

EXECUTIVE SUMMARY

Environmental Impact Assessment study of the proposed Tawang H.E. Project Stage-I (600 MW) was conducted in detail. This study was carried out according to the Terms of Reference (ToR) defined by the Expert Appraisal Committee (EAC) of MoEF, Government of India at the time of scoping of the said project. The entire report is compiled into two parts, Environmental Impact Assessment (EIA) and Environmental Management Plan (EMP).

The first part i.e. EIA is comprised of base line information about the project, project area and project catchment. It is divided into 13 chapters which deal with environmental aspects like physiography, hydrology, land use/ land cover, air environment, terrestrial ecology, aquatic ecology, socio-economic status, etc. There is a separate chapter on envisaged impacts due to the proposed project on different aspects of environment and local population.

The second part i.e. EMP, deals with various management plans and mitigation measures. There are 14 management plans including biodiversity management plan, catchment area treatment plan (for free draining catchment), dam break analysis and disaster management plan, etc.

I. ENVIRONMENTAL IMPACT ASSESMENT (EIA)

EIA comprises of the baseline information about the project and project area, collected from both primary and secondary sources. The study area is divided into two parts – first area of direct impact includes the project area in which different project components like dam, powerhouse, adits, quarry sites, muck disposal area etc. will be located. Area of indirect impact is the area within 10 km radius from dam and powerhouse etc. The collected information is compiled in the following 13 chapters.

1. INTRODUCTION

The proposed Tawang H.E. Project Stage-I is proposed on the Tawang River near Power House of Nuranang Chhu Hydel Project in Tawang district of Arunachal Pradesh. The total catchment area measures approximately, 2937 sq km (27°30'00" – 28°24'00" N latitude and 91°47'00" – 92°28'00" E longitude. In **Table 1** salient features of the Project are given. The

landscape of the catchment area is entirely mountainous, situated above 2000 m. The area is characterized by rugged topography, high mountain ridges with steep slopes and deep incised valleys carved by Tawang Chhu river. The snow covered area of the district ranges nearly from 3300 m to 6600 m, which mostly includes bare mountains and are mostly uninhabited. The high altitude mountain belt ranges from 2000 m to 3300 m, which contains plateaus and narrow valleys and is sparsely populated. Location and layout of the project are shown in **Fig. 1 and Fig. 2**, respectively.

Table 1 Salient features of the proposed Tawang H.E. Project Stage-I

LOCATION

State	:	Arunachal Pradesh
District	:	Tawang
River	:	Tawang Chhu
Barrage Site	:	Near Nuranang Chhu Powerhouse
Nearest BG rail head	:	Guwahati & Nagaon
Nearest airport	:	Guwahati & Tezpur
Latitude	:	27°35'20"
Longitude	:	91°59'03"

HYDROLOGY

Catchment area	:	2937 sq km
Location of catchment		
	Latitude	: 27°30'00" to 28°24'00"
	Longitude	: 91°47'00" to 92°28'00"
Average annual rainfall (at Murga Bridge)	:	1710 mm
Maximum temperature	:	31.1 ° C
Minimum temperature	:	-2.9 ° C
Max 10 daily discharge	:	299.6 cumec
Min 10 daily discharge	:	28.2 cumec

RESERVOIR

Full reservoir level (FRL)	:	EL 2090 m
Min. Draw Down Level (MDDL)	:	EL 2087 m
Gross storage		
	at FRL	: 167.2 Ham
	at MDDL	: 131.43 Ham
Area Under		

Submergence at FRL	:	12.46 Ha
STAGE DIVERSION		
Diversion Discharge	:	624 cumec
No. of Stages	:	2 No.
Length of Dyke		
Stage-I	:	370 m
Stage-II	:	250 m
Top of Dyke	:	EL 2072 m
BARRAGE		
Type	:	RCC RAFT WITH PIERS
Top elevation	:	EL 2092 m
Crest elevation	:	EL 2068 m
Downstream Floor Level	:	EL 2061 m
Length at top	:	130.5 m
Thickness of d/s Raft	:	5 m
Upstream Floor Level	:	EL 2066 m
Upstream Floor Thickness	:	2 m
Thickness of Pier	:	3.5 m
Height	:	26 m
SPELLWAY		
Design flood	:	12680 cumec
Type	:	Orifice type
Crest elevation	:	EL 2068 m
Number (including one emergency bay)	:	9
Size (W x H)	:	9.5 x 14.75 m
Energy dissipation	:	Stilling Basin with End sill
INTAKE		
Invert level	:	EL 2074 m
Number	:	2
Size of gate opening (W x H)	:	5.5 m x 5.5 m
Trash Rack	:	Inclined type
Size of Trash Rack (W x H)	:	10 m x 10 m
DESILTING CHAMBERS		
Type	:	Dufour
Number	:	2
Size (W x H)	:	14 m x 18 m
Length	:	320 m
Design discharge per chamber	:	81.00 cumec

GOC Floor	:	EL 2095 m
Outlet Gate Size (W x H)	:	5.5 m x 5.5 m

SILT FLUSIG TUNNELS

Branch Tunnels

Number	:	2
Shape & Size (W x D)	:	2.0 m x 1.5 m, D-Shape
No. of Gate in Each Tunnel	:	2 Nos. (One service & one emergency)
Size of Gate	:	2 m x 1.5 m
SFT Size & Shape	:	2 m x 3.5 m, D-Shape

HEAD RACE TUNNEL

Number	:	1
Size	:	7.0 m
Shape	:	Horseshoe
Length	:	13.987 km
Design discharge	:	129.00 cumec
Overload discharge	:	142.00 cumec

POWER HOUSE

Type	:	Underground
Installed Capacity	:	600 MW
Number of Units	:	3
Power house cavern size (L x W x H)	:	148 m x 22 m x 54 m
Turbine Axis Elevation	:	EL 1541.0 m
Type of turbine	:	Francis Vertical Axis
Max. Gross Head	:	543.0 m
Max. Head Loss	:	19.5 m
Rated Net Head	:	521.0 m

TRANSFORMER CUM GIS CAVERN CUM DRAFT TUBE GOC

Cavern Size ((L x W x H)	:	143 m x 17.5 m x 28.5 m
Draft tube gate		
Number	:	3
Size	:	4.0 m x 4.2 m

TAILRACE TUNNEL

Number	:	1
Size	:	7.0 m
Shape	:	Horseshoe
Length	:	1680 m
Design Discharge	:	129.00 cumec

Tailrace Surge Gallery	:	7.0 m dia D-shaped, 530 m long
HFL at TRT outlet	:	EL 1554.20 m
Max. TWL	:	EL 1549.0 m
Min. TWL (one unit Running)	:	EL 1548.0 m
TRT outlet gate		
Number	:	2
Size	:	3.5 m x 7.0 m

POTHEAD YARD

Size	:	30 m x 190 m
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POWER GENERATED

Installed capacity	:	600 MW
Annual energy generation with	:	2968.80 MU

2 METHODOLOGY

In the present study standard methods which were earlier developed at the Centre and published elsewhere, were followed for Environment Impact Assessment of Tawang H.E. Project Stage-I. Studies on water resource development projects by various authors were particularly consulted in the present study as well. A brief account of the methodologies followed in the present study of Tawang H.E. Project Stage-I is given below under different headings. All the methods were structured for the identification, collection and organization of environmental impact data. The information thus gathered has been analysed and presented in the form of a number of visual formats for easy interpretation and decision-making.

Primary surveys were conducted in different seasons of the year (i.e. summer, monsoon and winter) to collect data on geology, forest types, flora, fauna and various ecological parameters including air, soil and water. During these survey, data and information were collected on geophysical and biological attributes of the catchment area in brief, influence area (10 km radius) and project areas in detail. In addition, comprehensive surveys and studies were also conducted for understanding the aquatic ecology and fish life of Tawang river and its tributaries. Primary surveys in the entire catchment area were also conducted for the purpose of ground truthing and augmenting the remotely sensed data. For this purpose various attributes such as land features, rivers, forests and vegetation types were recorded on the ground in the catchment area. Survey on flora, fauna, air, water, fish, soil, geology etc. and ground truthing were conducted during July 2007, December 2007 and April 2008. Catchment survey was done in July 2008. Eventually in June, 2009 socio-economic survey was carried out.

Spatial database on physiographic features were taken from various sources including the Survey of India (SOI) toposheets and satellite data, which were analyzed with the help of Geographic Information System (GIS). This data was collected, arranged and presented as thematic maps according to the EIA methods used in the study. The thematic maps are presented in the form of general drainage map of the catchment and its sub-watersheds, relief map, aspect map, slope map etc. In addition, river gradient profile of the Tawang Chhu and its major tributaries from its upper reaches to the proposed barrage site was plotted to understand the degree of erodibility. Land use and land cover mapping was carried out by standard methods of analysis of remotely sensed data followed by ground truthing, ground control point data collection and interpretation of satellite data

Besides, the regional geology around the project area highlighting geomorphology, stratigraphy and structural features was based on the existing information on these aspects contained in Detailed Project Report (NHPC, 2010) of the project. In addition, the important parameters of seismicity were assessed using published literature on seismic history and seismotectonic nature of the regional rock types in the area. Seismotectonic setup of the region has also been described with the help of published literatures (Kumar, 1997 besides referring to the “Seismotectonic Catalogue of India and its Environments” published by Geological Survey of India (GSI publication 2000) and the earthquake data given by the India Meteorological Department (IMD).

In the Hydro-meteorology section, the rainfall data could be made available for three stations in the catchment which lie in the vicinity of the proposed Tawang H.E. Project Stage-I. Average annual rainfall i.e. 2053 mm has been calculated on the basis of three rain gauge stations i.e. Murga bridge, Yusum and Tawang. At Murga bridge data was available for the period of January 2000 to May 2005 at Yusum, it was also available from March 2003 to May 2005 and at Tawang it was available from March 2004 to July 2008. The data of 10 daily water discharges were also available at three gauge sites. This data set was utilized for calculating monthly and annual water discharge of Tawang H.E. Project Stage-I. Variation pattern of annual flood peaks and sediment load in the Tawang Chhu river were also studied.

