciers located in the permanent snow zone and is thus perennial in nature. The catchment areas above diversion trench weir site of Stage II is near village Lappo which also includes the overlapping catchment of Stage IV near village Toktu, comprises of steep mountains, with a portion covered under dense forest and major parts under permanent snow line.

The total catchment area up to trench weir of stage-II is 400 sq. km. out of which 96.95 sq. km. area lies under permanent snow line. The Kerang Khad traverses for 44 km from its origin before confluence with river Satluj where the Khad becomes wider as it passes through less steep course amidst rocky and gravel covered slopes. The river bed has rock outcrops, pebbles and large boulders offering resistance to the stream flow and making the flow turbulent. The bed slope of the Khad reduces gradually from village Lippa downwards Pager Garang is a major tributary of Kerang Khad (Taiti Garang) and meets at its left bank near village Lippa. The L-section of Kerang Khad from its origin to its confluence with river Sutlej is presented in **Figure 4.2**. The L-section also indicates the off taking points of canals from Kerang Khad and also the point of confluence of other small rivulets with it.

4.2.3 Basin Characteristics of Free Draining Area for Integrated Kashang HEP

The basin area of integrated Kashang HEP is an integration of two distinct valleys Kashang and Kerang watershed area. IA2C5 pertaining to Sutlej Basin in sub catchment 'C'. The free draining catchment of Kashang Khad up to trench weir site is 124.03 sq. km. and is made up of two sub watershed viz IA2C5(1) and IA2C5(2) having 86.85 sq. km. and 37.18 sq. km. area respectively. The catchment area under sub watershed IA2C5(1) is grossly El 4200 m above msl and is mostly snow bound. The free draining catchment of Kerang Khad up to trench weir site of Stage-II is 400.04 sq. km. and is made up of two sub watershed viz. IA2C5(3) and IA2C5(4). The area under sub watershed IA2C5(3) is 295.55 sq. km. being mostly snow bound, whereas, the area under the other sub watershed is 104.49 sq. km.

Table-4.1 describes the basin characteristics of different sub watersheds in the free drainage catchment.

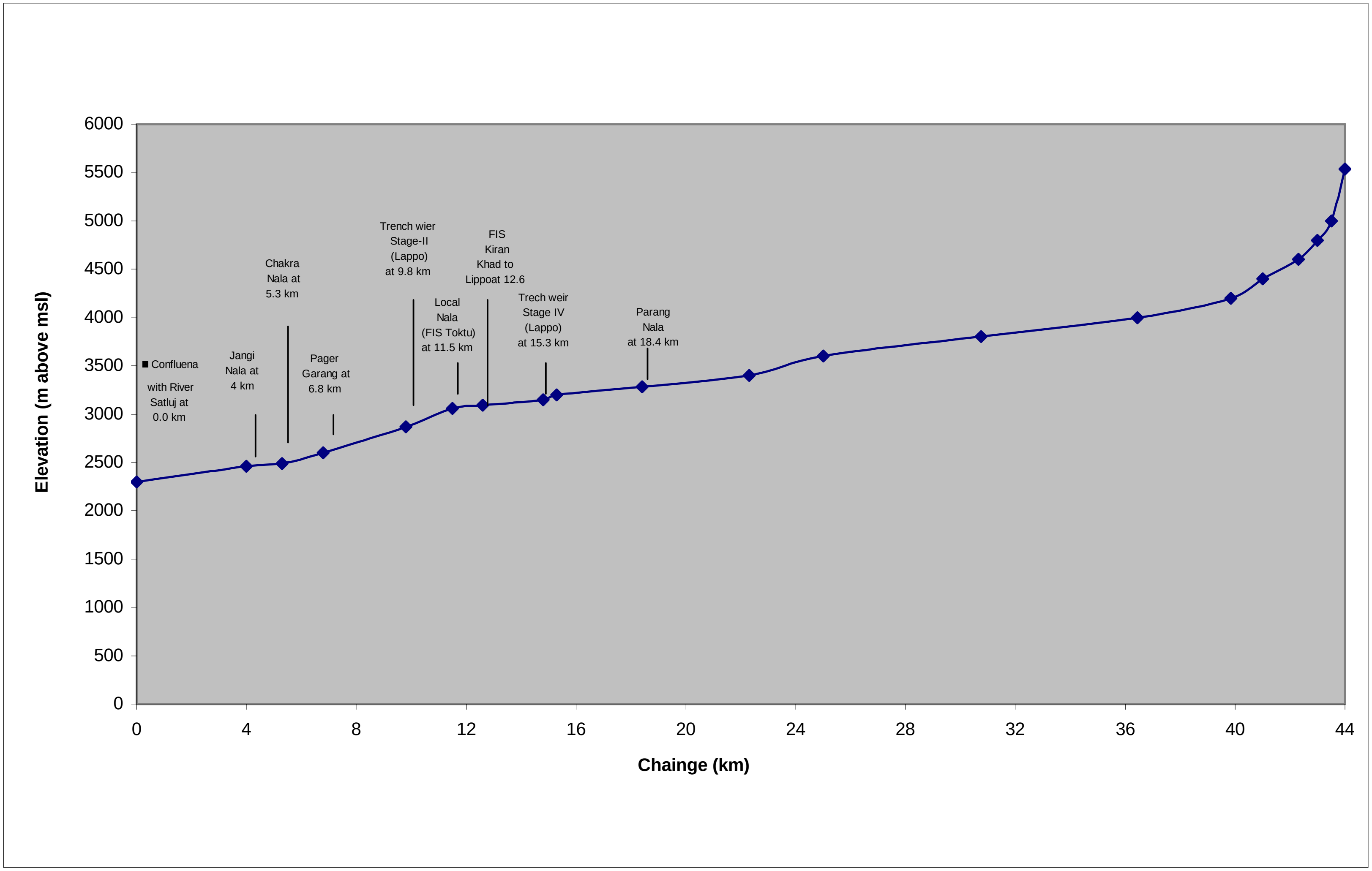


Figure 4.2: L-Section of Kerang Khad from its Origin to its Confluence with River Satluj

Table 4.1: Basin Characteristics of Different Sub-Watershed in Free Drainage Catchment

Name of subwatershed	Watershed Details	Sub-watershed Code	Sub-watershed Name	Area (sq. km.)
Kashang	Region (1) Indus Drainage	IA2C5 (1)	Rogle	86.85
	Basin (A) Satluj Catchment (2)	IA2C5(2)	Dolo Dogri	37.18
Kerang	Sub catchment (C) Main Upper Satluj up to China border	IA2C5(3)	Larsa	295.55
	Watershed 5	IA2C5(4)	Lappo	104.49
		Total		524.07

4.2.4 Drainage Pattern

Drainage is the single most entity, which defines the network antecedent river. The detail drainage pattern of the study area is shown in **Figure 4.3.** The major tributaries to river Sutlej in free drainage area are Kashang Khad and Kerang Khad. The drainage pattern of the area may be classified into following classes:

4.2.4.1 Gross Trellis

The trellis drainage pattern is normally developed in the hillside slopes and usually aligned along the strike of the rock formation. The softer rocks like phyllitic slates exhibit such drainage. The trellis drainage pattern is well developed in the terraces and lower most reaches of the valley. The majority of the area possesses a dendritic to sub-dendritic drainage containing irregular branching of the smaller tributaries. The closeness of these small branches is dependent on the permeability of the underlying rocks and the amount and nature of precipitation. It is the most common drainage pattern of hillside slopes of the study area.

4.2.4.2 Gross Radial, Local Annular

The radial drainage pattern is a characteristic feature of the high altitudinal zone specially the summit surfaces. Lithologically, these areas are constituted by the resistant and impervious rocks with steep slopes. The sub-parallel drainage pattern comprises a series of streams which run approximately parallel to each other. They are evolved in areas of uniformly dipping rocks.

4.2.4.3 Gross Sub-Parallel, Local Sub-rectangular

The major river in the study area is antecedent in nature. The sinuosity, braiding and meandering in the river course is generally noticed, although at some places, they are straight and narrow. Due to the increase of the drainage area and the discharge, the river valley becomes wider in downstream side with generally flattened gradient. The stream orders generated for the present study area are presented in **Table-4.2**.

Table 4.2: Stream Order Generated for the Present Study Area

Locality	No. of streams of various order									
	I Order		II Order		III Order		IV Order		V Order	
	No.	Length, m.	No.	Length, m.	No.	Length, m.	No.	Length, m.	No.	Length, m.
Kerang Basin	807	558838	180	144719	51	60142	4	14088.81	2	30808
Kashang Basin	86	89080	28	22425	8	7789	1	11766	-	-

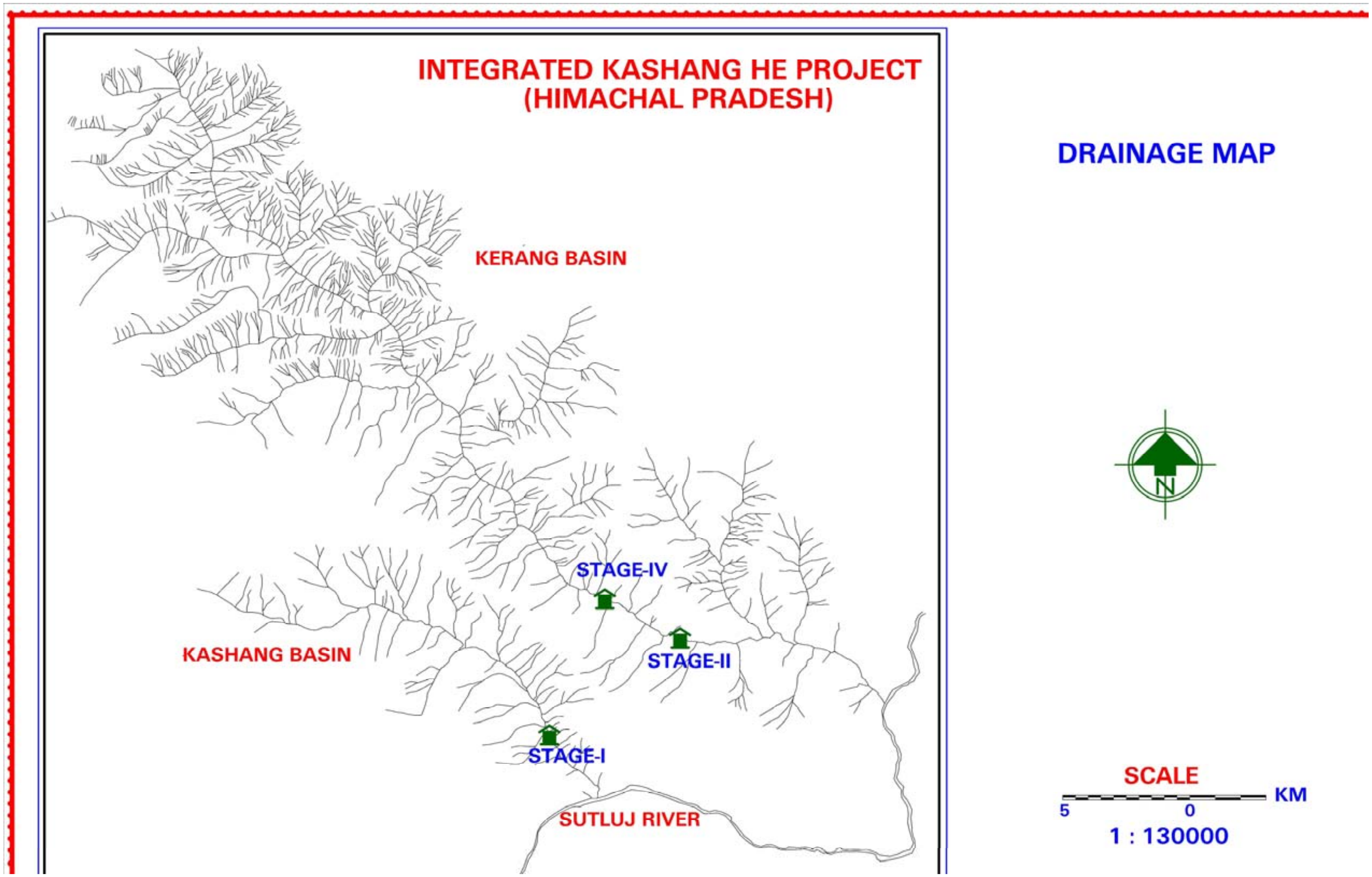


Figure 4.3: Drainage Map of Free Draining Catchment Area

4.3 HYDROLOGY

4.3.1 Water Availability for Integrated Project

The integrated Kashang HEP envisages diversion of flow of Kashang Khad through trench weir at village Dolo Dagri (Stage-I) and flow of Kerang Khad through trench weir at Toktu (Stage-IV) and through trench weir at village Lappo (Stage-II). Based on observed long term hydrological tendencies and reliable ten daily observed discharge data for 25 years at hydrometric station at Bhaba whose watershed is contiguous to that of Kashang Khad, long term ten daily flow series and hydrographs for Kashang and Kerang Khads have been established. The basic principles adopted to derive long term hydrological series for Kasang and Kerang are summarized as follows:-

- Estimate long term mean precipitation over Kashang and Kerang watersheds based on observed mean monsoon precipitation for the period 1991-2000, after the consistency of data was checked with the observed flow at Bhaba.
- Annual run-off at Kashang and Kerang for the period 1980-2004 is computed from observed long term mean monsoon precipitation, based on relations established for the Bhaba watershed.
- Seasonal distribution of the annual run-off volume for each year is based on the distribution observed on Kashang and Kerang records.
- 90% and 50% dependable flow based on the 10 daily reconstituted flow series at site of each of the diversion weirs of the scheme for the period 1980-2004, and on the consideration of net run off volume which can be effectively used for generation of energy after discounting flood volume in excess of plant capacity, 90% and 50% dependable years were arrived at the reconstituted 10 daily flow series for 90% dependable year (1997) and for 50% dependable year (1984) for each of the diversion weir sites and are being presented in **Table-4.3** and **Table-4.4**.

The discharge quantity of Kashang and Kerang Khad is substantially less when compared to discharge of river Satluj at Karcham site. Kashang and Kerang flow represents approximately 1:58% and 3.53% discharge of river Satluj at Karcham. The discharge varies with seasons. In winter the stream surface freezes, while the sub-surface flow continues and volume gets considerably reduced. The regime of Kashang and Kerang Khads is typical of snowfed rivers with discharge significantly increasing during the day and decreasing during night.

Figure 4.4 is a plot of percentage of exceedence (%) and the river flow (cumecs) for Kashang, Kerang (Stage-IV) and Kerang (Stage-II or K. K. Link). Figure 4.6 through 4.8 present the details of flow duration curves for Kashang (Stage-I), Kerang (K. K. Link) and Kerang (Stage-IV) respectively. It is inferred from these curves that for 50% time of the year, the flow of Kashang, Kerang (K K Link) and Kerang (Stage IV) is of the order of 4.3 cumecs, 9.6 cumecs and 9.0 cumecs respectively whereas for 90% time of the year the flow is of the order of 2.2 cumecs, 4.9 cumecs and 4.6 cumecs respectively.

Table 4.3: 90% Dependable Year-1997-Reconstituted 10 day flow (m^3/s)

Ten Daily	Kashang	Kerang (KK Link)	Kerang (Scheme IV)
Min	**1.74**	**3.90**	**3.65**
Max	**13.68**	**30.65**	**28.66**
Avg	**5.06**	**11.34**	**10.60**
January 1-10	2.04	4.58	4.28
January 11-20	1.90	4.25	3.97
January 21-31	1.86	4.16	3.89
February 1-10	1.81	4.05	3.79
February 11-20	1.81	4.05	3.79
February 21-28	1.74	3.90	3.65
March 1-10	1.90	4.25	3.97
March 11-20	1.78	3.98	3.72
March 21-31	1.81	4.05	3.79
April 1-10	1.80	4.03	3.77
April 11-20	2.06	4.62	4.32
April 21-30	3.85	8.62	8.06
May 1-10	4.07	9.12	8.53
May 11-20	5.15	11.54	10.79
May 21-31	5.70	12.77	11.94
June 1-10	6.41	14.36	13.43
June 11-20	8.14	18.23	17.04
June 21-30	9.38	21.01	19.64
July 1-10	12.25	27.45	25.67

Ten Daily	Kashang	Kerang (KK Link)	Kerang (Scheme IV)
July 11-20	13.68	30.65	28.66
July 21-31	12.35	27.67	25.88
August 1-10	12.05	26.99	25.23
August 11-20	11.03	24.71	23.10
August 21-31	9.12	20.43	19.10
September 1-10	6.59	14.76	13.80
September 11-20	5.65	12.66	11.84
September 21-30	5.29	11.85	11.08
October 1-10	4.36	9.77	9.14
October 11-20	4.14	9.27	8.67
October 21-31	3.70	8.28	7.75
November 1-10	3.33	7.46	6.97
November 11-20	3.24	7.25	6.78
November 21-30	2.93	6.57	6.15
December 1-10	2.91	6.53	6.10
December 11-21	2.89	6.48	6.06
December 21-31	2.71	6.06	5.67

Table 4.4: 50% Dependable Year-1984-Reconstituted 10 day flow (m^3/s)

Ten Daily	Kashang	Kerang (KK Link)	Kerang (Scheme IV)
Min	**2.5**	**5.5**	**5.2**
Max	**15.3**	**34.3**	**32.0**
Avg	**5.8**	**13.1**	**12.2**
January 1-10	2.8	6.3	5.9
January 11-20	2.8	6.4	6.0
January 21-31	2.8	6.3	5.9
February 1-10	2.8	6.3	5.9
February 11-20	3.0	6.8	6.4
February 21-28	3.2	7.1	6.6
March 1-10	3.3	7.3	6.8
March 11-20	3.0	6.7	6.3
March 21-31	3.3	7.4	6.9
April 1-10	3.6	8.1	7.6
April 11-20	4.0	8.9	8.3
April 21-30	4.9	10.9	10.2
May 1-10	6.5	14.6	13.6
May 11-20	7.9	17.7	16.6
May 21-31	8.1	18.1	16.9
June 1-10	9.3	20.8	19.5
June 11-20	9.9	22.2	20.8
June 21-30	15.3	34.3	32.0
July 1-10	9.3	20.9	19.6
July 11-20	9.8	22.0	20.6
July 21-31	11.8	26.4	24.7
August 1-10	13.3	29.9	27.9
August 11-20	10.8	24.2	22.7
August 21-31	10.0	22.5	21.0
September 1-10	7.5	16.7	15.6

Ten Daily	Kashang	Kerang (KK Link)	Kerang (Scheme IV)
September 11-20	5.8	13.0	12.1
September 21-30	5.4	12.2	11.4
October 1-10	4.4	9.9	9.2
October 11-20	3.8	8.5	8.0
October 21-31	3.0	6.7	6.3
November 1-10	3.3	7.4	6.9
November 11-20	3.1	7.0	6.5
November 21-30	3.1	6.9	6.4
December 1-10	3.1	6.8	6.4
December 11-21	2.8	6.2	5.8
December 21-31	2.5	5.5	5.2

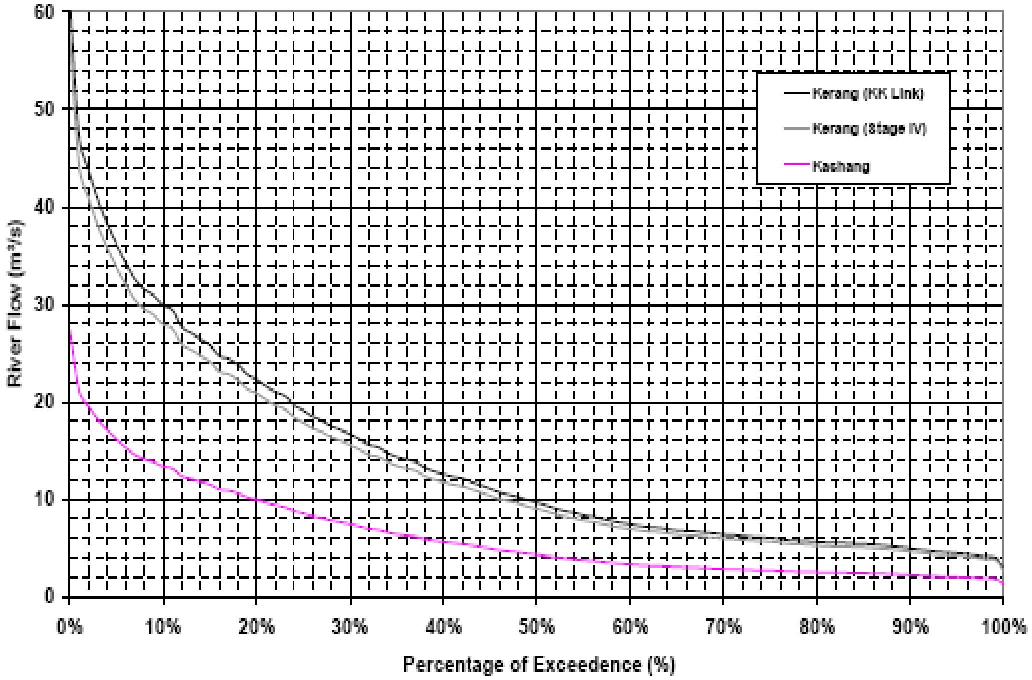


Figure 4.4: Kashang and Kerang Flow Duration Curve

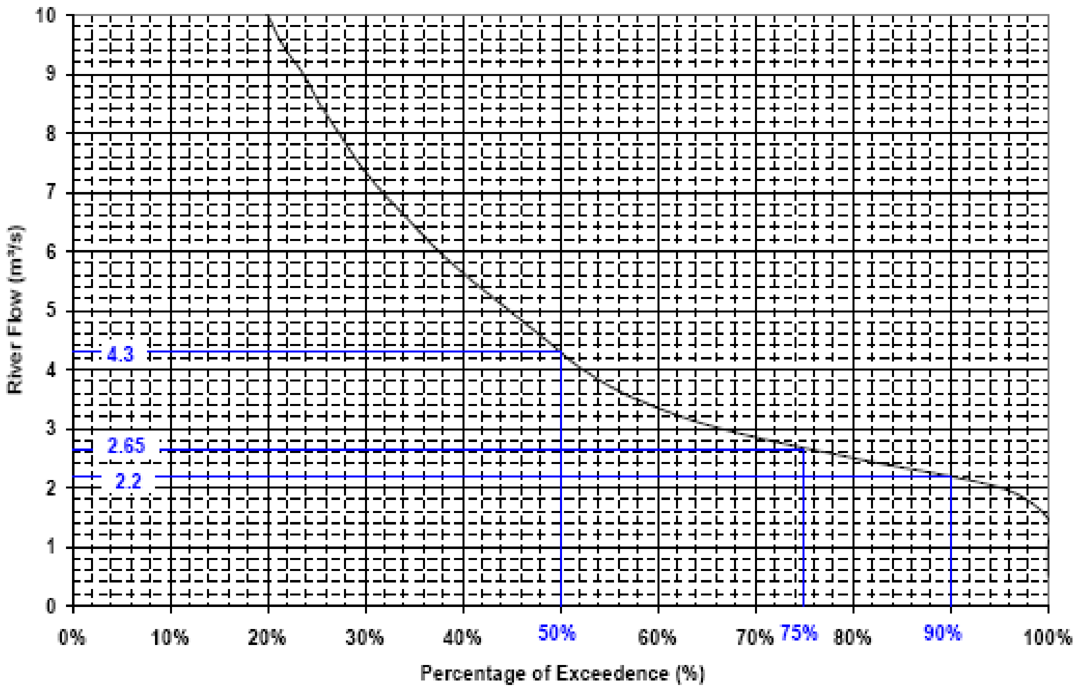


Figure 4.5: % of Exceedence (%)

