EXECUTIVE SUMMARY

1. INTRODUCTION

Sikkim constitutes part of Eastern Himalaya and is situated between $27^0$00'46" to $28^0$07'48" N latitude and $88^0$00'58" to $88^0$55'25"E longitude, with an area of 7096 sq km and measuring approximately 112 km from the north to south and 90 km from east to west; the elevation ranges from 300 m to over 8540 m above sea level (Mt. Khangchendzonga). Sikkim is drained by large number of perennial rivers, which merge into two prominent rivers, the Teesta and the Rangit. River Rangit is a tributary of Teesta and joins it at Melli, the boundary between Sikkim and West Bengal.

2. RAHI KYOUNG H.E. PROJECT

The proposed Rahi Kyoung HEP, a run-of-the-river project with installed capacity of 25 MW is one of the projects on Rahi Chhu a small natural drainage channel contributing flow to the Tolung Chhu tributary within the larger Teesta River basin on the Teesta River's right bank developed by M/s. Sikkim Engineering Pvt. Ltd., in North Sikkim district in the state of Sikkim. Total catchment area of the project upstream of the weir site is 53.50 km^2. The length of the Rahi Chhu river up to the proposed diversion structure is estimated around 14 km with very steep gradient. Rahi Kyoung Hydro Electric Project would involve construction of a 2.5 m wide and 21 m long trench weir across the Rahi Chhu River near Salim-Pakhil Village. A feeder channel of length 31 m will carry the water from the intake to the surface desilting basin. The Head Race Tunnel (HRT) would be D-shaped of finished size 2.6 m (W) × 3.05 m (H) and would be about 2.462 Km long. The Installed Capacity of the Project would be 25 MW comprising three generating units, each of 8.33 MW capacity. The diversion structure of trench weir type would be located close to Salim-Pakhil Village. The location of the project is shown in **Figure 1.**

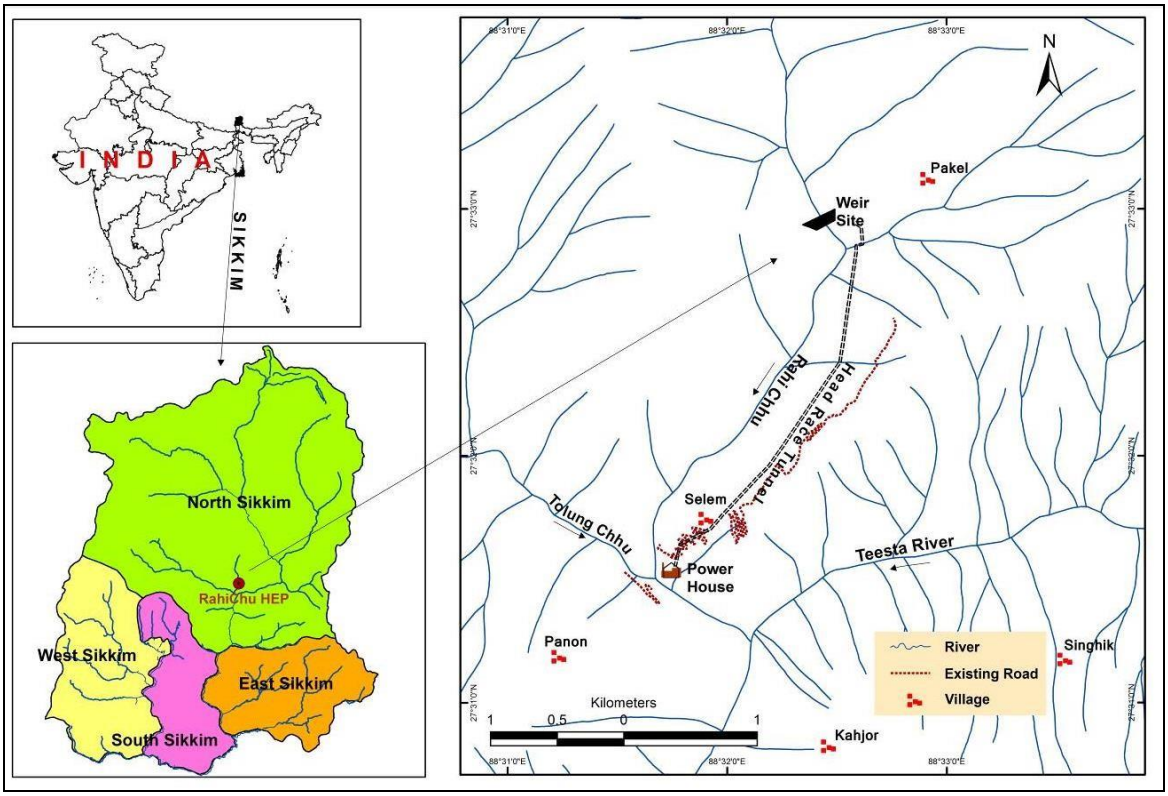


Figure1.1: Location Map of Rahi Kyoung H.E. Project

The salient features of the project are given in **Table 1**. The layout map of the project is given at **Figure 2**.

Table 1: Salient features of Rahi Kyoung H.E. project

Location	
State	Sikkim
District	North Sikkim
Village	Near Saffu
Access	
Major Airport	Bagdogra
Rail Head	New Jalpaiguri and Siliguri
Road Head	42 km from Mangan via Tung Bridge on the Teesta River and Saffu village that would include a road of about 7 km length from Saffu village on the Saffu-Sangkalan road being construction by the Border Roads Organisation (BRO).
Geographical co-ordinates of the diversion site	
Latitude (N)	27^0 32’ 52.348”
Longitude (E)	88^0 32’ 30.377”
Map reference	Survey of India topo-sheets: 78-A-10-2, 78-A-103
Meteorology	
Average Rainfall	About 2830 mm
Atmospheric Temperature	
Maximum Temp.	Up to about 23^0 C

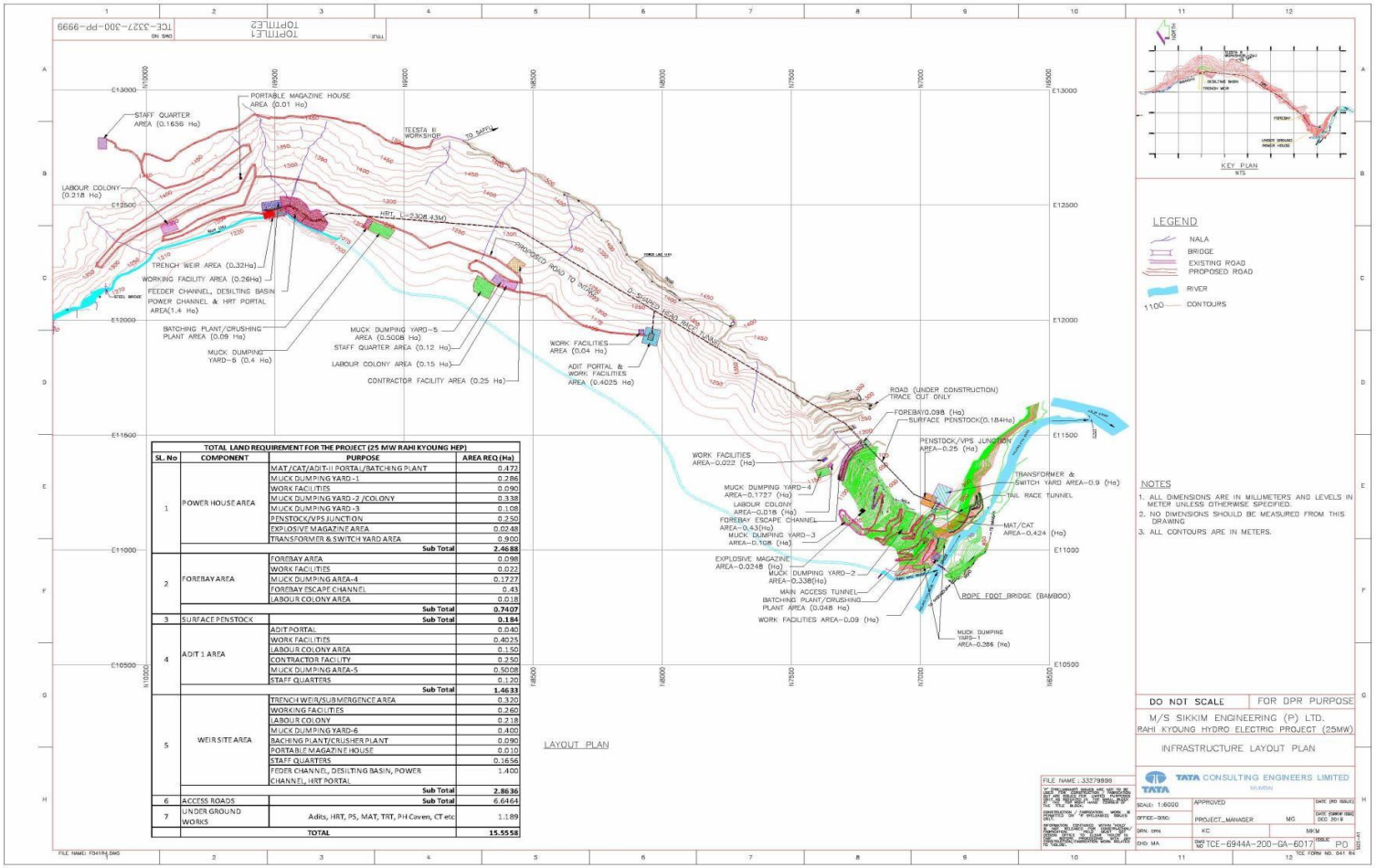
Minimum Temp.	Up to about 4.3^0 C
Hydrology	
Catchment Area	53.50 km^2
Design Flood	317 m^3s^{-1}
Power potential	
Gross head (m)	375 m
Rated head (m)	363.80
Design discharge (m^3s^{-1})	7.94
Installed capacity (MW)	25
75% Dependable Energy (MU) with 95% machine availability	108.01
Plant load factor	49.3%
Net Saleable energy (MU)	93.76
Diversion Structure (Head works)	
Type of structure	Trench weir
Length of weir (m)	21.00
Width of trench weir(m)	3.5
Average bed level at weir(m)	1154
Full Supply Level (m)	1153
Maximum Water Level (m)	1155.24
Feeder channel	
Length of feeder channel (m)	31
Shape	Rectangular
Bed slope / Side Slope	1 in 900
Bed Width (m)	3.0 m
Full Supply Depth (m)	1.84 m
De silting Basin	
Type	Surface with central flushing conduit
Maximum Incoming discharges (m^3s^{-1})	11.51
Length without transition (m)	49.0
Width (m)	10.0
Height above hoppers up to FSL (m)	6.0
Pipe for silt flushing at lower level	0.6 m dia. , 30 m long