Soil resource mapping of the Tawang H.E. Project Stage-I area was prepared from the basic data / map of soil classification prepared by the National Bureau of Soil Survey and Land Use Planning, (Indian Council of Agriculture Research), Regional Centre, New Delhi (NBSS Publ. 57b,

1997). To assess the baseline soil quality in the region, soil samples were collected and analyzed (**Fig. 6**). For this reason, samples were lifted from the 12 different locations extending from Yusum Basti to Nuranang Fall. These locations were grouped into five sites viz., S₁, S₂, S₃, S₄ and S₅ (**Fig. 3**). The soil samples were collected for three seasons and physical parameters such as the nitrate, phosphate and organic matter (fungi, bacteria) of soil were analysed using the standard methodology.

Forest types and various plant and tree species were recorded during the field visits in 2007 and 2008. Besides the primary surveys in the project areas, the floristic data for the catchment was also procured from the published literature. To understand the community structure, vegetation sampling was carried out at different locations in the project area (**Fig. 3**). For sampling various strata of vegetation, the area was divided into three sites/stands viz., barrage site, powerhouse site upper reaches and powerhouse site lower reaches.

For faunal elements (mammals, birds, herpetofauna, butterflies) primary as well secondary sources of information were utilized while collecting data. In addition a detailed survey was carried out on the birds and butterflies of the region. We selected various sites which would likely to be disturbed by the various activities of the project. The important sites were proposed barrage site, proposed power house site, Jang village etc.

The water sampling was conducted at different locations in the 10 km river stretch of Tawang river in order to collect the baseline data for Tawang H.E. Project stage-I. The sampling was conducted for three seasons (pre-monsoon, monsoon and winter). Physico-chemical parameters and biological parameters were studied to assess the water quality of the river. It was carried out at 9 locations in 10 km river stretch of Tawang, which were grouped into 3 sites. The study of fish species was also carried out in the Tawang. The various species of fish were identified with the help of the literature. Conservation Assessment Management Plan of Biodiversity - Conservation Prioritization Project Workshop (CAMP-BCPP, 1997), organized by National Bureau of Fish Genetic Resources (NBFGR), Lucknow, was followed to know the conservation status of the fish species found in river Tawang.

The ambient air characteristics (SPM, NO_x and SO₂) were recorded with the help of Respirable Dust Sampler (Envirotech APM 460BL) with gaseous sampling attachment (Envirotech APM 411TE). The machine was run at the NHPC Guest House, Tawang, proposed

Power House site of Stage I and at Jang village near proposed barrage site. Traffic density was recorded at the NHPC office at Tawang town and Jang village near barrage site. Noise levels were recorded using the instrument D 2023 (Cygnets), TYPE 2 (as per IS 9779, 1981). The data was recorded at different locations namely proposed power house site, proposed barrage site near Jang village and Tawang town.

Socio-economic profile includes brief description of Arunachal Pradesh, Tawang district and the circles in which project components are located. History, cultural aspects, ethnic values and tribal life of Arunachal Pradesh and Tawang district are mentioned briefly. A detailed account on the demography, education, occupation, and other amenities of the villages located in 10 km radius and project affected villages is discussed in EIA report. In order to collect the baseline data for preparation of R & R plan a door to door survey for project affected families was carried out for the proposed project. A detailed questionnaire was prepared for this purpose.

The vulnerability of an ecosystem to various impacts, resulting from an activity or multiple activities, was identified and accordingly impacts were predicted.

3 PHYSIOGRAPHY

The physiographic condition of a region refers to the sculptures on the natural landscape and ongoing changes by several geomorphic agents like water, glacier, wind etc. In the present study, various physiographic parameters were analyzed through remote sensing and GIS techniques. A database of different aspects was formulated for all constituent sub-watersheds of Tawang Chhu catchment.

3.1 Drainage Network

Tawang Chhu and Nyamjang Chhu are the two main rivers in Tawang district. Tawang Chhu emerges after the confluence of Mago Chhu and Nyukcharong Chhu rivers at an elevation of 2240 m. Nyukcharong Chhu originates from Tibet in the Eastern Himalayan ranges and flows towards southern direction and joins Seti Chhu after 52 km of travel in Tibet. It further flows in southward direction and enters India after Shoe/Tsona Chhu joins it from left side at 3060 m near Shyamding. Mago Chhu originates in India at an elevation of 3360 m. It traverses south-west and joins Nyukcharong Chhu near Kyelatongbo and the river after confluence is known as Tawang Chhu. Tawang Chhu flows towards Bhutan through a narrow valley in most part of its length and

crosses international boundaries after cruising in India for a distance of 45 km. The overall drainage network of the catchment area shows combination of dendritic, trellis and parallel drainage patterns (**Fig. 4**). Several small and large lakes are located within the catchment area.

3.2 Gradient Profile

The longitudinal profile of the Tawang Chhu including its headwater, where the river is known as Shoe Chhu in Tibet covers a distance of about 140 km between 4700 m elevation in the north and 2060 m elevation at the proposed barrage site. The gradient profiles of major tributary streams like Nyukcharong Chhu, Mago Chhu, Goshu Chhu and Nuranang Chhu are also calculated. At the central part of the profile major tributary streams meet the main river. In this stretch the river spans an elevation of 2000 m in 47 km travel. Thus, the gradient of Tawang Chhu in this stretch is 1:23.5. The Mago Chhu travels for 45.65 km within the elevation range of 2400 to 5100 m. This channel has the gradient of 1:16.91. One of the prominent knick points observed along Mago Chhu lies at 75 km from the headwater region. Here, the water elevation in the river drops down from 3900 to 3500 m in a span of about one kilometer distance. Another knick point was observed near the confluence of Tawang Chhu and Mago Chhu. The presence of knick points indicates major structural discontinuity across the stream. Steep gradients are also observed for Nuranang Chhu (1:7.34) and Nyukcharong Chhu (1:12.83).

3.3 Relief

The Tawang Chhu catchment area has been divided into 12 elevation bands. Among the high elevation classes, there are four elevation classes above 4000 m (4000-4400 m, 4400-4800 m, 4800-5200 m and 5200-5600 m) which are widely spread in the entire catchment. Together these elevation classes cover an area of 258424 ha i.e., 88% of the entire catchment. These elevation classes are widely spread in the northern part of the catchment, moreover in the Tibet part. Elevation classes above 5600-6000 m are spread on small area of 1.13% of the catchment, spatially these classes are restricted to extreme north of the catchment and head water region. Elevation class with 6000-6400 m is spread on a small area of 352.43 ha and elevation with above 6400 m is spread only on a mere area of 1.25 ha. Lower elevation classes are limited along the valleys of main channel of Mago Chhu, Tawang Chhu and Nyukcharong Chhu rivers.

3.4 Slope

The catchment has been divided into 6 slope categories. Out of these classes, moderately sloping area has largest area coverage of 38.55% of the total catchment area. Strongly sloping is

spatially spread on an area of 81678.73 ha of land i.e., 27.81% of the catchment area. Another prominent slope class in the catchment is gently sloping class. It is widely distributed along the northern part of the catchment. It covers an area of 27.11% of the total catchment area. Moderately steep slope presents in an area of 6.17% of the total catchment area. This slope class is more prominent in the southern part along Nyukcharong Chhu, Goshu Chhu and Dungma Chhu valleys. Steep and very steep slope classes areas are present in 0.36% of the catchment area (**Fig. 5**).

3.5 Aspect

The slope classes are proportionately distributed in the entire catchment, except of flat area which covers the maximum area of 83554.15 ha of land. It accounts for 28.45% of the total catchment area. Slopes with SW-W-NW direction occupy 19% of the total catchment area and it is widespread throughout the catchment. The slopes with NW-N-NE aspect occupy 18.24% of the catchment. Slopes having NE-E-SE facet occupy 17.82% of the total area. It is distributed throughout the catchment. Eventually, slopes with SE-S-SW facet are distributed on 16.39% of the total land in the catchment area.

4 HYDROMETEOROLOGY

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

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

C to 31.1° C, respectively. The month of January is coldest month, when average temperature ranges from -0.1° C to 8.2° C while August is hottest month measuring annual temperature range of 11.3° C to 20.9° C. Average annual rainfall calculated from three rain gauge stations at Murga bridge, Yusum and Tawang is 2053 mm. At Yusum, maximum rainfall (569 mm) is received in the month of July, at Tawang maximum (386 mm) is received in the month of July, while at Murga bridge maximum (273.2 mm) is received in August. The annual precipitation received at Yusum (2665 mm) is higher than at Murga Bridge (1710 mm) and Tawang (1784 mm). Considerable portion of the basin receives precipitation in the form of snow. Snow accumulates during October to March, and it melts during April to July. No detailed data on the wind aspects are available, however, India Meteorological Department provided wind data for winter season. Average wind speed was measured to 6.0 km/h while average wind direction was 228 deg.

The annual average of water discharge was recorded as 42.5 cumec at China Bridge which increased to 89.0 cumec at barrage site in Tawang Chhu. For Mago Chhu the annual average of water discharge was 40.8 cumec. For the period of 17 years (1992-2008) maximum water discharge of 299.6 cumec was recorded in the month of August. The maximum and minimum 10-daily average discharge corresponds to 299.6 cumec in the mid August, 2007 and 28.2 cumec in the beginning of February, 1998. The average run-off coefficient for Murga bridge (nearby barrage site) for the period of 2000-2007 is computed to be 0.60, which measures 0.63 after deducing the snowmelt contribution. The rainfall-run off correlation has also been carried out by taking into account the snowmelt contribution, which is deduced from the total observed run off to compute the contribution of the rainfed catchment.

The suspended sediment data were observed at Yusum site from August 2002 to April 2007 and at Murga bridge site from May 2001 to May 2007. The average annual suspended sediment load at Murga bridge site works out to be 0.121 Mtons / year, of which coarse, medium and fine constitute 0.004 MTons (3.2%), 0.02 MTons (14.6%) and 0.10 MTons (82.2%), respectively. Assuming 20% of the sediment load is transported as bed load, the total annual sediment load (suspended + bed load) comes out to be 0.14 Mtons / year. On the basis of this sediment load, the silt rate of Tawang H.E. Project Stage-I comes out to be 49.3 tons/sq. km/year.