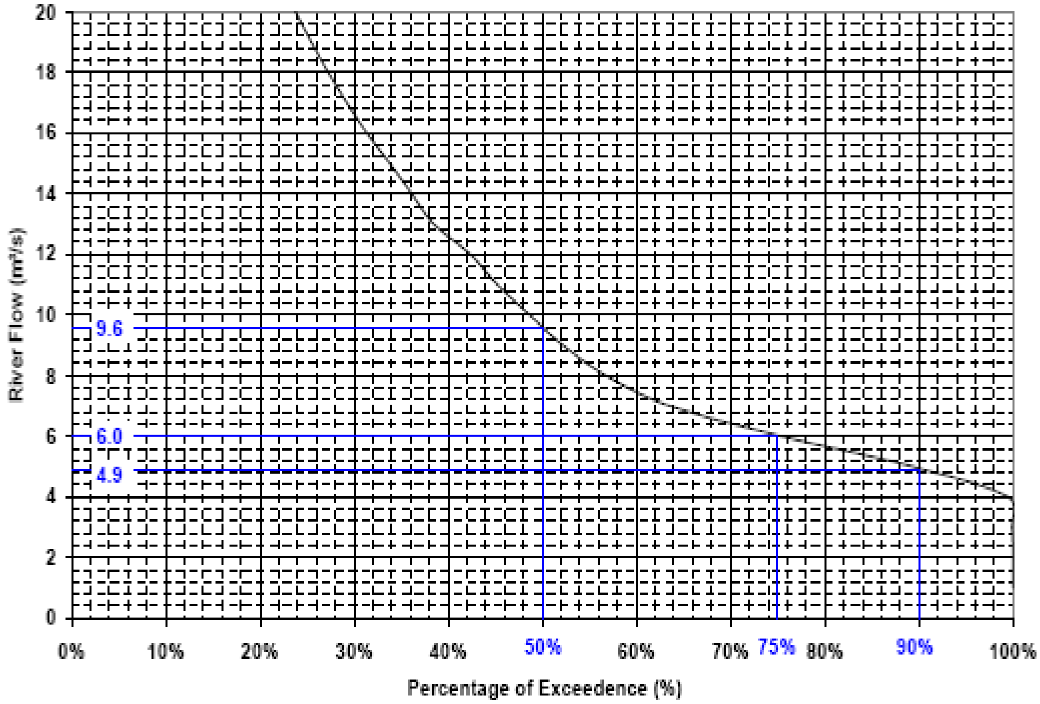


Figure 4.6: Kerang (K K Link) Flow Duration Curve

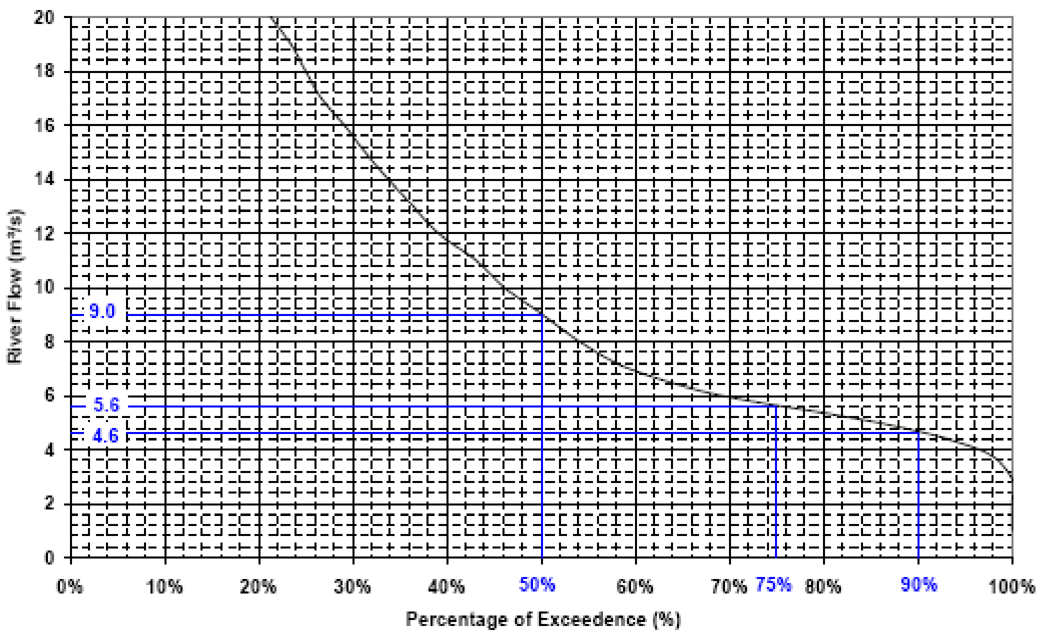


Figure 4.7: % of Exceedence (%)

4.3.2 Sedimentation

On the basis of daily suspended load observation on Kashang Khad and Kerang Khad at discharge site near trench weir of Stage-I and Stage-II respectably, for the year 2004, the average annual suspended sediment load has been computed ad 3.36 ha.m/year/100 sq km and 1.58 ha.m./year/100 sq km. respectively. The rate of sedimentation is understandably not appreciable in view of the fact that 70-75% of the catchment is snow fed which do not appreciably add to the silt load. Besides this, the area experiences scanty rainfall which is gentle over the catchment. It is the glacial supplies which are silt laden. The sediment load is mainly attributed by melting of glaciers when the glacial flow is accompanied by the moraine deposits and the scree material. Such fluvioglacial deposits in the lower reaches which are barren or have scatted vegetation are also subject to run-off led erosion besides wind erosion. The toe erosion near the bed of the streams also contribute to be sediment load in the discharge. After implementation of the CAT plan when moisture retention capacity of the Soil shall increase with increase of forest canopy in the degraded areas and with slope modifications of nallas/small rivulets due to erection of hard measures like DRSM/wire crate check dams the erosion process shall reduce due to modified velocity of flow of run-off. The stream bank protection works shall not only revet the valley slope behind them but also let deposition of silt/sediment in between the repelling spurs constructed to divert the flow from affected banks.

4.3.2.1 Arrangement for Sediment Exclusion

The trash rack proposed to be provided at the crest of each of the trench weirs has 20 mm nominal size openings. Thus the diverted water is likely to induct sediments upto 20 mm. nominal size for arresting which a shingle excluder shall be provided at the end of the trench weir to ensure shingle free discharge into the inlet channel. From time to time shingles accumulated in the pit will be flushed into the khad through a flushing channel having a bed slope of about l in 10. The shingle free discharge is conducted through inlet channel through an orifice into an overflow weir provided immediately upstream of desanding basin to return to the river the excess water drawn from the trench weir or during plant shut down. A continuous desanding arrangement in the from of either vortex type or the Dufour type setting basin designed to exclude particles greater than 0.2 mm size with 90% or higher efficiency shall be provided before the diverted water is channelised into the water conductor system leading to the turbines.

4.3.2.2 Flushing of Balancing Reservoir

Two balancing reservoirs of capacity 54000 cum and 106000 cum. respectively have been proposed in the project to guarantee maximum power production during the two peaking periods of the day i.e. 7.30 AM to 9.30 AM, from 6.30 PM to 8.30 PM in winter (Nov. to March) and from 7.00 AM to 8:30 AM and from 7:30 PM to 9:30 PM in summer (April to Oct). Though the hydraulic design of HRT and balancing reservoirs and fixing of invert slopes generate such flow velocities that accumulation of such fine sediments, which could not be extracted from desanding arrangement, would be minimized, yet some quantity of fine sediment is likely to settle in the balancing reservoir. In order to facilitate flushing of such sediment from the bed of the balancing storage through a pipe, one meter in diameter, the invert of the balancing reservoir upstream of the pressure shaft inlet has been provided lin 20 slope in a length of 15 m towards the left side. The flushing/outlet pipe has been embedded in balancing reservoir wall and provided with a valve to facilitate flow of flushing water through conduit/channel to Kashang Khad.

4.4 WATER USE

The Integrated Kashang HEP is conceived to harness water of Kashang and Kerang Khads for non-consumptive use of power generation by diverting water from Kashang Khad through vertical drop diversion weir at Dolo Dogri (Stage-I) and from Kerang Khad through diversion weirs at Toktu (Stage-IV) and Lappo (Stage-II). At present neither any micro or mini hydro electric project has been constructed on these Khads, nor is there any industry utilizing the water of these streams or discharging effluent into these streams. During operation phase the proposed project contemplates non-consumptive use of water by diversion to a maximum of 9.3 cumecs from Kashang Khad and 22 cumecs of water from Kerang Khad thorough k-k link tunnel for hydro-power generation at underground Power House near Powari village with tail race discharging into Kashang Khad near confluence with River Satluj.

The 18 km. length of Kashang Khad, from its origin to the point of confluence with River Satluj, is not intercepted by any substantial stream/nala. The point of diversion is about 4 km from confluence with River Satluj and in this reach of the stream there does not exist either any flow irrigation scheme or any water supply scheme tapping directly from the stream. However the construction work of FIS Jhangi Phase-II, with authorized head discharge of 0.38 cumecs, is in progress. This FIS off takes from Kashang Khad 4 km upstream of trench weir site of Stage-I. The length of the channel is 26.8 km and is proposed to cater to

564 ha CCA by meeting irrigation demand of main crops like ogla, phaphra peas, rajma and apples. The irrigation demand rises from months of May to September only. Due to snow no crop is possible during October to end of April.

Emanating from glacier near Larsa way pass (El 5538 m) Kerang Khad, locally known as Taiti Garang, traverses 44 km before confluencing with River Satluj. This Khad is joined by a major tributary known as Pager Garang near village Lippa at RD 6.8 km. Though a few other streams viz. Porang and a local stream d/s of Asrang village add to discharge of Kerang Khad insignificantly Pager Garang bring about minimal discharge of 0.30 cumecs. But it meets Kerang Khad near Lippa about 3.0 km d/s of trench weir of Stage-II. Two irrigation schemes viz 7.5 km long FIS Khamus (0.11 cumecs) and 5.25 km long FIS Panasarring (0.11 cumecs) off take from Pager Khad about 4 km upstream of Lippa village.

Consumpive use of Kerang Khad, upstream of diversion weir site Toktu (Stage-IV), is being presently made through 3 km long FIS Porang Khad (0.07 cumecs) offtaking from Porang Nala, a tributary of Kerang Khad. Another 1.5 km long FIS Toktu (0.015 cumecs) off takes from a local rivulet which joins Kerang khad in between Toktu and Lappo villages. Another 9.5 km long FIS Keran Khad to Lippa (0.1 cumecs) for irrigation of 82 ha CCA is under construction and shall take off from Kerang Khad near Asrang village. Besides these FIS there are mainly water supply schemes which mainly take off from springs and not directly through kerang khads or its tributaries. There is no consumptive use of water of kerang khad d/s of trench weir of Stage-II weir right upto confluence point with river Satluj. The statistics of various FIS off taking or under construction from Kashang and Kerang khad is elucidated in **Table 4.5** and water supply scheme in **Table 4.6**.

Table 4.5: Statistics of Flow Irrigation Scheme From Kashang and Kerang Khads U/S & D/S of trench weir sits.

S. No	Name of Flow Irrigation Scheme	Status	Name of feeding stream	Location	Length (km)	CCA (ha)	Discharge (Cumecs)	Remark
1	FIS Porang Kanda	Commis sioned	Porang	U/S of Toktu (Stage-IV)	3	90	0.07	Porang Nala is a right bank tributary of Kerang Khad.

2	FIS Toktu	Commissioned	Local Nala	2 km d/s of Toktu	1.5	15	0.015	Local Nala is a right bank tributary of Kerang Khad.
3	FIS Kerang Khad to Lippa	Under Construction	Kerang Khad	1.0 km d/s of Toktu	9.5	82	0.10	FIS directly takes off from Kerang Khad in between Toktu and Lappo village.
4	FIS Jhangi Phase-II	Under Construction	Kashang Khad		26.8	564	0.28	FIS directly takes off from Kashang Khad about 4 km u/s of trench weir site (Stage-I)

Table 4.6: Details of Water Supply Schemes

S. No	Name of Scheme	Source	Required Discharge of Source	
			Litre per day	Cumecs
1	WSS Toktu	Local spring	43524	0.0005
2	WSS Asrang	Spring at Pooja Mating	84988	0.001
3	WSS Tasyang	Local spring	14960	0.00017
4	WSS Rizing Khanda	Spring at Song Tong Tun	1260	0.000015
5	WSS Turtang Kanda	Local spring	16940	0.00019
6	WSS Thopan	Local spring	14130	0.00016
7	WSS Lappo	Local spring	19390	0.00022
8	WSS Lippa	Spring at Chak Nala	117550	0.0013

Environmental Flow Requirement

Environmental consideration requires that a minimum flow is always guaranteed into the river downstream of the diversion structures to meet the requirement of aquatic life, drinking water, wild life, fisheries, riparian rights and religious rites. The Hydro-Power Policy-2006, Himachal Pradesh, postulates that in case of R-OR scheme there shall be a minimum flow of 15% water immediately downstream of the diversion structure of the project all the times including lean seasons. Thus the minimum stipulated flow has been worked out on the basis of average of lean months flow in the months of December to February in 90% dependable Year which is Year 1997 for Kerang and Kashang Khads. The computation of minimum flow required is presented in **Table-4.7** and is adequate in the wake of fact that there is no other consumptive use of water of these sterams d/s of trench weir sites.

Table 4.7: Computation of Minimum Flow Requirement

Mont	Inflow (Cumecs)		
	Kashang	**Kerang (Stage II & III)**	**Kerang (Stage-IV)**
December			
1-10	2.6	5.7	5.4
11-20	2.3	5.2	4.9
21-31	2.1	4.7	4.4
January			
1-10	2.0	4.6	4.3
11-20	1.9	4.3	4.0
21-31	1.9	4.2	3.9
February			
1-10	1.8	4.0	3.8
11-20	1.8	4.0	3.8
21-28	1.7	3.9	3.6
Average	2.01	4.51	4.23
Minimum Flow Required @15%	0.30	0.67	0.64

Due to abstraction of water from Kashang Khad (Stage-I), about 4 km stretch of Khad would be affected for which a minimum flow of 0.30 cumecs immediately below intake would be maintained during lean season while during months of June to August all discharge in excess of 9 cumecs shall be passed below intake. In view of the fact that below intake the khad flows in deep gorge with approx. 200 m/km slope and there is neither any consumptive use of water in this reach nor any effluent is added, minimum flow of 0.3 cumecs shall suffice the environmental needs.

About 9.8 km reach of Kerang khad d/s of intake of Stage-II shall be affected due to water abstraction. A minimum flow of 0.67 cumecs immediately below the intake point would be maintained. Besides this about 0.20 cumecs of water from Pager Khad and 0.03 cumecs from Chakra Khad which meet Kerang Khad at RD 6.8 km and 6.3 km respectively will also add to the minimum flow. It is also worthwhile to pointout here that after functioning of Stage-IV, a minimum discharge of about 0.10 cumecs from two local khads between Asrang and Lappo shall also be available for meeting the minimum flow requirement. Thus after completion of Satge-IV, about 1.0 cumecs of water shall be available throughout the lean season in Kerang Khad which would more than suffice the environmental needs.

4.5 WATER QUALITY

The quality of water is vital concern for mankind since it is directly linked with human welfare. Water quality characteristics of aquatic environment arise from multitude of physical, chemical and biological interactions. The water bodies are continuously subjected to dynamic state of changes with respect to their geo-chemical characteristics. The dynamic balance in aquatic ecosystem is upset by human activities, resulting in pollution which is obvious by bad taste of drinking water, offensive odour, unchecked growth of aquatic weeds, and decrease in number of fish, oil and grease floating on water bodies. These disturb the normal uses of water for public water supply, industry, agriculture etc.

4.5.1 Water Quality Assessment

Samples of surface water and ground water were collected from Satluj river, Kashang Khad, Kerang Khad, Mewar Khad & confluence points and Spring & Hand Pump in Pangi village. To assess the water quality of the area samples were tested for physico-chemical parameters.

The details of water quality sites are given in **Table 4.8** and **Figure 4.8**. The water samples were collected during winter (March 2008) and pre-monsoon (June 2008) at these locations to assess the water quality in the study area. The results are presented in **Table 4.9 and 4.10** for the winter and pre-monsoon season respectively.

Table 4.8: Location of Various water sample sites

Station Code	Station Name	Distance (km) from Weir Site	Direction from Weir Site	Description
SW1	Weir Site, Dola Dogri	-	-	Surface Water
SW2	Satluj River near Power House	03	SE	Surface Water
SW3	Kashang Khad near Power House	2.5	SE	Surface Water
SW4	Kerang Khad (Lapo Dogri)	07	NE	Surface Water
SW5	River Satluj at confluence point with Kerang Khad	13	E	Surface Water
SW6	Mewar Khad near Pangi Vilalge	4.0	SW	Surface Water
GW1	Pangi Village near Bus Stand	03	SW	Ground Water (Hand Pump)
GW2	Spring Water in Pangi Village	3.5	SW	Ground Water (Spring Water)

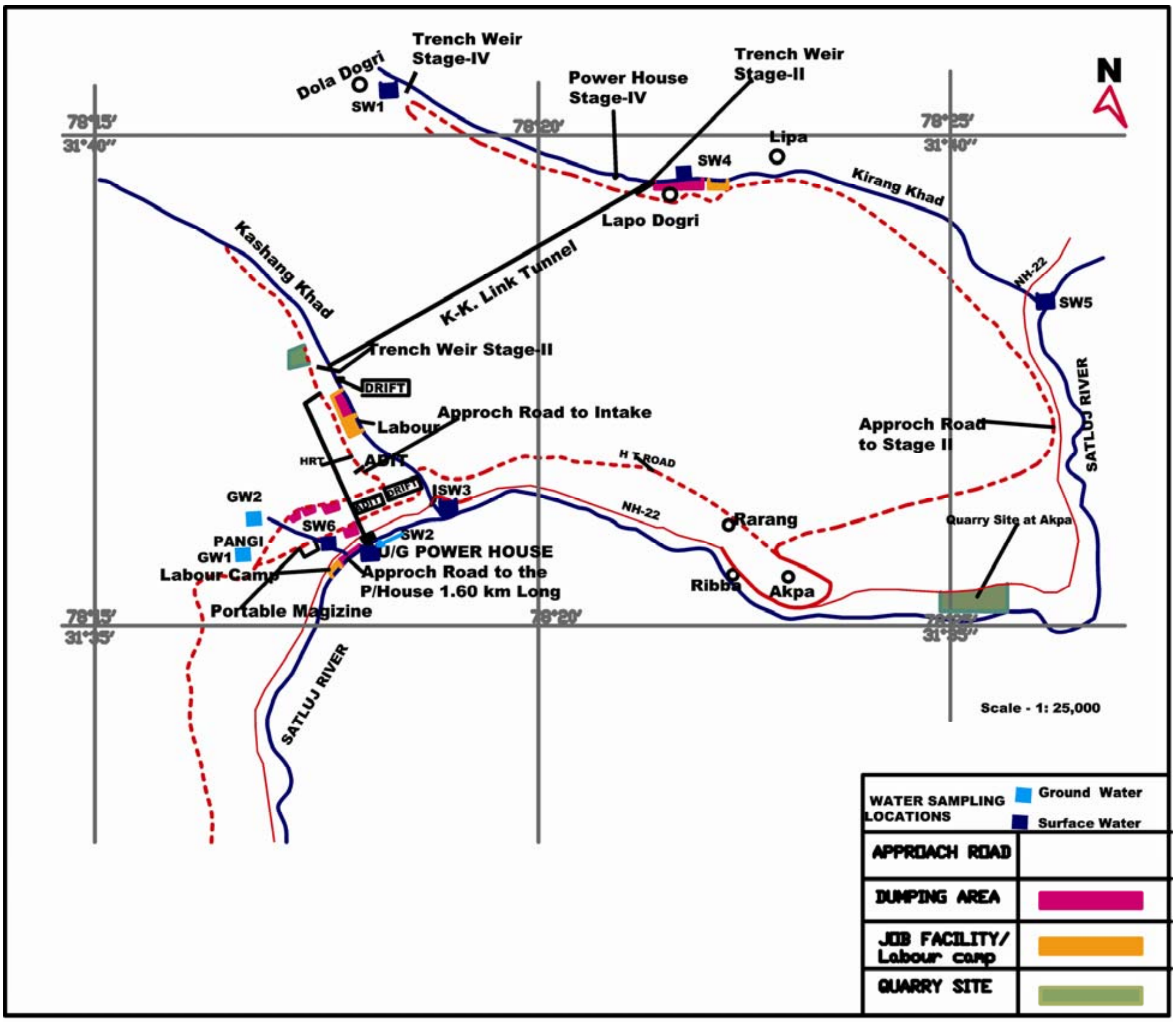


Figure 4.8: Locations of Water Sampling Sites

Table 4.9: Water Quality of the study area during Winter (March 2008)

