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POWER Pvt. Ltd.

TATO 1 HYDRO ELECTRIC PROJECT

1. Executive Summary

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Executive Summary of ENVIRONMENTAL IMPACT ASSESSMENT & MANAGEMENT PLAN OF TATO-I HYDROELECTRIC PROJECT, Arunachal Pradesh

Prepared for:

Siyota Hydro Power Pvt. Ltd., New Delhi

CENTRE FOR INTER-DISCIPLINARY STUDIES OF

MOUNTAIN & HILL ENVIRONMENT

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1. Developer Foreword

The strategy and philosophy followed by Velcan Energy, in all countries and for all projects, is to develop midsized run-of-the-river Hydroelectric Projects, which minimize the impact on the environment and local populations while allowing energy generation without greenhouse gases emissions.

Such kind of projects is highly environment friendly because contrary to large reservoir projects, they do involve only small ponds or very small ponds, and therefore small or very small submergence areas. In addition Velcan Energy takes up exclusively the development of Projects which do not require displacement of people.

Tato-1 HEP is developed with the cooperation of local inhabitants right from the beginning of the field investigations and feasibility studies, and compensations and benefits are allocated through contracts, sponsoring and welfare activities even before the start of Project construction.

- ✓ Very small submergence area: 3 ha including 1.8 ha of river bed (net submergence impact of 1.2 ha).
- ✓ Small land requirement & very small impact on forest: net surface land impact 47.7 ha.
- ✓ Very small weir 7.5 m high
- ✓ No displacement of people.
- ✓ No wildlife sanctuary affected.
- ✓ Minimum environmental flow to guarantee sustenance of downstream aquatic life & afforestation measures.
- ✓ Local people getting benefit right from investigation phase.
- ✓ Total budget for environmental and social mitigation measures: Rs 2854.27 Lakhs.
- ✓ Rehabilitation measures and Local Area Development budget: Rs 1207.12 Lakhs (do not include the compensations per the Land Acquisition Act, which will be paid in addition whenever applicable)

A summary of baseline data, methodology technical impacts and corresponding mitigation measures is presented hereafter.

2. General Description

Tato-I H.E project is the last project of a cascade of three projects developed by Velcan Energy Group on the Yarjep River (Shi-Local name), between Mechuka and Tato circles, in West Siang district of Arunachal Pradesh.

Tato-I H.E. Project is located in Tato and Mechuka circles of West Siang district in Arunachal Pradesh (**Fig. 1**). The nearest road head at Gapo is about 170 Km from Aalo, the head quarters of district West Siang. Tato-I Hydroelectric Project is a run of the river scheme proposed on the Yarjep river (also known as Shi in the lower reaches), which is a right bank tributary of the Siyom river). It is immediately in the downstream of the Heo Hydroelectric Project and largely utilizes its discharged water along with additional discharge accumulated by the Yarjep tributaries between Heo Dam and Power House. Tato-I project is directly connected to the outlet of Heo HEP project. The project intake is located approximately 10 km downstream of the confluence of the Sae Chu with the Yarjep Chu (Shi), about 20 km downstream of Mechuka. The proposed intake site is located between 94°18’43’’E longitude and 28°32’32’’N latitude near Meying village. Proposed Power house site is located between 94°21’31’’E longitude and 28°31’53’’N latitude near Heyo village. The nearest road heads are Gapo and Tato villages which are linked to Mechuka and Tato towns. From Gapo village, a foot track is used to access the proposed intake site. The power house site is accessible from a foot track starting in the middle of the road between Gapo and Tato villages. The nearest road is connected to National Highway-52 via state road and is about 295 km from Akajan in Assam. For Tato-I project the nearest meter gauge rail head is at Silapathar (approx 300 km) and broad gauge at Nagaon (approx. 700 km) in Assam. From the project site, the nearest operational airport is around 344 Km, located at Dibrugarh in Dibrugarh district of Assam and the nearest international airport is around 830 km located at Guwahati, the capital city of Assam.

Tato-I H.E. Project involves a 7.5 m high trench weir intake, a horse shoe head race tunnel (HRT) of 3.9 km long and a surface powerhouse with an installed capacity of 186 MW. Total catchment area of the project is 1154 sq km. The standard projected flood (SPF) and maximum probable flood were calculated to be 3400 and 4100 cumecs, respectively. The construction of the Project will be completed in 4 years. The details of salient features of the project are given in the EIA report. The Project is designed with a small Pond, which involves a submergence of 3 Ha including 1.8 ha of river bed. The Total Land requirement is about

52.8 Ha, including underground structures of 2.3 Ha and river bed area of 2.8 Ha. Detailed salient features of the project are given in Table 1.