5 GEOLOGY & SEISMICITY

The Sub-Himalaya mostly comprises sedimentaries known as Siwalik and are separated

from the Brahmaputra plains by Foothill thrust (FHT). The Siwaliks extend up to Bhalukpong which is about 280 km from Tawang. Towards north the Sub-Himalaya is thrust over Lesser Himalaya along Main Boundary Thrust. Lesser Himalaya is mainly formed by Upper Proterozoic to Lower Cambrian detrital sediments from the passive Indian margin intercalated with some granites and acid volcanics (1840 ± 70 Ma). The Lesser Himalaya in the region is represented by Bhareli and Bichom formations both of Gondwana Group, Bomdila group and Dirang Formations. The Lesser Himalaya is observed up to Dirang which is located about 143 km from Tawang. The Lesser Himalaya towards the west abuts against Mishmi Hills while towards the north it is bounded by the Main Central Thrust (MCT).

Further north, the Lesser Himalaya is overlain by Higher Himalaya and separated from it by Main Central Thrust. The MCT appears between Dirang formation and the overlying Sela Group of Higher Himalaya near Dirang. The Higher Himalaya is a 30 km thick medium to high grade metamorphic sequence of meta sedimentary rocks which are intruded at many places by granites of Ordovician (approx. 500 Ma) and early Miocene (approx. 22 Ma) age. Although most of the meta-sediments forming the Higher Himalayan Crystalline Sequence (HHCS) are of late Proterozoic to early Cambrian age, much younger meta-sediments can also be found in several areas. The project area lies in Higher Himalaya belt and is located about 30 km north of MCT and about 100 km south of Indus Tsangpo Suture Zone.

Further north, the Higher Himalaya is overlain by Tethys or Tibetan Himalaya which comprises strongly folded and imbricated, weakly metamorphosed sedimentaries. Tethys Himalaya is separated from overlying Trans Himalayan formations by Indus Tsangpo Suture zone. The Indus Tsangpo Suture Zone (ISZ) defines the zone of collision between the Indian plate and Eurasian plate. This suture zone is formed by the Ophiolite Mélanges, which are composed of an intercalation of flysch and ophiolites from the Neotethys oceanic crust.

Lithostratigraphically, the rocks exposed in the area belong to Sela Group and Lumla Formation. Das *et al.* (1975) introduced the term 'Sela Group' to include garnetiferous biotite gneiss, lit par lit gneiss/migmatite, calc gneiss, high grade gneiss and schist etc. exposed around Sela pass and high grade gneiss, schist, amphibolite, calc-silicate and migmatite extending from Tawang up to 40 km NW of Sela. Jain & Tiwari (1977) divided the rocks of the area into the Sela Group, the Bomdila Group and the Gipsu Formation, each separated by a prominent thrust. The rocks around Lumla were classified by them as Gipsu Formation belonging to Bomdila Group.

Jain and Basu Roy (1978) classified the rock sequence exposed around Lumla into Lumla Formation.

Sela Group of rocks is the oldest sequence consisting of polyphase deformed high grade metasediments of green schist to amphibolite facies. The sequence corresponding to the Dirang Formation in the Tethyan Himalaya is referred to as the Lumla Formation (Tripathi *et al.*, 1979). Resting over the Sela Group it is best exposed in Tawang-Woming La section (Singh, 1988). In other areas it may include the Taksing Formation and the Monigong and Pididi Formation (Singh and De, 1989). It is constituted of low grade meta-sedimentaries comprising schistose quartzite with bands of biotite±garnet±staurolite schist, calc-silicate and marble (Kumar, 1997). It is intruded by tourmaline granites of Tertiary age.

The project components are proposed to be constructed within rock types of Sela Group. Gneisses with intrusive of leucogranite, pegmatite and amphibolites constituting Sela group of rocks are disposed around the project area. Seismotectonically the area encompassing the proposed project is located in Main Himalayan Belt in Arunachal Himalaya. Northern part of the terrain is occupied by the Trans Himalayan Tectogen with late to post tectonic granitoid batholiths. This pocket is followed to the south in the western part by the ophiolite and accretionary complex of Tsangpo Suture Zone. However, along this tectono-stratigraphic level, towards east only an incipient development of ophiolite is observed. Further south the Himalayan Belt exposes Proterozoic crystallines, Proterozoic folded cover rocks, Palaeozoic sequence and volcanics that have been tectonically reworked during Himalayan fold thrust movements. Within the Siang window fossiliferous Cenozoic cover sequence along with basic volcanics is present.

Major structural elements of this region are Tsangpo Suture, the Main Central Thrust (MCT), Main Boundary Thrust (MBT) and intermittently exposed Foot Hill Thrust (FHT) along with some subsidiary thrusts and transverse faults (Narula *et al.*, 2000). Different tectonic domains in this area exhibit different seismicity clusters, trends and blocks.

6 SOIL

Total catchment area in the Tawang H.E. Project Stage-I is around 293700 ha. Only an area of 125585 ha was considered for the preparation of soil resource mapping to describe different types of soils because remaining area is the part of Tibet. The soils of proposed Tawang

H.E Project Stage-I are comprised mainly of three soil families (Entic Haplumbrepts, Typic Udorthents and Lithic Udorthents) having 5 soil units. The Entic Haplumbrepts-Typic Udorthents and Lithic Udorthents-Typic Udorthents are predominant families in which units 2 and 1 covers 15.78% and 11.61% area of the project (**Fig. 6**). Majority of the soils of the catchment is excessively drained, loamy skeletal and susceptible to severe to very severe erosion. Soil association - Entic Haplumbrepts – Typic Udorthents is predominant group of influence zone, accounts nearly for 51% of the total area. The predominant soils are moderately - deep, excessively drained and loamy- skeletal on moderately steeply sloping summits having loamy surface. The soils are susceptible to severe to very severe erosion.

The proposed barrage site and dumping areas of Tawang HEP Stage-I is covered by Entic Haplumbrepts and Typic Udorthents soil associations, which are characterized by loamy-skeletal and sandy-skeletal soils. The proposed power house site is covered with Lithic Udorthents - Typic Udorthents soil association. The soils are characterized by deep to moderately shallow, excessively drained, loamy-skeletal soils on very steeply sloping summits having loamy surface with severe to very severe erosion hazard. The Head Race Tunnel passes through both associations as mentioned above.

Soils texture influence the physical properties like porosity, permeability, water holding capacity and nutrients. Gravels and pebbles constituted small portions of the soils collected from the project areas. Very fine sand accounts for the major portion in the soils ranging from 24.06% - 36.85%. Fine silt with clay, important reservoir of plant nutrient, ranged from 0.64% to 16.01% with minimum at site 3. The soils recorded low moisture contents which can be attributed low density of plant species in the region. Bulk density is correlated with proportions of clay in the soils. The water holding capacity (WHC) was found to range from 43.32 to 85.26% with maximum at proposed barrage site near Nuranang fall.

7 LAND USE/ LAND COVER

Land use and land cover mapping of the Tawang H.E. Project Stage-I was carried out by standard methods like digital image processing (DIP) supported by ground truthing. The land use and land cover of the Tawang Chhu catchment area includes dense forest, open forest, scrub, degraded forest, alpine meadow, cultivation, moraines, barren / rocky land, river / nallahs, lakes, and snow. Large area of the catchment (174741 ha) is prevalently covered by snow, which

occupies 59.50% of the total area. It is prominently spread in the northern part of the catchment. Dense, open and degraded forest lands together occupy 31617.80 ha, which is 10.7% of the total area. Forest cover is spatially spread in the southern part of the catchment. However, degraded forest is sparsely spread with area coverage of 84.96 ha. Alpine meadow occupies an area of 4874.25 ha, which forms only 1.66 % of the catchment area. Moraines occupy 38020.69 ha, which is 12.95% of the catchment area. Significant area of 36161.92 ha is covered by barren / rocky land, which is 12.31% of the total area. River / nallahs and lakes together occupy an area of 4430.68 ha, which contributes 1.51% of the total catchment (**Fig. 7**).

The submergence area extends up to 1.15 km from the u/s of barrage site and it covers an area of 12.46 ha. A total of 3.49 ha of scrubs will be submerged. In addition to it, 0.78 ha and 2.61 ha of open forest and dense forest, respectively would also be submerged due to the project. However settlements and agricultural lands are not coming under submergence.

8 FLORISTICS AND FOREST TYPES

Arunachal Pradesh is reported to have 80.43 % of its total geographic area under forest cover, which includes very dense, moderately dense and open forest (FSI, 2009). The catchment of the proposed Tawang HE Project Stage-I covers 10 major representatives of forest types of the Eastern Himalaya viz., Sub-tropical wet hill forests, Sub-tropical pine forests, Wet temperate forests, Mixed coniferous forests, Alder forests, Low level blue pine forests, Sub-alpine Rhododendron forests and Alpine Birch-Rhododendron forest, Dwarf Rhododendron scrubs and Pastures. However, the project area covers East Himalayan sub-tropical forests comprising sub-tropical wet hill and Himalayan pine forests.. The forests in the project area fall in Jung subdivision of Tawang Forest division.

Sub-tropical wet hill and pine forests are found in the lower valleys of the project area. Wet temperate and low level blue pine coniferous forests in the mid hills, while at higher elevations mixed coniferous forests, sub-alpine rhododendron and alpine forests are found.

The ecological study in the project area of Tawang HE Project Stage-I was undertaken with the objectives of preparing a checklist of flora in the submergence area and locations where project components are proposed and its adjoining areas; listing of rare/endangered, economically important and medicinal plant species; determination of frequency, density and

basal cover of different vegetation components. A total of 103 species of plants were recorded under the ecological investigation during sampling seasons. Out of which 23 were trees, 24 shrubs and 56 herbs. The ground vegetation comprised of ephemeral, annual and perennial species of grasses, sedges, legumes and non legume forbs. Further in the study area (within 10 km radius), angiosperms are represented by 420 species belonging to 274 genera and 91 families, out of which 315 species under 204 genera and 76 families belong to dicots while 105 species under 70 genera and 15 families belong to monocots. Gymnosperms are represented by 5 species under 4 genera and 3 families.