Sl. No.	*Parameters*	Unit	Weir Site, Dola Dogri	**Satluj River near Power House**	**Kashang Khad near Power House**	**Kerang Khad (Lapo Dogri)**	**Mewar Khad near Pangi Vilalge**	**River Satluj at confluence point with Kerang Khad**	**Pangi Village near Bus Stand (Hand Pump)**	**Spring Water near Pangi Village**
A. Physical Parameters										
1.	Temperature	^{0}C	4.0	10.0	9.0	7.0	9.0	9.0	12.0	12.0
2.	pH	-	7.10	7.88	7.12	7.11	7.05	7.70	7.59	7.48
3.	Conductivity	µS/cm	92	300	98	90	52	237	420	340
4.	Total Dissolved Solids	mg/l	58	180	61	56	33	140	250	210
5.	Dissolved Oxygen	mg/l	9.5	9.0	9.6	8.0	8.5	8.6	3.6	4.8
6.	Turbidity	NTU	0.1	1.0	1.0	0.1	1.0	1.0	0.1	0.1
B. Chemical Parameters										
7.	Total Alkalinity (as $CaCO_3$)	mg/l	18	110	22	20	18	66	196	192
8.	Calcium Hardness (as $CaCO_3$)	mg/l	14	4	18	16	10	70	92	76
9.	Magnesium Hardness (as $CaCO_3$)	mg/l	10	55	12	12	8	26	114	26
10.	Total Hardness (as $CaCO_3$)	mg/l	24	102	30	28	18	96	206	102
11.	Chloride	mg/l	4	8	3	5	2	2	7	5
12.	Iron	mg/l	BDL	0.6	BDL	BDL	BDL	0.5	0.10	0.20
13.	Nitrate as N	mg/l	1.4	3.6	1.6	1.8	3	2	9	BDL
14.	Phosphate	mg/l	0.5	0.8	0.6	0.6	0.5	0.5	0.8	0.5
15.	Manganese	mg/l	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
16.	Sulphate	mg/l	12	25	7	24	5	25	8	13
17.	Bio-Chemical Oxygen Demand	mg/l	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
18.	Chemical Oxygen Demand	mg/l	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
C. Bacteriological Parameters										
19.	E-Coli	MPN /100 ml	ND	6	4	ND	10	8	ND	ND
20.	Total Coliform	MPN /100 ml	ND	240	60	ND	80	200	ND	ND

BDL – Below Detection Limit

ND – Not Detectable

Table 4.10: Water Quality of the study area during Pre-monsoon (June 2008)

Sl. No.	*Parameters*	Unit	Weir Site, Dola Dogri	Satluj River near Power House	Kashang Khad near Power House	Kerang Khad (Lapo Dogri)	Mewar Khad near Pangi Vilalge	River Satluj at confluence point with Kerang Khad	Pangi Village near Bus Stand (Hand Pump)	Spring Water near Pangi Village
B. Physical Parameters										
1.	Temperature	^0C	10.0	19.0	16.0	12.0	16.0	18.0	15.0	16.0
2.	pH	-	7.15	7.85	7.20	7.10	7.10	7.80	7.60	7.50
3.	Conductivity	µS/cm	102	312	104	96	56	220	432	360
4.	Total Dissolved Solids	mg/l	60	194	71	60	32	144	280	225
5.	Dissolved Oxygen	mg/l	9.0	8.5	9.0	7.6	8.0	7.8	3.2	4.3
6.	Turbidity	NTU	0.1	1.0	1.0	0.1	1.0	1.0	0.1	0.1
B. Chemical Parameters										
7.	Total Alkalinity (as $CaCO_3$)	mg/l	18	112	24	22	20	68	210	194
8.	Calcium Hardness (as $CaCO_3$)	mg/l	14	56	20	16	11	72	92	78
9.	Magnesium Hardness (as $CaCO_3$)	mg/l	12	55	14	13	9	28	116	25
10.	Total Hardness (as $CaCO_3$)	mg/l	26	111	34	29	20	100	208	103
11.	Chloride	mg/l	5	9	4	6	3	3	8	6
12.	Iron	mg/l	BDL	0.6	BDL	BDL	BDL	0.5	0.10	0.20
13.	Nitrate as N	mg/l	1.6	3.8	1.6	1.9	3.0	3.0	7.0	BDL
14.	Phosphate	mg/l	0.4	0.9	0.5	0.5	0.6	0.6	0.7	0.5
15.	Manganese	mg/l	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
16.	Sulphate	mg/l	10	26	8	27	6	26	7	12
17.	Bio-Chemical Oxygen Demand	mg/l	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
18.	Chemical Oxygen Demand	mg/l	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
C. Bacteriological Parameters										
19.	E-Coli	MPN /100 ml	ND	10	10	ND	12	18	ND	ND
20.	Total Coliform	MPN /100 ml	ND	260	100	ND	100	220	ND	ND

BDL – Below Detection Limit, ND – Not Detectable

The water quality results shows that all the parameters are within the permissible limit of Drinking Water Standards (IS: 10500), except the bacteriological parameters.

CHAPTER 5

AIR AND NOISE ENVIRONMENT

5.1 INTRODUCTION

Hydroelectric power projects are site specific in nature, whereby, the construction activity such as excavation of roads, construction of dam and power house along with other appurtenant structures remains confined to a specific area. In addition to this, the construction activity also entails operation of heavy vehicles and other machines along with operation of crushing and batching plans, which emits dust and aerosols in the atmosphere causing air pollution. Operation of heavy vehicles and other plants also causes noise pollution in such an area.

5.2 AMBIENT AIR QUALITY

The earth's atmosphere contains a number of gases such as Oxygen (21%), Nitrogen (78%), Water vapor (1-3%), Carbon dioxide (0.33%), Hydrogen, Nitrogen, Ozone, etc. in a relatively fixed ratio. The balance in distribution of the above gases may change due to man induced activities and the concentration of different gases may change accordingly.

Dust and vehicular emissions may change the concentration of suspended solid particles in the air and may cause drastic changes in the levels of Suspended Particulate Matter (SPM) and Respirable Suspended Particulate Matter (RSPM), which is hazardous to human being and plants. Sulpher dioxide (SO2), Oxides of Nitrogen (NO_x), SPM and RSPM are the four major air pollutants, which cause concern to environment and other living beings. In order to generate, a data base on the existing status of these pollutants, the study area was evaluated for setting up four locations to conduct air quality monitoring as per the details given in **Table 5.1** and **Figure 5.1**.

5.2.1 Ambient Air Quality Analysis

A well-designed monitoring programme was carried out to assess the status of ambient air quality in the project area. The parameters studied were SPM, SO2, NO_x and RPM. The monitoring was conducted during the period of March 2008 for winter season and June 2008 for pre-monsoon season. The monitoring was done by using Respirable Dust Sampler at 4 (four) stations with a frequency of twice a week for two weeks in a season. The samples were collected and analyzed as per methods specified by Bureau of Indian Standards (IS: 5182). The objective was to assess the existing level of air pollutants. 24 hourly sampling for two consecutive days was done at each station.

The results are presented in **Tables 5.2 to 5.9**.

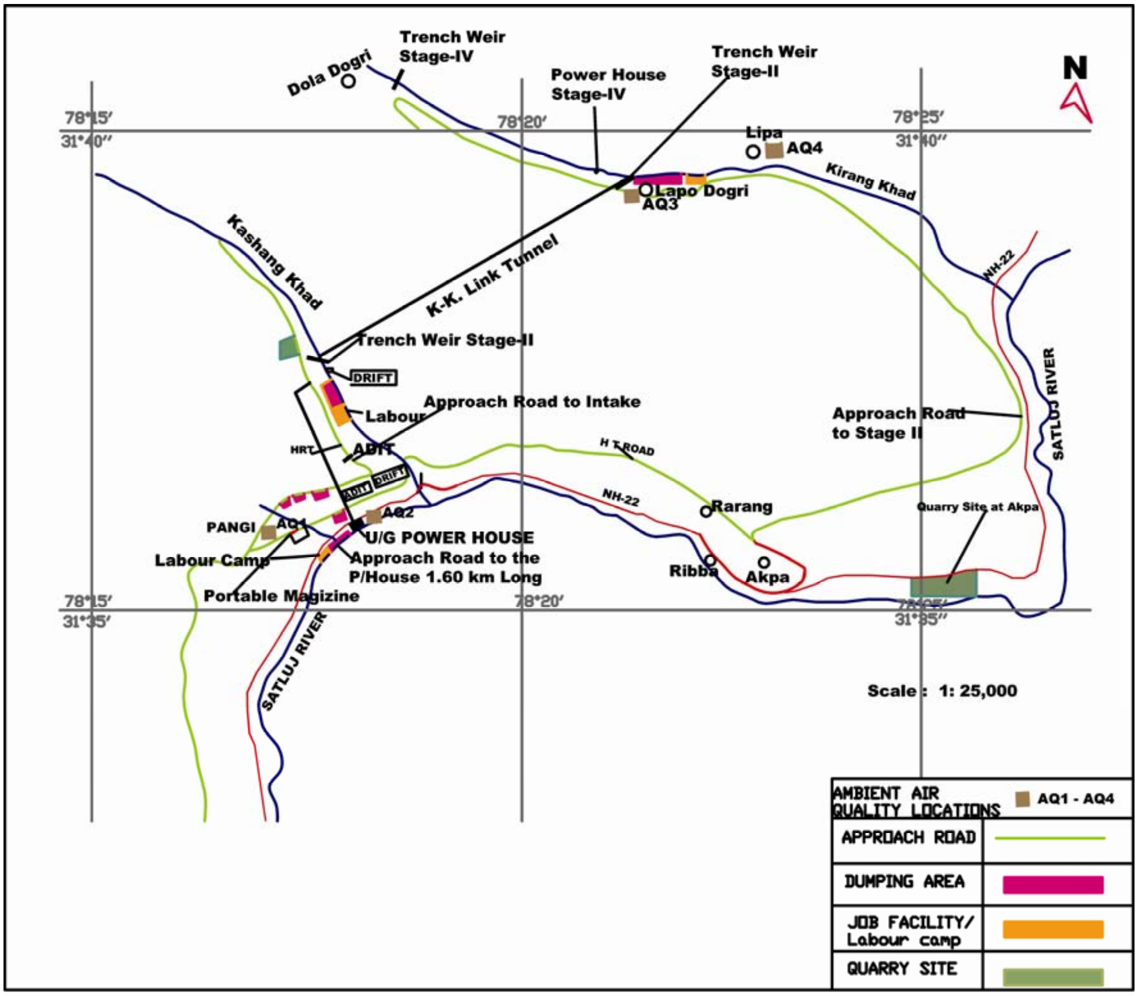


FIGURE 5.1 AMBIENT AIR QUALITY SAMPLING LOCATIONS

Table 5.1: Location of Ambient Air Quality Monitoring Stations

Sr. No.	Station Name	Direction *	Distance, Km. (Approx.)*
1	Pangi Village	SW	03
2	Near Power House	SE	03
3	Lapo Dogri	NE	07
4	Lipa	NNE	10

* Direction, distance are w.r.t. proposed trench weir site.

Table 5.2: Ambient Air Quality Status with respect to Respirable Particulate Matter (Winter)

Name of location	Location Code	Concentration, µg/m³			NAAQ Standards, µg/m³ (for Residential and Other areas)	Remarks
		Max.	Min.	Avg.		
Pangi Village	A1	32	26	28	100	Within the National Ambient Air Quality Standards for 24 hrs. monitoring
Near Power House	A2	45	32	41	100	
Lapo Dogri	A3	25	20	23	100	
Lipa	A4	29	21	24	100	

Table 5.3: Ambient Air Quality Status with respect to Respirable Particulate Matter (Pre-Monsoon)

Name of location	Location Code	Concentration, µg/m³			NAAQ Standards, µg/m³ (for Residential and Other areas)	Remarks
		Max.	Min.	Avg.		
Pangi Village	A1	42	32	34	100	Within the National Ambient Air Quality Standards for 24 hrs. monitoring
Near Power House	A2	54	38	48	100	
Lapo Dogri	A3	32	24	26	100	
Lipa	A4	30	22	25	100	

Table 5.4: Ambient Air Quality Status with respect to Suspended Particulate Matter (Winter)

Name of location	Location Code	Concentration, µg/m³			NAAQ Standards, µg/m³ (for Residential and Other areas)	Remarks
		Max.	Min.	Avg.		
Pangi Village	A1	130	110	118	200	Within the National Ambient Air Quality Standards for 24 hrs. monitoring
Near Power House	A2	160	154	158	200	
Lapo Dogri	A3	120	105	116	200	
Lipa	A4	128	112	120	200	

Table 5.5: Ambient Air Quality Status with respect to SPM (Pre-Monsoon)

Name of location	Location Code	Concentration, µg/m³			NAAQ Standards, µg/m³ (for Residential and Other areas)	Remarks
		Max.	Min.	Avg.		
Pangi Village	A1	138	124	130	200	Within the National Ambient Air Quality Standards for 24 hrs. monitoring
Near Power House	A2	180	160	172	200	
Lapo Dogri	A3	144	118	124	200	
Lipa	A4	140	121	127	200	

Table 5.6: Ambient Air Quality Status with respect to Sulphur Dioxide (Winter)

Name of location	Location Code	Concentration, µg/m³			NAAQ Standards, µg/m³ (for Residential and Other areas)	Remarks
		Max.	Min.	Avg.		
Pangi Village	A1	BDL	BDL	BDL	80	Within the National Ambient Air Quality Standards for 24 hrs. monitoring
Near Power House	A2	08	BDL	04	80	
Lapo Dogri	A3	BDL	BDL	BDL	80	
Lipa	A4	BDL	BDL	BDL	80	

BDL – Below Detection Limit

Table 5.7: Ambient Air Quality Status with respect to Sulphur Dioxide (Pre-Monsoon)

Name of location	Location Code	Concentration, µg/m³			NAAQ Standards, µg/m³ (for Residential and Other areas)	Remarks
		Max.	Min.	Avg.		
Pangi Village	A1	9	7	8.0	80	Within the National Ambient Air Quality Standards for 24 hrs. monitoring
Near Power House	A2	12	8	10.0	80	
Lapo Dogri	A3	8	7	7.5	80	
Lipa	A4	8	BDL	4.0	80	

BDL – Below Detection Limit

Table 5.8: Ambient Air Quality Status with respect to Nitrogen Oxide (Winter)

Name of location	Location Code	Concentration, µg/m³			NAAQ Standards, µg/m³ (for Residential and Other areas)	Remarks
		Max.	Min	Avg.		
Pangi Village	A1	20	12	16	80	Within the National Ambient Air Quality Standards for 24 hrs. monitoring
Near Power House	A2	22	16	18	80	
Lapo Dogri	A3	14	09	12	80	
Lipa	A4	16	11	13	80	

Table 5.9: Ambient Air Quality Status with respect to Nitrogen Oxide (Pre-Monsoon)

Name of location	Location Code	Concentration, µg/m³			NAAQ Standards, µg/m³ (for Residential and Other areas)	Remarks
		Max.	Min.	Avg.		
Pangi Village	A1	22	14	18	80	Within the National Ambient Air Quality Standards for 24 hrs. monitoring
Near Power House	A2	24	17	21	80	
Lapo Dogri	A3	14	10	12	80	
Lipa	A4	16	13	14	80	

BDL: Below Detection Limit

It is evident from the above Tables that the air quality in the proposed project area and its surroundings is pollution free. The pollutant concentration in the air is well below the permissible limit as there are no industries in the area and the density of vehicular traffic is not alarming. The forest cover in and around the site is quick dense and serves as a carbon sink. All the pollutant gases in the atmosphere are also within safe limits. In addition to this there are plenty of water vapours in the air, acting as a dilutant and do not allow the dust to scatter much. The phenomenon like smog and acid rains have never been observed in these areas and neither do such conditions are likely to occur.

However, with the construction of the trench weir, powerhouse, colonies and other infrastructural facilities in the area, the air quality will be affected during construction period. The movement of heavy vehicles and operation of other construction equipments will also add to the obnoxious gases being released into the atmosphere. The concentration of these kinds of gases and dust emission, however, will be cleared on daily basis as the area is located in a valley and the gush of strong winds during morning and evening hours is a common phenomenon.

5.3 NOISE ENVIRONNENT

Noise is an important pollutant, which affects the environment and poses health and communication hazards. The intensity of noise is measured in decibel (db). The intensity of more than 65 db becomes alarming from pollution point of view. At the construction sites, the intensity of noise will usually be much higher for which safeguard measures will be adopted so that the noise pollution can be controlled.

In order to collect the base line data on noise pollution five locations were identified as presented in **Table 5.10** and **Figure. 5.2**.

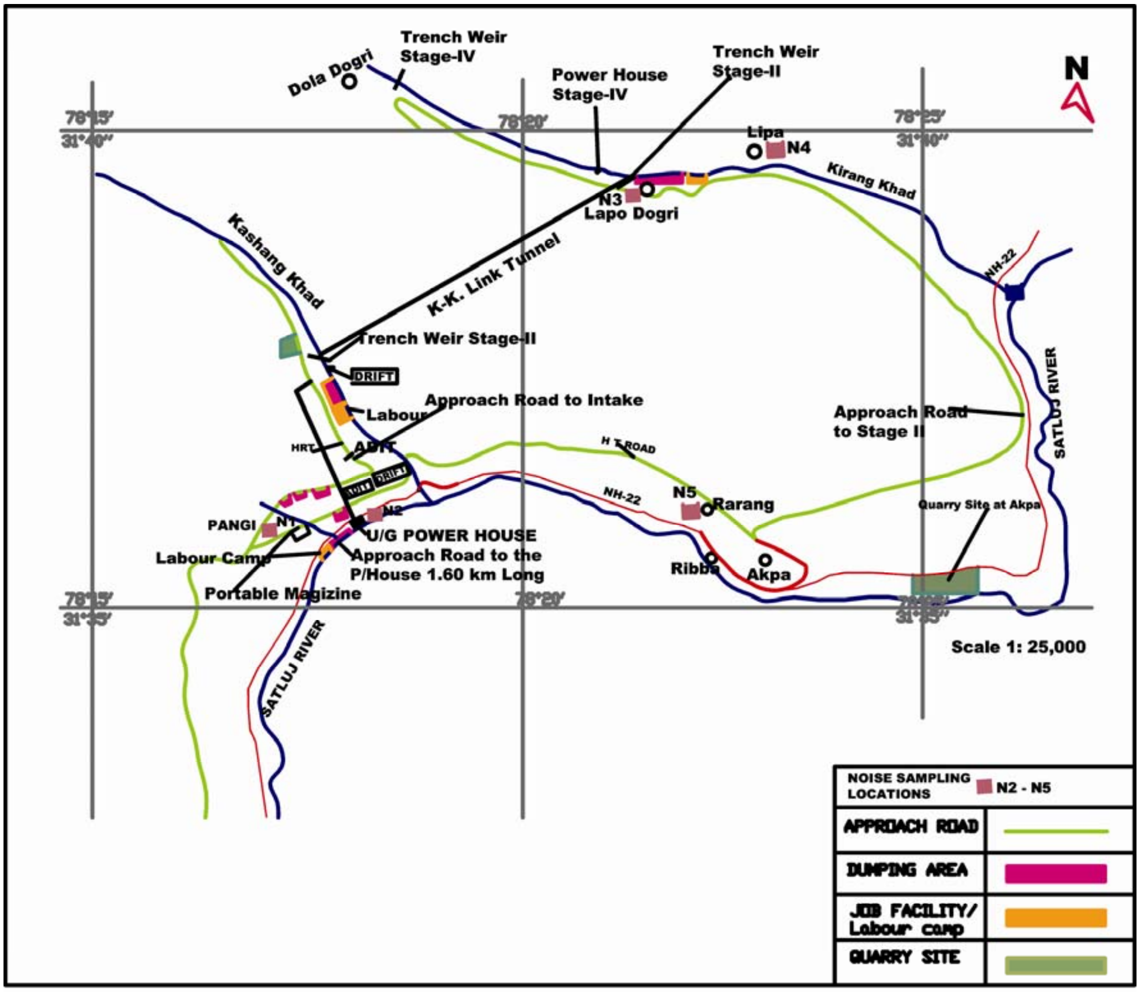


FIGURE 5.2 NOISE SAMPLING LOCATIONS

Table 5.10: Location of Noise Monitoring

Station Code	Station Name	Location w.r.t. Trench Weir Site		Description
		Distance (k.m.)	Direction	
N1	Pangi Village (Temple)	03	SW	Residential
N2	Near Power House (NH-22)	03	SE	Commercial
N3	Lapo Dogri	07	NE	Residential
N4	Lipa	10	NNE	Sensitive
N5	Rarang (PHC)	06	E	Sensitive

The noise level data at the above mentioned sites were collected during March 2008 for winter season and June 2008 for pre-monsoon season as per the details given in **Tables 5.11 - 5.12.**

Table 5.11: Noise Level of the Study Area (Winter)

Sl. No.	Location	Leq (day), dB (A)	Leq (Night), dB (A)	Leq, dB (A), day & night
1.	Pangi Village (Temple)	50	36	42
2.	Near Power House (NH-22)	55	40	52
3.	Lapo Dogri	48	37	41
4.	Lipa	50	38	42
5.	Rarang (PHC)	49	38	44

Table 5.12: Noise Level of the Study Area (Pre-Monsoon)

Sl. No.	Location	Leq (day), dB (A)	Leq (Night), dB (A)	Leq, dB (A), day & night
1.	Pangi Village (Temple)	52	38	44
2.	Near Power House (NH-22)	56	42	53
3.	Lapo Dogri	50	38	44
4.	Lipa	49	39	44
5.	Rarang (PHC)	50	40	45

The results show that the noise level in the study area are well within the permissible standards in respect of noise, which are 65, 55 and 50 dB (A) in day time and 55, 45 and 40 during night time for commercial, residential and silence zone respectively. The daytime noise level measured during 6:00 am to 10:00 pm and nighttime measured from 10:00 pm to 6:00 am. The Noise level is slightly higher near power house as compared to the other locations due to movement of vehicles on NH-22.

CHAPTER 6

STATUS OF BIOLOGICAL ENVIRONMENT

6.1 INTRODUCTION

In the present day scenario, infrastructural development is essential for the welfare of human beings inhabiting the planet since it brings more comfort to the society. However, it may specifically be mentioned over here that over utilization of the resources for substantial increase in the comforts is directly impinging upon the environmental health. Developmental activities no doubt, are essentially required for the larger interest of the human kind yet, over utilization of natural resources in the process certainly require a relook into some of the criterion otherwise required to be fitted in the process for sustainable development. The government machinery should therefore, be not averse to the development but should ask the implementors and managers to devise suitable strategies for paying required attention towards the development of issue based parameters for ultimate protection of the environment.

Many river valley projects are being implemented for the last 100 years or so all across the world. These projects besides providing safeguards against floods also provide electricity for increasing over all productivity of the region or of the country. Though efforts in the direction are still continuing, yet it is estimated that approximately 99 per cent of precipitation in the form of rain, snow etc. directly merges with the oceans without being utilized properly on their way. This certainly requires sincere thoughts/ efforts to harness it for the ultimate benefit of the mankind. The proposed project has been named as '**Integrated Kashang Hydroelectric Project**' which is to be executed by **Himachal Pradesh Power Corporation Limited**, a unit of Himachal Pradesh State Electricity Board (HPSEB).