Table 1. Salient features of Tato-I H.E. project in West Siang district of Arunachal Pradesh

LOCATION	
State	Arunachal Pradesh
District	West Siang
River	Yarjep (Shi)
Geographical Coordinates of Water Intake	
Longitudes	94°18’43’’E
Latitudes	28°32’32’’N
Geographical Coordinates of Power house	
Longitudes	94°21’31’’E
Latitudes	28°31’53’’N
Nearest Airport	Dibrugarh
Nearest Rail Head (Broad gauge)	Nagaon
HYDROLOGY	
Catchment area at the water intake (km2)	1 154
PMF (m3/s)	4 100
SPF (m3/s)	3 400
WATER INTAKE	
Type	Trench weir Intake coupled with HEO PH outlet
Length(m)	55
Max discharge (m3/s)	10
RESERVOIR	
Full Reservoir Level at the water intake (m)	1195.2
Full Reservoir Level at HRC (m)	1189
Submergence area (ha)	3
WATERWAYS	
HEAD RACE CHANNEL	
Length (m)	1100

Shape & Size	rectangular 6x6.6 m
Design discharge (m3/s)	133
Slope	0.1%
HEAD RACE TUNNEL	
Length (km)	3.9
Diameter (m) & Shape	6.4 Horse shoe, 300mm concrete lined
Design discharge (m3/s)	133
Head Pond Level (m)	1187.9
SURGE SHAFT	
Type	Vertical Orifice
Diameter (m)	14
Vertical height (m)	85
PRESSURE SHAFT	
Number	1
Diameter (m)	5.75
Length (m)	633
POWER HOUSE	
Type	Surface
Head (m): Gross / Design Net	164 / 153.4
Size of power house L x W x H (m)	42 x 72 x 37
Installed capacity (MW)	186
Type of Turbine	Francis vertical
Number & Capacity (MW)	3 x 62 MW

The design of project has been developed by the Engineering Department of VELCAN Energy. Reputed International consultants have also contributed significantly to the civil design, geology, geotechnics, and hydrology according to the latest international and Indian standards.