Asteraceae with 32 genera and 52 species and Poaceae with 33 genera and 43 species are the largest families of dicots and monocots, respectively. Among Gymnosperms, Pinaceae is the dominant family represented by 2 genera and 3 species. The dominant genera represented by 5 or more species in the study area are *Anaphalis* (5 species), *Arisaema* (5 species), *Berberis* (5 species), *Carex* (6 species), *Cyperus* (6 species), *Ficus* (5 species), *Persicaria* (5 species), *Potentilla* (6 species), *Rhododendron* (9 species) and *Saussurea* (5 species).

As per BSI Red Data Book, no rare and endemic plant species are reported from the project area. However, the catchment area has pristine forests that contain some unique plant species. *Caltha palustris* var. *purpurea*, *Trollius farreri* and *Schisandra plena*, etc. are some of the reported endemic plants from high hills of Arunachal and adjacent Tibet Himalaya (Nayar, 1996). Since these plants are reported to occur in the high altitude areas, there is no possibility that some of these plants may occur in the project area.

The diversity of vegetation in project area and adjacent areas was also assessed in terms of the physiognomy of its floral elements. The herbaceous species (66.90%) constitute bulk of the flora followed by shrubs (15.34%), trees (13.18%), climbers (4.55%) and parasitic plants (0.47%). About 45% families of the flowering plants are comprised of only herbaceous species of which Ranunculaceae, Asteraceae, Cyperaceae and Poaceae are the dominant ones, each represented by more than 15 species. This region harbours a wide range of medicinal plants used in Ayurvedic, Homoeopathic and Unani medicines also used by the local people. Some of the medicinal plants like *Achyranthes aspera*, *Acorus calamus*, *Artemisia nilagirica*, *Bergenia ciliata*, *Cyperus rotundus*, *Houttuynia cordata*, and *Viola betonicifolia* are quite common in the sub-tropical parts of proposed project area. *Berberis macrosepala*, *Clematis montana*, *Lyonia*

ovalifolia, *Origanum vulgare*, *Zanthoxylum acanthopodium*, etc. are important medicinal plants occurring in the temperate areas.

The important crops of the region are finger millets, barley, maize, potato etc. Many wild vegetables and fruits are also consumed locally. Among the wild edible plants consumed are the leaves and young twigs of *Amaranthus spinosus*, *Fagopyrum esculentum*, *Girardinia diversifolia*, *Rumex nepalensis*, etc. The tubers and rhizomes of *Colocasia esculenta* are commonly consumed as vegetables. Fruits of *Castanea sativa*, *Phyllanthus emblica*, *Prunus cerasoides*, *Rubus ellipticus*, etc. are eaten.

9 FAUNA

The fauna of the region has palaeartic and Indo-malayan affinities. The fauna of palaeartic affinities includes Snow leopard (*Uncia uncia*), Serow (*Capricornis sumatraensis*), Red Goral (*Naemorhaedus baileyi*), Musk Deer (*Moschus chrysogaster*), Bharal (*Pseudois nayaur*), Black-necked crane (*Grus nigricollis*), Monal Pheasant (*Lophophorus impejanus*), etc. The wild Yak (*Bos grunniens*) is found in the higher reaches of the region particularly areas bordering Tibetan plateau. The animal species like Wild boar (*Sus scrofa*), Himalayan yellow-throated marten (*Martes flavigula*) etc. inhabiting the valleys are close to the Indo-malayan fauna. A few elements like Red Panda (*Ailurus fulgens*), Clouded leopard (*Neofelis nebulosa*) etc show their affinities with the Indo-chinese and Indo-Malayan regions.

Mammalian fauna comprises 31 species belonging to 16 families. Of the 31 species 19 inhabit 10 km surrounding area of the proposed project sites. Artiodactyla comprise Deer, Sambar, Goral, Takin, Serow, Bharal, Yaks and Wild boars coming from 4 families. Barking deer and Hog deer are found at altitudes between 1500 – 2400 m in the region. These are the common deer species of the influence zone of the proposed project, inhabiting dense bushy forests. Both species are categorized under the Schedule III of WPA (1972). Musk deer and Sambar occur between 3000 – 4000 m and 1200 – 2000 m. Musk deer inhabits upper reaches of Nuranang Valley and Sela pass and Bumla region. Sambar occurs in the surrounding of project areas. Musk deer is categorized under the ‘endangered’ category of IUCN and Schedule I of WPA (1972). Goral and Serow are distributed between 2000 – 3000 m in the catchment area. Sometimes Gorals descend up to 1200 m to forage food and water. Takin is less known species in the area, known to occur between 2000 – 3000 m. Wild Yak is restricted to the high altitudes

over 4000 m. Red goral is a wood dwelling animal inhabiting altitudes between 1500 to 4500 m. Blue sheep and Argali are restricted in the upper reaches like Sela pass and Bumla areas. It is found over 4000 m between tree line and trans-Himalayan tracts. Serow is described under the 'vulnerable' category of IUCN red list and Schedule I of WPA (1972). Wild boar is distributed up to 1500 m. It inhabits open areas and raids agricultural fields. Wild boar has been placed under the Schedule III category of WPA (1972).

Mammals were recorded from the project areas with the help of direct and indirect evidences. Himalayan marten (*Martes flavigula*) was sighted near proposed power house complex and Jang village. Himalayan marmot (*Marmota himalayana*) was spotted near Jaswant Garh (within influence zone). Pellets of macaques and deer were observed at various spots upstream of proposed barrage site. A skull, preserved as a trophy of Wild boar (*Sus scrofa*) was seen at a household of Jang village near the barrage site. Local people were reported to observe herd of Blue Sheep near Sela pass frequently.

The avian fauna of the catchment area comprises 104 species of birds belonging to 35 families. It includes sandpipers, swifts, crane, plover, vultures, eagles, pheasants, partridges, woodpeckers, barbets, hoopoe, doves, pigeons, owls, tits, flycatchers, bulbuls, thrushes, laughing thrushes, drongo, crows, magpies, shrikes, redstarts, finches, minivets, warblers, babblers, wagtails etc. Timalidae is the largest family comprising 18 species. A total of 20 families viz. Falconidae, Gruidae, Charadriidae, Scolopacidae, Strigidae, Apodidae, Upupidae, Campephagidae, Prionopidae, Rhipiduridae, Cinclidae, Prunellidae, Cisticolidae, Aegithalidae, Sittidae, Nectariniidae, Dicaeidae, Dicuridae, Emberizidae and Passeridae are monotypic in the region. Sclater's Monal, Blood pheasant, Satyr tragopan, Black-necked crane, Red-billed chough, and Alpine Accentor inhabit high reaches over 3000 m in the catchment area. The remaining species are well distributed in the surrounding areas within 10 km radius. Crested Serpent Eagle, Golden Eagle, Himalayan Griffon, Eurasian Griffon, Oriental turtle Dove and Hill Pigeon are widely distributed in the region. The species like Crimson-breasted Woodpecker, Darjeeling Woodpecker, Golden-throated Barbet, Great barbet, Wedge-tailed Green pigeon, Mountain imperial Pigeon etc. prefer to inhabit forests from 1700 to 2000 m in the catchment area of the proposed project. The majority of the species of thrushes, warblers, laughing thrushes inhabit bushes in the Tawang valley. Redstarts and wagtails are found in the open areas near water bodies. Majority of the species in the catchment area are resident, in which sparse resident accounts for 50% and widespread resident is 34% of the total species. Wood Sandpiper (*Tringa*

glareola), Grey Wagtail (*Motacilla cinerea*) and Yellow Wagtail (*M. flava*) are widespread winter visitors while Long-billed plover (*Charadrius placidus*) is a sparse winter visitor in the surrounding and the catchment area.

The Avifauna from the proposed power house to the barrage sites and immediate surrounding areas comprises 33 species belonging to families Charadriidae, Picidae, Megalaimidae, Columbidae, Pycnodidae, Laniidae, Muscicapidae, Sylviidae, Fringillidae, Nectariniidae, and Passeridae. A total of 84 individuals were spotted from the project areas, of which Eurasian Tree Sparrow accounts for maximum. Around 52% of the species are widespread residents whereas nearly 31% are sparse residents. *Charadrius placidus* was only sparse winter visitor species. No migrant and vagrant species were recorded from the project areas. *Passer montanus*, *Stigmatopelia chinensis*, *Myophonus caeruleus*, *Dicrurus macrocercus* and *Yuhina gularis* were most abundant species of the region. None of the threatened and scheduled species was recorded from the project areas.

Amphibian fauna comprises *Bufo melanostictus*, *Bufo himalayana*, *Amolops afghanus*, *Rana cyanophlyctis*, *R. tigerina*, *Polypedates maculatus* belonging to families Bufonidae and Ranidae. None of the herpetofaunal species of the catchment area is locally and globally threatened.

A total of 15 species of butterflies were recorded from the project sites and its close vicinities belong to families Papilionidae, Pieridae, Lycaenidae, Riodinidae and Nymphalidae. Most of the species were recorded from Jang village near settlement. Metallic Cerulean, Punchinello, Indian Cabbage White and Common Sailer were most abundant species. None of the recorded species were threatened or endemic to Arunachal Pradesh. Blue Baron and Common Mime are categorized as Schedule I species while Metallic Cerulean is Schedule II species (WPA, 1972).

10 AQUATIC ECOLOGY & WATER QUALITY

10.1 Water Quality, Physical and Biological properties

In this study water quality assessment of Tawang Chhu is discussed. Water samples were taken during the three seasons i.e., winter, pre-monsoon and monsoon seasons from various locations. The water samples were analyzed for various physical, chemical and biological

parameters to get an overview of water quality. **Table 2** gives details of physico-chemical parameters of river water. Tawang river is rich in planktonic, benthic and macro-invertebrates populations. The density of suspended algae increases gradually in downstream river stretches. The plankton density was highest in the winter season

Highest water current velocity was recorded in monsoon season as the water discharge was also higher. Water temperature is another physical factor which exerts direct as well as indirect influences on abiotic and biotic characteristic of aquatic ecosystems. Water temperature followed a seasonal pattern as the lowest temperature was recorded in winter season (6°C) and highest in the monsoon season (15 to 17° C). River water at all the sites investigated was relatively alkaline. The pH values ranged from 7.43 to 9.70 with highest pH being recorded in monsoon season and the lowest in winter season. Dissolved oxygen concentrations were high except in Monsoon season, where the concentrations fell down to 5.53 mg/l as the turbidity is generally high which prevents photosynthetic activities of aquatic organisms. The high Dissolved oxygen contents in winter are due to low water temperature and less turbidity. All these factors together contribute in increased dissolved oxygen content in winter season. Total dissolved solids (TDS) and electrical conductivity of water ranged from 15 to 147 mg/l and 24 µS/cm to 240 µS/cm, respectively.