Head Race Tunnel	
Shape	D-Shaped
Length (m)	2462
Slope	1:500
Size (m)	2.6 (W) X 3.05 (H)
Adit-I	D-Shaped, 3.0 (W) X 3.35 (H), 73m long
Fore bay (Partly underground and partly surface)	
Shape	D-shaped (Underground) and Rectangular (surface)
Length (m)	83
Width (m)	5.0

Depth (m) for 2 min. storage	2.5
FSL at Forebay (m)	1147.956
Minimum Drawdown Level (MDDL),m	1145.456
Overflow Channel	
Location	Provided on right side of forebay
Size (m) and Shape	3 (Bed width), Trapezoidal
Discharging capacity (m3s-1)	7.94
Length of channel (m)	550 m (Approx.)
Penstock and Pressure Shaft	
Number	
Main penstock	1
Unit penstock	3
Diameter of main penstock (m) / unit penstock (m)	1.59/ 0.92
Thickness of steel liner (mm)	8 to 32
Grade of Steel	A537, Class-I
Length of main penstock(m)	353.848
Length of main pressure shaft (m)	71.0 (horizontal), 180.51 (vertical)
Underground Power House	
Size of machine hall cavern (m)	50.0 (L) X 14.0 (W) X 24.0 (H)
Installed capacity (MW)	3 X 8.33
Main Access Tunnel (MAT)	D-shaped,6.0m (W) X5.5 m(H) and 135 m long
Construction adit to top of powerhouse cavern/ventilation duct	D-shaped, 2.3m(W) X 3.15m(H) and 125 m long
Maximum Tail water level (m)	778.0
Electro-mechanical	
Turbine	
No. and Type	3 Nos., Horizontal Pelton with Three Jets
Efficiency	92%
Maximum available gross head(m)	375
Rated head(m)	363.80
Design discharge(m3s-1)	7.94
Speed	600 rpm
Inlet Valve	Spherical Valve
Generator	

Type	Synchronous type
Rated Out put	3 x 8.33 MW
Efficiency	98%
Power factor	0.90
Speed	600 rpm
Voltage	11 kV ± 10%
Tailrace Tunnel	
Shape	D-Shaped
Length (m)	124
Slope	1: 1500

Size (m)	2.6 (W) X 3.05 (H)
Costs	
Price level	Sep 2016
Interest During Construction and Front End Fees (INR)	12.64 Cr.
Completed project cost (INR)	215.00 Cr.



TOTAL LAND REQUIREMENT FOR THE PROJECT (25 MW RAHI KYOUNG HEP)

SL. No	COMPONENT	PURPOSE	AREA REQ (Ha)
1	POWER HOUSE AREA	MAT/CAT/ADIT-II PORTAL/BATCHING PLANT	0.472
		MUCK DUMPING YARD -1	0.286
		WORK FACILITIES	0.090
		MUCK DUMPING YARD -2 /COLONY	0.338
		MUCK DUMPING YARD -3	0.108
		PENSTOCK/VPS JUNCTION	0.250
		EXPLOSIVE MAGAZINE AREA	0.0248
		TRANSFORMER & SWITCH YARD AREA	0.900
		Sub Total	**2.4688**
2	FOREBAY AREA	FOREBAY AREA	0.098
		WORK FACILITIES	0.022
		MUCK DUMPING AREA-4	0.1727
		FOREBAY ESCAPE CHANNEL	0.43
		LABOUR COLONY AREA	0.018
		Sub Total	**0.7407**
3	SURFACE PENSTOCK	**Sub Total**	**0.184**
4	ADIT 1 AREA	ADIT PORTAL	0.040
		WORK FACILITIES	0.4025
		LABOUR COLONY AREA	0.150
		CONTRACTOR FACILITY	0.250
		MUCK DUMPING AREA-5	0.5008
		STAFF QUARTERS	0.120
		Sub Total	**1.4633**
5	WEIR SITE AREA	TRENCH WEIR/SUBMERGENCE AREA	0.320
		WORKING FACILITIES	0.260
		LABOUR COLONY	0.218
		MUCK DUMPING YARD-6	0.400
		BACHING PLANT/CRUSHER PLANT	0.090
		PORTABLE MAGAZINE HOUSE	0.010
		STAFF QUARTERS	0.1656
		FEDER CHANNEL, DESILTING BASIN, POWER CHANNEL, HRT PORTAL	1.400
		Sub Total	**2.8636**
6	ACCESS ROADS	**Sub Total**	**6.6464**
7	UNDER GROUND WORKS	Adits, HRT, PS, MAT, TRT, PH Caven, CT etc	1.189
		TOTAL	**15.5558**

Figure 2: Layout map of Rahi Kyoung H.E. Project

3. ENVIRONMENTAL BASELINE STATUS

Rahi Chhu (25 MW) is in proximity to Khanchendzonga National Park and as such needs appraisal at central level for grant of scoping clearance in terms of EIA Notification, 2006 and subsequent amendments. Therefore, Rahi Chhu HEP require environmental appraisal from the Ministry of Environment Forests and Climate Change (MoEF&CC), Government of India.

Scoping clearance of Rahi Chhu HEP of 25 MW project was accorded by Ministry of Environment Forests and Climate Change (MoEF&CC), Government of India vide letter no. J-12011/11/2015-IA-I dated July 14, 2015

Data on the existing environmental parameters in the study area delineated as per the approved Terms of Reference (TOR) for EIA studies by Ministry of Environment, Forests & Climate Chang (MoEF&CC), Government of India was collected to understand the present setting of the environment at the project site. The base line status is described briefly in the following sections:

3.1 Drainage

2 The Rahi Chhu, is a tributary of Tolung Chhu, which in turn is a major tributary of the Teesta River. The Rahi Chhu has its origin in the glaciers of Sikkim at an elevation of over 3660 m above mean sea level. The Rahi Chhu in general flows in a south-west direction meeting the Tolung Chhu almost perpendicularly. The terrain hosts a rich growth of vegetation. Numerous valleys with cultivated terraces are seen in the catchment area. The catchment area of the proposed Rahi Chhu HEP is 50.15 km^2 and the total length of the Rahi Chhu in the catchment area is around 12 km with a very steep gradient. The elevation of the catchment varies from El. 1164.0m to El. 5000.0m.

3.1 Physiography

Physio- graphically the catchment falls in Sub-Himalayan region where relative relief is in the range of 700 m to nearly 5000 m i.e. rugged to mountainous topography and terrain consists of hill ranges sloping down to the plain of West Bengal. Majority of study area falls within elevation range of 800 to 5000m.