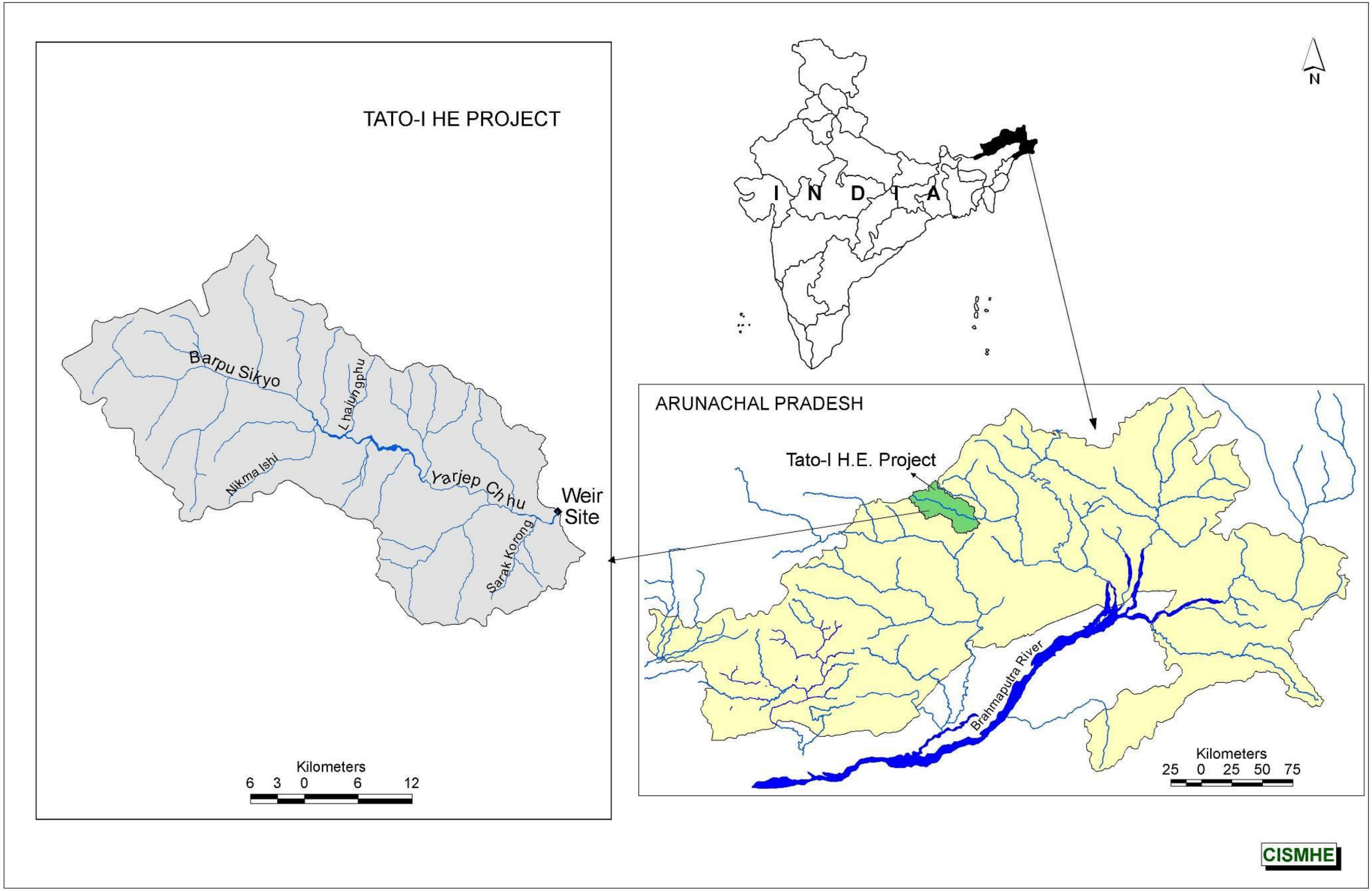

Figure 1: Location map of Tato-I H.E. project

3. Project Background and Legal & Administrative Framework

VELCAN Energy Group has entered into a MoA with the State of Arunachal Pradesh for the development of the Tato-I. H.E. Project on Build, Own, Operate and Transfer (BOOT) basis.

The final stretch of river available for Project development was finally determined by the Government of Arunachal Pradesh on 31st July 2009, through the signature of an amendment to the Memorandum of Agreement. In addition, the first two years of Hydrological & Meteorological studies and data collection showed more available water than initially estimated and the installed capacity of the Project was increased to 170 MW accordingly, through the aforesaid Amendment dated 31st July 2009. Following the signature of this Amendment, involving new features, the Tato-I H. E. Project had to be thoroughly designed again in order to arrive at a new PFR which was submitted in November 2009.

Water Availability Studies have been approved by the C.E.A / C.W.C in July 2010. The Power Potential Studies have been submitted in July 2010 to the C.E.A, which finally requested the Project developer, in April 2011, to increase again the installed capacity from 170 MW to 186 MW. Hence the Power Potential Studies have been approved with a capacity of 186 MW.

The Ministry of Environment and Forests, Govt. of India, granted to SHPPL the revised TORs and clearance of preconstruction activities, updated with the new project capacity and features in April 2010 for the first increase and then in October 2011 for the second increase. VELCAN Group has set up local operations in order to conduct the field surveys and investigations. One Guest House is located in Mechuka and the local head office is located at Aalo. Locally, VELCAN Group is employing a team on permanent employment basis in the West Siang District, in addition to a variable team of daily labours or temporary employees depending on site works requirements. Local population has been integrated to the project development right from the beginning through welfare activities or employment.

Velcan Energy Group has performed surveys & investigations for project reconnaissance and then for DPR preparation:

- Hydrological and climatic surveys of the area
- Topographical Surveys
- Geological mapping
- Sub-surface geological investigations
- Environmental surveys for EIA/EMP preparation.

Tato-I HE Project is proposed to be developed by meeting statutory environmental requirements of Arunachal Pradesh as well as the Central Government. The Ministry of Environment & Forests (MoEF) is the nodal regulatory agency of the Central Government for planning, promotion, co-ordination and overseeing the formulation and implementation of environmental and forest policy, legislations and programs. Given the installed capacity of the Project, regulatory functions like grant of Environment Clearance (EC), Forest Clearance (FC) are part of the mandate of the Ministry of Environment & Forests (MoEF).

4. Environmental Impact Assessment / Environmental Management Plan

The aim of the Environmental Impact Assessment (EIA) is to enumerate the entire panel of environmental issues involved in the construction and exploitation of the Tato-I structures, with the scope listed in the Terms of Reference (TOR) accorded by the MoEF during scoping and pre-construction clearance of the named project. Standard methodologies of Environment Impact Assessment were followed in the EIA study of Tato-I H.E. Project. The present study has been based on the guidelines for EIA reported by several workers and institutions including CISMHE. All the methods were structured for the identification, collection and organization of environmental impacts data. The information, thus gathered, has been analyzed and presented in the form of a number of visual formats for easy interpretation and decision-making. The study was carried out in catchment area, influence area (10 km periphery of proposed intake) and project area (directly impacted area). Spatial database on physiographic features were taken from various sources including Survey of India (SOI) toposheets, satellite data and analyzed with the help of Geographic Information System (GIS) tools. Successive phases of the EIA study include reconnaissance visit, survey and data collection, determination of environmental baseline setup, identification, prediction and evaluation of impacts and possible mitigation measures and formulation of environment management plans.