Integrated Kashang Hydroelectric Project is proposed for development using waters of Kashang and Kerang streams, right bank tributaries of river Sutlej. The project is located in Kinnaur district of Himachal Pradesh, India (Figure-1) and is owned by Himachal Pradesh State Electricity Board (HPSEB).

Kashang and Kerang River Valleys are adjacent to each other and are separated by a high altitude ridge in the area of the project. Topographic features permit diversion of Kashang Khad at an altitude of roughly 2830 m to an underground Powerhouse located on the right bank of Sutlej river, developing a head of approximately 830 m. Topographic and geolocial features between Kerang and Kashang Valleys are also conducive to diversion of Kerang Khad, which has higher inflows than Kashang into the Kashang water conductor system for significant augmentation of generating capacity at Kashang Powerhouse.

As far as the harnessing and future use of the excess water during monsoon season is concerned, the project that way is very well conceived. However, future ecological consequences as a result of the change in the landscape, submergence of productive agricultural and forest lands situated on the banks of the river needs thorough understanding of the area which then will enable the implementers to devise suitable strategies.

A] Vegetation

1 Collection of information on vegetation including rare and endangered species, ecologically sensitive species, species of medicinal and commercial importance and species of special interest to local population of tourist influence

2 Biodiversity and Importance Value Index, Species Diversity Index, Concentration of dominance, Species richness etc.,

B] Fauna

Faunal status of the areas falling under the HEP.

Accordingly, for Environmental Impact Assessment (EIA) studies, the total area has been sub-divided into the following areas;

1. Trench Weir Stage-I at Dollo – Dogri
2. Dumping Site at Dollo – Dogri
3. Powerhouse and Dumping Site Stage-I & III at National Highway
4. Intake Trench Weir State-IV at Toktu
5. Power House Stage-IV at Lappo near Lippa
6. Influence Area under 10 kms periphery of the proposed Hydroelectric Project

Research issues to be covered in these areas have been identified those will include, floral and faunal diversity including aquatic ecology.

ASSESSMENT OF PLANT DIVERSITY OF THE AREA

General Concept

Depletion of biodiversity is mainly due to intense anthropogenic pressure owing to **"Population Explosion"** mainly for expansion of agriculture, over exploitation of forests for day to day needs, over grazing and illicit felling, shifting cultivation, development activities like, irrigation, construction of hydroelectric dams, road construction including mining activities- all leading to dysgenic selection. Rationale use of the resources is therefore, quite important in the management of biodiversity, the habitat, species and gene fools prevalent in an area, because once it is lost, it becomes an uphill task to reverse the process. Therefore, a detailed knowledge of the diversity of the area definitely helps in managing the area properly following suitable practices.

A basic and an important step for visualizing and understanding the system that how it responds to any project activity is to survey existing conditions – the baseline environment. The baseline survey must provide the necessary information on the site-specific environmental settings of the project and should also encompass the different seasons, migrations, breeding and so on and should be, if feasible, long enough to establish pre-project trends. One important challenge in assessing baseline conditions is the limited time frame for a thorough assessment, since such type of field surveys requires sufficient time and resources. And to be of significant value in the impact assessment, survey work needs to be initiated early in the process. There should be enough scope to take as long as necessary and appropriate to cover aspects such as migrations, seasons, rainy seasons and so on.

FLORISTICS

Floristic Surveys for assessing plant diversity and its status over a period of time forms an integral part of Impact Assessment techniques. The Convention on Biological Diversity provided strong support for the purpose, especially related to biodiversity. However, such studies normally lack proper baseline floristic data, the use of relevant scientific literature, identification of criteria for assessing impact magnitude and significance and subsequent plans for proper monitoring of the flora.

Plant communities basically are the indicators of the total environment. They respond not only to one environmental factor but also to an interacting group of factors. Plant communities integrate these influences and react sensitively to change in the balance of environmental stresses being primary producers in the ecosystem. With time, these plant communities bring lot of changes even in the soil system. Once the biodiversity is lost, it cannot be recreated thereby bringing permanent damage to human society which solely depends on the biodiversity. Efforts are therefore, eventually required to conserve this biodiversity at all levels.

While taking up any major developmental programme, biodiversity assessment is increasingly being recognized as a pre-requisite. Documenting biodiversity is the prime objective not only at global or national levels but also at regional levels. Floristic surveys serve to understand species distribution pattern along the range of complex environmental variables and as such are of immense significance in understanding the biodiversity of the region. The relationship is likely to be stronger within smaller geographical boundaries where environmental variables are relatively uniform compared to larger areas experiencing greater diversity.

6.3.1 Methodology Adopted

Quadrats of size 10m x10m, 3m x3m and 1m x1m were laid out randomly for enumerating trees, shrubs, herbs and regeneration respectively in the above mentioned areas. The seedlings were considered as herb while saplings as shrubs. The vegetation data was analyzed for density, frequency and abundance as per the standard formulae given by Curtis and McIntosh (1950). The relative values of density, frequency and dominance were summed to get importance value index (IVI) of individual species. The abundance to frequency ratio (A/F) of different species was determined for eliciting the distribution pattern. This ratio indicates regular (<0.025), random (0.025 to 0.050) and contiguous (>0.050) distribution (Curtis and Cottam, 1956).

The species diversity was calculated by using **Shannon-Wiener diversity index (H)** (Shannon-Wiener, 1963).

$$H = -\sum_{i=1}^{s} (Ni/N) \ln (Ni/N)$$

Concentration of Dominance (C) was measured by Simpson's index (Simpson, 1949).

$$C = \sum_{i=1}^{s} (Ni/N)^2$$

Where Ni = importance value of species i and N= total importance value of all species for both the species.

Richness Index was estimated as per Margalef (1958) *i .e.* R = S-1/ln N

Evenness Index was calculated as per Hill (1973) *i. e.* E = H/ ln S

Where S= total number of species, N= total number of individuals of all the species, H = Index of diversity.

6.3.2 Results

Phyto-sociological Analysis:

1. Trench Weir Stage-I at Dollo – Dogri

A total of 3 tree species were encountered from the area **(Table-6.1).** *Cedrus deodara* was dominant species having maximum density, frequency and abundance. This was followed by *Juglans regia* and *Salix alba*. *C. deodara* recorded highest value of IVI (195.55) followed by *J. regia* (64.36) and *S. alba* (40.09). The community identified as result of survey was *C. deodara – Juglans regia*. The distribution of all the species was contiguous.

In case of shrubs and tree saplings, total number of species was 7 **(Table 6.2).** *Indigofera gerardiana* was dominant shrub having maximum density, frequency and abundance. On the basis of IVI, *I. gerardiana* recorded highest value (112.07) followed by *S. alba* (68.65) and *Sorbaria tomentosa* (60.93). The distribution patterns of all the species was contiguous.

Amongst the 37 species of herbs **(Table 6.3),** *Polygonum polystachya* was the dominant herb with maximum density and frequency. This was followed by *Cherophyllum reflexum* and *Thymus linearis*, in terms of density. *T. linearis* recorded the highest value of abundance followed by *Equisetum arvense* and *Artemesia dracunculus*. *P. polystachya* recorded the maximum value of IVI (59.43) followed by *T. linearis* (22.21) and *A. dracunculus* (16.58). The distribution of all the species was contiguous.

The value for concentration of dominance for trees, shrubs and herbs were 0.489, 0.245 and 0.064 whereas, index of diversity (H) for trees, shrubs and herbs showed respective values of 0.878, 1.598 and 3.248, respectively. The values of Richness Index for tree, shrub and herb were 0.52, 1.02 and 5.47, respectively whereas values for Evenness index for these categories were 0.80, 0.87 and 0.89, respectively.

Table 6.1: Phyto-sociology of Tree encountered at Trench Weir Stage-I, Dollo Dogri

Sl. No	Species	Density / ha.	Frequency	Abundance	Abundance / Frequency	IVI
1	*Cedrus deodara*	300.00	27.78	3.60	0.13	195.55
2	*Juglans regia*	83.33	11.11	2.50	0.23	64.36
3	*Salix alba*	66.67	11.11	2.00	0.18	40.09

C = 0.489 H = 0.878

Table 6.2: Phytosociology of Shrub encountered at Trench Weir Stage-I, Dollo Dogri

Sl. No.	Species	Density/ ha.	Frequency	Abundance	Abundance/ Frequency	IVI
1	*Desmodium tiliaefolium*	648.15	16.67	3.50	0.21	13.38
2	*Indigofera gerardiana*	8796.30	66.67	11.88	0.18	112.07
3	*Lonicera hispida*	1203.70	16.67	6.50	0.39	17.24
4	*Rubus sp.*	277.78	8.33	3.00	0.36	5.95
5	*Salix denticulata*	1388.89	25.00	5.00	0.20	21.08
6	*Sorbaria tomentosa*	4166.67	33.33	11.25	0.34	60.93
7	*Salix alba (s)*	3981.48	41.67	8.60	0.21	68.65

C=0.245 H=1.598

Table 6.3: Phytosociology of Herbs encountered at Trench Weir Stage-I, Dollo Dogri

Sl. No.	Species	Density/ Sqm.	Frequency	Abundance	Abundance/ Frequency	IVI
1	*Anemone obtusiloba*	0.07	16.67	3.50	0.21	6.98
2	*Artemisia brevifolia*	0.03	8.33	4.00	0.48	3.50
3	*Artemisia dracunculus*	0.10	25.00	9.33	0.37	16.58
4	*Capsella bursapastris*	0.07	16.67	2.50	0.15	5.32
5	*Cherophyllum reflexum*	0.13	33.33	2.00	0.06	9.72
6	*Cicer microphyllum*	0.03	8.33	1.00	0.12	2.35
7	*Conyza stricta*	0.03	8.33	1.00	0.12	2.35
8	*Corydalis govaniana*	0.03	8.33	2.00	0.24	4.12
9	*Dioscorea deltoidea*	0.03	8.33	1.00	0.12	2.73
10	*Equisetum arvense*	0.07	16.67	10.00	0.60	10.81
11	*Gallium asparine*	0.07	16.67	4.00	0.24	5.80
12	*Gallium asperifolium*	0.07	16.67	6.00	0.36	7.28
13	*Gallium rontundifolium*	0.07	16.67	5.00	0.30	7.07
14	*Geranium pratense*	0.03	8.33	1.00	0.12	2.06
15	*Geranium wallichianum*	0.07	16.67	2.00	0.12	4.97
16	*Heracleum candicans*	0.03	8.33	2.00	0.24	7.91
17	*Lychnis nutans*	0.03	8.33	1.00	0.12	2.61
18	*Malva rotundifolia*	0.07	16.67	2.50	0.15	5.57
19	*Mentha longifolia*	0.07	16.67	5.00	0.30	10.70
20	*Nepeta erecta*	0.07	16.67	1.00	0.06	4.70
21	*Origanum vulgare*	0.07	16.67	7.50	0.45	8.82
22	*Plantago lanceolata*	0.03	8.33	2.00	0.24	2.75
23	*Plantago tibetica*	0.07	16.67	2.00	0.12	5.31
24	*Polygonum paronychioides*	0.07	16.67	3.00	0.18	5.67
25	*Polygonum polystachya*	0.23	58.33	5.71	0.10	59.43
26	*Potentilla argyrophylla*	0.10	25.00	1.00	0.04	7.84

27	*Potentilla atrosanguinea*	0.03	8.33	2.00	0.24	2.85
28	*Potentilla parviflora*	0.07	16.67	2.00	0.12	5.40
29	*Rumex nepalensis*	0.10	25.00	1.00	0.04	12.42
30	*Salvia nubicola*	0.03	8.33	3.00	0.36	5.34
31	*Selinum tenuifolium*	0.07	16.67	3.00	0.18	7.96
32	*Silene inflata*	0.07	16.67	3.00	0.18	6.63
33	*Stellaria media*	0.03	8.33	4.00	0.48	3.61
34	*Thymus linearis*	0.13	33.33	11.25	0.34	22.21
35	*Urtica dioica*	0.03	8.33	3.00	0.36	4.39
36	*Urtica hyperborea*	0.03	8.33	4.00	0.48	6.24
37	*Verbascum thapsus*	0.03	8.33	4.00	0.48	9.70

C = 0.064 H = 3.248

2. Dumping Site at Dollo – Dogri

A total of 2 tree species were encountered from the area **(Table 6.4).** *J. regia* was dominant species having maximum density and frequency followed by *C. deodara*. *C. deodara* recorded highest value of IVI (168.74) followed by *J. regia* (132.21). The community identified as result of survey was *C. deodara – J. regia*.
In case of shrubs and tree saplings, total number of species was 7 **(Table 6.5).** *S. tomentosa* was dominant shrub having maximum density, frequency and IVI. This was followed by *I. gerardiana* and *Desmodium tiliaefolium*. The abundance to frequency ratio indicates that distribution patterns of all the species were contiguous.

Amongst the 28 species of herbs **(Table 6.6),** *A. dracunculus* was the dominant herb with maximum density and frequency. This was followed by *T. linearis* and *Artemisia bravifolia*, in terms of density. *P. polystachya* recorded the highest value of IVI (49.10) followed by *A. dracunculus* (46.46) and *A. brevifolia* (16.95). The distribution of all the species except *Anemone obtusiloba, Heracleum candicans* and *Mentha longifolia* was contiguous.

The value for concentration of dominance for trees, shrubs and herbs were 0.551, 0.358 and 0.074 whereas, index of diversity (H) for trees, shrubs and herbs showed respective values of 0.685, 1.283 and 2.969, respectively. The values of richness index for tree, shrub and herb were 0.27, 1.05 and 4.09, respectively whereas values for Evenness index for these categories were 0.98, 0.66 and 0.89, respectively.

Table 6.4: Phytosociology of Tree encountered in the Dumping site at Dollo Dogri

Sl. No.	Species	Density/ ha.	Frequency	Abundance	Abundance/ Frequency	IVI
1	*Cedrus deodara*	185.71	57.14	3.25	0.06	168.74
2	*Juglans regia*	200.00	85.71	2.33	0.03	132.21

C=0.551 H=0.685

Table 6.5: Phytosociology of Shrub encountered in the Dumping site at Dollo Dogri

Sl. No.	Species	Density/ ha.	Frequency	Abundance	Abundance/ Frequency	IVI
1	*Desmodium tiliaefolium*	1000.00	20.00	4.50	0.23	18.13
2	*Indigofera gerardiana*	6444.44	60.00	9.67	0.16	108.21
3	*Juglans regia(s)*	111.11	10.00	1.00	0.10	6.50
4	*Pinus wallichiana (s)*	111.11	10.00	1.00	0.10	6.76
5	*Rosa webbiana*	555.56	10.00	5.00	0.50	9.38
6	*Salix alba(s)*	444.44	10.00	4.00	0.40	10.07
7	*Sorbaria tomentosa*	8222.22	70.00	10.57	0.15	140.94

C=0.358 H=1.283

Table 6.6: Phytosociology of Herbs encountered in the Dumping site at Dollo Dogri

Sl. No.	Species	Density/ Sqm.	Frequency	Abundance	Abundance/ Frequency	IVI
1.	*Adiantum caudatum*	1.00	25.00	4.00	0.16	9.64
2.	*Anemone obtusiloba*	0.25	25.00	1.00	0.04	5.14
3.	*Arenaria festucoides*	1.88	25.00	7.50	0.30	12.01
4.	*Artemisia brevifolia*	2.00	25.00	8.00	0.32	16.95
5.	*Artemisia dracunculus*	5.63	62.50	9.00	0.14	46.46
6.	*Asparagus filicinus*	0.13	12.50	1.00	0.08	2.78
7.	*Chenopodium album*	1.25	37.50	3.33	0.09	12.24
8.	*Cherophyllum reflexum*	0.63	25.00	2.50	0.10	7.02
9.	*Cynoglossum micranthum*	0.25	12.50	2.00	0.16	3.22
10.	*Dictamnus albus*	0.75	25.00	3.00	0.12	8.76
11.	*Fragaria vesca*	0.38	12.50	3.00	0.24	3.63
12.	*Geranium wallichianum*	0.75	25.00	3.00	0.12	10.20
13.	*Heracleum candicans*	0.25	25.00	1.00	0.04	14.74
14.	*Malva rotundifolia*	0.38	12.50	3.00	0.24	4.00
15.	*Mentha longifolia*	0.63	50.00	1.25	0.03	11.79
16.	*Nepeta erecta*	0.50	25.00	2.00	0.08	6.20

17.	*Origanum vulgare*	0.63	12.50	5.00	0.40	5.30
18.	*Polygonum polystachya*	1.38	37.50	3.67	0.10	49.10
19.	*Potentilla atrosanguinea*	0.13	12.50	1.00	0.08	2.90
20.	*Rumex nepalensis*	0.50	25.00	2.00	0.08	13.60
21.	*Salvia moorcroftiana*	0.38	12.50	3.00	0.24	7.41
22.	*Silene inflata*	0.50	25.00	2.00	0.08	6.74
23.	*Thalictrum paniculatum*	0.13	12.50	1.00	0.08	2.85
24.	*Thymus linearis*	2.50	25.00	10.00	0.40	15.59
25.	*Trifolium repens*	0.88	25.00	3.50	0.14	7.96
26.	*Urtica dioica*	0.50	12.50	4.00	0.32	5.55
27.	*Verbascum thapsus*	0.13	12.50	1.00	0.08	5.21
28.	*Viola biflora*	0.25	12.50	2.00	0.16	3.01

C=0.074 H=2.969

3. Powerhouse and Dumping Site Stage-I & III at National Highway

A total of 3 tree species were encountered from the area **(Table 6.7).** *Pinus gerardiana* was dominant species having maximum density, frequency and abundance followed by *Robinia pseudacacia* and *Ailanthus excelsa.* On the basis of IVI, *P. gerardiana* recorded maximum value followed by *R. pseudoacacia* and *Ailanthus excelsa*. The community identified as result of survey was *P. gerardiana – R. pseudoacia*.

Among the 4 species of shrubs **(Table 6.8),** *S. tomentosa* was dominant shrub having maximum density followed by *Daphne oleoides* and *Desmodium tiliaefolium*. *S. tomentosa* recorded the highest value of IVI followed by *Pinus gerardiana* (s) and *Daphne oleoides.* The abundance to frequency ratio indicates that a distribution pattern of all the species except *P. gerardiana* was contiguous.

In case of herbs, total number of species was 12 **(Table 6.9),** *A. brevifolia, Cannabis sativa, Rumex hastatus* and *Verbascum thapsus* recorded the highest and same values for density and frequency. *R. hastatus* recorded the highest value of abundance followed by *A. brevifolia*. *V. thapsus* showed the highest value of IVI followed by *Rumex hastatus*, *A. brevifolia* and *C. sativa.* The distribution of all the species except *Clematis orientalis, P. gerardiana* and *V. thapsus* and *Mentha longifolia* was contiguous.

The value for concentration of dominance for trees, shrubs and herbs were 0.597, 0.337 and 0.112 whereas, index of diversity (H) for trees, shrubs and herbs showed values of 0.729, 1.23 and 2.33, respectively. The values of richness index for tree, shrub and herb were 0.69, 0.63 and 1.80, respectively whereas values for Evenness index for these categories were 0.66, 0.89 and 0.94, respectively.

Table 6.7: Phyto-sociology of Trees Encountered at Powerhouse and Dumping Site Stage-I & III, NH

Sl. No.	Species	Density/ ha.	Frequency	Abundance	Abundance/ Frequency	IVI
1	*Ailanthus excelsa*	33.33	33.33	1.00	0.030	31.89
2	*Pinus gerardiana*	266.67	100.00	2.67	0.027	225.67
3	*Robinia pseudoacacia*	66.67	33.33	2.00	0.060	42.59

C=0.597 H=0.729

Table 6.8: Phyto-sociology of Shrubs Encountered at Powerhouse and Dumping Site Stage-I & III, NH

Sl. No.	Species	Density/ ha.	Frequency	Abundance	Abundance/ Frequency	IVI
1	*Daphne oleoides*	2962.96	33.33	8.00	0.24	46.33
2	*Desmodium tiliaefolium*	2222.22	33.33	6.00	0.18	42.44
3	*Pinus gerardiana (s)*	1481.48	66.67	2.00	0.03	60.20
4	*Sorbaria tomentosa*	5555.56	66.67	7.50	0.11	151.03

C=0.337 H=1.23

Table 6.9: Phyto-sociology of Herbs Encountered at Powerhouse and Dumping Site Stage-I & III, NH

Sl. No.	Species	Density/ ha.	Frequency	Abundance	Abundance/ Frequency	IVI
1	*Artemisia brevifolia*	0.67	66.67	7.50	0.11	37.02
2	*Cannabis sativa*	0.67	66.67	5.00	0.08	30.62
3	*Clematis orientalis*	0.33	33.33	1.00	0.03	8.55
4	*Geranium wallichianum*	0.33	33.33	2.00	0.06	10.13
5	*Impatiens sulcata*	0.33	33.33	2.00	0.06	10.84
6	*Mentha longifolia*	0.33	33.33	5.00	0.15	17.00
7	*Pinus gerardiana ®*	0.33	33.33	1.00	0.03	17.02
8	*Rumex hastatus*	0.67	66.67	8.00	0.12	41.40
9	*Rumex nepalensis*	0.33	33.33	3.00	0.09	22.35
10	*Urtica diocia*	0.33	33.33	5.00	0.15	20.90
11	*Verbascum thapsus*	0.67	66.67	2.00	0.03	59.84
12	*Xanthium strumarium*	0.33	33.33	3.00	0.09	23.96

C = 0.112 H = 2.33

4. **Intake Trench Weir Stage-IV at Toktu**

A total of 4 tree species were encountered from the area **(Table 6.10).** *Juniperus macropoda* was dominant species having maximum density, frequency and abundance. *J. macropoda* recorded the highest value of IVI followed by *J. regia, Pinus wallichiana* and *Salix alba.* Distribution pattern of all the species was random. The community identified as result of survey was *J. macropoda – J. regia*. Amongst the 11 species of shrubs and tree saplings **(Table 6.11),** *Rosa webbiana* was dominant shrub having maximum density, frequency and abundance. This was followed by *Rubus niveus, Myricaria germanica* and *S. alba* in terms of density. On the basis of IVI, *R. webbiana* recorded the highest value (89.32) followed by *R. niveus* (44.46) and *S. alba* (44.40). The abundance to frequency ratio indicates that a distribution pattern of all the species was contiguous.

In case of herbs, total number of species was 32 **(Table 6.12),** *A. dracunculus* was the dominant herb having maximum density followed by *Thymus linearis* and *Rheum webbianum.* In terms of abundance, *Sedum ewersii* recorded highest values followed by *Arenaria festucoides* and *T. linearis*. *A. dracunculus* recorded the maximum value of IVI (25.73) followed by *H. candicans* (21.52) and *S. ewersii* (20.66). Distribution of all the species was continguous.