The slope in the study area falls under various slope categories. Nearly 78% of the study area is under moderately steep to steep slopes. The area under steep category i.e. with slopes higher than 30-45% is more than 40 % of the total area.

3.2 Soil

The majority of project study area i.e. about 12.26 % falls under Sub-group **Typic Haplumbrepts** which are characterized by very deep, well drained, fine-loamy soils on moderately steeply sloping having loamy surface with moderate erosion hazard and it is associated with **Typic Udorthents** with moderately deep, excessively drained, coarse-loamy over fragmental soils with loamy surface, moderate erosion and slight stoniness.

The soil of the area is typically sandy loam type. Soil of study area is acidic in nature at most of the sites with pH values ranging from 5.9 to 6.2. The bulk density of soil varied from 1.09 to 1.30 (gm/cc). Organic matter content is due to presence of decomposed leaf litter. Electrical conductivity ranged between 802.5 µS/cm and 939.0 µS/cm. The concentration main nutrients like Nitrogen and phosphorus in the soil is indicative of medium soil fertility rating whereas the concentration of potassium is on the lower side. It is also a measure of the solidity of soil, as determined from analysis of water extracted from the soil. The ESP and SAR values indicate that soils are stable.

3.3 Ambient Air Quality

The sources of air pollution in the study area are vehicular traffic, dust arising from unpaved village roads and domestic fuel burning. The air environment around project site is free from any significant pollution source. Air quality monitoring was carried out as per the new air quality parameters conforming to the National Ambient Air Quality Standards for Industrial Residential, Rural & Other Areas.

The summary of ambient SO_2 concentration observed ranged from 2.1 to 7.1 □g/m^3 and the NO_x values ranged from 5.9 to 12.8 □g/m^3 at various stations covered as a part of the study. The So_2 and NO_x level observed at various sampling stations was much lower than the permissible limit of industrial, residential and rural areas.

The PM_{10} values ranged from 6.2 to 18.2 □g/m^3. The PM_{10} level at various stations covered during ambient air monitoring was below the permissible limit (60 µg/m^3) specified for industrial, residential, rural and other areas.

The $PM_{2.5}$ values ranged from 3.1 to 12.0 □g/m^3. The $PM_{2.5}$ level at various stations covered during ambient air quality monitoring was well below the permissible limits (40 µg/m^3) specified for industrial, residential, rural and other areas.

3.4 Noise & Traffic

Unwanted sound that is loud and unpleasant or unexpected is termed as noise pollution. It has adverse impact on the daily activities of the human being and animals. The adverse impact of the noise on human and animals also depends upon time, season and the quality of sound. Noise levels were monitored during the studies at various locations in the Direct Impact Area of the project. The sound levels on an average ranged from 44 to 56 dB(A). Main source of noise pollution in the study area are observed from the flow of river and vehicular movement.

Traffic density monitoring data was recorded by physically counting the number of different types of vehicles passing through a particular point in a fixed time interval. Traffic density was recorded maximum at Singhik village.

3.5 Land use/ Land cover

The land use/ land cover pattern of the study was interpreted from latest satellite data and the classified land use/ land cover categories interpreted. Majority of the study area is under forest cover (85.46%) followed by area under scrub vegetation followed by agriculture and settlements. A detail of the area under different land use in the study area is given in table below.

Landuse/ Landcover	Area (sqkm)	(%)
Dense Forest	84.41	22.55
Moderately Dense Forest	163.00	43.55
Open Forest	81.55	21.79
Scrub Land	17.92	4.79
Barren Land	5.81	1.55
Settlement	1.23	0.33
Snow Cover	20.12	5.38
Waterbody	0.27	0.07
	374.32	**100.00**

3.6 Forest Types

The forests present in the Rahi Kyoung project study area and catchment area, have been grouped into different forest types following the classification of Champion & Seth (1968). The major forest types found in this catchment are given below.

- 3*C/C3 b* East Himalayan moist mixed deciduous forest
- 8B/C1 East Himalayan sub-tropical wet hill forest
- 11 B/C1 East Himalayan wet temperate forests
- 11B/C1a Lauraceous forest
- 11B/C1b Buk oak forests
- 11B/C1c High level Oak forests
- 12/C3 East Himalayan Mixed coniferous forests
- 14/C2 East Himalayan Sub-alpine birch/fir forest
- 15/C1 Birch / Rhododendron moist alpine scrub forest
- 15/C2 Deciduous alpine scrub
- 15/C3 Alpine pastures

3.7 Floristics

3.8.1 Taxonomic Diversity

During the field surveys and also based upon available information, an inventory of 324 plant species in the study area was prepared. The number of plant species recorded in various taxonomic groups is discussed below:

- **Angiosperms**

In all 204 species of angiosperms belonging to 78 families were recorded. These include trees, shrubs, herbs and climbers. The dominant families in the study area are Poaceae, Utricaceae and Asteraceae.

- **Pteridophytes**

The project area is rich in number of Pteridophyte species. This group is represented by 10 species belonging to 6 families. Pteridaceae is the largest family represented by 4 species, followed by Polypodiaceawith 2 species.

- **Bryophytes**

In the study area nine species of bryophytes were recorded and belonging to 4 families. *Marchantia* sp. and *Polytrichum sp.* were commonly found.

- **Lichens**

5 lichen species were found in the study area belonging to 4 families. *Usnea* sp*.* and *Parmelia wallichiana* were the most frequently occurring species found hanging from the trees.

3.8.2 Density, Diversity and Dominance

The density of trees varied from site to site depending upon elevation, land use pattern and the extent of area subjected to road construction in the area. The overall tree density throughout the study area ranged from minimum of 420 number of trees/ha to maximum of 470 trees/ha. Highest tree density was recorded at sampling site V1 and V5; located in the upstream of proposed weir site and near confluence of Rahi Chhu with Tolung Chhu respectively. Density of shrub layer varied from 3083 plants/ha to 6000 plants/ha, lowest density was found at sites located in downstream of proposed weir site and highest at sampling site located in the right bank of Rahi Chhu in the upstream of Rahi Chhu confluence with Tolung Chhu. The density of herbaceous plant species varied from season to season amongst all sampling sites. In monsoon season herb density is highest at at all sampling site.

Amongst the trees the diversity Index ranged from low of 1.74 to highest of 2.75 at sampling site V6 located in downstream of proposed project area. For shrubs the highest diversity was recorded at sampling site V6 in downstream of proposed project area (left bank of Tolung Chhu) i.e. 2.63 and lowest i.e. 2.15 at sampling site V3 located in the downstream of proposed weir site (Right bank of Rahi Chhu). The species diversity in herbs was always

higher during monsoon period and varied from 2.60 (site V5) to 2.74 (site V1 & V3) at different sampling location. During winter diversity index varied from low of 1.91 at Site-V1 to 2.39 at Site-V3. During pre monsoon highest diversity value 2.55 was recorded from site V3 & V6 and lowest 2.33 was recorded from site located near confluence of Rahi Chhu and Tolung Chhu.

3.8.3 Economically Important Plants

The local people utilise various plants species in their day to day life. Mainly plants are used as timber, fuel wood, fodder, vegetable, medicinal, thatching and wild edible. Knowledgeable and elder persons of study area villages were interviewed and information on plants parts (seed, bark, leaf & root) used and indigenous knowledge was gathered. Secondary information was also collected to know the ethnobotanical importance of the region. Commonly used plants species for medicinal purposes in the area are given below:

Sl. No.	Family	Botanical Name	Vern./ Local Name	Plant part used
1	Amaranthaceae	*Achyranthes aspera*	Chir-chita	Whole plant
2	Polygonaceae	*Aconogonum molle*	Thotne	Young Shoots
3	Acoraceae	*Acorus calamus*	Bojho	Rhizome
4	Asteraceae	*Ageratum conyzoides*	Osari	Leaves
5	Betulaceae	*Alnus nepalensis*	Utis	Bark
6	Caesalpiniaceae	*Bauhinia purpurea*	Tanki	Flower bud
7	Bischofiaceae	*Bischofia javanica*	Kainjal	Leaves & bark
8	Loganiaceae	*Buddleja asiatica*	Bhinsenpatee	Leaves, flower & stem
9	Apiaceae	*Centella asiatica*	Gora taprey	Leaf
10	Lauraceae	*Cinnamomum tamala*	Tejpata	Leaves
11	Menispermaceae	*Cissampelos pareira*	Akanadu	Leaf
12	Ranunculaceae	*Clematis buchnaniana*	Pinaasey lahara	Root
13	Zingiberaceae	*Costus speciosus*	Keu	Stem
14	Solanaceae	*Datura stramonium*	Datura	Seed
15	Hydrangeaceae	*Dichroa febrifuga*	Basak	Root, leaves
16	Dioscoreaceae	*Dioscerea bulbifora*	Gittha	Tuber
17	Thymelaeaceae	*Edgeworthia gardeneri*	Argaily	Shrub
18	Juglandaceae	*Engelhardtia spicata*	Silapoma	Bark
19	Moraceae	*Ficus religiosa*	Peepal	Whole plant
20	Burseraceae	*Garuga pinnata*	Dubdabey	Bark, root
21	Flacourticeae	*Gynocardia odorata*	Gantey	Seed
22	Saururaceae	*Houttuynia cordata*	Nombaring	Leaves
23	Juglandaceae	*Juglans regia*	Okhar	Bark
24	Ericaceae	*Lyonia ovalifolia*	Anyar	Leaf
25	Begnoniaceae	*Oroxylum indicum*	Paksam	Seed
26	Bignoniaceae	*Oroxylum indicum*	Totola	Bark, root
27	Euphorbiaceae	*Ostodes paniculata*	Byapari	Leaves

28	Rubiaceae	*Rubia cordifolia*	Majito	Root, fruits
29	Rosaceae	*Rubus ellipticus*	Aeiselu	Root, fruits
30	Theaceae	*Schima wallichii*	Chilaune	Stem
31	*Poaceae*	*Thysanolaena latifolia*	Amliso	Roots
32	Lythraceae	*Woodfordia fruticosa*	Dhayeroo	Flower, bark
33	Zingiberaceae	*Zingiber officinale*	Adrak	Rhizome

3.8.4 RET Species

The conservation status of all 243 species of angiosperms and lower plants recorded from the study area was assessed. Their conservation status following IUCN Red list of Threatened Species. Version 2014.3 was studied. Out of these, *Saurauia punduana* is categorized under Critically Endangered (CE) category and 19 species reported from the area are under Least Concern (LC) category.

3.8 Faunal Elements

3.9.1 Mammals

During the surveys mammalian species sighted in the study area are Assamese macaque (*Macaca assamensis*) and Himalayan striped squirrel (*Tamiops mcclellandii*). Besides these no other wild animal was sighted during field investigation. The probable occurence of other mammal species was documented through the skins of Indian muntjak, Assamese macaque, teeth of leopard. Species like Snow leopard and Red Panda categories under Schedule I of Wildlife Protection Act 1972, also reported from the Khangchendzonga National Park adjacent to the project area. However, according to the list prepared based upon secondary data 26 species of mammals are reported from the area.

3.9.2 Avi-fauna

A total of 39 species of bird species belonging to 21 families was compiled based upon sighting during field survey as well as secondary data. During the field survey, 21 species were sighted in their natural habitats like small bushy vegetation, bare stone grounds, river banks and nearby the human habitation. The area supports suitable habitation for birds which mainly feeds on berries and insects. The birds like Great Barbet, Fulvous and Breasted Woodpecker recorded in the forest area because they feed mainly on wild fruits, berries and insects. Some birds like White capped water red start and Plumbeous Water Redstart feed generally on insects like mayflies, stoneflies etc. and hence were recorded mostly near the river and other water sources.

3.9.3 Herpetofauna

The herpetofauna were sampled on the same transects marked for mammals. The sampling also carried along river banks and the sampling was repeated during night following the time constrained Visual Encounter Rates (VES) method. Spiny tailed House Gecko, Indian Rock

Python and Speckled little Sun skink were sighted during field survey. In all 10 species of reptiles and lizards are reported from the study area and these belong to 8 families.

3.9.4 Insects and Butterflies

The insects including butterflies are common in the area are sighted throughout the study period. The presence of the insects was abundant in post monsoon and pre monsoon season however their availability was less in winter months.

Total 22 insect species are reported from the study area. The Cabbage white, Jester, common leopard and Common Tiger were some common species and frequently sighted in catchment area.

3.9.5 Threatened & Endangered Fauna

Six species viz; Snow Leopard (*Panthera uncia),* Red Panda (*Ailurus fulgens),* Leopard (*Panthera pardus),* Leopard Cat (*Prionailurus bengalensis*), Indian Fish Cat (*Felis viverrina*) and Himalayan black bear (*Ursus thibetanus*) are listed in Schdeule-I of Indian Wildlife Protection Act 1972 (IWPA 1972). Whereas, Jackal *(Canis aureus),* Jungle cat (*Felis chaus*), Himalayan palm civet (*Paguma larvata*), Assamese macaque (*Macaca assamensis*) and Rhesus macaque (*Macaca mulatta*) are the species listed under Schedule II and 4 species are under Schedule II and one species is under schedule I of IWPA 1972.

Only Six of the mammals in the study area fall under the category RET fauna. Snow Leopard (*Panthera uncia)* and Red Panda (*Ailurus fulgens)* are under Endangered category, Himalayan black bear (*Ursus thibetanus*) and Common Leopard (*Panthera pardus*) is falls under Vulnerable category and Goral (*Naemorhedus goralcomes*) and Assamese macaque (*Macaca assamensis*) are under Near Threatened category as per IUCN Red list of Threatened Species.

Amongst birds sighted during field study, *Milvus migrans* (Black Kite) is the species listed under Schedule I as per the Wildlife (Protection) Act 1972**.** Most of the species reported from the study area are under Schedule IV of as per the Wildlife (Protection) Act 1972. While, *Psittacula alexandri* (Red breasted Parakeet) is the species under Near Threatened category of IUCN, rest of the the birds recorded from the study area belong to Least Concern category as per IUCN Redlist Ver 3.1.

3.9 Water Quality and Aquatic Ecology

3.10.1 Physico-chemical Water Quality

To study various physico-chemical and biological characteristics of Rahi Chhu and its tributaries, the sampling was carried out at 6 sites in the study area.

The temperature of the river water and its major tributaries fluctuated from 19.1°C to 20.2°C in monsoon season, 9.2C to 12.3C in pre winter season and 17.4°C to 18.2°C in pre monsoon season. The turbidity level was nil in winter and Pre monsoon whereas in monsoon it increased and was in the range of 2.1 to 3.7 NTU.

Hardness values were recorded quite low in the water samples which is indicating that water of Rahi Chhu, Tolung Chhu and Teesta River is soft in nature as the values varied from 26.6-44.9 mg/l in all the respective seasons.

The river water was relatively alkaline and the pH range recorded at all the sites was more than 7.5 during all the three seasons and ranged from 7.51 to 8.25. In all the sampling sites maximum dissolved oxygen was observed from the sampling sites located in Rahi Chhu as 8.20 mg/l during monsoon season and 9.88 mg/l during winter season. Phosphate and nitrate concentrations were quite low in the river. Heavy metals were absent at all the sampling sites as there is no industry located in the study area.

3.10.2 Biological Parameters

Periphyton

In all total, 39 species of periphyton were identified in the samples collected from proposed hydroelectric project study area. The periphyton community comprised of 28 species of Bacillariophyceae and 11 species of Fragilariophyceae. Maximum number of species (39) was recorded during winter, followed by 30 species in Pre monsoon and 24 species in monsoon. Out of 39 species 16 species were found in all the three seasons. *Gomphonema* is most dominant benthic microflora in Rahi Chhu river and is represented by 8 species. *Achnathes* was represented by 7 species. *Cymbella, Navicula* and *Synedra* are the other dominant benthic genra represented by 5 species of each.

Phytoplankton

In all total 41 species of phytoplankton were identified in the samples collected from proposed hydroelectric project study area. Maximum number of species (38) was recorded during winter, followed by 29 in Pre monsoon and 27 in monsoon season. *Gomphonema* is most dominant genus in Rahi Chhu river and is represented by 8 species followed by genus *Achnanthes* with 7 species and *Cymbella and Synedra* each was represented by 4 species in the study area.

Zooplankton

Zooplanktons are represented by protozoan, rotifer and cladoceran and formed very small part of planktonic community. Total 8 species of zooplankton could be identified from Rahi Chhu and its tributaries. The density of zooplanktons ranged from 110 cells/lit to 186 cells/lit in winter season, 64 cells/lit (W2) to 96 cells/lit in pre-monsoon season and 21 – 65 cells/lit during monsoon.

Macro-invertebrates

The macro-invertebrate community contributes immensely to the functioning of the stream or river ecosystem. Macro-invertebrate fauna of the study area comprised with 6 families of 3 orders. Ephemeroptera order is represented by families Heptageniidae, Baetidae and Ephemerellidae. Order Trichoptera was represented by Hydropsychidae family. Diptera was represented by Chironomidae and Simuliidae families in the study area *Cinygmula*, *Baetis, Hydropsyche* and *Simulium pictipes* genera were most abundant in study area.