The Environmental Management Plan (EMP) is conducted in order to minimize the effects of the project on the surrounding environment by establishing a sustainable work line.

5. Baseline Environmental Status

5.1. Land Environment

5.1.1. Physiography

The proposed intake site is located on the Yarjep (Shi). This river forms one of the major tributaries of Siyom River in Arunachal Pradesh. In the middle stretch, Yarjep Chu runs from WNW to ESE and several tributary streams flowing from north hills to south and southern hills to north join this river in the Indian part of the catchment. The area of the Tato-I project's influence zone is around 43525.4 ha, and covers a scale from 1050 to 4300 m above sea level (asl). The drainage network of the catchment area up to the weir site is shown in **Fig. 2**.

5.1.2. Geology & Seismicity

The Himalayan ranges continuing from NW India to NE India occurs as a "gigantic crescent" in this part of the country with its convex side towards south and extends from the Western border of Bhutan to Lohit valley in the east and is divisible into four linear zones namely the Tibetan Himalaya, Higher Himalaya, Lesser Himalaya, and Sub Himalaya abutting against the Trans Himalayan range, and the Mishmi Hills famously known as the Eastern Syntaxial Bend.

The project area falls in Dirang formation resting over the Sela group of rocks. The formation comprises a thick sequence of low grade metasedimentaries comprising garnet-muscovite schist, phyllite, sericite- quartzite, calc silicate and tremolite-actinolite marble, truncated in the north by MCT.

The rocks exposed at the Weir site are predominantly quartzite with sub-ordinate quartzo-feldspathic gneiss ± some schist bands. The head race channel or the power channel is primarily located in reaches covered by riverine deposits and zone of accumulation of palaeo-slide debris. Formation of channel will be essentially in cut reaches. The proposed Head Race

Tunnel (HRT) alignment passes through a rough and rugged terrain with very difficult access on the left bank of Yarjep River. The Head Race Tunnel crosses a number of cross drainage systems and one of them is Pirpit Korang nalah falling on the alignment just before the second bend and first major bend where low cover is expected. The Powerhouse is located on the left bank and a small nalah is joining the main river on this bank. A suitable crossing arrangement has been made at appropriate levels so that the nalah does not foul the construction activity. The location of the powerhouse is considered favorable taking advantage of the flat surface available on the left abutment. The predominant rock type at the powerhouse site is banded gneisses which are exposed on both the banks of the Yarjep (Shi) River.

The area falls in Seismic Zone V of the Seismic Zoning Map as adumbrated in the Indian Standard Criteria for Earthquake Resistant Design of structures. However, the project area manifests relatively fewer incidences of earthquakes and the focal mechanism of two fault plane solutions of two nearby events to the south indicates strike slip mechanism.