The value for concentration of dominance for trees, shrubs and herbs were 0.394, 0.159 and 0.059 whereas, index of diversity (H) for trees, shrubs and herbs showed respective values of 1.105, 2.09 and 3.127, respectively. The values of richness index for tree, shrub and herb were 0.86, 1.75 and 4.90, respectively whereas values for Evenness index for these categories were 0.79, 0.87 and 0.90, respectively.

Table 6.10: Phyto-sociology of Trees Encountered in Intake Trench Ware Stage-IV at Toktu

Sl. No.	Species	Density / ha.	Frequency	Abundance	Abundance/ Frequency	IVI
1	*Juglans regia*	40.00	40.00	1.00	0.03	84.87
2	*Juniperus macropoda*	240.00	80.00	3.00	0.04	164.21
3	*Pinus wallichiana*	20.00	20.00	1.00	0.05	27.83
4	*Salix alba*	20.00	20.00	1.00	0.05	23.10

C=0.394 H=1.105

Table 6.11: Phytosociology of Shrub Encountered in Intake Trench Ware Stage-IV at Toktu

Sl. No.	Species	Density / ha.	Frequency	Abundance	Abundance/ Frequency	IVI
1	*Berberis jaeschkeana*	493.83	5.56	8.00	1.44	6.796
2	*Cotoneaster bacillaris*	925.93	11.11	7.50	0.68	18.278
3	*Juniperus communis*	370.37	5.56	6.00	1.08	9.109
4	*Juniperus macropoda(s)*	617.28	16.67	3.33	0.20	22.802
5	*Lonicera hispida*	617.28	5.56	10.00	1.80	7.351
6	*Myricaria germanica*	1851.85	16.67	10.00	0.60	28.669
7	*Ribes alpestre*	617.28	11.11	5.00	0.45	11.791
8	*Rosa webbiana*	5864.20	50.00	10.56	0.21	89.323
9	*Rubus niveus*	2777.78	27.78	9.00	0.32	44.465
10	*Salix alba(s)*	1604.94	27.78	5.20	0.19	44.409
11	*Salix denticulata*	987.65	11.11	8.00	0.72	16.460

C = 0.159 H = 2.09

Table 6.12: Phyto-sociology of Herb Encountered in Intake Trench Ware Stage-IV at Toktu

Sl. No.	Species	Density / Sqm.	Frequency	Abundance	Abundance/ Frequency	IVI
1	*Allium carolinianum*	0.20	6.67	3.00	0.45	3.58
2	*Anemone rivularis*	0.53	13.33	4.00	0.30	10.45
3	*Aquilegia fragrans*	0.07	6.67	1.00	0.15	1.97
4	*Arenaria festucoides*	1.20	13.33	9.00	0.68	9.90
5	*Artemisia brevifolia*	0.93	13.33	7.00	0.53	9.70
6	*Artemisia dracunculus*	2.33	40.00	5.83	0.15	25.73
7	*Astragalus rhizanthus*	0.60	20.00	3.00	0.15	8.14
8	*Bupleurum latifolium*	0.47	20.00	2.33	0.12	7.53
9	*Carum carvi*	0.13	6.67	2.00	0.30	2.36
10	*Chenopodium album*	0.27	6.67	4.00	0.60	3.88
11	*Cherophyllum reflexum*	0.13	6.67	2.00	0.30	2.42
12	*Cynoglossum micranthum*	0.20	13.33	1.50	0.11	4.22
13	*Echinops cornigerus*	0.47	13.33	3.50	0.26	7.86
14	*Ferula jaeschkeana*	0.40	13.33	3.00	0.23	8.90
15	*Fragaria vesca*	0.20	6.67	3.00	0.45	2.79
16	*Fragaria vesca*	0.20	6.67	3.00	0.45	2.71
17	*Geranium wallichianum*	0.67	13.33	5.00	0.38	7.33
18	*Heracleum candicans*	0.87	33.33	2.60	0.08	21.52
19	*Hyoscymus niger*	0.33	13.33	2.50	0.19	9.46
20	*Lychnis nutans*	0.07	6.67	1.00	0.15	2.05

21	*Malva rotundifolia*	0.20	6.67	3.00	0.45	3.08
22	*Melilotus alba*	0.27	6.67	4.00	0.60	3.47
23	*Nepeta erecta*	0.53	20.00	2.67	0.13	9.51
24	*Oxyria digyna*	0.20	6.67	3.00	0.45	3.21
25	*Rheum webbianum*	1.53	40.00	3.83	0.10	46.12
26	*Rubia cordifolia*	0.20	13.33	1.50	0.11	4.22
27	*Rumex nepalensis*	0.40	13.33	3.00	0.23	9.97
28	*Sedum ewersii*	1.33	13.33	10.00	0.75	20.66
29	*Selinum tenuifolium*	0.27	6.67	4.00	0.60	4.51
30	*Thalictrum cultratum*	0.73	20.00	3.67	0.18	12.13
31	*Thymus linearis*	1.67	20.00	8.33	0.42	15.06
32	*Urtica dioica*	0.93	13.33	7.00	0.53	15.59

C = 0.059 H = 3.127

5. Power House Stage-IV at Lappo Near Lippa

A total of 7 tree species were encountered from the area **(Table 6.13).** *C. deodara* was dominant species having maximum density, frequency and abundance followed by *P. gerardiana* and *Populus ciliata.* In terms of IVI, *C. deodara*, recorded the highest value (154.05) followed by *P. gerardiana* (62.09), *P. ciliata* (26.77) and *Alnus nitida* (18.42). The community identified as result of survey was *C. deodara – P. gerardiana*. Distribution pattern of all the species except *C. deodara* and *S. alba* was contiguous.

Amongst the 9 species of shrubs and tree saplings **(Table 6.14),** *Rosa webbiana* was dominant shrub in terms density and abundance. This was followed by *Abelia triflora* and *S. alba*. On the basis of IVI, *C. deodara* (R) recorded the highest value for IVI followed by *R. webbiana.* The abundance to frequency ratio indicates that a distribution pattern of all the species except *J. macropoda* and *P. wallichiana* was contiguous.

In case of herbs including regeneration, total number of species was 28 **(Table 6.15),** *A. dracunculus* was the dominant herb having maximum density and frequency followed by *A. brevifolia* and *Arenaria festucoides.* The value of abundance was the maximum for *A. brevifolia* followed by *A. dracunculus.* In terms of IVI, *A. dracunculus* recorded the highest value (59.06) followed by *A. brevifolia* (34.51) and *Rheum webbianum* (21.94). Distribution of all the species except *Anemone rivularis, Bupleurum falcatum* and *Rheum australe* was contiguous.

The value for concentration of dominance for trees, shrubs and herbs were 0.324, 0.134 and 0.077 whereas, index of diversity (H) for trees, shrubs and herbs showed respective values of 1.45, 2.087 and 2.952, respectively. The values of richness index for tree, shrub and herb were 1.50, 1.45 and 4.14, respectively whereas values for Evenness index for these categories were 0.74, 0.94 and 0.88, respectively.

Table 6.13: Phytosociology of Trees Encountered in Powerhouse Stage-IV at Lappo Near Lippa

Sl. No.	Species	Density/ ha.	Frequency	Abundance	Abundance/ Frequency	IVI
1	*Alnus nitida*	37.50	25.00	1.50	0.06	18.42
2	*Cedrus deodara*	275.00	100.00	2.75	0.03	154.05
3	*Juniperus macropoda*	37.50	25.00	1.50	0.06	16.44
4	*Pinus gearadiana*	112.50	87.50	1.29	0.01	62.09
5	*Pinus wallichiana*	12.50	12.50	1.00	0.08	7.89
6	*Populus ciliata*	50.00	25.00	2.00	0.08	26.77
7	*Salix alba*	25.00	25.00	1.00	0.04	13.51

C = 0.324 H = 1.450

Table 6.14: Phytosociology of Shrub Encountered in Powerhouse Stage-IV at Lappo Near Lippa

Sl. No.	Species	Density/ ha.	Frequency	Abundance	Abundance/ Frequency	IVI
1	*Abelia triflora*	2444.44	20.00	11.00	0.55	31.68
2	*Cedrus deodara (s)*	1333.33	40.00	3.00	0.08	53.96
3	*Juniperus macropoda(s)*	222.22	20.00	1.00	0.05	13.51
4	*Lonicera hispida*	2000.00	40.00	4.50	0.11	36.66
5	*Pinus wallichiana (s)*	222.22	20.00	1.00	0.05	14.50
6	*Ribes alpestre*	666.67	20.00	3.00	0.15	15.10
7	*Rosa webbiana*	2666.67	20.00	12.00	0.60	43.76
8	*Salix alba (s)*	2000.00	20.00	9.00	0.45	53.13
9	*Sorbaria tomentosa*	1777.78	20.00	8.00	0.40	37.70

C = 0.134 H = 2.087

Table 6.15: Phytosociology of Herb Encountered in Powerhouse Stage-IV at Lappo Near Lippa

Sl. No.	Species	Density/ Sqm.	Frequency	Abundance	Abundance/ Frequency	IVI
1	*Allium carolinianum*	0.40	10.00	4.00	0.40	9.02
2	*Anemone rivularis*	0.20	20.00	1.00	0.05	5.77
3	*Arenaria festucoides*	2.40	30.00	8.00	0.27	17.34
4	*Artemisia brevifolia*	4.00	40.00	10.00	0.25	34.51
5	*Artemisia dracunculus*	6.80	70.00	9.71	0.14	59.06
6	*Bupleurum falcatum*	0.30	30.00	1.00	0.03	7.57
7	*Bupleurum latifolium*	0.20	10.00	2.00	0.20	3.30
8	*Capparis spinosa*	0.10	10.00	1.00	0.10	3.06
9	*Cedrus deodara (R)*	0.10	10.00	1.00	0.10	4.94
10	*Chenopodium foliolosum*	0.60	30.00	2.00	0.07	13.08
11	*Cherophyllum reflexum*	0.50	20.00	2.50	0.13	7.20
12	*Cicer microphyllum*	0.20	10.00	2.00	0.20	3.75

13	*Cynoglossum micranthum*	0.20	10.00	2.00	0.20	3.40
14	*Heracleum candicanse*	0.20	10.00	2.00	0.20	6.10
15	*Impatiens glandulifera*	0.40	10.00	4.00	0.40	5.58
16	*Impatiens sulcata*	0.30	20.00	1.50	0.08	7.09
17	*Juniperus macropoda (R)*	0.10	10.00	1.00	0.10	3.48
18	*Melilotus alba*	0.40	10.00	4.00	0.40	4.43
19	*Oxyria digyna*	0.90	20.00	4.50	0.23	11.88
20	*Pinus gerardiana (R)*	0.10	10.00	1.00	0.10	4.84
21	*Rheum australe*	0.20	20.00	1.00	0.05	10.96
22	*Rheum webbianum*	0.60	20.00	3.00	0.15	21.94
23	*Rubia cordifolia*	0.40	10.00	4.00	0.40	4.61
24	*Salix alba (R)*	0.80	10.00	8.00	0.80	11.67
25	*Salvia glutinosa*	0.30	10.00	3.00	0.30	5.58
26	*Silene inflata*	0.60	20.00	3.00	0.15	7.37
27	*Thalictrum cultratum*	1.40	30.00	4.67	0.16	18.27
28	*Verbascum thapsus*	0.10	10.00	1.00	0.10	4.22

C = 0.346 H = 1.509

6. Influence Area under 10 kms Periphery of the Proposed Hydroelectric Project

Influence area was further sub-divided into the following areas and the results obtained have been explained as below:

i. Powerhouse Stage I & III on National Highway to Powari:

A total of 12 tree species were encountered from the area **(Table 6.16).** *P. gerardiana* was dominant species having maximum density followed by *Alnus nitida*. The value of frequency and abundance was highest for *P. gerardiana*. *P. gerardiana* recorded the highest value of IVI (90.11) followed by *A.* nitida (61.99) and *Populus ciliata* (25.33). The community identified as result of survey was *P. gerardiana – A. nitida*. Distribution pattern of all the species except *A. nitida* and *Populus ciliata* was contiguous.

Amongst the 7 species of shrubs and tree saplings **(Table 6.17),** *Daphne oleoides* was dominant species in terms of density and frequency. The value of abundance was highest for *Sorbaria tomentosa* followed by *D. oleoides*. *D. oleoides* recorded the highest value of IVI followed by *S. tomentosa* and *Quercus ilex*. The abundance to frequency ratio indicates that a distribution pattern of all the species was contiguous.

In case of herbs including regeneration, total number of species was 22 **(Table 6.18).** In terms of density and frequency, *A. brevifolia* was the dominant herb followed by *Verbascum thapsus*. The value of abundance was the maximum for *A. brevifolia* followed by *Rumex hastatus*. *A. brevifolia* recorded the maximum value of IVI (68.21) followed by *V. thapsus* (36.48) and *R. hastatus* (16.58). Distribution of all the species was contiguous.

The value for concentration of dominance for trees, shrubs and herbs were 0.16, 0.251 and 0.091 whereas, index of diversity (H) for trees, shrubs and herbs showed respective values of 2.14, 1.61 and 2.76, respectively. The values of richness index for tree, shrub and herb were 3.03, 1.09 and 3.21, respectively whereas values for Evenness index for these categories were 0.86, 0.83 and 0.89, respectively.

Table 6.16: Phyto-sociology of Trees Encountered in Powerhouse Stage I & III at NH to Powari

Sl. No.	Species	Density/ ha.	Frequency %	Abundance	Abundance/ Frequency	IVI
1	*Alnus nitida*	83.33	41.67	2.00	0.05	61.99
2	*Celtis australis*	8.33	8.33	1.00	0.12	7.78
3	*Ficus palmata*	8.33	8.33	1.00	0.12	20.85
4	*Fraxinus xanthoxylloides*	16.67	16.67	1.00	0.06	14.20
5	*Juglans regia*	20.00	8.33	2.40	0.29	13.92
6	*Pinus gerardiana*	133.33	50.00	2.67	0.05	90.11
7	*Populus alba*	8.33	8.33	1.00	0.12	7.78
8	*Populus ciliata*	25.00	25.00	1.00	0.04	25.33
9	*Populus nigra*	16.67	16.67	1.00	0.06	16.89
10	*Quercus ilex*	25.00	16.67	1.50	0.09	16.83
11	*Robinia pseudoacacia*	16.67	16.67	1.00	0.06	14.45
12	*Salix alba*	16.67	8.33	2.00	0.24	10.44

C = 0.160 H = 2.14

Table 6.17: Phyto-sociology of Shrub Encountered in Powerhouse Stage I & III at NH to Powari

Sl. No.	Species	Density/ ha.	Frequency %	Abundance	Abundance/ Frequency	IVI
1	*Ailanthus excelsa (s)*	277.78	12.50	2.00	0.16	14.80
2	*Daphne oleoides*	6388.89	50.00	11.50	0.23	105.41
3	*Fraxinus xanthoxylloides (s)*	833.33	12.50	6.00	0.48	22.45
4	*Prinsepia utilis*	833.33	12.50	6.00	0.48	19.74
5	*Quercus ilex(s)*	416.67	12.50	3.00	0.24	17.00
6	*Rabdosia lophanthoides*	1111.11	12.50	8.00	0.64	23.34
7	*Sorbaria tomentosa*	3472.22	25.00	12.50	0.50	97.78

C = 0.251 H = 1.61

Table 6.18: Phytosociology of Herbs Encountered in Powerhouse Stage I & III at NH to Powari

Sl. No.	Species	Density/ Sqm.	Frequency %	Abundance	Abundance/ Frequency	IVI
1.	*Amaranthus viridis*	0.10	10.00	1.00	0.10	5.40
2.	*Artemisia brevifolia*	0.60	60.00	17.50	0.29	68.21
3.	*Artemisia dracunculus*	0.20	20.00	7.50	0.38	14.08
4.	*Astragalus rhizanthus*	0.20	20.00	2.00	0.10	15.72
5.	*Cannabis sativa*	0.20	20.00	6.00	0.30	14.26
6.	*Chenopodium album*	0.10	10.00	2.00	0.20	5.01
7.	*Conyza stricta*	0.10	10.00	4.00	0.40	5.37
8.	*Gallium rotundifolium*	0.10	10.00	4.00	0.40	4.43
9.	*Hyoscyamus niger*	0.10	10.00	3.00	0.30	13.72
10.	*Lespedeza gerardiana*	0.20	20.00	3.00	0.15	12.09
11.	*Lychnis nutans*	0.20	20.00	1.50	0.08	9.22
12.	*Mentha longifolia*	0.10	10.00	5.00	0.50	6.40
13.	*Nasturtium officinale*	0.10	10.00	2.00	0.20	4.50
14.	*Rumex hastatus*	0.20	20.00	10.00	0.50	16.58
15.	*Rumex nepalensis*	0.10	10.00	3.00	0.30	8.14
16.	*Senecio chrysanthemoides*	0.20	20.00	4.00	0.20	11.05
17.	*Sorberia tomentosa* ®	0.20	20.00	6.00	0.30	14.69
18.	*Tagetes minuta*	0.10	10.00	4.00	0.40	5.97
19.	*Trifolium repens*	0.20	20.00	2.00	0.10	7.95
20.	*Urtica dioica*	0.10	10.00	3.00	0.30	6.63
21.	*Urtica hyperborea*	0.20	20.00	2.50	0.13	14.11
22.	*Verbascum thapsus*	0.30	30.00	2.00	0.07	36.48

C = 0.091 H = 2.76

ii. Powerhouse Stage I & III on National Highway to Akpa:

A total of 9 tree species were encountered from the area **(Table 6.19).** *P. gerardiana* was dominant species having maximum density and frequency. The value of abundance was highest for *Ailanthus excels* followed by *P. gerardiana*. *A. nitida* recorded the highest value of IVI (96.18) followed by *P. gerardiana* (64.45) and *P. alba* (25.84). The community identified as result of survey was *A. nitida – P. gerardiana*. Distribution pattern of all the species except *A. nitida* and *Fraxinus xanthoxyloides* was contiguous.

Amongst the 16 species of shrubs and tree saplings **(Table 6.20),** *Daphne oleoides* was dominant species in terms of density. This was followed by *Elaeagnus angustifolia* and *Colutea nepalensis.* The value of abudance for *S. tomentosa* was the maximum followed by *D. oleoides* and *Rosa webbiana*. *S. tomentosa* recorded the highest value of IVI (46.64) followed by *E. angustifolia* (37.06) and *D. oleoides* (31.44). The abundance to frequency ratio indicates that a distribution pattern of all the species was contiguous.

In case of herbs, total number of species was 28 **(Table 6.21),** *Arenaria griffithii* was the dominant herb having maximum density and abundance**.** This was followed by *A. brevifolia* and *Bergenia ciliata* in terms of density. On the basis of IVI, *B. ciliata*, showed the maximum value followed by *A. griffithii, A. brevifolia* and *Mentha longifolia*. Distribution of all the species was contiguous.

The value for concentration of dominance for trees, shrubs and herbs were 0.184, 0.087 and 0.067 whereas, index of diversity (H) for trees, shrubs and herbs showed respective values of 1.925, 2.598 and 3.024, respectively. The values of richness index for tree, shrub and herb were 2.18, 2.96 and 4.37, respectively whereas values for Evenness index for these categories were 0.87, 0.93 and 0.91, respectively.

Table 6.19: Phytosociology of Trees encountered at Powerhouse stage I & III at NH to Akpa

Sl. No.	Species	Density / ha.	Frequency	Abundance	Abundance/ Frequency	IVI
1	*Ailanthus excelsa*	37.50	12.50	3.00	0.24	19.62
2	*Alnus nitida*	75.00	50.00	1.50	0.03	96.18
3	*Celtis australis*	25.00	25.00	1.00	0.04	21.31
4	*Ficus palmata*	12.50	12.50	1.00	0.08	9.46
5	*Fraxinus xanthoxylloides*	37.50	37.50	1.00	0.03	28.71
6	*Pinus gerardiana*	112.50	50.00	2.25	0.05	64.45
7	*Populus alba*	37.50	25.00	1.50	0.06	25.84
8	*Populus nigra*	12.50	12.50	1.00	0.08	10.43
9	*Salix alba*	37.50	25.00	1.50	0.06	23.37

C = 0.184 H = 1.925

Table 6.20: Phytosociology of Shrubs encountered at Powerhouse Stage I & III at NH to Akpa

Sl. No.	Species	Density/ ha.	Frequency	Abundance	Abundance/ Frequency	IVI
1	*Alnus nitida (s)*	222.22	6.67	3.00	0.45	8.93
2	*Buddlegia asiatica*	518.52	13.33	3.50	0.26	18.44
3	*Colutea nepalensis*	888.89	13.33	6.00	0.45	27.37
4	*Daphne oleoides*	1185.19	13.33	8.00	0.60	31.44
5	*Elaeagnus angustifolia*	1111.11	13.33	7.50	0.56	37.06
6	*Ficus palmata(s)*	148.15	6.67	2.00	0.30	8.00
7	*Fraxinus xanthoxylloides (s)*	222.22	6.67	3.00	0.45	8.93
8	*Olea cuspidata*	148.15	6.67	2.00	0.30	7.34
9	*Pinus gerardiana (s)*	370.37	13.33	2.50	0.19	20.94
10	*Rabdosia lophanthoides*	296.30	6.67	4.00	0.60	10.51
11	*Ribes alpestre*	370.37	6.67	5.00	0.75	10.75

12	*Rosa moschata*	814.81	20.00	3.67	0.18	26.99
13	*Rosa webbiana*	592.59	6.67	8.00	1.20	16.27
14	*Rubus niveus*	148.15	6.67	2.00	0.30	6.80
15	*Salix tetrasperma (s)*	296.30	6.67	4.00	0.60	13.38
16	*Sorbaria tomentosa*	1481.48	13.33	10.00	0.75	46.64

C = 0.087 H = 2.598

Table 6.21: Phytosociology of Herb Encountered at Powerhouse stage I & III at NH to Akpa

Sl. No.	Species	Density / Sq m	Frequency	Abundance	Abundance/ Frequency	IVI
1	*Alnus nitida (R)*	0.10	10.00	1.00	0.10	4.99
2	*Arenaria griffithii*	3.20	40.00	8.00	0.20	24.40
3	*Artemisia brevifolia*	2.30	40.00	5.75	0.14	22.97
4	*Artemisia dracunculus*	0.60	10.00	6.00	0.60	5.90
5	*Asparagus filicinus*	0.20	10.00	2.00	0.20	3.54
6	*Astragalus chlorostachys*	0.50	20.00	2.50	0.13	8.23
7	*Bergenia ciliate*	1.60	20.00	8.00	0.40	51.79
8	*Bupleurum falcatum*	0.30	20.00	1.50	0.08	5.95
9	*Cannabis sativa*	0.10	10.00	1.00	0.10	2.59
10	*Capparis spinosa*	0.30	10.00	3.00	0.30	4.54
11	*Chenopodium ambrosioides*	0.50	10.00	5.00	0.50	5.15
12	*Datisca cannabina*	0.50	20.00	2.50	0.13	10.13
13	*Echinops cornigerus*	0.90	20.00	4.50	0.23	13.88
14	*Ephedra gerardiana*	1.20	20.00	6.00	0.30	12.48
15	*Impatiens sulcata*	0.30	10.00	3.00	0.30	4.44
16	*Incarvillea arguta*	0.40	10.00	4.00	0.40	4.41
17	*Juglans regia*	40.00	40.00	1.00	0.03	84.87
18	*Lespedeza gerardiana*	0.80	20.00	4.00	0.20	12.94
19	*Lychnis nutans*	0.70	30.00	2.33	0.08	10.95
20	*Mentha longifolia*	1.60	40.00	4.00	0.10	21.53
21	*Nepeta ereca*	0.20	10.00	2.00	0.20	3.26
22	*Oxalis corniculata*	0.40	10.00	4.00	0.40	4.41
23	*Plantago tibetica*	0.20	10.00	2.00	0.20	3.17
24	*Polygonum capitatum*	0.40	10.00	4.00	0.40	4.29
25	*Rumex hastatus*	0.80	20.00	4.00	0.20	10.40
26	*Rumex nepalensis*	0.80	20.00	4.00	0.20	16.82
27	*Salvia nubicola*	0.60	20.00	3.00	0.15	10.71
28	*Solanum nigrum*	0.30	10.00	3.00	0.30	4.54
29	*Verbascum thapsus*	0.40	20.00	2.00	0.10	11.59

C=0.067 H=3.024

iii. Intake Trench Weir Stage-IV at Toktu to Akpa:

A total of 17 tree species were encountered from the area **(Table 6.22).** *P. gerardiana* was dominant species having maximum density and abundance followed by *Betula utilis, Robinia pseudoacacia*. In terms of IVI *P. gerardiana* recorded the highest value followed by *C. deodara, A. nitida* and *R. pseudoacacia*. The community identified as result of survey was *P. gerardiana – C. deodara*. Distribution pattern of all the species except *A. nitida* and *C. deodara* was contiguous.