The biological community in a river is a product of the various physical and geomorphologic forms and processes of the river. Total coliform test, which indicates the contamination of water due to sewage outfalls, indicated no such contamination from the study area. The density of zooplankton ranged from 12 to 54 individuals/ lit. Phytoplankton or suspended algae formed an important component of aquatic flora as they are the primary producers in aquatic ecosystem. The density of suspended algae ranged from 918 to 15940 cells/lit. Maximum density was found in winter season due to low temperature conditions, high dissolved oxygen content and increased transparency. Diatoms formed the major component of suspended algae as well as of Phytobenthos. The density of Phytobenthos ranged from 6194 - 27239 cells/ lit. Details of various biotic components are given in **Table 3**.

A total of 63 species of diatoms were identified in Tawang River. Out of 63 species, 23 species were common to both benthic as well as planktonic diatoms. Benthic diatoms showed more species richness (53 species) than the planktonic forms (33 species). There were 30 species which were found exclusively in benthic forms, while, number of species found exclusively in planktonic form were 10.

Table 2 Physico-chemical characteristics of water of Tawang Chhu River

Site	Pre- Monsoon			Monsoon			Winter Season		
	W1	W2	W3	W1	W2	W3	W1	W2	W3
Water current velocity (m/s)	2.00	1.54	1.30	3.05	3.53	3.17	1.21	1.45	1.30
Water Temperature (°C)	9.00	8.00	9.00	15.00	17.00	17.00	6.00	7.00	8.00
pH	8.16	8.10	8.70	9.21	9.70	8.75	8.69	7.43	8.70
Dissolved Oxygen (mg/l)	9.53	11.66	10.53	5.53	8.80	6.05	13.19	12.60	12.24
Electrical Conductivity (µS/cm)	116.66	120.66	86.00	50.66	116.00	117.00	240.00	24.00	204.6
Total dissolved Solids (mg/l)	70.00	70.00	50.00	30.00	80.00	80.00	147.00	15.00	130.00
BOD (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND
COD (mg/l)	0.50	0.45	0.55	0.65	0.61	0.67	0.34	0.33	0.36
Total alkalinity (mg/l)	40.00	44.00	34.00	20.00	38.00	38.00	56.00	52.00	52.00
Salinity (ppt)	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total hardness (mg/l)	68.00	48.00	36.00	48.00	96.00	96.00	84.00	12.00	72.00
Calcium Hardness (mg/l)	32.00	36.00	30.00	36.00	80.00	76.00	67.50	8.40	63.00
Calcium ion (mg/l)	12.80	14.40	12.00	14.40	32.00	30.40	26.91	3.36	25.23
Magnesium Hardness (mg/l)	36.00	12.00	6.00	12.00	16.00	20.00	16.50	3.60	9.00
Magnesium ion (mg/l)	8.74	2.91	1.45	2.91	3.88	4.86	4.00	0.87	2.18
Chloride (mg/l)	7.99	6.99	8.99	5.99	5.99	6.99	9.99	7.99	7.99
Nitrate (mg/l)	0.67	0.52	0.74	ND	ND	ND	0.42	0.32	0.21
Phosphate (mg/l)	ND	0.12	ND	0	0.03	ND	ND	ND	ND
Iron (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND
Manganese (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND

W1: Barrage site; W2: Power House site, W3: Downstream Power house site, ND: Not detected

Table 3 Densities of different biotic communities in Tawang Chhu River

Biotic communities	Pre-Monsoon			Monsoon			Winter		
	W1	W2	W3	W1	W2	W3	W1	W2	W3
<i>E. coli</i> (A/P)	A	A	A	A	A	A	A	A	A
Coliforms (A/P)	A	A	A	A	A	A	A	A	A
Zooplankton (indiv./lit)	23	24	53	24	21	12	54	35	21
Suspended algae (cells/lit)	4086	8722	9765	918	1102	1097	6634	15940	14380
Phytobenthos (cell/mm ²)	11489	19962	14247	7904	8060	6194	15327	18831	27239
Macro-invertebrates (indiv./m ²)	121	55	154	311	532	400	945	66	522

A: Absent

P : Present

The diatom species which were abundant in both benthic as well as planktonic forms were *Achnantheidium minutissima*, *Achnantheidium microcephala*, and *Achnantheidium linearis* followed by *Hannaea arcus*, *Synedra ulna* var. *oxyrhynchus*, and *Fragilaria construens*. The diatom assemblage composition was characteristic of Diatoms occurring at kryal sites which are generally nonmotile with strong attachment abilities that can resist high discharge and abrasion by glacial flour, belonging to the so-called pioneer species with high resilience (e.g., *Achnantheidium* spp., *Diatoma* spp., *Fragilaria* spp., and *Hannaea arcus*) (Hieber, 2001). *Synedra vaucheriae*, *Achnantheidium austriaca* and *Cyclotella* sp. dominated the species occurring exclusively in benthic forms, while *Achnantheidium exilis*, *Fragilaria vaucheria* and *Reimeria sinuata* dominated the planktonic forms.

10.2 Fish & Fisheries

Ichthyofauna of Tawang river (Arunachal Pradesh) comprises about 12 species belonging to families Cyprinidae, Salmonidae, Cobitidae, Bagridae, Amblycipitidae and Sisoridae.

Snow trout comprises *Schizothorax richardsonii* and *Schizothoraichthys progastus*. These are widely distributed in the Himalayan rivers up to 2000 m. These fish are column feeders with powerful muscular streamlined body. Snow trouts are herbivores, feed on benthic algae and account for major and important part of the capture fishery in the region. Both these species are endemic to Himalaya. *Schizothorax richardsonii* is considered as ‘vulnerable’ species (CAMP-BCPP, 1997). *Salmo trutta fario* (Brown trout) is an exotic fish species, introduced in Tawang Chhu from a hatchery established by State Fishery Department at Nuranang Chhu. Fry of brown trout are directly stocked in Tawang Chhu, however, a self sustainable population of brown trout could not be established in the river so far. They come rarely in the fish catch. *Botia berdmorei* (Blyth’s loach) and *B. rostrata* (Gangetic loach) are bottom dweller fish and are carnivorous. They get shelter among the pebbles and shingles in shallow waters. They are not of any commercial fishery interest due to their small size but are considered as aquarium fish. *Botia berdmorei* is designated as ‘endangered’ species. Generally, these species do not come in the catch, particularly by the caste net and hooks. Cat fish group comprises *Mystus vittatus* and *Amblyiceps mangois*, which belong to families Bagridae and Amblycipitidae, respectively. *Mystus vittatus* prefers to inhabit muddy bottom, therefore, very rarely comes in the catch. *Amblyiceps mangois* is a benthopelagic freshwater species which clings to the stones/pebbles in the rapid water current. Both species are not of any commercial fishery interest. Sisorid group of fish comprises *Erethistoides montana*, *Euchiloglanis*

hodgarti, *Exostoma berdmorei*, *Gagata cenia* and *Pseudechneis sulcatus*. None of these species is of commercial interest and all are rheophilic and bottom feeders. *Erethistoides montana* has been categorized as ‘critically endangered’ fish, whereas *Euchiloglanis hodgarti* and *Pseudechneis sulcatus* are designated as ‘vulnerable’.

Average catch per unit effort (CPUE) was recorded to be 0.04 kg/per day and 0.054 kg/day in winter and pre-monsoon seasons, respectively. In addition, hook and line methods were also used to land the fish. The capture fishery depends mainly on the snow trout (*Schizothorax richardsonii* and *Schizothoraichthys progastus*). The low CPUE and scanty population indicated by the low density of fish in the upper reaches which may be due to passage of river through deep and narrow gorges, and presence of cold glacier and snow-melt water, which is not conducive for much fish diversity at these altitudes.

11 AIR ENVIRONMENT

In the entire Tawang district point source pollution is absent. The diffuse source comprises fuel wood, traffic fuel and forest fire, etc. The traffic density in the project area was recorded during April, December and July months at Tawang town and Jang village near proposed project. Vehicular density in Tawang accounts for more than 60% as compared with Jang village. Light vehicles are important means of public transport in the region whereas two wheelers are highest in private transport. Notably, defence vehicles contributed considerable number of heavy and light vehicles at Jang (National Highway). Maximum level of SO₂ was recorded at Tawang town during the month of December which may be due to relatively heavier traffic flow in the region as it is relatively larger settlement. The only source of NO_x emissions in the region is vehicles. Maximum levels of NO_x were observed at Tawang town (3.60 µg/m³) in the monsoon season. At Tawang-I power house site, the levels of NO_x recorded were 2.39 µg/m³ during the winter season.

The Ambient levels of RSPM and NRSPM have been measured at different locations in the project area. At proposed power house site, the TSPM levels were the highest (465.64 µg/m³) in the pre-monsoon period. NRSPM was the major component of TSPM during all seasons. In this region the main sources of SPM are vehicles, open degraded land areas, road construction and landslides. In

the monsoon season TSPM concentrations were lower due to settling down of dust and other particles with rains.

The adverse impacts of noise also depend on time and seasons, particularly in case of animals and birds. Tawang I power house site is away from road head and settlements, therefore, sound level was measured to be as low as 56 dB. The highest sound level (78.50 dB) was recorded at Tawang town in month of April. Proposed Power house site recorded 55.12 – 59.24 dB of sound level.