The higher densities of macro-invertebrates were observed during the winter season (34 ind./m^2 to 54 ind./m^2) followed by the pre-monsoon season (28 ind./ m^2 to 40 ind./ m^2). The density of macro-invertebrate were observed to be less during monsoon season (19 ind./m^2 to 32 ind./m^2) as compared to summer and winter which may be due to turbulent flow and deposition of silt on substratum habitat of these fauna.

3.10 Fisheries

During the study, experimental fishing was conducted by using of cast net and Gill net at different stretches from Rahi Chhu, Tolung Chhu and Teesta with the help of local fishermen. No fish landed in the net during the experimental fishing in the study area. However, with the help of published literature and consultation with local a total of 22 species could be confirmed from the Teesta river and Tolung Chhu. However, no fish species were reported from the upper catchment of Rahi Chhu. The bed slope of the Rahi Chhu River at the proposed diversion weir site is about 1 in 6. This is a very steeply falling stretch.

Fish diversity in the Study Area

S.No.	Order / Family	Name of Species	Local Name	Conservation Status	
				IUCN	NBFGR (2010)
	Cypriniformes				
1	Cobitidae	*Pangio pangia*	Lamo gadela	-	VU
2	Cyprinidae	*Acrossocheilus hexagonolepis*	Catly	-	-
3	Cyprinidae	*Bagarius bagarius latius*	Lohari	-	VU
4	Cyprinidae	*Ctenopharyngodon idellus*	Ghas khane	-	-
5	Cyprinidae	*Cyprinion semiplotum*	Chepti	VU	-
6	Cyprinidae	*Cyprinus carpio*	Carp	VU	-
7	Cyprinidae	*Garra gotyla gotyla*	Budhna	-	VU
8	Cyprinidae	*Garra gotyla stenorhynchus*	Budhna	-	EN
9	Cyprinidae	*Garra mullya*	Budhna	LC	VU
10	Cyprinidae	*Labeo dyocheilus*	Ther	LC	VU
11	Cyprinidae	*Schizothorax curvifrons*	Asla	-	VU
12	Cyprinidae	*Schizothorax richardsonii*	Asla	VU	VU
13	Cyprinidae	*Tor putitora*	Mahseer, Sahar	EN	EN
14	Nemacheilidae	*Nemacheilus sikkimensis*	Gadela	-	EN
15	Nemacheilidae	*Schistura devdevi*	Gadela	NT	-
16	Nemacheilidae	*Schistura kangjupkhulensis*	Gadela	EN	-
17	Nemacheilidae	*Schistura multifasciata*	Gadela	LC	-
	Siluriformes				
18	Sisoridae	*Bagarius bagarius*	Ganchha maccha	NT	VU

19	Sisoridae	*Glyptothorax gracilis*	Kahray	DD	-
20	Sisoridae	*Glyptothorax sinense*	Kahray	DD	-
21	Sisoridae	*Glyptothorax sinense manipurensis*	Kahray	DD	-
22	Sisoridae	*Glyptothorax sinense sikkimensis*	Kahray	-	-

4 SOCIAL ENVIRONMENT

4.1 Socio Economic Profile of the Study Area

The Study Area for the collection of data on socio-economic status has been delineated as the area within 10 km radius of the main project components like diversion structure, reservoir area upto tail end of the reservoir and tail water discharge outlet on the downstream side. Study area consists of 23 villages and 1 town spread over Mangan tehsil of North Sikkim district.

Total population of the study area comprising of 23 villages and 1 town is 22666 belonging to 4744 households. In the studied villages, female population is comprised of 46.49%, with a sex ratio of 869 female per 1000 males. The average family size in the study area villages is 4.8 persons per household. As per Census of India, 2011, nearly 4.63% of the population of the Sikkim state belongs to Scheduled Castes while the population of Scheduled Tribes is only 33.8%. In study area, 2.77% and 65.40% of the total population belongs to Scheduled Castes and Scheduled Tribes, respectively. 31.83% population belongs to general category.

Average literacy rate in Sikkim is 81.42%. The literacy rate in the villages falling under study area is 77.57%, with 56.73% males and 43.27% females. Male literacy rate is fairly high as compared to that of female literacy rate.

49.43% of the total population of study area is working population. Of this working population 71.81% are main workers and 28.18% are marginal workers. 50.57% of the total population of the study area population is considered as non-workers.

5 ASSESSMENT OF IMPACTS

5.1 Impacts during Construction Phase

Majority of the environmental impacts attributed to construction works are temporary in nature, lasting mainly during the construction phase and often do not extend much beyond the construction period. However, as the construction phase of Hydroelectric Projects is fairly large and extend into several years, if these issues are not properly addressed, the impacts can continue even after the construction phase for longer duration. Even though

the impacts due to construction are temporary in nature, they need to be reviewed closely as they could be significant due to the nature and intensity of the impacts.

5.1.1 Impacts due to immigration of Construction Workers

At the time of peak construction work in the project, around 350 persons are expected to be engaged, including those from the local population. Majority of the Construction workers will migrate into the area. Immigration of such a large population for a long duration in remote area can cause serious impact on various environmental resources including socio-economic profile of local population. The congregation of large number of construction workers during the peak construction phase is likely to create problems of sewage disposal, solid waste management, tree cutting to meet fuel requirement, etc. Appropriate mitigating measures have been suggested in EMP, which needs to be implemented to minimize such impacts. This population is expected to reside in the project area at any given time.

5.1.2 Construction of Main Project Components

Rahi Chhu HEP envisages construction of 3.5 m wide and 21 m long trench weir is proposed to be constructed across Rahi Chhu River. The headrace tunnel of 2.462 km length with design discharge of 7.94 cumec. Powerhouse is underground with Horizontol Pelton with three Jets type turbines. The installed capacity of the power house will be 25 MW (3 X 8.33 MW). Tail race Tunnel – D-shaped 2.6(W) X 3.05(H) and 124.0m long. . Excavation will have impact in terms of muck generation. Excavation and concreting process will require use of various construction equipment's such as batching plants, aggregate processing plants, dumper trucks, excavators, dozers, shotcrete machines, jack hammers, generators, pumps, etc. leading to generation of pollution in terms of emissions, wastewater, noise and solid waste.

5.1.3 Quarrying Operations

The required quantity of aggregates will be met with from the suitable excavated material from the project. Aggregate for concreting shall predominantly be used from in-situ rock and river bed material, about 15254 m^3 of the excavated muck from head works and tunnels shall also be used for coarse and fine aggregate production. In case of shortfall material will be purchased from the local crusher and aggregate processing plant.

The impact will be the noise generated during aggregate acquisition through explosive and crushing, which could affect wildlife in the area, air pollution is caused during the crushing operation to get the aggregates to the appropriate size and transport of the aggregates to the site.

5.1.4 Operation of Construction Plant and Equipment

During the construction phase, various types of equipment will be brought to the site and construction plants and repair workshops will be set up. These include crushers, batching plant, drillers, earth movers, rock bolters, etc. The siting of these construction equipments

would require significant amount of space. In addition, land will also be temporarily acquired, i.e. for the duration of project construction; for storage of the quarried material before crushing, crushed material, cement, steel, etc.

These construction plant and repair workshops will have impact on ambient air quality due to fugitive emissions associated with operation of DG sets to meet the power requirements and other equipments; impact on water quality due to wastewater generation and impact on soil due to solid waste generation. Management of such impacts with operation control and appropriate pollution control equipment is essential to minimize their effect on surrounding environment including local population and wildlife and same is discussed in EMP. Additionally, proper siting of these facilities can also reduce the impact due to their location. Their locations have been identified during the preparation of Detailed Project Report, keeping in view the technical and economic criteria; however, same can be further refined during set up, keeping in view:

- Proximity to the site of use
- Sensitivity of forests in the nearby areas
- Wildlife, if any, in the nearby area
- Proximity from habitations
- Predominant wind direction
- Natural slope and drainage

5.1.5 Muck Disposal

The project work would require about 113151 cum of soil excavation and rock excavation. The total muck (including swell factor) to be generated is about **164069 cum**. About 112821 cum of muck generated from soil and rock excavation is proposed to be used for producing coarse and fine aggregate for concrete production and in fillings for developing areas for construction facilities. Remaining muck will be disposed off at designated muck disposal sites spread in total area of 1.8055 ha.
Keeping the above requirement and vicinity of the excavation sites in view, six muck disposal areas named as MD-1, MD-2, MD-3, MD-4, MD-5 and MD-6 have been identified.