Amongst the 20 species of shrubs and tree saplings **(Table 6.23),** *S. tomentosa* was dominant species in terms of density and frequency. This was followed by *Lonicera hispida* and *Rosa webbiana* in terms of density. The value of abudance was the maximum for *Juniperus communis* followed by *Colutea nepalensis* and *Myricaria germanica.* On the basis of IVI, *R. webbiana* recorded the highest value followed by *M. germanica* and *S. alba.* Distribution pattern of all the species was contiguous.

In case of herbs including regeneration, total number of species was 64 **(Table 6.24),** *A. dracunculus* was the dominant herb having maximum density and frequency**.** This was followed by *A. brevifolia* and *Ephedra gerardiana* in terms of density. The value of abundance was the maximum for *A. brevifolia* followed by *Ephedra* gerardiana and *Arenaria festucoides. A. dracunculus* showed the maximum value IVI (26.33) followed by *A. brevifolia* (24.97) and *Ephedra gerardiana* (17.98). Distribution of all the species was contiguous.

The value for concentration of dominance for trees, shrubs and herbs were 0.103, 0.097 and 0.034 whereas, index of diversity (H) for trees, shrubs and herbs showed respective values of 2.588, 2.620 and 3.795, respectively. The values of richness index for tree, shrub and herb were 3.32, 3.07 and 9.27, respectively whereas values for Evenness index for these categories were 0.91, 0.87 and 0.90, respectively.

Table 6.22: Phytosociology of Trees encountered in Intake Trench Weir Stage IV at Toktu to Akpa

Sl. No.	Species	Density/ ha.	Frequency	Abundance	Abundance/ Frequency	IVI
1.	*Acer caesium*	10.00	5.00	2.00	0.40	16.00
2.	*Ailanthus excelsa*	10.00	5.00	2.00	0.40	5.84
3.	*Alnus nitida*	10.00	40.00	2.00	0.05	34.73
4.	*Betula utilis*	15.00	15.00	3.00	0.20	16.67
5.	*Cedrus deodara*	11.43	45.00	2.29	0.05	50.32
6.	*Celtis australis*	10.00	5.00	2.00	0.40	14.45
7.	*Fraxinus xanthoxylloides*	8.33	20.00	1.67	0.08	14.17
8.	*Juglans regia*	7.50	15.00	1.50	0.10	16.83

9.	*Juniperus macropoda*	10.00	15.00	2.00	0.13	12.26
10	*Pinus gerardiana*	19.17	40.00	3.83	0.10	57.80
11	*Pinus wallichiana*	6.67	20.00	1.33	0.07	15.81
12	*Populus alba*	5.00	5.00	1.00	0.20	3.83
13	*Populus ciliata*	5.00	15.00	1.00	0.07	9.06
14	*Populus nigra*	5.00	5.00	1.00	0.20	6.79
15	*Robinia pseudoacacia*	11.67	20.00	2.33	0.12	16.98
16	*Salix alba*	5.00	15.00	1.00	0.07	9.06
17	*Salix tetrasperma*	5.00	5.00	1.00	0.20	5.50

C = 0.103 H = 2.586

Table 6.23: Phyto-sociology of Shrub encountered in Intake Trench Weir Stage IV at Toktu to Akpa

Sl. No.	Species	Density/ ha.	Frequency	Abundance	Abundance/ Frequency	IVI
1.	*Abelia triflora*	977.78	8.00	11.00	1.38	14.53
2.	*Ailanthus excelsa(s)*	88.89	4.00	2.00	0.50	2.92
3.	*Alnus nitida(s)*	88.89	8.00	1.00	0.13	4.63
4.	*Berberis jaeschkeana*	177.78	4.00	4.00	1.00	3.11
5.	*Cedrus deodara (s)*	355.56	12.00	2.67	0.22	9.88
6.	*Colutea nepalensis*	1511.11	12.00	11.33	0.94	20.52
7.	*Cotoneastor bacillaris*	622.22	4.00	14.00	3.50	7.09
8.	*Daphne oleoides*	755.56	8.00	8.50	1.06	10.39
9.	*Fraxinus xanthoxylloides (s)*	177.78	4.00	4.00	1.00	4.87
10.	*Juniperus communis*	622.22	4.00	14.00	3.50	10.46
11.	*Juniperus macropoda(s)*	44.44	4.00	1.00	0.25	2.51
12.	*Lonicera hispida*	2266.67	24.00	8.50	0.35	29.15
13.	*Myricaria germanica*	1911.11	16.00	10.75	0.67	31.05
14.	*Pinus wallichiana*	44.44	4.00	1.00	0.25	2.51
15.	*Ribes alpestre*	933.33	8.00	10.50	1.31	10.14
16.	*Rosa webbiana*	2000.00	28.00	6.43	0.23	32.67
17.	*Rubus niveus*	311.11	8.00	3.50	0.44	6.14
18.	*Rubus sp*	622.22	8.00	7.00	0.88	9.84
19.	*Salix alba (s)*	1377.78	20.00	6.20	0.31	26.23
20.	*Sobaria tomentosa*	3022.22	32.00	8.50	0.27	61.27

C=0.097 H=2.62

Table 6.24: Phytosociology of Herbs encountered in Intake Trench Weir Stage IV at Toktu to Akpa

Sl. No.	Species	Density/ ha.	Frequency	Abundance	Abundance/ Frequency	IVI
1.	*Allium carolinianum*	0.47	9.38	5.00	0.53	9.35
2.	*Anaphalis contorta*	0.13	3.13	4.00	1.28	1.45
3.	*Anemone rivularis*	0.59	9.38	6.33	0.68	7.69
4.	*Angelica glauca*	0.22	9.38	2.33	0.25	4.50
5.	*Arenaria festicoides*	0.72	6.25	11.50	1.84	4.96

6.	*Artemisia brevifolia*	3.19	25.00	12.75	0.51	24.97
7.	*Artemisia dracunculus*	3.25	31.25	10.40	0.33	26.33
8.	*Aster flaccidus*	0.13	3.13	4.00	1.28	1.49
9.	*Astragalus rhizanthus*	0.13	3.13	4.00	1.28	1.77
10.	*Betula utilis (R)*	0.13	6.25	2.00	0.32	2.24
11.	*Bistorta affinis*	0.25	6.25	4.00	0.64	2.90
12.	*Caltha paulustris*	0.16	3.13	5.00	1.60	3.34
13.	*Cannabis sativa*	0.09	3.13	3.00	0.96	1.58
14.	*Cedrus deodara (R)*	0.16	12.50	1.25	0.10	7.30
15.	*Chenopodium album*	0.19	6.25	3.00	0.48	2.87
16.	*Chenopodium foliolosum*	0.16	6.25	2.50	0.40	2.37
17.	*Cicer microphyllum*	0.13	6.25	2.00	0.32	2.29
18.	*Corydalis govaniana*	0.06	3.13	2.00	0.64	1.37
19.	*Cynoglossum micranthum*	0.06	3.13	2.00	0.64	1.06
20.	*Dactylorhiza hatagirea*	0.31	6.25	5.00	0.80	5.41
21.	*Datisca cannabina*	0.13	3.13	4.00	1.28	2.96
22.	*Datura stramonium*	0.13	3.13	4.00	1.28	2.49
23.	*Delphinium denudatum*	0.06	3.13	2.00	0.64	1.41
24.	*Dianthus angulatus*	0.09	3.13	3.00	0.96	1.20
25.	*Epilobium laxum*	0.41	9.38	4.33	0.46	4.37
26.	*Ephedra gerardiana*	1.16	9.38	12.33	1.32	17.98
27.	*Ferula jaeschkeana*	0.28	9.38	3.00	0.32	5.81
28.	*Fregaria vesca*	0.19	6.25	3.00	0.48	2.38
29.	*Geranium pratense*	0.28	9.38	3.00	0.32	3.54
30.	*Heracleum candicanse*	0.28	18.75	1.50	0.08	10.18
31.	*Hyoscyamus niger*	0.09	3.13	3.00	0.96	1.78
32.	*Impatiens gladulifera*	0.09	3.13	3.00	0.96	1.42
33.	*Impatiens sulcata*	0.25	6.25	4.00	0.64	3.34
34.	*Ipomoea nil*	0.03	3.13	1.00	0.32	0.84
35.	*Lespedeza gerardiana*	0.06	3.13	2.00	0.64	1.29
36.	*Melilotus alba*	0.09	3.13	3.00	0.96	1.20
37.	*Mentha longifolia*	0.84	9.38	9.00	0.96	7.59
38.	*Nasturtium officinale*	0.16	6.25	2.50	0.40	2.51
39.	*Origanum vulgare*	0.69	9.38	7.33	0.78	7.20
40.	*Oxyria digyna*	0.09	3.13	3.00	0.96	1.37
41.	*Pedicularis bicornuta*	0.78	12.50	6.25	0.50	7.56
42.	*Pinus gerardiana (R)*	0.06	6.25	1.00	0.16	2.71
43.	*Pinus walliachiana (R)*	0.03	3.13	1.00	0.32	1.35
44.	*Plantago lanceolata*	0.19	3.13	6.00	1.92	2.39
45.	*Polygonatum verticillatum*	0.06	3.13	2.00	0.64	1.26
46.	*Polygonum polystachya*	0.41	9.38	4.33	0.46	6.64

47.	*Primula glomerata*	0.09	6.25	1.50	0.24	2.47
48.	*Ranunculus hirtellus*	0.13	3.13	4.00	1.28	1.45
49.	*Rheum australe*	0.06	3.13	2.00	0.64	1.74
50.	*Rheum webbianum*	0.28	15.63	1.80	0.12	7.36
51.	*Rumex hastatus*	0.41	6.25	6.50	1.04	3.43
52.	*Rumex nepalensis*	0.78	25.00	3.13	0.13	16.94
53.	*Salix alba (R)*	0.03	3.13	1.00	0.32	0.94
54.	*Salvia glutinosa*	0.16	6.25	2.50	0.40	3.22
55.	*Salvia moorcroftiana*	0.34	12.50	2.75	0.22	8.25
56.	*Senecio chrysanthemoides*	0.88	12.50	7.00	0.56	8.46
57.	*Silene inflata*	0.13	3.13	4.00	1.28	1.67
58.	*Sorbaria tomentosa*	0.28	6.25	4.50	0.72	3.82
59.	*Taraxacum officinale*	0.13	9.38	1.33	0.14	3.08
60.	*Thallictrum cultratum*	0.13	3.13	4.00	1.28	1.89
61.	*Thymus linearis*	0.31	3.13	10.00	3.20	2.44
63	*Urtica dioica*	0.31	6.25	5.00	0.80	5.41
64	*Verbascum thapsus*	0.25	12.50	2.00	0.16	6.73

C=0.034 H=3.795

iv. Trench Weir Stage-I at Dollo – Dogri to to Pangi:

A total of 11 tree species were encountered from the area **(Table 6.25).** *Cedrus deodara* was dominant species having maximum density, frequency and abundance. This was followed by *P. gerardiana* in terms of density. The value of abundance was the maximum for *Cedrus deodara*. *C. deodara* recorded the highest value of IVI (159.22) followed by *P. gerardiana* (71.92) and *Juglans regia* (14.43). The community identified as result of survey was *P. gerardiana – C. deodara*. Distribution pattern of all the species except *P. gerardiana* was contiguous.

Amongst the 14 species of shrubs and tree saplings **(Table 6.26),** *Daphne oleoides* was dominant species in terms of density and frequency. This was followed by *Lonicera quinquelocularis* and *S. tomentosa* in terms of density. The value of abudance was the maximum for *S. tomentosa* followed by *D. oleoides. S. tomentosa* recorded the highest value of IVI (73.56) followed by *D. oleoides* (57.61) and *Indigofera gerardiana* (28.23). Distribution pattern of all the species was contiguous.

In case of herbs, total number of species was 37 **(Table 6.27),** *A. brevifolia* was the dominant herb having maximum density**.** This was followed by *A. dracunculus* and *T. linearis*. The value of abundance was the maximum for *T. linearis* followed by *A. brevifolia, Rumex hastatus* and *E. gerardiana.* In terms of IVI, *A. brevifolia* recorded the highest value (38.65) followed by *A. dracunculus* (36.86), *Urtica dioica* (18.91) and *Lespedeza gerardiana* (16.91). Distribution of all the species was continguous.

The value for concentration of dominance for trees, shrubs and herbs were 0.346, 0.132 and 0.057 whereas, index of diversity (H) for trees, shrubs and herbs showed respective values of 1.509, 2.301 and 3.202, respectively. The values of richness index for tree, shrub and herb were 2.01, 2.17 and 5.28, respectively whereas values for Evenness index for these categories were 0.63, 0.87 and 0.89, respectively.

Table 6.25: Phytosociology of Trees Encountered in Trench Weir Stage-I at Dolo Dogri to Pangi

S. No.	Species	Density/ ha	Frequency %	Abundance	Abundance/ Frequency	IVI
1.	*Alnus nitida*	30.00	10.00	3.00	0.30	9.36
2.	*Cedrus deodara*	330.00	100.00	3.30	0.03	159.22
3.	*Fraxinus xanthoxylloides*	20.00	10.00	2.00	0.20	6.73
4.	*Juglans regia*	30.00	20.00	1.50	0.08	14.43
5.	*Pinus gerardiana*	210.00	80.00	2.63	0.03	71.92
6.	*Pinus wallichiana*	10.00	10.00	1.00	0.10	5.93
7.	*Populus ciliata*	20.00	10.00	2.00	0.20	7.08
8.	*Populus nigra*	10.00	10.00	1.00	0.10	5.15
9.	*Quercus ilex*	20.00	10.00	2.00	0.20	6.79
10.	*Robinia pseudoacacia*	20.00	10.00	2.00	0.20	6.70
11.	*Salix alba*	20.00	10.00	2.00	0.20	6.70

C=0.346 H=1.509

Table 6.26: Phytosociology of Shrub encountered in Trench Weir Stage-I at Dolo Dogri to Pangi

S. No.	Species	Density/ ha	Frequency %	Abundance	Abundance/ Frequency	IVI
1.	*Buddleja asiatica*	925.93	16.67	5.00	0.30	14.75
2.	*Cedrus deodara (s)*	92.59	8.33	1.00	0.12	5.30
3.	*Daphne oleoides*	3703.70	33.33	10.00	0.30	57.61
4.	*Desmodium tiliaefolium*	555.56	8.33	6.00	0.72	13.45
5.	*Fraxinus xanthoxyloides(s)*	92.59	8.33	1.00	0.12	4.81
6.	*Indigofera gerardiana*	1203.70	25.00	4.33	0.17	28.23
7.	*Lonicera hispida*	1111.11	16.67	6.00	0.36	15.64
8.	*Lonicera quinquelocularis*	2222.22	25.00	8.00	0.32	27.41
9.	*Pinus gerardiana (s)*	185.19	16.67	1.00	0.06	10.00
10.	*Pinus wallichiana (s)*	92.59	8.33	1.00	0.12	5.87
11.	*Rhabdosia lophanthoides*	740.74	8.33	8.00	0.96	9.20
12.	*Rosa webbiana*	462.96	16.67	2.50	0.15	12.72
13.	*Rubus sp.*	1203.70	16.67	6.50	0.39	20.60
14.	*Sorbaria tomentosa*	2129.63	16.67	11.50	0.69	73.56

C=0.132 H=2.301

Table 6.27: Phytosociology of Herb encountered in Trench Weir Stage-I at Dolo Dogri to Pangi

S. No.	Species	Density/ Sq m	Frequency %	Abundance	Abundance/ Frequency	IVI
1.	*Allium carolinianum*	0.33	13.33	2.50	0.19	7.02
2.	*Artemisia brevifolia*	4.80	40.00	12.00	0.30	38.65
3.	*Artemisia dracunculus*	4.00	46.67	8.57	0.18	36.86
4.	*Astralagus chlorostachys*	0.13	6.67	2.00	0.30	4.19
5.	*Bergenia ciliata*	0.33	6.67	5.00	0.75	15.97
6.	*Cannnabis sativus*	0.20	6.67	3.00	0.45	3.04
7.	*Chenopodium album*	0.67	20.00	3.33	0.17	9.75
8.	*Chenopodium ambrosioides*	0.13	13.33	1.00	0.08	3.94
9.	*Chenopodium foliolosum*	0.07	6.67	1.00	0.15	2.03
10.	*Cherophyllum reflexum*	0.07	6.67	1.00	0.15	1.89
11.	*Clematis barbellata*	0.07	6.67	1.00	0.15	1.87
12.	*Clematis orientalis*	0.13	6.67	2.00	0.30	2.36
13.	*Datura stramonium*	0.07	6.67	1.00	0.15	3.43
14.	*Ephedra gerardiana*	0.67	6.67	10.00	1.50	8.57
15.	*Ferula jaeschkeana*	0.27	13.33	2.00	0.15	7.87
16.	*Fragaria vesca*	0.20	6.67	3.00	0.45	2.44
17.	*Gallium acutum*	0.33	6.67	5.00	0.75	3.21
18.	*Gallium rotundifolium*	0.53	6.67	8.00	1.20	4.46
19.	*Geranium wallichianum*	0.20	6.67	3.00	0.45	2.66
20.	*Heracleum candicanse*	0.13	6.67	2.00	0.30	4.76
21.	*Lespedeza gerardiana*	0.93	13.33	7.00	0.53	16.91
22.	*Malva rotundifolia*	0.13	6.67	2.00	0.30	2.23
23.	*Melilotus alba*	0.13	6.67	2.00	0.30	2.25
24.	*Origanum vulgare*	0.33	6.67	5.00	0.75	3.38
25.	*Plantago tibetica*	0.20	6.67	3.00	0.45	2.86
26.	*Rumex hastatus*	1.33	13.33	10.00	0.75	10.13
27.	*Rumex nepalensis*	0.87	26.67	3.25	0.12	16.25
28.	*Salvia moorcroftiana*	0.53	13.33	4.00	0.30	10.92
29.	*Senecio chrysanthemoides*	0.47	13.33	3.50	0.26	6.42
30.	*Silene inflata*	0.13	6.67	2.00	0.30	2.27
31.	*Solanum nigrum*	0.07	6.67	1.00	0.15	2.18
32.	*Thallictrum cultratum*	0.20	6.67	3.00	0.45	2.69
33.	*Thymus linearis*	1.73	13.33	13.00	0.98	11.95
34.	*Urtica dioica*	1.53	20.00	7.67	0.38	18.91
35.	*Verbascum thapsus*	0.27	26.67	1.00	0.04	13.73
36.	*Viola biflora*	0.27	13.33	2.00	0.15	4.18
37.	*Xanthium strumarium*	0.33	13.33	2.50	0.19	7.93

C=0.057 H=3.20

Note: S = Sapling; R = Regeneration

Values in the **Table 6.28** provide a comparison of different phytosocilogical parameters as recorded in the study area during pre and post monsoon period. Similarly, some of the important species as encountered during the survey have been presented in the **Plates**.

Threat Status of the Foristic Diversity:

Flora recorded from the study sites during the survey when compared with the available literature revealed that the following species recorded from the region fall under the categories of threat status:

Hyoscyamus niger, Ephedra gerardiana, Ferula jaeschkeana, Heracleum candicans, Betula utilis, Juniperus macropoda, Dactylorhiza hatagirea, Datisca cannabina, Rheum webbianum, Dioscorea deltoidea, Rheum australe.