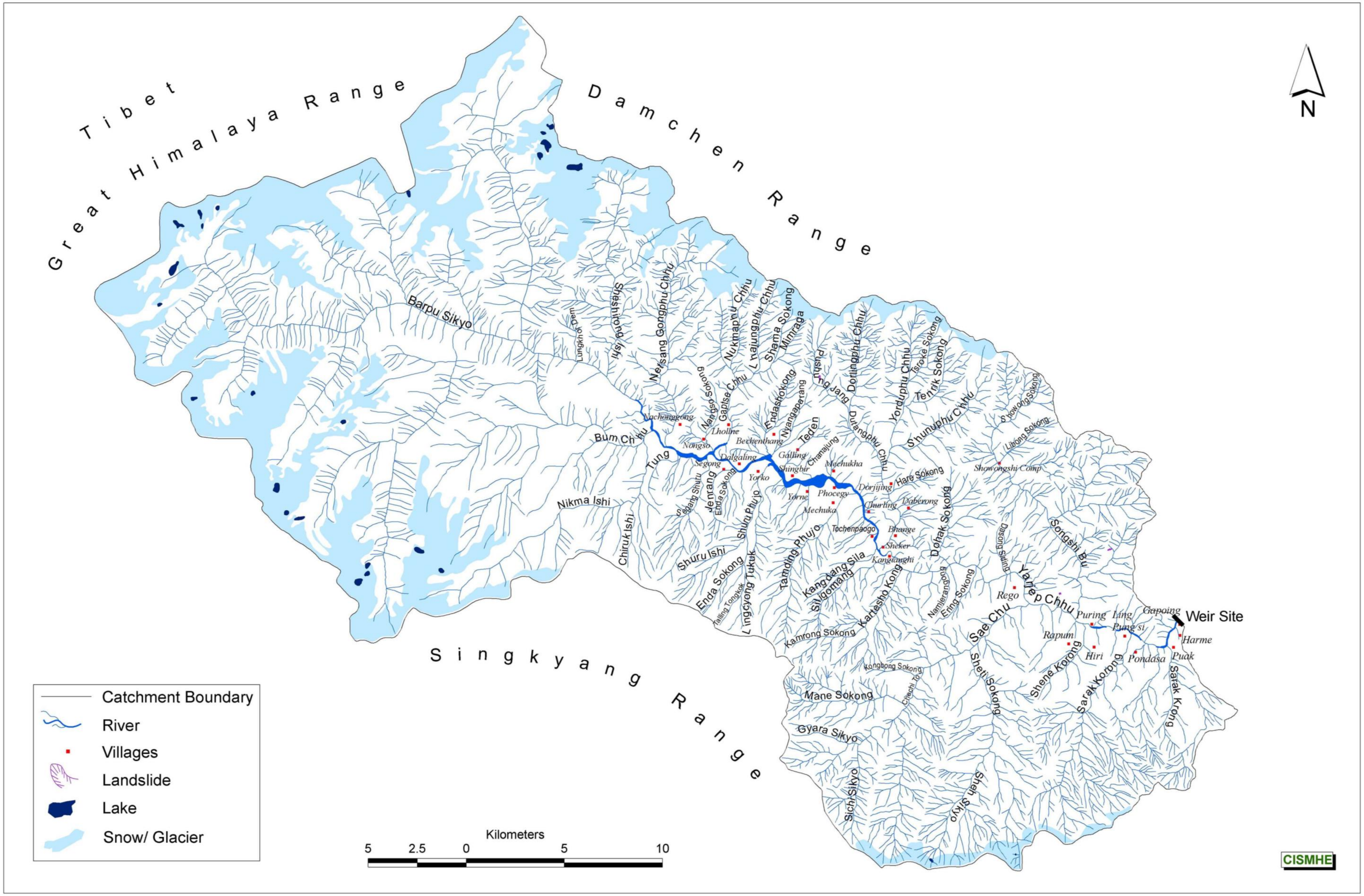

Figure 2: Drainage map of Yarjep (Shi) River in the catchment area of the proposed Tato-I H.E. project up to the proposed weir site

5.1.3. Soil

The study covers soil properties for the catchment area, project influence area and project area. Soil association of Lithic Udorthents – Dystrict Eutrochretps is predominant in these areas. All the project components like weir, HRT, powerhouse colony area, etc. of the Tato-I H.E. project are located on the soil association of Lithic Udorthents – Typic Udorthents. Soil is characteristics of loamy skeletal and shallow to moderately deep and it is prone to very severe to severe erosion. Physical, chemical and biological properties of soil, which can impact the viability of the project, are further developed in the EIA study.

5.1.4. Land Use and Land Cover

Land use and land cover mapping of the Tato-I H.E. Project was carried out by standard methods like digital image processing (DIP) supported by ground truthing. The land use and land cover of the Tato-I catchment area includes Dense forest, Open Forest, Scrub/Alpine scrub, Degraded forest, Alpine Meadow, Cultivation, Moraines, Barren, River, Lakes, Snow and glaciers. The catchment area is prevalently covered by Dense Forest, which occupies 37.86% of the total 115 400 ha area as shown in **Fig 3**.

Additionally, MoEF has been following a general practice of baseline data to be collected in a 10 km radius of a project while conducting EIA studies. A base map was developed to demarcate the submergence zone and influence zone of the Tato-I H.E project. Therefore land cover and land use maps will be examined within the 10 km radius of power house and intake sites. It is called as the study area (Influence zone and the submergence area). The land cover and land use patches in the influence zone are covered notably with dense forest on either bank of the Yarjep Chhu and Siyom River, which accounts for 37.78% of the total influence zone.