Muck, if not securely transported and dumped at pre-designated sites, can have serious environmental impacts, such as:

- Can be washed away into the main river which can cause negative impacts on the aquatic ecosystem of the river.
- Can lead to impacts on various aspects of environment. Normally, the land is cleared before muck disposal. During clearing operations, trees are cut, and undergrowth perishes as a result of muck disposal.
- In many of the sites, muck is stacked without adequate stabilization measures. In such a scenario, the muck moves along with runoff and creates landslide like situations. Many a times, boulders/large stone pieces enter the river/water body, affecting the benthic fauna and other components of aquatic biota.

- Normally muck disposal is done at low lying areas, which get filled up due to stacking of muck. This can sometimes affect the natural drainage pattern of the area leading to accumulation of water or partial flooding of some area which can provide ideal breeding habitat for mosquitoes.

A detailed Muck Disposal Plan has been prepared to minimize the impact and is given in Environmental Management Plan.

5.1.6 Road Construction

For approaching the Trench Weir intake area and desilting basin, a permanent road of about 1.7 km would be constructed from the portal area of Adit I to connect the intake area. About 1 km permanent road would be constructed from the existing road under construction near the forebay area to reach Adit I portal. This road will connect with the permanent road proposed to approach the weir intake. A network of roads is also required to approach various locations of project site such as Main Access Tunnel (MAT) and Tailrace Tunnel (TRT) portal, Dumping yards etc. It has been assessed that about 4.04 km length of new road is required to be constructed to facilitate construction of various components. Similarly, for access to power house site, the road from Mangan to Confluence of Tolung Chhu and Rahi Chhu would have to be widened and realigned at places to get safe grade for heavy traffic and to transport heavy machinery to the power house site during construction. One bridge requires to be constructed on the Tolung Chhu River just downstream of the confluence of Tolung Chhu and Rahi Chhu to access the power house site.

The major impacts likely to accrue as a result of construction of the roads are: Loss of forest and vegetation by cutting of trees

- Geological disturbance due to blasting, excavation, etc.
- Soil erosion as the slope cutting operation disturbs the natural slope and leads to land slips and landslides.
- Interruption of drainage and change in drainage pattern
- Disturbance of water resources with blasting and discriminate disposal of fuel and lubricants from road construction machinery
- Siltation of water channels/ reservoirs from excavated debris
- Effect on flora and fauna
- Air pollution due to dust from debris, road construction machinery, etc.

The indirect impact of the construction of new roads is the increase in accessibility to otherwise undisturbed areas, resulting in greater human interference and subsequent adverse impacts on the ecosystem. Appropriate management measures required to mitigate adverse environmental impacts during road construction have been recommended.

5.1.7 Impact due to Acquisition of Land

Hydroelectric projects are location specific and require land to be acquired for various project activities. For the development of Rahi Kyoung Hydroelectric Project, land would be acquired for construction of project components, submergence area, muck dumping,

quarrying, construction camps and colony, etc. Total land required for the construction of Rahi Kyoung H.E. Project activities is approximately ha. Based on the final project layout, land requirement has been finalized as 15.56 ha; as per the break up given below.

Land requirement for Rahi Kyoung HE project

SL. No	COMPONENT	PURPOSE	AREA REQ (Ha)
1	Power House Area	MAT /CAT/ADIT-II Portal/Batching Plant	0.472
		Muck Dumping Yard -1	0.286
		Work Facilities	0.090
		Muck Dumping Yard -2 /Colony	0.338
		Muck Dumping Yard -3	0.108
		Penstock/VPS Junction	0.250
		Explosive Magazine Area	0.0248
		Transformer & Switch Yard Area	0.900
		Sub Total	**2.4688**
2	Forebay Area	Forebay Area	0.098
		Work Facilities	0.022
		Muck Dumping Area-4	0.1727
		Forebay Escape Channel	0.43
		Labour Colony Area	0.018
		Sub Total	**0.7407**
3	Surface Penstock	**Sub Total**	**0.184**
4	ADIT 1 Area	ADIT Portal	0.040
		Work Facilities	0.4025
		Labour Colony Area	0.150
		Contractor Facility	0.250
		Muck Dumping Area-5	0.5008
		Staff Quarters	0.120
		Sub Total	**1.4633**
5	Weir Site Area	Trench Weir/Submergence Area	0.320
		Working Facilities	0.260
		Labour Colony	0.218
		Muck Dumping Yard-6	0.400
		Batching Plant/Crusher Plant	0.090
		Portable Magazine House	0.010
		Staff Quarters	0.1656
		Feeder Channel, Desilting Basin, Power Channel, HRT Portal	1.400
		Sub Total	2.8636
6	Access Roads	**Sub Total**	6.6464
7	Under Ground Works	ADITS, HRT, PS, MAT, TRT, PH Carven, CT etc.	1.189
	TOTAL		**15.5558**

Major impact of land acquisition is permanent change of landuse, which is unavoidable. Additionally, land acquisition has impacts on local population by way of loss of their agriculture land and hence livelihood and also impact on flora and fauna by way of loss of forest land and clearing of vegetation on acquired land. These impacts will be mitigated by implementing R & R plan, Biodiversity Conservation and Forest Management Plan, as discussed in EMP.

5.1.8 Impact on Water Quality

Sewage from Construction worker Camps

The disposal of untreated sewage can lead to water pollution, resulting in increase in coliforms and other various pathogens, which can lead to incidence of water borne diseases. Therefore, project authorities would be taking appropriate measures to check such disposal into the river. In order to avoid any deterioration in water quality due to disposal of untreated sewage from labour camps, appropriate sewage treatment facilities will be commissioned in the labour camps.

Effluent from Construction Plants and Workshops

Discharge of untreated wastewater will adversely affect the water quality of receiving water body. Turbidity and oil & grease levels will increase substantially in small tributaries, especially, in lean season. To minimize the impact, such effluent needs to be treated in situ before discharge to any water body or for land application.

a) Disposal of Muck

The major impact on the water quality arises when the muck is disposed along the river bank. The project authorities have identified suitable muck disposal sites which are located near the river channel. The muck will essentially come from the tunneling, road-building activity, and other excavation works. The unsorted waste going into the river channel will greatly contribute to the turbidity of water continuously for long time periods. The high turbidity is known to reduce the photosynthetic efficiency of primary producers in the river and as a result, the biological productivity will be greatly reduced. Therefore, the prolonged turbid conditions would have negative impact on the aquatic life.

5.1.9 Impact on Terrestrial Flora

Major impact on the flora in and around the project area would be due to increased level of human interferences. The workers may also cut trees to meet their requirements for fuelwood, construction of houses, furniture. Normally in such situations, lot of indiscriminate use or wastage of wood is also observed, especially in remote or inaccessible areas. Thus, it is necessary to implement adequate surveillance to mitigate the adverse impacts on terrestrial flora during project construction phase.

5.1.10 Impact on Terrestrial Fauna

Disturbance to Wildlife

During the construction period, large number of machinery and construction workers shall be mobilized, which may create disturbance to wildlife population in the vicinity of project area. The operation of various equipments will generate significant noise, especially during blasting which will have adverse impact on fauna of the area. The noise may scare the fauna and force them to migrate to other areas. Likewise siting of construction plants, workshops, stores, labour camps etc. could also lead to adverse impact on fauna of the area. During the construction phase, accessibility to area will lead to influx of workers and the people associated with the allied activities from outside will also increase. Increase in human interference could have an impact on terrestrial ecosystem.

The other major impact could be the blasting to be carried out during construction phase. This impact needs to be mitigated by adopting controlled blasting and strict surveillance regime and the same is proposed to be used in the project. This will reduce the noise level and vibrations due to blasting to a great extent.

5.1.11 Impact on Aquatic Ecology

Major sources of construction related impacts on water quality will be from erosion of the disturbed area required for the construction activities (construction sites, concrete batch plants, material storage areas, vehicle maintenance areas, disposal areas), from waste water discharge from the construction labour camps and from contaminated water (oil, grease, petro chemicals, cement and chemicals) resulting from various construction activities. The primary impact will be the potential for introducing sediments and pollutants to the adjacent river body during the period of construction, thereby affecting aquatic habitats and water source for residents and wildlife downstream of the construction areas.

5.1.12 Impact on Noise Environment

Sources of noise will be the vehicles and equipment for excavation and stationary equipment, including concrete batch plant located at the construction sites. Other sources of noise will be the use of explosives for blasting purposes for construction activities, drilling machines and quarrying and crushing activities.