Table 6.28: Values of Different Phytosociological Parameters in the Study Area

Study Area	Concentration of Dominance (C)			Species Diversity Index (H)			Richness Index (R)			Evenness Index (E)		
	Trees	Shrubs	Herbs	Trees	Shrubs	Herbs	Trees	Shrubs	Herbs	Trees	Shrubs	Herbs
1. Trench Weir Stage-I at Dollo-Dogri	0.489	0.245	0.064	0.878	1.598	3.248	0.52	1.01	5.47	0.80	0.82	0.89
2. Dumping Site at Dollo-Dogri	0.511	0.358	0.074	0.685	1.283	2.969	0.27	1.05	4.09	0.98	0.66	0.89
3. Powerhouse and Dumpting Site Stage-I & III at NH	0.597	0.337	0.112	0.729	1.232	2.332	0.69	0.63	1.80	0.66	0.89	0.94
4. Intake Trench Weir Stage-IV at Toktu	0.394	0.159	0.059	1.105	2.090	3.127	0.86	1.75	4.90	0.79	0.87	0.90
5. Powerhouse Stage-IV at Lappo near Lippa	0.324	0.134	0.077	1.450	2.087	2.952	1.50	1.45	4.14	0.74	0.94	0.88
6. Influence Area under 10 Kms Periphery												
i) Powerhouse Stage-I & IV at NH to Powari	0.160	0.251	0.091	2.140	1.615	2.762	3.03	1.09	3.21	0.86	0.83	0.89
ii) Powerhouse Stage-I & IV at NH to Akpa	0.184	0.087	0.067	1.925	2.598	3.024	2.18	2.96	4.37	0.87	0.93	0.91
iii) Intake Trench Weir Stage-IV at Tokto to Akpa	0.103	0.097	0.034	2.586	2.620	3.759	3.32	3.07	9.27	0.91	0.87	0.90
iv) Trench Weir Stage-I at Dollo-Dogri to Pangi	0.346	0.132	0.057	1.509	2.301	3.202	2.01	2.17	5.28	0.63	0.87	0.88

ETHNOBOTANICAL STUDIES IN THE STUDY AREA

INTRODUCTION

Nature has nourished life since its existence and from the very beginning, life sustained itself on the available resources. However, human beings have always utilized major part of these natural resources than any other organism on this planet. In a country like India, where population spearheaded with low economic status and small land- holdings, poses a very high pressure on the natural resources and the situation further worsens in the hilly region of the country where terrain and inaccessibility becomes the major constraint which then force the people to utilize whatever is accessible in the vicinity of their dwellings.

In simple words, Ethnobotany includes all sorts of relationships between people and plants. The definition of ethnobotany can be summed up in four words i.e. People, Plants, Interactions and Uses. Plants provide us readymade food, medicines for ailment, fodder and forage for our domestic animals, fuel wood for burning, flowers for aesthetics and celebration, raw materials for many industries, timber for construction and many more useful items.

A survey was conducted in Pangi, Akpa, Asarang, Lippa and Toktu villages to document the plant species used by the people to meet their day-today requirements. During the survey, ethno-botanical information on 62 plant species was documented (**Table 6.29)**. It was found that these plant species are used for medicinal, timber, fuel wood, fodder, ornamental, agricultural tools, thatching, fencing, etc. This supports the truth that there is a great influence of human life on the local vegetation.

Medicinal Plants:
Information on medicinal uses of 21 plant species was documented during the study. Medicinal plants commonly used by the people of the area included, *Angelica glauca* (Chora), *Allium sp* (Junglibiaj), *Berberis lycium* (Kashmal), *Berginia ciliata, Cannabis sativa, Corydalis govaniana, Dactylorhiza hatagirea (*Salampanja), *Datisca cannabina, Datura stramonium, Delphinium denudatum, Ephedera gerardiana* (Somlata), *Ferula jaeskeana, Heracleum candicans, Hyoscyaus niger, Juniperus macropoda (Dhoop), Juniperus communis* (Dhoop), *Nasturtium officinale, Origanum vulgare, Rheum webbianaum* (Revandchini), *Tagetus minuata* and *Thymus linearis.* Although, people have knowledge on medicinal uses of plants, only few people follow the traditional medicinal system. Species such as *Ephedera gerardiana* (Somlata) and *Rheum webbianaum* (Revandchini) are commercially exploited in large scale. These medicinal plants recorded in the proposed project area and their adjoining areas are also distributed elsewhere in the NW Himalaya.

Collection of Fodder:
During the survey, it was found that local people collected fodder from the study area**.** Plant species such as *Celtis australis, Quercus ilex* and *Robinia pseudoacacia* (Robinia) were collected for fodder.

Food Plants:
Vegetables and Potherbs:
Flowers of *Indigofera gerardiana* are eaten as a salad. *Nasturtium officinale, Solanum nigrum, Amaranthus viridis, Chenopodium album, Rumex hastatus* and *Urtica dioica*, are used as a potherbs. Seeds of *Pinus gerardiana* are eaten raw or cooked. *Prinsepia utilis* seed oil is used for burning and as a cooking medium.

Edible Fruits:
Wild fruits form an important diet of the local people. Some ripe wild fruits/nuts eaten in the area are obtained from plant species such as; *Berberis lycium*, *Duchesnea indica*, *Pyrus pashia, Rosa macrophylla, Rubus biflorus, R.ellipticus, Prunus armeniaca* (Chulli), *Prunus cornuata* (Jamun), *Punica granatum* (Anar) *Solanum nigrum, Ficus palmata, Pinus gerardiana (Chilgoza/neoza)* and *Juglans regia* (Akhrot).

Chilgoza/ Neoza is collected in large scale from the cones of *Pinus gerardiana* by the local people for their own consumption and for commercial purposes. Seeds of Chilgoza are the only commercial edible pine nut available in India and accordingly major source of its indigenous supply is Kinnaur district of Himachal Pradesh. The seeds locally called and marketed as "Chilgoza" is eaten as dry fruits, which is rich in oil, starch and albumenoids. The seeds are also credited with carminative, stimulant and expectorant properties. It is one of the most important cash crops of tribal people residing in the Kinnaur district of Himachal Pradesh. The local people have the right to collect neoza without paying any fee/royalty to the Forest Department. It is estimated that 1200 to 1500 quintal of neoza is collected annually. It fetches about 1.2 to 1.5 crore annually (At 1992-1993 rates).

Table 6.29: List of ethno-botanically important plant species recorded in the proposed dam site and its adjoining area

Sl. No	Species	Habit	Edible	Fodder	Fuel wood	Medicinal	Timber	Ornamental
1	*Allium carolinianum (Junglibiaj)*	Herbs	+			+		
2	*Amaranthus viridis*	Herbs				+		
3	*Angelica glauca (Chora)*	shrubs	+			+		
4	*Artemisia scoparia*	Herbs				+		
5	*Artemisia vestita*	Herbs				+		
6	*Asparagus scandens*	Herbs				+		
7	*Berberis lycium (Kashmal)*	shrubs	+			+		
8	*Berginia ciliata*	Herbs	+			+		
9	*Betula utilis*	Trees		+	+			+
10	*Cannabis sativa*	Herbs	+			+		
11	*Cedrus deodara*	Trees				+	+	+
12	*Celtis australis*	Trees	+	+	+	+		
13	*Chenopodium album*	Herbs	+					
14	*Chenopodium foliolosum*	Herbs	+					
15	*Corydalis govaniana*	Herbs				+		
16	*Dactylorhiza hatagirea (Salampanja)*	Herbs				+		
17	*Datisca cannabina*	shrubs				+		
18	*Datura stramonium*	shrubs				+		
19	*Datura suaveolens*	Herbs				+		
20	*Delphinium denudatum*	Herbs				+		
21	*Duchesnea indica*	Herbs	+					
22	*Ephedera gerardiana (Somlata)*	shrubs				+		
23	*Ferula jaeskeana*	shrubs	+			+		
24	*Ficus palmata*	Trees	+					
25	*Fragaria vesca*	Herbs	+					
26	*Fraxinus xanthoxyloides*	Trees			+	+	+	
27	*Heracleum candicans*	shrubs				+		
28	*Hyoscyaus niger*	Herbs				+		
29	*Indigofera gerardiana*	shrubs	+					
30	*Jacaranda mimosifolia*	Trees						+
31	*Juglans regia*	Trees	+			+		

Sl. No	Species	Habit	Edible	Fodder	Fuel wood	Medicinal	Timber	Ornamental
32	*Juniperus communis (Dhoop)*	shrubs				+		
33	*Juniperus macropoda (Dhoop)*	Trees				+		
34	*Morus alba*	Trees	+				+	
35	*Nasturtium officinale*	Herbs	+			+		
36	*Origanum vulgare*	Herbs				+		
37	*Oxalis corniculata*	Herbs	+					
38	*Pinus gerardiana*	Trees	+		+			
39	*Pinus roxburghii*	Trees				+	+	
40	*Pistacia chinensis*	Trees				+		
41	*Plantago major*	Herbs				+		
42	*Populus alba*	Trees					+	
43	*Populus ciliata*	Trees					+	
44	*Populus deltoides*	Trees					+	
45	*Populus nigra*	Trees					+	
46	*Prinsepia utilis*	Shrubs	+			+		
47	*Prunus armeniaca*	Trees	+					
48	*Prunus cerasoides*	shrubs	+					
49	*Punica granatum*	shrubs	+			+		
50	*Pyrus pashia*	Trees	+		+	+		
51	*Quercus ilex*	Trees		+				
52	*Rheum webbianaum (Revandchini)*	Shrubs				+		
53	*Robinia pseudoacacia*	Trees		+				
54	*Rosa macrophylla*	Shrubs	+					+
55	*Rubus biflorus*	Herbs	+					
56	*Rubus ellipticus*	shrubs	+			+		
57	*Rumex haustatus*	Herbs	+					
58	*Salix alba*	Trees					+	+
59	*Solanum nigrum*	Herbs	+			+		
60	*Tagetus minuata*	Herbs				+		
61	*Thymus linearis*	Herbs				+		
62	*Urtica dioica*	Shrubs	+			+		

FAUNAL DIVERSITY OF THE STUDY SITE: AN OVERVIEW

During the surveys we have selected only two groups of Arthropoda as the indicator of the ecosystem in the Kashang Project Area. The butterfly groups belonging to the insect order Lepidoptera and spider groups belonging to the arachnid order Araneae, were selected for evaluation of arthropod diversity. Butterfly being the most abundant voracious feeders of herbs, shrubs and other lower vegetations of forests acts as an indicator of diversity of flora in the ecosystem. On the contrary, the spider groups acts as the predatory species and their diversity indicate the abundance of insect prey prevalent in the region. As a whole the host-prey-predator relationship work together to maintain the ecological balance between the plants and animals and thereby an equilibrium in nature is maintained.

During the surveys, three major locations of the project area, were selected for the study. These are,

1. Area from Pangi bridge to Kashang Khad (indicated as K in the faunal list)
2. Areas from Lippa, Asrang to Kiren Khad (indicated as L in the faunal list)
3. Areas from Kharo bridge to Thopan (indicated as T in the faunal List)

In the Lepidoptera group, 19 different species of butterfly belonging to 5 families, *viz.*, Papilionidae, Satyridae, Pieridae, Nymphalidae and Lycaenidae, were found predominant in the region. *Venessa cashmiriensis*, commonly called as Indian Tortoiseshell that feeds on nettle plants, and *Candida canis* were the most abundant butterfly species in the region.

Among the predatory group, 22 different species of spiders belonging to 8 families, viz., Agelenidae, Linyphidae, Pscheridae, Salticidae, Corinnidae, Tetragnathidae, Uloboridae, Araneidae, were found to be the most abundant species in the region. *Agelina stamila* and *Tikaderia pscherina* belonging to the family Agelenidae, choose its habitat in the crevices of rocks and tree trunks. Whereas the presence of *Linyphia hartensis* of the family Linyphidae and *Leucauge decorata* of the family Tetragnathidae, indicate richness of moist ground vegetation. *Neoscona nautica* belonging to the family Araneidae, being the nocturnal predatory spider, inhabit open forest area.

FAUNAL LISTINGS FROM KHASHANG HYDROELECTRIC PROJECT AREA

During this survey butterfly (Lepidoptera) was selected as an indicator insect group and spiders (Arachnida) was selected as an indicator insect- predator group.

Sl. No.	Insect Group	Species	Family	Locality	Frequency
1	BUTTERFLY (LEPIDOPTERA)	*Polyura athamas*	Papilionidae	L	6
2		*Papilio polytes*	Papilionidae	L,T	5, 4
3		*Graphium sarpedon luctatius*	Papilionidae	T	5, 3
4		*Graphium colanthus*	Papilionidae	T	9
5		*Erabia nirmala*	Satyridae	L	6
6		*Aulocera swaha*	Satyridae	L	7
7		*Pieris brassicae*	Pieridae	K,L,T	7,5,7
8		*Pieris candida indica*	Pieridae	K	7
9		*Coleus croceus edusina*	Pieridae	K	9
10		*Candida canis*	Pieridae	KL	7,4
11		*Pontia daplidice*	Pieridae	KLT	5,5,6
12		*Venessa csahmeriensis*	Nymphalidae	K, L	6,6
13		*Venessa* sp.	Nymphalidae	L	3
14		*Mycalesis francisca*	Nymphalidae	L,T	7,8
15		*Neptis hylas*	Nymphalidae	T	5
16		*Lethe* sp.	Nymphalidae	T	5
17		*Argynnis* sp.	Nymphalidae	L	2
18		*Lycaena phleas*	Lycaenidae	K,L	7,4
19		*Zizeeria lysimon*	Lycaenidae	T	3

Sl. No.	Predator Group	Species	Family	Locality	Frequency
1	SPIDER (ARACHNIDA: ARANEAE)	*Agelina stamila*	Agelenidae	K,L,T	20,8,11
2		*Tikaderia pscherina*	Agelenidae	K,L,T	9,9,14
3		*Linyphia straminea*	Linyphidae	K,L,T	33,20,21
4		*Linyphia hartensis*	Linyphidae	T	20,19,31
5		*Neriene* sp.	Linyphidae	K	36
6		*Psechrus ghecuanus*	Psechridae	K,L	12,25
7		*Psechrus himalayanus*	Psechridae	K,L	17,19
8		*Plexippus paykhuli*	Salticidae	T	9
9		*Salticus beneficus*	Salticidae	T	7
10		*Binor pseudomaculata*	Salticidae	K	9
11		*Menemerus fulvus*	Salticidae	K,T	11,8
12		*Rhene mus*	Salticidae	K	13
13		*Castianeira himalayansis*	Corinnidae	L,T	22,16
14		*Castianeira zetes*	Corinnidae	T	11
15		*Corrina sp.*	Corinnidae	L,T	8
16		*Leucauge decorata*	Tetragnathidae	T	19
17		*Uloborus bigibbosus*	Uloboridae	T	22
18		*Miagrammopes extensus*	Uloboridae	T	31
19		*Hiptyotes himalayansis*	Uloboridae	T	15
20		*Neoscona nautica*	Araneidae	K,L,T	10,22,9
21		*Cyclosa confraga*	Araneidae	K,L,T	11,7,9
22		*Araneus* sp.	Araneidae	K	17

Locality: 1. Pangi bridge to Kashang Khad = K
2. Lippa, Asrang to Kiren Khad = L
3. Kharo bridge to Thopan = T

REFERENCES

Curtis, J.T. & G. Cottam. 1956. *Plant Ecology Work Book: Laboratory Field Reference Manual*. Burgess Publishing Co., Minnesota. 193 pp.

Curtis, J.T. & R. P. McIntosh. 1950. The interrelations of certain analytic and synthetic phytosociological characters. *Ecology*, **31**: 434-435.

Hill, M.O. 1973. Diversity and its evenness, a unifying notation and its consequences. *Ecology*, 54: 427-432.

Margalef, R. 1958. Temporal succession and spatial heterogeneity in phyto-plankton.In: A. A. Buzzati-Traverso. (Ed.). *Perspective in Marine Biology*. University of California Press, Berkeley. Pp. 323-347.

Misra, K.C. 1989. *Manual of Plant Ecology*. 3rd (ed) Oxford & IBH Publishing Co., Pvt. Ltd., New Delhi. 193 pp.

Nayar, M.P. and Sastry (1990) Red data book of Indian plants. Botanical Survey of India, Calcutta.

Shannon, C.E. & W. Wiener. 1963. *The Mathematical Theory of Communication*. Univ. of Illinois Press. Urbana, U.S.A.

Simpson, E.H. 1949. Measurement of diversity. *Nature*, **163**: 688.

CHAPTER-7

SOCIO- ECONOMIC ENVIRONMENT: BASELINE STATUS

7.1 INTRODUCTION

Integrated Kashang Hydroelectric Project is proposed for development using water of Kashang and Kerang streams, right bank tributaries of river Sutlej. The project is located in Kinnaur District of Himachal Pradesh, India and is owned by Himachal Pradesh State Electricity Board (HPSEB).

Kashsang and Kerang river valleys are adjacent to each other and are separated by a high altitude ridge in the area of the project. Topographic features permit diversion of Kashang Khad at an altitude of roughly 2830 m to an underground powerhouse located on the right bank of Sutlej river, developing a head of approximately 830 m. Topographic and geologically features between Kerang and Kashang valleys are also conducive to diversion Kerang khad, which ahs higher inflows than Kashang, into the Kashang water conductor system for significant augmentation of generating capacity at Kashang powerhouse.

Various alternative possibilities for integration of the two streams have been assessed, in one of the alternatives, diversion of Kerang khad is envisaged at elevation 3150 m-to an underground powerhouse to be located on the left bank of Kashang khad near the site from where the Kashang khad is proposed for diversion. The differential head is dissipated through power generation and tail water is channelized into Kashang water conductor for additional generation of power in Kashang powerhouse. The scheme entails working in high altitudes with logistic as well as working-season constraints and could seriously jeopardize the economic merits of the integration as its implementation schedule be susceptible to delays.

Another integration alternative identified during the course of the present comprises divesion of Kerang Khad at a lower elevation so that the Kerang water can be brought directly to Kashang water conductor through a “link” tunnel. Many of the logistic difficulties involved in the first alternative would be circumvented in this scheme as all work sites are easily accessible and no major infrastructure development work is involved. The Kerang water will be efficiently and expediently utilized over the high head available in Kashang scheme, resulting insignificant economic benefits. Development of the power potential of the two schemes as originally envisaged through integration can be completed by exploiting the remaining head available in Kerang khad through an underground powerhouse –based scheme located on the right bank of Kerang Khad.

The proposed integrated Kashang Project comprises four distinct stages of development:

- Stage–I, comprising diversion of the Kashang stream, at El. 2829 m, to an underground powerhouse located on the right bank of Sutlej near Powari village, developing a head of approximately 830 m;
- Stage–II, comprising diversion of the Kerang stream, at El. 2870 m, into an underground water conductor system leading the up streams and of stage –I water conductor system;
- Stage –III, consisting of augmenting the generating capacity of stage –I powerhouse using Kerang water over the 820 m head available in Kashang stage-I powerhouse.
- Stage –IV, comprising a more or less independent scheme harnessing the power potential of Kerang stream up stream of the diversion site of stage –II. In this scheme, a head of approximately 300 m, could be utilized to develop power in an underground powerhouse located on the right bank of Kerang khad.

The project would have a total installed capacity of 243 MW: 195 MW in Kashang powerhouse and 48 MW in Kerang right bank powerhouse.

7.2 SOCIAL AND CULTURAL BACKGROUND OF THE CATCHMENT AREA

The free draining catchment area of Kashang Khad upto proposed trench weir site of Stage-I at village Dolo Dogri is 124.03 sq km and lies between El 5938 m to 2820 m above msl. Out of 124.03 sq km catchment 30.96 sq km is snow bound. The free draining catchment of Kerang Khad up to the proposed trench weir site of Stage-II at village Lappo is 400.04 sq km and lies between El. 5848 m to 2870 m above msl, out of which 96.95 sq km is snow bound. The sub watershed Kerang also houses Lippa – Asrang Wildlife Sanctuary extending over 30.89 sq km area. Himachal Pradesh 'Kashang Project' falls in the Kinanur district of Himachal Pradesh. Physiographically, the area is within the outer lesser Himalayan zone. By far the greater portion of the district is drained by the Kerang khad or its tributaries. The social milieu of this region is comprised mostly of the Hindu community, consisting of Scheduled Tribes.

7.2.1 Demographic Structure of the Local Population

The Kinnaur District is having 660 villages/62 panchayats with a total population of about 78,334 (according to 2001 census), where the majority of the population lives in rural areas. In this district cultivators constitute the majority of the population. The sex ratio of district is 979: 1000 whereas; the ratio is 970:1000 in Himachal Pradesh in a whole. The literacy rate of Kinnaur district is 75.2 % in comparison to the state, which is around 77.13 %.

As per socio-economic survey, 4 villages are falling in affected zone. The field survey for demographic profile of affected villages revealed that in Pangi village, 11-82-60 ha private land will be affected.

7.3 DEFINITIONS

Project Affected Family means a family/person whose place of residence or other properties or source of livelihood are substantially affected by the process of acquisition of land for the project and who has been residing continuously for a period of not less then three years preceding the date of declaration of the affected zone or practicing any trade, occupation or vocation continuously for a period of not less than three years in the affected zone, preceding the date of declaration of the affected zone.

Project Affected People (PAP) include those people whose less than 50% agricultural land will be acquired for project purpose.

Project Affected Villages (PAVs) include those people whose less than 50% agricultural land will be acquired for project purpose.

Fully Affected Families include those families whose more than 50% agricultural land will be acquired for project purpose.

Partially Affected Families include those families whose less than 50% agricultural land will be acquired for project purpose.

Displaced Family means any tenure holder, tenant, government lessee-or owner of other, property, who on account of acquisition of his land including plot in the abadi or other property in the affected zone for the purpose of the project, has been displaced from such land or other property.

7.4 IDENTIFICATION OF PROJECT AFFECTED FAMILIES

The details of affected settlement and population like demographic information, livestock and other household assets have been obtained through door to door field survey conducted at household levels whereas the details of land likely to be acquired in different (project affected) villages have been obtained from the concerned Revenue Authorities and HPSEB. According to the land records and ground truth survey 253 household in Pangi village of Kinnaur district are likely to be affected due to the acquisition of land/house/shops for “ Kashang Project”. Land of other 3 project affected villages has not been acquired yet. Families were categorized into along 0-10 bigha, 10-20 bigha 20-30 bigha and Landless farmers on the basis of the land holding that remains with them after acquisition of the land. The village wise details of the project-affected families and villages are given in Table 7. 1.

Table 7.1 : Categorization of affected families of Kashang Project

Project affected Villages	Categories of Farmers			
	0-10 Bigha	10-20 Bigha	20-30 Bigha	Landless Bigha
Pangi	14.50%	5.66%	2.78%	0.38%
Lippa	2.80%	0.72%	0.18%	0.18%
Toktu	2.68%	4.69%	0.67%	0%
Asrang	2.01%	0.57%	0.86%	0.28%

Further, during the door to door socio-economic survey of 4 villages, a total number of 397 families were interviewed, in all likelihood the number of families in four villages would increase during land acquisition when the finalization of disbursement of compensation takes place as the all the claimant will stand up and real time bifurcation of families will be presented to Land Acquisition Officer by the state government.

7.4.1 Demographic Profile of PAP

7.4.1.1 Village- wise Distribution of PAP

PAP include the population getting affected and losing (Part or full) land, homestead, cattle shed, livelihood, income and common property resources due to the establishment of the "Kashang Project". The distribution of PAP i.e. the people who are losing private land, cultivable land, cattle shed, shops and horticultural trees due to the project activity for Pangi village has been estimated. Out of total respondent population of PAP (1041), 43.90 % (457) are males and 39.86 % (415) are females in Pangi village.