12 SOCIO-CULTURAL ECONOMIC PROFILE

Arunachal Pradesh covers an area of 83,743 sq. km and lies between latitudes 26° 28' to 29° 30' N and longitudes 91° 30' to 97° 30' E. Arunachal Pradesh is bordered by Bhutan in the west, Myanmar in the southeast, Tibet in the north and the Indian State of Assam in the south. Itanagar is the capital of Arunachal Pradesh, which is located in Papum Pare district. The total population of Arunachal Pradesh is 10,91,117 with a sex ratio of 893 (Census, 2001). The average population density is 13 persons per sq. km. About 64% of the total population of the state belongs to the Scheduled tribe with maximum in Kurung Kumey district and minimum in Lohit district. Average literacy rate in Arunachal Pradesh is 54.74% with maximum in males (64.07%). Administratively, Arunachal Pradesh is divided into 16 districts, Tawang is one of the district bordered with Bhutan in the west and south-west, Tibet in the north and north-east, West Kameng District in the south and south-east.

Project components of Tawang H.E. Project Stage-I falls in 5 administrative circles viz., Tawang, Jang, Mukto, Thingbu and Kitpi circles. Kitpi circle was separated from Tawang Circle after Census of India 2001. Total population of these circles is 28458 come from 5858 households. The average sex ratio of circles is 711 with maximum in Mukto circle. The population of Scheduled Castes (SC) and Scheduled Tribes (ST) account for 0.45% and 69% of the total population, respectively. The age class 0-6 year shares 14.6% of total population as per the Census 2001. Average literacy rate in the circles under discussion is 46.2% with considerably high in males. Most of the tribes depend on agriculture. Main crops in the region are Paddy, wheat, millets and maize. Peoples are employed in tourism industry, constructions, government jobs, agriculture and household activities.

A total of 25 villages belonging to 5 circles are directly affected due to acquisition of community land for the proposed Tawang H.E. Project Stage I. Socio-economic data of affected villages is based on the Census 2001. Total population of affected villages is 8335 come from 1817 households. Average sex ratio in these villages is 901. Scheduled tribe population accounts for 83.2% of the total population. Scheduled castes mainly reside in Jang and Teli villages. Literacy rate (33.6 %) in affected villages is lower than that of administrative circles of project area. The literacy rate is considerably higher in male population (43.5 %) as compared with females (22.6 %). Rice, maize, millets and pulses are main crops of the affected villages. Around 57.4% of the total population is employed in various works, viz. agriculture, small scale business, house building, labour work in road construction and government jobs. All affected villages of Jang and Tawang circles are connected to the national highway and have electricity and tap water facilities. Majority of the affected villages have nearby centres of primary and secondary education. None of the affected villages has senior secondary education, post office, banking and primary health care facilities. Only Gomkelleng village of Mukto circle avail all above facilities from the nearest place.

No family is getting displaced due to construction of project. A total of 292 households/khatedars of 18 villages will be affected due to the acquisition of 113.8 ha private land for Tawang H.E. Project Stage-I. Total population of affected families is 1420 of which age group 0-6 years accounts for 11.4% of the total population. Sex ratio in affected families is 1076, which is considerably higher than that of affected villages. All affected families belong to Scheduled Tribe. Jang is largest village, from where maximum households are affected. Literacy rate in the affected families is 43.0%. Only 3.7 % of the total population has got or getting higher education (graduate or post-graduate). In addition to the formal education, nearly 2.8 % of the total population has got monastic education (Lamaism) of buddhist ideal. Around 41.8% of total population of affected families is involved in various occupation. The majority of working persons of affected families are engaged in agriculture (83.7 %) while only 6.2 % are employed in government services. Other occupations in the affected families are small scale business, non government services and labour works.

Livestock of affected families comprises cows, buffaloes, oxen, goats, sheep, mules, yak and poultry. About 47.9 % of the affected families are categorized under the 'below poverty line'. Other categories of vulnerable persons among project affected families are widows (2.6%) and handicapped (0.5 %). Most of the affected villages of Tawang H.E. Project Stage-I are connected

either to National Highway or link roads. Transportation facilities are not adequate and density of vehicular movement is very low. All villages have electricity and tap water facilities. All affected families have *pucca* houses, made of concrete or stone masonry. The villages inhabited by affected families are poor in health facilities and some of the villagers have to travel for 40 km to access hospital facility. The consumption of energy is based on the fuel wood, kerosene and LPG.

Effect of the project on various socio-economic aspects is summarized below in Table 4:

Table 4 Socio-economic Aspects

S. No.	Aspects	Number/Area (ha)
1	Private land affected	113.8 ha
2	Community forest land affected	125.3 ha
3	Unclassed State Forest affected	66.5 ha
4	Villages affected	25 nos.
5	Households/ Khatedars affected	292 nos.

Land requirement for the project is presented below in Table 5:

Table 5 Land requirement for the project

S. No.	Components	Forest Land	USF*	Community Forest Land	Private Land	Total
1	Reservoir Area	-	5.00	7.50	-	12.50
2	Barrage complex and colony site including TW1-G2, TW1-G3, TW1-R1, MDA 1, Adit 1 CFA	-	25.00	30.00	20.00	75.00
3	Muck dumping area MDA 2, 3, 4, 5	-	3.00	16.20	4.80	24.00
4	Adits 2, 3, 4, 5 CFA including TW1-R4	-	14.50	14.50	36.00	65.00
5	Main office & colony site	-	-	17.00	-	17.00
6	TW1-G1, TW1-C1, TW1-C2, TW1-R3, TW1-R6, TW1-R7	-	3.00	7.10	-	10.10
7	Power house complex & Colony site including MDA-6, TW1-R2	-	8.00	32.00	38.00	78.00
8	New roads	-	8.00	1.00	15.00	24.00
	Total	-	66.50	125.30	113.80	305.60

* Unclassed State Forest

In order to know the public opinion on Tawang H.E. Project Stage-I, the people of the area was interviewed during the socio-economic survey. Affected families belong to Monpa tribe, which is unique in tradition, culture and customs. The land of majority of the affected families is associated with Tawang Monastery.

13 IMPACT ASSESSMENT

The impacts were identified on the basis of their nature, magnitude and potential. The impacts may be major (land use changes, barrage structure, submergence, habitat destruction, etc.) and minor (pressure on wildlife, deterioration of water quality, etc.), positive (infrastructure development, work opportunity for local, fisheries development, etc.) and negative, direct (submergence of vegetation, obstacles in the way of fish migration, local economy), indirect (cultural and social resources, forest resources, etc.), local (most of the impacts are confined to the project areas) and strategic (a few impacts have strategic importance like local area development). The impacts of the project are summarized below:

- i) Proposed barrage would inundate a small area of 12.46 ha alongside Tawang river. The submergence area is covered with dense/open forests. None of the plant species in submergence area is threatened and endemic to Tawang.
- ii) Around 24 ha of land will be disturbed due to construction of new roads passing through Berghar, Paidhar, Teli, Upper Seru and Lower Seru villages. However, the construction of roads may also trigger minor slips and downfall movement of soil aggregates.
- iii) Influx of labourers may exert additional pressures on the natural resources. However, this impact is temporary in nature.
- iv) No family is getting displaced due to the construction of the project. However, 125.3 ha community forest land belonging to 25 villages and 66.5 ha unclassified state forest will be acquired for the construction of project. In addition, 113.8 ha land belonging to 292 households/khatedars will also be acquired for the project.
- v) Nearly 75 ha of land is required for barrage complex and colony site (including TW1-G2, TW1-G3, TW1-R1, MDA 1 and Adit 1 CFA). The area has degraded forests. Thus, heavy felling of trees is not anticipated in this region.

- vi) The proposed barrage would lead to habitat fragmentation, which directly affects fish migration. Major impacts are not anticipated due to fragmentation as river water harbours very low species of fish. Snow trout, however are important species which undertake downstream/upstream migration for the breeding purpose during the monsoon season.
- vii) Loose soils as a result of excavation would increase the SPM level in the air. However, this activity would occur only during construction phase.
- viii) The noise generated by various machinery works, tunneling and blasting would lead to adverse impact on wildlife. Such types of activities are limited in construction phase.
- ix) Entire stretch of HRT from intake to powerhouse shall be housed within rock formations of Sela Group. The rock types of Sela Group consist of gneisses which are intruded by leucogranites, pegmatites and amphibolites. They are expected to provide fair to good tunneling media.
- x) The expected number of labourers and technical staff coming from outside for the construction of the project would be nearly 1000 and 500, respectively. The migrant workers lead to other impacts like cultural invasion and social conflicts, act as carriers of various diseases like AIDS, VDS, gastro-enteritis, etc. However, this impact is temporary in nature as migrant workers would vacate the area after construction of the project.
- xi) Local people would be beneficiaries of work opportunities due to the project and infrastructure like schools, hospitals, roads, free electricity, buses, etc.
- xii) Project would play a vital role in development of Tawang and contribute to revenue of state.
- xiii) A stretch of river Tawang in the downstream would undergo scarcity of water. However, 3.5 cumecs of water would be released from the barrage in lean season. None of the families in downstream section depends on the river water.
- xiv) No encroachment on historical or cultural sites would take place according to the available documents and current studies.
- xv) As per the current study, no inundation of mineral resources or loss of mineral resource development potential shall take place due to the project.
- xvi) Air pollution may occur during construction phase due to vehicular movement and due to drilling, blasting and other construction activities. However, this is temporary and lasts for construction period only.

II ENVIRONMENTAL MANAGEMENT PLAN

Environmental Management Plans deal with the management and mitigation measures of the impacts discussed in part one (EIA). Various management plans on different aspects of Environment have been discussed below. Total cost of the management plan is summarized in last chapter of EMP report.

1. BIODIVERSITY MANAGEMENT AND CONSERVATION PLAN

The present biodiversity conservation and management plan for Tawang H.E. Project Stage-I in Arunachal Pradesh is aimed to the conservation of natural resources and to circumvent the stress on biodiversity. Arunachal Pradesh is an abode of a large number of tribes, which are closely associated with nature and natural resources. Considering the customs, culture and socio-economic conditions of the local tribes the following issues were taken into account in formulating the biodiversity management and conservation plan:

- (i) To maintain a sustainable approach between customs and culture of the local communities and biodiversity conservation,
- (ii) Conservation of threatened, endemic and newly recorded species,
- (iii) Special efforts for *in situ* or *ex situ* conservation of critical / important plant / animal species, if any, affected by the project,
- (iv) To protect the traditional knowledge of the local people,
- (v) To provide incentives for research, training and public education to increase awareness with respect to biodiversity.