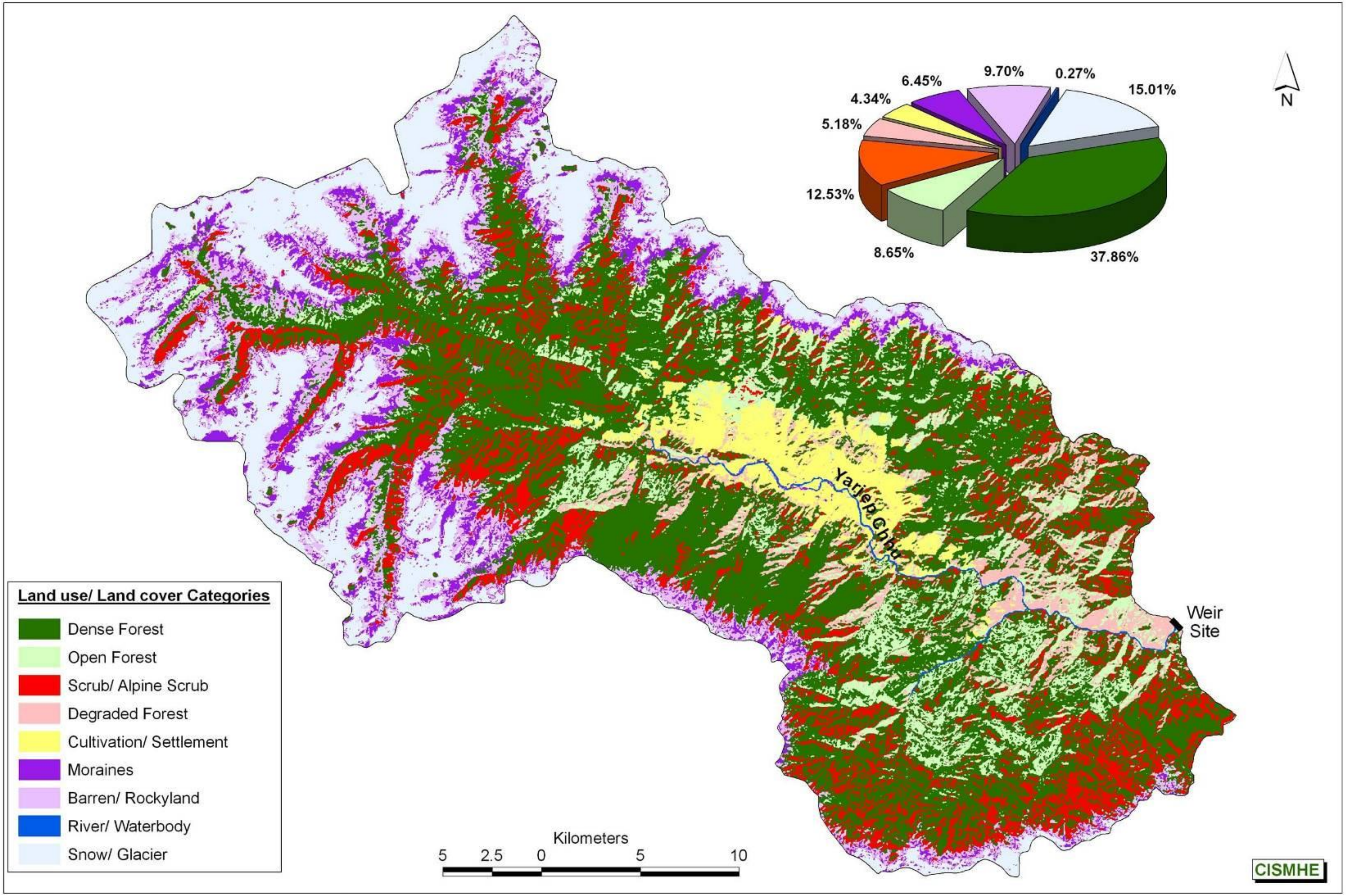

Figure 3: Land use & cover map of the catchment area of Tato-I H.E. project up to the proposed weir site

5.2. Fluids Environment

5.2.1. Air Quality & Noise Pollution

The main sources of outdoor air pollution in the project area may be road construction activities (excavation, paving etc…), vehicular movement and Jhum fires while burning of fuel woods is the only source of indoor air pollution. SPM levels varied in the range 83.61 to 311.00 µg/m3. RSPM varied in the range of 13.75 to 137.61 µg/m3 and SO2 and NOx are below detection limits. These values are well within the National Ambient Air Quality Standards (NAASQ).

Except the gurgling sounds of river, there is no other unwarranted sound in the project sites. The baseline data of air environment, detailed in the study, would be useful in preparing the mitigation measures of air quality during the construction phase. All parameters are anticipated to increase significantly during the construction phase.

5.2.2. Water Quality

Stream flow, which is strongly correlated to many critical physicochemical characteristics of rivers, such as water temperature, channel geomorphology, and habitat diversity, can be considered a "master variable" that limits the distribution and abundance of river species and regulates the ecological integrity of flowing water systems. The study of the water quality in Yarjep (Shi)stretch from Mechuka to downstream Tato in West Siang district of Arunachal Pradesh was conducted in three seasons, Winter season (February, 2009), Pre- monsoon (May, 2009) and Monsoon (August, 2009). Sampling was done at following three sites W1 (upstream of proposed intake site), W2 (proposed intake site) and W3 (proposed power house site). The profile of the water quality is presented in the report.