7.4.1.2 Educational Status of PAP

Educational status is positively correlated to the economic development of a person and the society as a whole. According to the survey conducted it has been found that in Pangi village the total number of students going to different nursery schools are 65, for primary school 146 and for junior high school are 300. In Lippa village, 150 students are going to primary school and 8 students are going to intermediate college. In Toktu village, 15 students are going in nursery school, 26 students to primary school. Whereas, in Asrang village 35 students are going to nursery school, 40 students to primary school and 20 to junior school.

7.4.1.3 Religion Status of PAP

The state of Himachal Pradesh is dominated by the Hindu community. Similarly majority of the families of project affected area belongs to the Hindu and Buddhist community. The study conducted in PAVs show that more than 99 % of the affected population belongs to the Hindu community.

7.4.1.4 Caste Categories of PAP

Social stratification on the basis of caste is very much prevalent in our society from the date back to the history. In the mountainous region, the population from general/upper castes is richer than SCs in terms of land and livestock from days back to the times of local kingdoms. As per the classification under our constitution castes are divided into 4 major groups i.e., General, SC, ST and OBC as per their social status. As per the study conducted 1 caste i.e ST is observed in the all four project affected villages.

7.5 ECONOMIC PROFILE OF PAP

The economic aspect of the project affected villages as well as the project affected families is one of the most important part of this survey. Besides this some salaried jobs in govt., and private sector, small-scale business, non-wood forest products etc. contribute to the income of the PAP. This part of the survey work deals with the occupational profile of PAP, their source of income, property ownership, details of movable and immovable property and the expenditure pattern.

7.5.1 Source of Income of PAP

Agriculture and Horticulture is the main occupation of the people of the project affected area and also the primary and most important source of income. Most of the area falling in the zone has a well-developed irrigation system with water channels drawn from the natural springs through the pipes.

The Socio-economic survey revealed that in Pangi village 22.09% people are engaged in agriculture whereas in Lippa, Toktu and Asrang villages 11.50%, 8.05%, 7.78% people respectively are engaged in agriculture. The income status of PAFs of 4 villages is given in table 7.2

Table 7.2: Annual income of PAFs from agriculture and other sources

Project Affected Villages	Annual Income (%)			
	<50,000	50,000-1lakh	1lakh-3 lakh	>3 lakh
Pangi	41.89	12.25	10.27	3.16
Lippa	62.79	11.62	20.93	4.65
Toktu	75	8.33	16.66	8.33
Asrang	76.92	-	7.69	7.69

7.5.2 Property ownership of PAFs

The data related to the ownership of property has been classified broadly into two categories namely movable and immovable. Movable property includes details related to the livestock and domestic goods (comprised of Electronic appliances, Vehicles etc.) and the immovable property includes the information on land holding, residential/non residential structures, Cattle sheds and trees.

7.5.3 Movable Property – Live Stock Population

The livestock is the major part of the economy of rural areas as they depend on them for milk, wool, meat, ploughing and transportation. Same is the case for the people of project affected villages. Other than these main utilizations cattles also provide them with the manure very rich in nutrient.

The whole project affected region is rich in live stock population particularly in Sheep and Goats due to availability of moderate amount of agricultural wastes and fodder from the nearby area.

Table 7.3: Details of live stock population owned by the PAVs (%) of Kashang Project

Project Affected Villages	Livestock (%)			
	Cow	Goat	Sheep	others
Pangi	14.22	48.80	34.99	1.96
Lippa	35.29	42.01	8.40	15.12
Toktu	10.22	18.18	68.18	3.40
Asrang	3.14	41.57	54.15	1.12

7.5.4 Movable Property – Material Assets

For assessing the family condition as per movable (material) assets information has been taken from the PAFs. The village-wise details are given in Table 7.5.

Table 7.5.: Details of material assets owned by PAP (%)

Project Affected Villages	TV	Radio
Pangi	44.66	28.85
Lippa	27.90	34.88
Toktu	8.33	4.5
Asrang	23.07	30.76

7.5.5 Immovable Property – Land Holdings

The study conducted on the PAFs of Kashang project shows that the land holding of the people ranges between 0.5-150 bigha/family. On the basis of land holding, PAFs have been classified into 5-categories provided in Table 7.6.

Table 7.6: Land holdings of PAP % of Kashang Project

Project Affected Villages	LAND HOLDING IN BIGHA				
	<5	5-10	10-25	25-50	>50
Pangi	28.45	21.73	20.55	4.34	0.79
Lippa	25.58	27.90	34.88	6.97	-
Toktu	-	13.33	50	16.66	-
Asrang	30.76	15.38	23.07	7.69	15.38

7.6 HEALTH AND NUTRITIONAL STATUS OF THE PAP

The health status determines the nature and state of human resource development. On the other hand several economic variables like income, employment, purchasing power and poverty determine the health status of the people. Health status of the people, in general, determine the average expectation of life, number of persons in the productive age group, production, productivity, earning capacity, employment and family welfare. The determinant factors of health status include food, nutrition, hygiene, medical facilities, and socio-cultural implications of health, environmental aspects, education and psychology and worldview of the people. The health status is manifested in general in the form of prevalent infant mortality rate, life expectancy, morbidity, maternal mortality, level of fertility and mortality etc. Besides this the health status is connected to the hygienic conditions and nutritional status of the person concerned. The hygienic condition can be understood in terms of personal hygiene, domestic hygiene, environmental hygiene and the community hygiene while the nutritional status denote the quality and quantity of the staple food, pulses, oil seeds, milk products, vegetable, flesh food, drinks.

7.7 FAMILY STRUCTURE – TYPE AND SIZE OF PAP

The family size and structure is a powerful means of socialization and an agency of informal social control. The Family is the basic and universal association / institution of human society and is a primary group supposed to perform social, economic, educational, recreational, religious and cultural functions and also provides social protection to its members, for their growth and development. It is the agency that makes the cultural transmission possible from generation to generations. Even today in traditional societies the role and function of the family is of vital importance. By and large, it can be concluded that the existence of mankind as a social being depends to a large extent on the existence of the family system.

It is observed that most of the families are nuclear in form. An average family consists of the husband, wife and their unmarried/married children. The size of family is confined one to ten members only. In terms of mean average family has 4-7, say five members only (Table 7.4).

Table 7.4: PAFs - Size of family of Kashang Project

Project Affected Villages	Members (%)		
	01-03	**04-07**	**>7**
Pangi	16.60	43.87	9.48
Lippa	9.30	15.16	39.53
Toktu	16.66	75.0	16.66
Asrang	15.38	46.15	30.76

Dependency on Natural Resources

In rural India, especially in hills which are very rich in natural resources people are very much dependent on them to carry out their daily work. Forest and the Setluj river with its tributaries play major role in the PAP day to day work. They depend largely on forests for fuel and fodder. As per the household survey carried out, all the PAP go to the forest for collection of fuelwood/ fodder.

AWARENESS ABOUT "KASHANG PROJECT"

Awareness and attitude in the present context mean awareness amongst the respondents regarding construction of the project, acquisition of land and compensation offer. The attitude and opinion of local population towards the project and related issues has been collected under the survey. People were divided on the issue of support regarding construction of the project. 94.46 % of the respondents were aware of the project.

Table 7.7: Attitude of affected families of Kashang Project

Questions	Yes (%)	No (%)
Do you know about the Project to be constructed in the area?	94.46	5.54

Reason for Supporting the Hydro Electric Project

PAP was asked weather they favoured the proposed "Kashang Hydroelectric Power Project". They came up with various reasons, both in favour and against. These reasons are mentioned in Table 7.8.

Table 7.8: Views of PAP in Kashang Project

Sl. No.	Reason for supporting Kashang Project	Views of PAP (%)
1	Water	43.08
2	Employment opportunities	41.89
3	Electricity	18.18
4	Don't know	28.45

CHAPTER 8

IDENTIFICATION, PREDICTION AND EVALUATION OF IMPACTS

8.1 INTRODUCTION

Due to construction of proposed project it is expected that there will be certain changes in the overall environmental matrix of the area as many man made alternation such as creation of reservoir of powerhouse sites and control room etc. The base line data of the existing environment, in the absence of the proposed activity, provides the status of natural environment and with the proposed activity it further provides a mechanism for prediction of the changes that are likely to occur. In the present study, evaluation of land, water, air, noise, flora, fauna and socio-economics was undertaken to understand the baseline environmental status of the area and estimation were made as how this will change with the commencement of the proposed activities. Anticipating the quantum of change, efforts were also made to analyze the degree of alternations and strategies for suitable management to ameliorate the negative impacts project activities. This exercise has provided a sound basis for formulation of different management plans, which are presented in the EMP document of the project.

8.2 IMPACTS ON LAND ENVIRONMENT

The impacts on land environment due to construction of the project have been evaluated and it was found that terrain around project site is going to have permanent and temporary changes in the landscape. The major impacts are described below:-

- Alteration of terrain due to construction of approach and access roads.
- Generation of muck and localized increase in erosion due to excavation of tunnel, powerhouse and other appurtenant components.
- Generation of solid waste due to construction and deployment of construction workforce.

8.2.1 Impacts on the Microclimate of the Area

The major construction activities involve underground excavation and concreting works in underground water conductor system and power house and the project does not entail any reservoir. Therefore, due to these activities there shall not be any effect on the ambient temperature, humidity, wind speed and direction and other meteorological parameters. The operation stage of a hydro electric project through an underground power house shall also not create any impact on the meteorology and climatology of the area.

8.2.2 Change in Landuse / Landcover

Construction Phase

- For construction of the project about 85.7356 ha. land will be acquired from private owners and forest department. Out of this 23.8357 ha land will be private land, being agriculture land which will be used for colonies, road construction and project components. The land use of about 6.0 ha of private land being used for establishing colonies shall not change as it will continue under Land Use Class Agriculture & Settlement but the land use of balance 17.8357 ha will change from agriculture to forest as extensive plantation in the area along road, dump area has been proposed. The underground components falling in forest area will not cause any impact on the land use. Similarly the land use of forest area diverted for dump areas and quarry sites will not cause any impact on land use as these shall continue to be under forest land use class.

- Excavation of underground components of the project will generate 1173895 cum of muck. Out of this about 293933 cum of muck is expected to be utilized as construction/filling material. The remaining 879962 cum of muck will be dumped in designated dumping areas, which may bring change in landscape of the dumping yard.

- The headrace tunnel, after entering into the bed rock, will have in general a rock cover varying from 5 m in the initial reaches to about 150-250 m near underground reservoir. No buildings are sited on surface immediately above the proposed alignment and in fact not upto 0.8 km distance from it. The K-K-Link is totally aligned across the ridge separating Kashang and Kerang Khad and has no village interspersed on surface above the tunnel alignment or to a distance of 1.5 km to 2.0 km from the axis of tunnel. The rock cover varies from 5 m to 1400 m. The alignment of Stage-IV tunnel shall also have a rock cover varying from 10 m to 250 m. The village Asrang and Toktu shall be located away from the tunnel axis and above it. In village Lapo Dogri a few houses shall be below the tunnel alignment but away from the tunnel axis. The sufficient rock cover coupled with controlled blasting technique shall reduce the vibrations imparted to a minimal.

Operational Phase

- During the operation phase no significant change on land use is expected, however, the land cover will improve, due to implementation of landscape and restoration and catchment area treatment works. Many of the redundant areas having no further usage will be brought under plantation.

8.2.3 Soil Erosion and Siltation

Construction Phase

- Soil erosion due to excavation of different components of the project, construction of roads and dumping of muck into disposal yards will accelerate soil erosion during the construction period and this increase siltation for which precaution like siltation tanks shall have to be resorted to at aggregate crushing and processing plants, dewatering from tunnels etc.

Operational Phase

- Soil erosion due to project activities will not exist in the operation phase as the construction would be completed and landscape restoration work would also be implemented. In addition to this under catchment area treatment stabilization of landslides / slip prone areas will restore erosion. The rate of siltation of both the Khads shall substantially reduce.

8.2.4 Impact on Geology

Construction Phase

Geological investigation for the project was carried out and details of the geology of the project area have been discussed in Chapter 3 of this report. As per site observations, the rock formations in the area are inherently loose and prone to landslides at various locations. However, as per site specific investigations, the geological formations in the selected project sites are judged stable and will be able to withstand the impacts of drilling and blasting. However, at any unstable formation encountered during tunneling, blasting may lead to high vibrations, which in turn may result in soil erosion, subsidence and loss of vegetation. Hence, controlled blasting is to be adopted at such geologically fragile locations. Likewise, the combined effect of selection of stable sites for construction of the link tunnel, and use of controlled blasting at fragile locations are expected to have a less impact on the geological environment.

Intensity of anticipated environmental impacts will be low based on environmental value and degree of disturbance. Therefore, intensity of anticipated environmental impact on geology of the area will be weak and extent of anticipated impact will be local. Duration of impact will be medium leading to low significance of the impact.

Operation Phase

No impact is anticipated on the geology of the area during the operation phase.

8.2.5 Impact on Hydrology

Construction Phase

Construction of proposed project may lead to two types of impact on the hydrology of the area i.e. surface water and ground water hydrology. These impacts have been described below:

Impact on the Surface Water Hydrology

The water from the khad will be drawn for construction activities at the diversion site. The water requirement during construction of the tunnel from other adits will be met from local sources. Hence, this divided water source will ensure that there is no excessive water demand on any single water resource. Moreover, if any groundwater is encountered during tunneling operations, it will be used for construction requirements to reduce surface water requirement. Further the existing drainage system in the area will not be modified or affected during the construction phase. Besides this the alignment of K-K-link tunnel and water conductor system of Stage-I is so made that no stream cuts across the ground surface immediately above it. As a matter of fact apart from few gully formation no stream of consequence is encountered on the surface within 1.0 km stretch on either side of the alignment. The alignment of Stage-IV tunnel shall pass well under 150 m to 200 m below two local streams. In that case HRT shall run parallel to Kerang Khad and very little area in between HRT and Kerang Khad shall be involved. There shall not ba any appreciable affect to surface streams which flow with heavy gradient over well defined course.

Hence, the intensity of anticipated environmental impacts is judged as low, based on environmental value and degree of disturbance. Therefore, intensity of anticipated environmental impact on hydrology of the area will be weak, anticipated impact local in extent and duration short leading to low significance of the impact.

Impact on Ground Water Resource

The ground water levels in the region could not be established, as is often the case in mountainous terrain. Since the water usage will be mainly from the khad water for construction purposes, no adverse impact on groundwater availability is expected. Dumping of wastes shall also be undertaken at specified exposed surface locations only and hence, no negative effect is envisaged on the groundwater quality of the area.

No springs exist on the proposed line of alignment of K-K-Link and HRT, balancing reservoir and pressure shaft of Stage-I. In fact, no stream has been observed up to 1.0 km distance on either side from the line of alignment. Hence, there shall not be any disturbance to ground water regime consequent to blasting for tunneling. Moreover, the underground tunnels shall be aligned very deep in the mountains with depth varying upto 500 m below the ground profile, and the size of the tunnel is insignificant. The ground water position of the area shall not change due to existing steep slope of surface and water tight lining of the tunnels.

Operation Phase

Impact on Surface Water Hydrology

During operation phase, the water from Kashang and Kerang khads will be diverted for power generation. Following guidelines issued by the Ministry of Environment & Forest, Govt. of India, the minimum flow based on average lean weather flow that will be maintained in the khad will be 0.30 and 0.65 cumecs respectively downstream of trench weir on Kashang and Kerang khad. Since, the water from the khads is neither used by the villages along the khad, nor is there any significant aquatic flora / faunal population, the reduced flow is not likely to have any adverse impact.

8.2.6 Environmental degradation due to labour immigration

Construction Phase

- During the construction phase congregation of approximately 1200 workers is likely to take place in the project area, for which semi permanent / temporary accommodation would be required. Due to this, pressure on land and water resource would occur. The disposal of sewage, solid waste would be required. If the labour force is not provided with proper fuel arrangements, the pressure on adjoining forest for fuel wood may take place. In order to reduce the dependence on forest the project proponent / contractors will be asked to provide adequate boarding and lodging to the workforce. Conflict between the migrants and the local population may occur for employment.

Operation Phase

- In the operation phase the project will have full-fledged infrastructure to meet our requirement of project workers. The labour force engaged in construction activity will also move away once the project work is completed; therefore no additional impact is expected.

8.3 IMPACTS ON AIR AND NOISE ENVIRONMENT

Construction Phase

- Temporary changes in air quality during construction phase are expected due to emission of hydrocarbons from vehicles and gases from blasting operations. The present levels of NO_x, SO_x, SPM, RSPM and TSPM indicate that the air does not contain abnormal concentration of the above. During construction monitoring of above parameters requires to be carried out periodically to keep the levels within prescribed limits by adopting rectification measures.

- Temporary changes in noise levels are expected during construction phase only. In order to check the noise, pollution noise filters may be erected around crushing and batching plants and regular maintenance of heavy earth vehicles may be adopted to reduce noise levels.

Operation Phase

- The ambient air quality during the operation phase is not expected to deteriorate.

- Noise level in power house is also not expected to increase as the powerhouse is underground.

8.4 IMPACTS ON WATER ENVIRONMENT

The water environment of Kashang and Kerang khad due to proposed project will have minor impact on the water quality and aquatic fauna of temporary nature. The project (R-O-R), with neither any dam nor barrage across khads, has no inbuilt surface reservoir, thus there is no stagnation of water.

Construction Phase

- During the construction phase of the project the river water is not supposed to catch considerable amount of sediment from the ongoing underground works as the water coming out from such area will be dislodged of sediment in the silt trapping tanks before being released to river.
- The silt laden water emanating from all other open air works and from the foundation works of power house, however will require sediment extraction before releasing the water into the river section.

- The muck disposal yards, quarry areas would be the areas of concerns for leaching of sediments during rains.

- The discharge coming out of batching and crushing plants would also bring considerable sediments in water due to washing of plants and aggregate material.

- The sewage generated at the labour camps and other residential areas may also bring considerable pollutants to river sections, if disposed off in the river section without treatment.

Operation Phase

- In the operation phase of the proposed project the water environment in general will not deteriorate owing to its being a run of the river scheme whereby the water will be continuously used for power generation and will be released simultaneously.

- However, the underground balancing reservoir will accumulate a very negligible amount of silt in its bottom for which silt flushing will be undertaken at periodic intervals. In view of the above the water quality deterioration is not anticipated considerably. The periodic monitoring of water quality will be required to evaluate the quality status.

- For downstream usages of river course will have a minimum environmental flow of 0.3 cumecs and 0.65 cumes respectively released from the downstream of weir site of Kashang (Stage-I) and Kerang (Stage-II) for downstream riparian usage. The discharge quantity in case of Kerang khad shall be further supplemented by the discharge flowing in Pager Garong and Chakra Nala both of which are located downstream of trench weir of Stage-II.

- Near Lippa village just downstream of the confluence of Pager Khad with Kerang Khad, there is a shoal formation due to the left bank of both khads following an outer curve which results in aggradation process of sediments. At this location the flow section has become wider and the effect is visible in shoal deposit. Though the process is natural and no threat or danger is caused to the village, yet the villagers apprehend that the shoal may pile up with the abstraction of water of Kerang khad. The villagers have shown their concern to the project proponents and the study teams during their visit. It is, therefore, proposed that besides normal flushing of silt deposits during floods, if needed, the abstraction of Kerang water shall be suspended or reduced so as to enable the flushing of new deposited silt loads near the banks.

8.5 IMPACTS ON FLORA AND FAUNA OF PROJECT AREA

The site of proposed project is in the enviable position because of its cultural, and social importance to the local populace besides having a diversity of natural resources. Therefore, it becomes imperative to minimize the loss of habitats and destruction of ecosystems upon which the region’s social, ecological and economic well being depends. Normally, aim of the conservation strategies is to build on, improve and coordinate the existing conservation measures to increase community ownership of nature’s conservation programs in the region under investigation.

8.5.1 Impact on Flora (Plant Biodiversity)

Based on the survey carried out during the present study the following impacts on flora/vegetation was predicted due to the construction of Integrated Kashang Hydroelectric Power project in Kinnaur District of Himachal Pradesh.

1. Degradation/destruction of Dry Temperate and Cold Desert Forests

Influx of outside population during construction of dam and other project related activities will certainly affect the quality of the habitat around the project site in many ways. Besides, there is possibility of regular decline especially in the plant diversity may be in the form of collection of fuel wood and mowing away of the floristics in the study area.

2. Loss of threatened/ economically important species

The results of baseline survey on the flora carried out during the study in the project and its adjoining area revealed that some of the species viz; *Hyoscyamus niger, Ephedra gerardiana, Ferula jaeschkeana, Heracleum candicans, Betula utilis, Juniperus macropoda, Dactylorhiza hatagirea, Datisca cannabina, Rheum webbianum, Dioscorea deltoidea, Rheum austral* recorded from the region fall under category of threat status (Rare/Endangered/Vulnerable) as per the Red Data Book on Indian Plants and CAMP reports. Since most of the project activities are under ground and threatened plant species do not coincide with the project activities. Moreover, plant species found in the studied project and its adjoining areas also occur in other parts of cold desert of Kinnaur district and therefore, as there is no threat for extinction of these species from the region. Sixty two plant species with medicinal, timber, fuel wood, fodder, ornamental value were recorded from the study area. In other words, the proposed project and its adjoining area provide food, fodder and fuel wood to the local people because of the presence of large number of species. Hence, to sustain livelihood of the rural people, massive plantation of species having medicinal, fodder, fuel wood values should be done in suitable areas.

8.5.2 Impacts on Fauna

So far as the insect and spider species of the area are concerned, we have listed 19 species of butterfly and 22 species of spiders. The species enlisted was not specifically endemic to the Khasang Khad area of Kinnour valley but are abundant in high hills of Himachal Pradesh. Noteworthy to mention is *Venessa cashmeriensis* (Lepidoptera:Nymphalidae) commonly called the "Indian Tortoiseshell" which was the most abundant species, and caterpillars of which feeds on *Urtica* spp., known as "Stinging Nettle". This species is an indicator of rich ground vegetation in the area. Similarly *Leucauge decorata* (Araneae:Tetragnathidae), an orb-weaving spider, that basically breed near watery and moist sources. This species is an excellent indicator of water-rich environment where there is thick presence of insect-prey.

Due to construction of different hydroelectric structures, none of these species would be directly impacted. But as the sites are best habitat for these species, alternative arrangements must be made. To keep a balanced environment for the survival of these small terrestrial invertebrates, a green belt around the project areas must be created which should be rich in ground vegetation.

HIMALAYAN FOREST RESEARCH INSTITUTE

(*Indian Council of Forestry Research & Education*)

Conifer Campus, Panthaghati

SHIMLA-171 009 (H.P.)

Contact us at:

Telephone: 0177 – 2626778
FAX: 0177 – 2626779
E-Mail: hfri@hotdak.net
Website: www.hfri.icfre.org