5.1.13 Impact on Air Quality

In general hydropower projects do not affect the air quality in a significant manner. The sources and activities that might affect air quality in the project area are vehicular traffic, dust arising from unpaved village roads and domestic fuel burning. The air environment around project site is free from any significant pollution source. Therefore, ambient air quality is quite good in and around the project area.

5.1.14 Traffic Analysis

Traffic analysis is carried out by understanding the existing carrying capacity of the roads near to the project site and the connecting main roads in the area. Then depending on the

capacity of the muck generation, the number of trucks that will be added to the present scenario will be compared to the carrying capacity.

5.1.15 Impact on Socio-economic Environment

a) Positive Impacts on Socio-Economic Environment

The following positive impacts are anticipated on the socio-economic environment of the local people of villages of project area during the project construction and operation phases:

i) A number of marginal activities and jobs would be available to the locals during construction phase.

ii) Developer bringing large scale investment to the area will also invest in local area development and benefit will be reaped by locals. Education, medical, transportation, road network and other infrastructure will improve.

iii) The availability of electricity in the rural areas will reduce the dependence of the locals on alternative energy sources namely forest.

iv) With increased availability of electricity, small-scale and cottage industries are likely to come up in the area.

v) The proposed project site is well connected by road. Efforts to be made to develop eco-tourism, which could earn additional revenue.

b) Negative Impacts on Socio-Economic Environment

Such projects, in addition, to positive impact on socio-economic environment may also bring certain negative impact due to influx of outside population. Workforce will reside in that area for around five years and also there will be large influx of drivers and other workers on temporary basis. This influx of people in otherwise isolated area may lead to various social and cultural conflicts during the construction stage. Developers need to take help of local leaders, Panchayat and NGOs to ensure minimum impact on this count.

c) Increased incidence of Diseases

Large scale activity in the area due to the proposed project may become a cause of spread of HIV/AIDS in the project area due to following reasons:

- Project requires long-term input of labour from outside the area.
- Project requires that significant numbers of project employees be separated from their families for long periods of time
- Project involves the creation of large, temporary construction camp(s). Increases mobility of people in and out of the area (job seekers, formal and informal service providers).
- Requires participation / resettlement of the local population.

d) Indirect and Cumulative Impacts on Natural Resources

The improved year round access to the whole project area from new and upgraded roads will enable people to settle in the area. Use of the improved access will enable movement from one area to another. This translates into the development of roadside villages, and a potential increased pressure on the natural resources in the vicinity of the roads. The

increased pressure will include uncontrolled logging, hunting of wildlife, non-timber forest product collection, livestock husbandry, the cultivation in forest areas and forest fires. These impacts are expected during the economic development of the river basin, and are expected to be managed by the basin level catchment area treatment plan, and the proposed Environmental Master Plan for the state.

5.2 Impacts during Operation Phase

On completion of the construction of the project, the land used for construction activities, muck dumping, quarrying, etc. will be restored. Construction workers who have resided in that area will move to another project site. By ensuring all the mitigation and management measures, as planned for this project, are implemented to minimize the impact of construction phase, large part of the area will go back to its original form. However, there will be some permanent changes such as barrage across the river, reservoir formation, powerhouse and project colony. Hydropower projects are considered as clean source of renewable energy as there are no significant pollution generation sources during project operation. There is no air and water pollution from the project operation. Similarly generation of solid and hazardous waste is also insignificant.

One critical impact of operation of hydropower projects has received substantial attention from environmentalists in last two to three decades based on the observations made on operational projects in developed countries is the decrease in flow in the downstream stretch. Diversion of water from barrage to powerhouse will make the intermediate stretch of the river almost dry especially during lean season. Impact becomes significant if several projects are planned in cascade and/or large headrace tunnels making the intermediate stretch (es) very large. Low flow in the section of the river adversely impacts the aquatic ecology including fish fauna, riparian vegetation and fauna dependent on it; and downstream users. These impacts cannot be totally mitigated, however, they can be minimized by scientifically assessing the environmental flow requirement of the intermediate stretch not only in lean season but also in other months.

5.2.1 Impact on Water Resources

a) Impact of reduction in downstream flow

The construction of weir and diversion of water for power generation would lead to the reduction in water discharge in the river stretch downstream of weir site. To maintain ecological needs and downstream requirement, environmental releases shall be suggested for monsoon, lean and other months for entire year.

b) Impact on Water Quality

Due to decrease in the discharge and change in water quality, the population of microorganisms will be affected. Algae like *Achnanthidium minutissima*, which is characteristic of fast flowing and clean river waters would be affected due to decreased discharge. The species like *Synedra ulna* and *Nitzschia* sp. will become abundant in the stretch between barrage site and powerhouse site as these species prefer shallow waters.

The various aspects covered as a part of impact on water quality during project operation phase are:

- **Effluent from project colony**

During the operation phase, due to absence of any large scale construction activity, the cause and source of water pollution will be much different. Since, only a small number of O&M staff will reside in the area in a well-designed colony with sewage treatment plant and other infrastructural facilities, the problems of water pollution due to disposal of sewage are not anticipated. The treated sewage will be reused for gardening and green belt around the colony.

5.2.2 Terrestrial Fauna

During project operation phase, the accessibility to the area will improve due to construction of roads, which in turn may increase human interferences leading to marginal adverse impacts on the terrestrial ecosystem. Since significant wildlife population is not found in the region, no major adverse impacts are anticipated on this account.

5.2.3 Aquatic Ecology

a) Impacts on aquatic ecology

Rahi Kyoung Hydro Electric Project would involve construction of a trench weir across the Rahi Chu River. Since it's a trench weir and doesn't form a reservoir. However the regulation of water and change in downstream discarge will bring about a number of alterations in physical, abiotic and biotic parameters both in upstream and downstream directions of the proposed weir site. The micro and macro benthic biota is likely to be most severely affected as a result of the proposed project.

b) Impacts on fisheries

This is one of the most serious impacts of hydropower projects during their operation phase. Operation of the plant will involve diversion of water by a trench weir. Reduced flows and changed flow regime downstream will alter the aquatic ecology and change the fish habitat altogether.

To minimize this impact, environmental flow will be maintain and releases from weir for monsoon, lean and other months for whole year to ensure that the intermediate stretch receives adequate flow round the year.

6 ENVIRONMENTAL MANAGEMENT PLAN

6.1 Biodiversity Conservation & Wildlife Management Plan

Keeping in view of the anticipated impacts, the main objectives of biodiversity conservation and wildlife management plan are as follows:

i. Maintenance of ecological balance through preservation and restoration of wherever it has been disturbed due to project developmental activities,

ii. Conservation and preservation of natural habitats in catchment and project area iii. Rehabilitation of critical species (endangered, rare and threatened species), if any with provisions for in situ or ex situ conservation of critical/ important plant/ animal species,

iv. Mitigation and control of project induced biotic and/or abiotic pressures/ influences that may affect the natural habitats,

v. Habitat enhancement in project area and catchment area by taking up afforestation and soil conservation measures,

vi. Creating all round awareness regarding conservation and ensuring people's participation in the conservation efforts and minimizing man-animal conflict like human-wild dog; human-elephant and

Following are the measures suggested for the said plan: i. Wildlife Habitat Preservation & Improvement ii. Establishment of Germplasm Bank and Seed Centre

iii. Contour Trenches iv. De-weeding and Sowing of Grass v. Biodiversity monitoring

vi. Awareness promotion

vii. Strengthening of Infrastructural Facilities of Forest Department viii. Biodiversity Management Committee (BMC)

The estimated cost of implementation of various activities envisaged in the Biodiversity Conservation and Management Plan would be **Rs. 70.00 lakh**.

6.2 Catchment Area Treatment (CAT) Plan

The Catchment Area Treatment (CAT) plan highlights the management techniques to control erosion in the catchment area of a water resource project. The life span of a reservoir is greatly reduced due to erosion in the catchment area. Adequate preventive measures are thus needed for the treatment of catchment for its stabilization against future erosion.

In the present study, CAT Plan has been formulated for the catchment till the proposed weir site on Rahi Chhu. The total area of the catchment is **53.50 sq km**. The plan has been prepared as per the guidelines of Soil & Land Use Survey of India (SLUSOI), Government of India.

The catchment area treatment involves

- Understanding of the erosion characteristics of the terrain and,
- Suggesting remedial measures to reduce the erosion rate.

The estimated cost of implementation of CAT plan including monitoring and evaluation is **Rs. 45.00 lakh**.

6.3 Fisheries Development Plan

In order to mitigate the adverse impact of Rahi Kyoung HE project on the aquatic ecology of the area fishes in particular the following measures shall be adopted to protect and preserve existing aquatic life:

- Releasing /ensuring minimum Environment flow in the river
- Fishries development through Fish Hatchry

A budgetary provision of **Rs. 33.23 lakh** has been kept for the Fishery Conservation and Management Plan of the project.