5.2.3. Hydro-Meteorology

The average monthly rainfall data for rain Gauge stations in the catchment area ranged between 186 to 908 mm/month during the monsoon and between 16 and 140 mm in December. Maximum rainfall is recorded during July particularly below 1500 m elevation. Precise figures are given in the study for Mechuka, Monigong, Raying, Kaying, Along and Tato R&G stations.

The optimization studies for the Tato-I H.E Project have been conducted on the basis of the 10 daily discharge data for 25 years. The average discharge in Yarjep (Shi) River during the monsoon months (June to September) varies from 151 to 228 cumec at intake site respectively, while the minimum and maximum are respectively 75 and 482 cumec during this period.

5.3. Biological Environment

The region of Arunachal Pradesh is located at the boundary of Indo-china and Indo-Malayan bio-geographic region and is one of the richest areas in habitat and species diversity. The state has wide variation in altitude, topography and climatic conditions, which result in a rich floral and faunal diversity.

5.3.1. Floristic and Forest Types

The forest of Arunachal Pradesh falls under five major categories of vegetation: tropical, sub-tropical, temperate broad-leaved and temperate coniferous, sub-alpine and alpine forests. All these types are represented in the study area of the Tato-I H.E. Project, and the EIA gives an exhaustive list of the floral species within each category.

Complementary studies on site have been conducted in order to quantify the density of natural organisms living in the areas of Tato-I project. The study focuses on communities, which are assemblages of organisms living in a particular area or aggregations of organisms which form a distinct ecological unit.

The present ecological study in the project area of Tato-I HE Project was undertaken with the objectives of preparing a checklist of flora in locations where project components are proposed and its adjoining areas (listing of rare/endangered, economically important and medicinal plant species; determination of frequency, abundance and density of different vegetation components). A total of 70 species of plants were recorded under the ecological investigation during different sampling seasons. Out of which 26 were trees, 13 shrubs and 31 herbs. The ground vegetation comprised of ephemeral, annual and perennial species of grasses, sedges, legumes and non legume forbs.

5.3.2. Faunal diversity

The study of Tato-I H.E. Project's EIA highlights the zoogeographical distribution, conservation status, endemism of the faunal species in catchment area, influence zone and project area. It also outlines the likely impacts of the proposed project on the faunal elements.

A total of 36 mammals species are expected to inhabit in the catchment area of Tato-I H.E. Project on Yarjep (Shi) River. Out of 36 species 31 are common in the catchment and influence areas, and 10 are assessed for their conservation (6 are 'vulnerable' species, one is 'endangered' and three 'insufficient known') by the Zoological Survey of India, the International Union of Conservation for Nature and the Wildlife Protection Act.

An exhaustive list of the species in the Arunachal Pradesh territory (mammalian fauna, avifauna, herpetofauna, butterflies...) is given in the study, along with their conservation statuses. A local survey has also been carried out in order to determine more precisely the wildlife environment in a short range around Tato-I H.E. structures.

5.3.3. Aqua Flora and Fauna

Biological quality of water flows can be assessed by different kinds of organisms: algae, riparian and aquatic vegetation, invertebrates and fishes (Kelly and Whitton, 1995). As they are part of the overall biodiversity, the study records density and abundance of these bio indicators in order to provide holistic information regarding the water biological quality of Yarjep Chu and its tributaries.

Yarjep (Shi) river is one of the main tributaries of Siyom River in middle stretch, which regroups 12 different species of fish according to a survey by Sen in 2006. However, Yarjep is not considered as rich as Siyom in fish resource. The inhabitants have little fishing activities as very low capture and disorganized fishing occur in the region. Specie *Schizothorax Richardsonii* is predominant in Yarjep (Shi) River, and most fishing depends on it. None of the species inhabiting Yarjep (Shi) River and tributaries is endemic to Siyom river system.

5.4. Socio Cultural & Economic Environment

Socio-cultural and economic statement in an EIA report essentially covers the demography, education, occupation, history, culture, ethnography, and lifestyle of the inhabitants which are directly and indirectly affected by the Tato-I H.E. project activities.

The district headquarter of West Siang is located at Aalo. According to Census (2001) the total population of West Siang district is 103,575 with sex ratio of 912 (females to 1,000 males). The population density of the district is 12 individuals per sq. km, nearly same as that of the State (13 person/sq km). The scheduled tribe population accounts for 81.7% of the total population in the district. The district recorded a total literacy rate of 59.47%.