For the implementation of the above action plans, the project authorities will provide the funds for Biodiversity Conservation and Management Plan. Total financial budget would be **Rs. 540.00 lakhs**. Out of which maximum funds were allocated for protection of vulnerable area and establishment of botanical garden.

2 CATCHMENT AREA TREATMENT PLAN

To minimize the soil erosion and its impact on the reservoir and as a part of Environmental Management Plan study for the proposed Tawang H.E. Project Stage I, a Catchment Area Treatment

(CAT) plan for the free draining area has been prepared for area with high soil erosion rates. The CAT plan targets towards the improvement of the environmental condition of the project area. All the measures that will be undertaken aim at treating the degraded and potential areas of severe soil erosion and very severe soil erosion. CAT plan provides benefits due to biological and engineering measures, and its utility in maintaining the ecosystem health. The main aim of the CAT is to rejuvenate various potential and degraded ecosystems in the catchment area for the longevity of the reservoir storage capacity.

Free draining catchment is identified for the study of soil erosion susceptibility and it is divided into 28 sub-watersheds (7 in Nyukcharong Chhu watershed and 21 in Mago Chhu watershed). Area indentified for soil erosion treatment is 840.96 ha. Out of this, 836.56 ha are classified under severe erosion intensity category and 4.40 ha under very severe erosion intensity category. The total area earmarked for the treatment comprises more than 0.67% of the free-draining catchment area, and about 4% of the total area under very severe and severe erosion intensity categories requiring treatment measures. For undertaking soil conservation measures various indirect or preventive measures like biological measures and direct or remedial measures like engineering measures are proposed. Use of techniques like geo-textiles and preference to the local material has been suggested for the treatment. In the free draining area total area for erosion-treatment will be 840.96 ha. Among the Engineering measures, 67 numbers of brushwood check dams and 81 numbers of DRSM check dams will be set-up. A total area of 110.77 ha, 152.22 ha and 116.85 ha will be treated by mulching, contour bunding and bench terracing, respectively. In the biological measures afforestation will be done in an area of 193.20 ha. NTFP Regeneration / Medicinal plants cultivation will be done in an area of 93.48 ha, Assisted natural regeneration in an area of 107.67 ha of land and finally pasture improvement in an area of 66.68 ha. The total cost of the Catchment Area Treatment Plan will be **Rs. 435.50 lakhs**.

3 FISHERIES DEVELOPMENT PLAN

In Tawang Chhu river and its tributaries; *Schizothorax richardsonii*, *Botia berdmorei*, *Erethistoides montana*, *Euchiloglanis hodgarti* and *Pseudecheneis sulcatus* are threatened species, in which *E. montana* is 'critically endangered' and *B. berdmorei* is 'endangered' (CAMP-BCPP, 1997).

The proposed plan of fishery development is aimed towards conservation of indigenous species of Tawang Chhu river and its tributaries. Some of the plans are listed below.

- i. Hatchery Unit
- ii. Reservoir Fishery and its Management
- iii. Fish pass/ways
- iv. Habitat improvement

This plan shall be executed by the Fishery Department of Arunachal Pradesh. The total financial outlay for the fisheries development would be **Rs. 100 lakhs**.

4 HEALTH MANAGEMENT

The proposed plan of health management was prepared considering the population density of surrounding villages and their accessibility. In order to provide adequate medical facilities in the region, the project authorities are suggested to strengthen existing medical facilities in the area.

A project hospital is proposed in the colony area of the proposed project. In addition to the project staff, the services of this hospital would be extended to the PAFs / local people of the region. The project authorities would take care of the hospital permanently. There is no budgetary allocation for the hospital because the expenditure for the project hospital has been earmarked in DPR under the project construction cost. In addition to it, a primary health centre is proposed at Shyaro village of Thingbu circles. The project authorities would provide funds to the sub-centre for 7 years. After 7 years the sub-centre would be handed over to State Government.

Strengthening the medical infrastructure would be also undertaken in which immunization programme, distribution of first aid boxes, organizing free medical camps, establishment of first aid posts and mobile medical vans will be covered. Total financial package for health management for the proposed Tawang H.E Project Stage I would be **Rs. 326 lakhs**.

5 WASTE MANAGEMENT

The construction of the Tawang H.E. Project Stage I would take about 7 years. The requirement of labourers and the technical staff would vary each year according to the construction

phases. The peak time migrant population would be 4816 (say 5000) persons (including family members). The solid waste expected to be generated annually would be approximately 854 tonnes. The proper collection and disposal of this waste, besides providing proper sanitary facilities to the labour colonies in the project area would be ensured by the project authorities in this plan. Integrated waste management system has been proposed for waste management and disposal. Integrated waste management includes source reduction, refuse, recycling, composting landfill and incineration. Physical, chemical and biological processes are used for various recovery methods. In order to manage the solid waste, dumpers and wheel barrows, sanitary facilities, restroom facilities, septic tanks, community toilets, bathrooms and washing places, sewage treatment plant and incinerators are suggested at various places in the project area. The total budget for the execution of the waste management plan would be **Rs. 362 lakhs**.

6 PROVISION OF FUEL

Primary objective of the energy conservation in the project areas is to protect the forest resources as people use fuel wood for various purposes. The proposed plan is formulated considering not only the project workers but also project affected families. These facilities can be extended to the direct impact and influence zone. For saving the fuel, proper housing designs are suggested. The house construction is part of infrastructure development so that no additional budget is allocated for housing design. In addition installation of solar panels, establishing LPG depots, Kerosene depots, setting up community kitchen / canteen, distribution of improved *Chullahs*, solar cookers and pressure cookers are also proposed. Total financial outlay for the provision of fuel would be **Rs. 134.00 lakhs**.

7 MUCK DISPOSAL & REJUVENATION OF MUCK DISPOSAL SITES

The loosely held muck can lead to the rise in SPM level, sedimentation load in Tawang Chhu river and phytoretardation of nearby vegetation. Therefore, it requires stability with appropriate methods to avoid the subsequent ecological problem. The muck disposal and rejuvenation of muck disposal sites involve both engineering and biological measures that depend on the eco-climatic conditions. The proposed Tawang H.E Project Stage I is likely to generate 26.16 lakh cum of disposable rock muck (after swelling) and 7.44 lakh cum of disposable common muck (after

swelling). Therefore, the total amount of muck to be disposed of will be about 34 lakh cum. Six dumping sites have been selected along side the Tawang Chhu river. To reduce the impact of muck several biological and engineering measures are proposed. Engineering measures to be used along the dumping sites are construction of retaining walls and compaction of muck. Biological measures include plantation and fencing. Total budget for the disposal and rehabilitation of muck would be **Rs. 4963.25 lakhs.**

8 RESTORATION OF QUARRY SITES

For the construction of different components of Tawang H.E. Project Stage-I, substantial excavation in rock and soil would be required. This would lead to formation of depression and craters. The quarrying for rock material and impervious soil would lead to removal of vegetation cover, top soil and leave the area barren. A total of 62.04 ha land would be affected due to quarry operations. Various biological, bio-engineering and engineering measures are proposed for the restoration of the quarry sites. Engineering measures include removal of top soil, filling of depressions, diversion of run-off and construction of retaining walls. Bio-engineering measures are carpeting with geo-textiles and mulching. Biological measures include soil reclamation through VAM and revegetation. The estimated cost for restoration of quarry sites including engineering, bio-engineering, biological measures and maintenance is **Rs 389.60 lakhs.**

9 RESTORATION OF CONSTRUCTION AREAS AND LANDSCAPING

Tawang H.E. Project Stage-I would involve construction of colonies for staff and laborers, roads linking to various components of project, offices, workshops, etc. A total area of 305.60 ha land in the region will be directly disturbed due to various construction activities of the proposed project, like submergence, barrage complex, roads, muck dumping sites, quarry sites, colonies, offices, etc. which will change the existing land use/land cover in the region. After completion of the construction work, it is required to restore the disturbed area to its original condition. Various engineering and biological measures have been suggested for restoration of these areas. Proposed mitigation measures will also help to arrest soil erosion in the region. During the construction phase, some localities in the area are likely to be prone to soil erosion. Construction of retaining walls would be necessary to stabilize the slopes in these areas. Biological measures would involve plantation of tree species and

shrubs in the colony area. Local plant species should be preferred for plantations. Road construction in the proposed project will also disturb the hill slopes and result in excavated material (muck). Retaining walls are proposed in the region to avoid slippage and land slides. Biological measures would involve plantation of saplings of various tree and shrub species along the road sides. Cost estimate for different components of landscaping and restoration is **Rs.143.00 lakhs**.