6.4 Solid Waste Management Plan

The project authority shall, within the territorial area of the project complex/ colony, be responsible for the implementation of the provision of Solid Wastes Management. Adequate facilities for collection, conveyance and disposal of solid waste will be developed. Any solid waste generated in the project complex/ project colony/ labour colony, shall be managed and handled appropriately. Various aspects of solid waste management include:

- Reuse/Recycling
- Storage/Segregation
- Collection and Transportation
- Disposal

The total budget in order to manage the solid waste generated from the construction camp/colony, and also during operation phase has been proposed to **Rs. 73.70 lakh.**

6.5 Public Health Delivery System

Medical services at secondary level play a vital and complimentary role to the tertiary and primary health care systems and together form a comprehensive district based health care system. Following activities are proposed:

- Ambulance: 1 no. with all the basic Medicare facilities and small DG set, etc. to cater for villages in the project area.
- Budget for running the ambulances including driver, fuel and maintenance for 3 years @ 5 lakhs per annum.
- First aid posts including sheds, furniture and basic equipment.
- Budget for running the first aid post @ Rs. 10.80 lakhs per annum including cost of medico, para-medico/Nurses and attendant, consumables, etc. for 3 years.
- Budget for strengthening existing medical facilities.

- Budget for Health Awareness/ Vaccination Camps @ Rs. 1.00 lakhs per annum for 3 years.

Budgetary estimates for public health delivery system to be implemented have been worked out as **Rs. 87.40 lakh.**

6.6 Energy Conservation Measures

With an estimated migrant population of 350 persons in the area, the existing facilities will become insufficient for supply of kitchen fuel for the migrant population during the construction of the project. Fuel for cooking and space heating is an essential requirement and in the absence of adequate fuel availability they will resort to tree cutting for use of fuel wood. Therefore, the project authorities would make adequate arrangements such as Community kitchen, Supply of Kitchen fuel, efficient cooking facilities and Solar Lantern.

A total grant of **Rs.81.10 lakh** has been assigned towards the provision of kitchen fuel, and other facilities including establishment of community kitchen or canteens for the migrant workers.

6.7 Muck Dumping Plan

The project work would require about 113151 cum of soil excavation and rock excavation. The total muck (including swell factor) to be generated is about **164069 cum**. About 112821 cum of muck generated from soil and rock excavation is proposed to be used for producing coarse and fine aggregate for concrete production and in fillings for developing areas for construction facilities. Remaining muck will be disposed off at designated muck disposal sites spread in total area of 1.8055 ha.

Keeping the above requirement and vicinity of the excavation sites in view, six muck disposal areas named as MD-1, MD-2, MD-3, MD-4, MD-5 and MD-6 have been identified.

The estimated cost of the relocation and rehabilitation of excavated material will be **Rs. 178.00 lakh.**

6.8 Landscaping, Restoration & Green Belt Development Plan

The proposed project would involve construction of trench weir, power house, adits, headrace tunnel, residential and staff colonies, roads, batching plants, etc. These activities will result either in the modification or destruction of the existing landscape of the area. It is therefore imperative that after the project work and related activities are over restoration work should be carried out in these disturb areas to bring them back to their similar or near-similar pre-construction conditions and land use.

Green belt development will comprise of plantations at various places like alongside roads, around the periphery of reservoir rim, and at different project offices and colonies.

The estimated cost for the restoration works, landscaping of quarry areas, road side plantations, and creation of green belt around reservoir and colonies and working sites would be **Rs. 32.21 lakh**.

6.9 Air & Water Management Plan

Various mitigation and management measures have been planned to reduce the impacts of air, noise and water pollution and implement safety measures to ensure that impacts on these counts are reduced to minimum possible during the entire construction phase. To implement such measures, it is important to prepare a budget of such measures and include in the project cost so that lack of fund should not constrain their implementation.

Some of the measures suggested have already been covered under other heads of environmental management; therefore, an estimate of only additional cost i.e. **Rs. 33.00 lakh** is proposed under this plan.

6.10 Compensatory Afforestation Plan

The Rahi Kyoung H.E. Project is being constructed in the jurisdiction of North Territorial Division, Mangan district, Sikkim. The total land required for the construction of Rahi Kyoung H.E. Project activities is approximately **15.56 ha** with **3.58** of forestland and **1.189 ha** land is underground (notional area).

The Forest Conservation Act, 1980 stipulates strict forest protection measures and procedures (Guide Line 1/08-1 (ii)) for compensatory afforestation on acceptance of diversion of forestland for non-forestry purposes.

i. If non-forest land is not available, compensatory plantation is to be raised on degraded forest land to the extent of twice the affected or lost forest area, and
ii. If non-forest land is available, the extent of compensatory plantation will be equivalent of the affected or lost forest area.

In the present proposal, compensatory afforestation has been proposed on degraded forest land of Saffo Reserve forest under Dzongu Range. Compensatory afforestation is to be taken up on 10 ha of land in the denuded or degraded forest areas. It is also proposed to have fencing work around the new plantation with angle iron to maintain the ecological balance of the areas.

The compensatory afforestation is proposed to be undertaken on degraded forest land identified in consultation with the State Forest Department. The estimated cost of Compensatory Afforestation programme is **Rs. 81.18 lakh.**

Total land requirement for diversion for non-forest use i.e. for the construction of Rahi Kyoung H.E. Project activities is **15.56 ha** with **3.58 ha** of forest land and **1.19 ha** underground (**Refer Table 10.1**). As the forest in the project area fall in the **Eco Class VI** as being of type

Himalayan Moist Temperate Forests therefore NPV @ Rs. 8.97 lakhs/ha would be required to be deposited in the Compensatory Afforestation Fund. The total cost of NPV has been computed as **Rs. 42.78 lakh**.

The total cost of the compensatory afforestation plan, NPV, compensation of trees and cost of damage to fence and infrastructure is **Rs. 123.96 lakh.**

6.11 Rehabilitation & Resettlement Plan

The Rehabilitation and Resettlement Plan has been prepared to comprehensively address the issues arising out of land acquisition, assessment of land/house/asset coming under acquisition, estimation of extent of loss and compensation to be offered in line with The Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Act, 2013 (RFCT_LARR) and State Rehabilitation and Resettlement Policy (SRRP), 2008 of Arunachal Pradesh.

For the development of Rahi Kyuoung Hydroelectric Project, land would be acquired for construction of project components, submergence area, muck dumping, quarrying, construction camps and colony, etc. Based on the final project layout, land requirement has been finalized as 15.56 ha.

In case of Rahi Kyoung HEP, 124 Project affected families from Salim-Pakyel village have been identified which will be affected by acquisition of land for the project, and who have rights over community land to be acquired for the project. R&R Plan has been prepared keeping in view the provisions of RFCT_LARR, National and State Policy to ensure that adequate benefits are given to the PAFs in terms of compensation and infrastructure development in the area so that quality of life is improved substantially.

Total financial requirement for implementation of the Rehabilitation and Resettlement plan and Economic Development Package is **Rs. 1009.00 lakh.**

6.12 Environmental Monitoring Plan

Monitoring shall be performed during all stages of the project (namely: construction, commissioning, and operation) to ensure that the impacts are no greater than predicted, and to verify the impact predictions. The monitoring program will indicate where changes to procedures or operations are required, in order to reduce impacts on the environment or local population. The monitoring program for the Rahi Kyoung HE Project will be undertaken to meet the following objectives:

- To monitor the environmental conditions of the Rahi Chhu;
- To check on whether mitigation and benefit enhancement measures have actually been adopted, and are proving effective in practice;

A sum of **Rs. 102.00 lakh** has been allocated to implement various activities and programmes envisaged under EMP.

6.13 Cost Estimates of EMP

An amount of **Rs. 1868.60 lakh** has been allocated for the implementation of different environmental management plans. The summary of total cost estimates for the execution of different plans is given in table below.

S. No.	Management Plans	Amount (Rs. in lakh)
1	Biodiversity Conservation & Wildlife Management Plan	70.00
2	Catchment Area Treatment Plan	45.00
3	Fisheries Development Plan	33.23
4	Solid Waste Management Plan	73.70
5	Public Health Delivery System	87.40
6	Energy Conservation Measures	81.10
7	Muck Dumping Plan	178.00
8	Landscaping, Restoration & Green Belt Development Plan	32.21
9	Air & Water Management Plan	33.00
10	Compensatory Afforestation Plan	123.96
11	Rehabilitation and Resettlement Plan	1009.00
12	Environmental Monitoring Program	102.00
Total		**1868.60**