10 CREATION OF GREEN BELT AROUND THE RESERVOIR

Establishment of a green belt around the reservoir of Tawang H.E. Project Stage-I has been proposed to reduce silt flow in the reservoir and thus increase its life. Main objectives of creating a green belt around a reservoir are to i) check soil erosion around a reservoir, ii) check landslides or slips around the reservoir, and iii) develop the habitat for wildlife particularly birds and butterflies. Development of green belt around the reservoir will also improve the habitat of birds and other wild animals around the region. In the proposed green belt plan, area has been divided into two layers for plantation of plant species depending upon the microclimatic condition that will develop after establishment of the reservoir in the region. The bottom layer (G1), which starts from the water level (at 2120 m contour line) and considered up to 2160 m contour line is around 16.39 ha in area. The upper layer (G2) is considered between contour lines 2160-2200 m with total area 16.99 ha. The micro climate of the layer G1 will be humid, and therefore, water loving plant species like *Alnus nepalensis*, *Macaranga pustulata*, *Rhus succadanea*, etc. are suggested for plantation. G2 layer will be slightly different than the G1 layer. The plants suggested for plantation in the region are *Carpinus viminea*, *Lyonia ovalifolia*, *Pinus wallichiana*, *Quercus griffithii*, etc. The budget allocated for different components of green belt like preparation of pits, manure, raising saplings, etc. is around **Rs. 15.73 lakhs**. The budget also includes maintenance of the executed work

11 MAINTENANCE OF AIR & WATER QUALITY AND NOISE LEVEL

During the construction phase of the Project, activities like site preparation, approach roads, excavation, drilling, blasting, foundation, tunneling, deployment of machinery, erection, transportation, dumping will be taken up. All these activities would affect the environment by increased noise levels and deteriorated water and air qualities. Suspended Particulate Matter (SPM) is the main air pollutant during construction. Large quantities of dust become wind borne and are carried away from

overburden dumps. The major pollutants, which get emitted from diesel vehicles, are hydrocarbons and SO₂. Noise would be generated at the time of construction of powerhouse, tunnel boring, machine operations, running of pumps, drilling machines, blasting, plying of dumpers etc. Continuous exposure of workers to high level of noise may result in annoyance, fatigue, and may cause temporary shift of threshold limit of hearing and even permanent loss of hearing. During the construction of tunnels, shaft and power house installations, surface water (river/ stream water) may get polluted due to the generation of large quantities of suspended particulate matter. In order to minimize the level of pollution in and around the construction sites a suitable strategy for the mitigation of pollutants is warranted. A part of mitigation measure is included in the **Waste Management Plan**. Most of the measures are precautionary while a few like wind barriers, masks, removal of weeds from reservoir and channelization of surface runoff would require budget. Total financial outlay for the maintenance of water, air quality and noise level would be **Rs. 50.00 lakhs** only.

12 REHABILITATION & RESETTLEMENT PLAN

The aim of any rehabilitation and resettlement (R & R) plan is to mitigate all unavoidable negative impacts caused due to the project and to resettle the affected persons and restore their livelihoods. The R & R Plan of Tawang HE Project Stage I has been prepared based on socio-economic survey of the affected population and in consultation with various stakeholders. The State Rehabilitation and Resettlement Policy 2008 of Arunachal Pradesh has been adopted for framing the R&R plan.

A total 305.60 ha of land would be required for various components of the proposed project. The maximum share of the land to be acquired is community forest land belonging to 25 villages. The villages come from five administrative circles. The private land to be acquired is 113.80 ha belonging to 292 households/khatedars of 18 villages. No family is getting displaced due to construction of the project.

12.1 Grants

12.1.1 Rights and privileges

The process of land acquisition will be dealt by NHPC with affected families and Government of Arunachal Pradesh. Land for various components involves community forest land,

Unclassed State Forest (USF) and private land. Project affected families (PAFs) shall be compensated as per the norms of State Government. The compensation amount for community forest land which belongs to 25 villages shall be provided @ **Rs. 1.56 lakhs per ha**. Also, the community shall be compensated @ **Rs.1.56 lakhs/ ha** for loss of customary rights and privileges of tribal people to collect and use forest produce (traditional land use) from USF. In addition to this, the community will be paid a sum equivalent to **25 %** of Net Present Value (Rs 1534.4 lakhs @ Rs 8 lakhs/ha for 191.8 ha) of the USF and community forest land. The provision of financial outlay of **Rs. 682.81 lakhs** for the rights and privileges has been made under B-land in DPR.

12.1.2 R & R Benefits

In addition to the rightful compensation, the requiring body shall provide the following financial benefits to the affected families whose private land will be acquired. The details of the R & R plan with budget are given in **Table 6**.

Table 6 R & R Plan with budget

S. No.	Benefits	Criteria	Amount (Rs. in lakhs)
1	Ex-gratia payment	Rs 50,000/PAF	146.00
2	Land development charges	Rs 25,000/PAF	73.00
3	Livelihood grant	750 days MAW* @ Rs 150/day	328.50
4	Assistance for agricultural production	Rs 20,000/PAF	58.40
5	Scheduled Tribe Family Grant	Rs 50,000/PAF	146.00
6	Provision of annuity policies for pension for life to vulnerable affected persons @ Rs. 500/ month	Lump sum	150.00
7	Free electricity @ 100 units per PAF per month	Lump sum	210.00
8	Subsistence Grant for Assetless	Lump sum	120.00
9	Stamp duty and registration charges for allotted land in lieu of acquired land	Lump sum	40.00
Total			1271.90

* Value of MAW will be as applicable in the State at the time of disbursement.

In addition, an amount of **Rs. 2367.00 lakhs** has been earmarked for community & social development which includes, training programme, merit scholarship scheme, income generation scheme, education facilities, bus stops / rain shelters, construction of footpaths, women technology park, electric substation, assistance to fisherman, communication facilities, community welfare centres, transportation facilities, creation of model village, crafts and skill up-gradation, market complex and miscellaneous activities. Total financial package for R & R plan would be **Rs. 3873.35 lakhs**. It includes R & R benefits amounting to Rs. 1271.90 lakhs, cost of community & social development amounting to Rs. 2367.00 lakhs, budget for monitoring and evaluation amounting to Rs. 50.00 lakhs and 5% contingency. Break up of the various R& R measures with their cost is given in **Table 7**.

Table 7 Break-up of various R& R measures

S. No.	Particulars	Amount (Rs. In lakhs)
I.	R & R Plan	
	(i) R & R Benefits	1271.90
	(ii) Community & Social Development	2367.00
	(iii) Monitoring and Evaluation	50.00
	Sub-Total	3688.90
	Contingency @ 5% of the above cost	184.45
	Total	3873.35
II.	Rights and Privileges (including 25% of NPV)	682.81

13 DAM (BARRAGE) BREAK MODELLING AND DISASTER MANAGEMENT PLAN

13.1 Dam (Barrage) Break Modelling

The Tawang Chhu river for a length of 15.1 km downstream of Tawang HE Project Stage-I barrage site has been represented in the model by cross sections taken at varying intervals depending upon topography. The Tawang Chhu river cross section at barrage axis has been connected to a storage area representing the reservoir. As the dam (barrage) breach flood levels far exceed the normal flood level marks and the flood spreads beyond the normal river course, the Manning's roughness coefficient for the dam (barrage) break studies should be assumed normally more than the other hydro-dynamic studies. The Manning's roughness coefficient for entire study reach of the river

has been taken as 0.040 considering the boulder river beds with grassy banks of hilly terrain. In the present study **HEC-RAS Model** has being used.

13.2 Disaster Management Plan

Dam (barrage) failure, though unlikely to happen, poses serious threat to human lives, property and infrastructures located downstream from the dam (barrage). In order to save a large numbers of injuries and huge damage to property, an integrated disaster management approach is essential. This approach includes disaster prevention, mitigation, and preparedness. However, failure of dam (barrage) is a low risk but high impact hazard as they do not occur often but can be extremely catastrophic. An inundation map depicting the downstream areas likely to be inundated by the dam (barrage) break flood is prepared. In the event of the barrage break, none of the village / settlement will be affected because they fall out of the inundation zone. However, infrastructure assets like short length of road and existing bridge are located on the margins of the likely flooded area. In such a scenario loss of property could be anticipated in the downstream due to barrage break. From the result it is evident that up to about 15 km D/S of the Tawang H.E. Stage I barrage, time required in reaching the flood wave elevation to the maximum is of the order of few minutes. It hardly leaves any possibility of any rescue or evacuation. Since the time available is very short, therefore Disaster Management Plan should concentrate on preventive actions. Preventive measures are Surveillance, Infrastructural Development, Emergency Action and Preparedness Plan. Communication System will be established and it is absolutely essential for the success of an emergency plan especially when time is of great essence. Beside Evacuation Plan and Evacuation Team, Medical Team is also needed. At last Mitigation and Rehabilitation plan is needed. The estimated total cost of execution of disaster management plan including the communication equipments would be **Rs. 740.00 lakhs**

14 ENVIRONMENTAL MONITORING PROGRAMME & STUDIES

Most adverse impacts are foreseen for the river water quality, fish, air quality, noise quality and vegetation of the construction sites. These issues are well addressed in the EMP report, however, they would require monitoring and surveillance at regular interval. Project developers are suggested to monitor these parameters through various agencies. These agencies shall conduct the survey and sampling of these parameters at regular interval for 7 years (for the period of construction). There is provision of funds to implement various plans by concerned agencies like State Pollution Control Board, State Forest

Department, State Fisheries Directorate, Department of Science & Technology, Disaster Management Cell etc. The concerned agencies would submit their report to Environment Cell of NHPC and would suggest mitigation measures. The progress will be monitored by Central Level Environmental Monitoring Committee (CLEMC) with the help of renowned ecologists, scientists, NGO etc. The funds for the monitoring will be borne by the project authorities. Total budget allocated for the Environment Monitoring Programmes and studies would be **Rs. 250.00 lakhs**.

15 SUMMARY OF COST ESTIMATE

Environmental Management Plan contains 14 different plans. There is also provision of rights and privileges against the loss of customary rights of collection of forest produce and traditional land use of community forest land and USF. Total amount to be spent for implementation of Environmental Management Plan is **Rs. 13005.24 lakhs**. The summary of the cost estimate is given in **Table 8**.

Table 8 Summary of cost estimates for various plans suggested in EMP report of Tawang H.E. Project Stage-I

S. No.	Particulars	Amount (Rs. in lakhs)
1.	Biodiversity Management and Conservation Plan	540.00
2.	Catchment Area Treatment Plan	435.50
3.	Fisheries Development Plan	100.00
4.	Health Management	326.00
5.	Waste Management	362.00
6.	Provision of Fuel	134.00
7.	Muck Disposal & Rejuvenation of Muck Disposal Sites	4963.25
8.	Restoration of Quarry Sites	389.60
9.	Restoration of Construction Areas and Landscaping	143.00
10.	Creation of Green Belt around the Reservoir	15.73
11.	Maintenance of Air & Water Quality and Noise Level	50.00
12.	Rehabilitation & Resettlement Plan	3873.35
12a.	Rights and Privileges (including 25% of NPV)*	682.81
13.	Disaster Management Plan	740.00
14.	Environment Monitoring Program & Studies	250.00
	Total	13005.24

* Part of B-Land of Detailed Project Report (DPR)