Influence area of Tato-I H.E. Project is inhabited by a total of 20 villages in which 10 come under the jurisdiction of Mechuka circle, 4 under Pidi circle and remaining 6 are under Tato circle. Total population of these villages is 2168 belonging to 390 households (Census, 2001). Average sex ratio in these villages is 974, which is better than state average. Scheduled tribe population accounts for 97.6% of the total population of influence area. Average literacy rate in these villages is 45.5%, considerably higher in male population. About 44.5% of the total population is employed in various works. The majority of the main workers are involved in cultivation including jhum. Most of the villages have facilities of tap non treated water, supplied from spring. Mechuka and Tato are the main centres of influence and gather the public facilities such as bank, post office, secondary school and primary health.

Four villages are affected by the various project components. It represents a total population of 493 individualities belonging to 91 households (Census 2001). The intake complex is proposed near Meying and Gapo villages while the power house complex would be located near Heyo village and Tato Village. The affected population is mainly constituted by 'Adi' tribes. The socio-economic and cultural profiles of these villages are given in the EIA report.

A total of 77 households (88 families) are directly affected due to acquisition of land. Total population of these households is 301 persons. All households belong to Schedule Tribe category and 30 families come under the BPL category (Below Poverty Level).

6. Environmental Impacts Assessment

The Environmental Impact Assessment relies on 4 steps: impact identification, impact prediction, impact evaluation and identification of mitigation. Impact identification brings together project characteristics and baseline environmental characteristics with the aim of ensuring that all potentially significant environmental impacts (adverse or favorable) are identified and taken into account. Quantitative predictions have been set as priority in order to take the most precise measures. The identification and prediction of likely impacts are the starting points which lead to identification of monitoring requirements and mitigating measures.

6.1. Impact Identification

Impacts study for the Tato-I H.E. Project has been divided into 4 environments:

- Terrestrial, which group geophysical matters and land ecosystem preservation.
- Aquatic, including water quality and aquatic biodiversity.
- Atmospheric, for air quality and noise pollution issues.
- Human, focusing on sociologic and economic impacts.

For each domain, impact study is levelled on every step of the project development: pre-construction, construction and exploitation.

6.2. Prediction of Impacts

The major impacts anticipated on land environment during construction phase are acquisition of land, quarrying operations, excavation of construction material, operation of constructing equipment, soil erosion, muck disposal and construction of roads. About 47.7 ha of surface land, mainly covered with open or dense forest would be changed into the degraded areas due to these activities. In order to clear the construction sites, trees would be removed from the area. The project envisages a weir construction, therefore, the total submergence is only 3 ha including river area. Thus, no major impact on the land use/land cover is anticipated. Some of the negative impacts are local and temporary, as they are expected to last mainly during the construction phase. The long term major impact on land would be the submergence area (3 ha including river bed) and the place dedicated to project components, mainly intake and power house.

Both sides of the Yarjep (Shi) River, downstream and upstream of the plant will be impacted. The diversion of river water from main channel is foreseen to trigger the habitat loss, changes in species composition, water quality, fish and fisheries. The change in the flow regime may have many environmental consequences. About 4.9 km river stretch would undergo through scarcity of water. Though few tributaries join Yarjep (Shi) River downstream on left bank, adverse impact cannot be denied.

Civil works during construction will inevitably downgrade air quality levels, such as average concentration of SPM, carbon dioxide and monoxide etc, would have impacts on the health of neighbouring environments during construction phase only. Noise pollution would be substantially increased. The activities of the construction phase would disturb the human population as well as wildlife. Such impacts would remain for short time during construction phase only. The impacts are temporary and reversible in nature.

Fish and fisheries would be impacted in various ways. During the construction phase, no significant changes in the species composition and habitat changes are anticipated. But in operation phase it would occur considerably due to the diversion of water from main river channel.

A total of around 1200 persons including the family members of workers are expected to enter the area of the project works,. During the construction phase the outsiders would account for more than 50% of the total population of influence area. Change in the demography may trigger the cultural tension between natives and outsiders. Also, there are fair possibilities of overexploitation of fuel wood, poaching, animal hunting and river pollution.

The area is dominated by 'Adi' tribes and its sub-tribes. These tribes are unique in their culture, customs and their traditions. The high number of migrant population of different culture may bring the anxiety among the tribe, which may result in the confliction during the construction phase.

Sometimes a temporary and numerous outsider population is associated with social unrest in a context of confliction. The natives may be affected to some extent. In addition, the migrant population could carry of new diseases.

7. Environmental Management Plan

The Environment Management Plan is a document of mitigation measures, which are taken to avoid, minimize, remedy or compensate for the predicted adverse impacts of the project and to take full advantages of the positive effects of the Tato-I project. Each management plan budget is detailed in the report, as it will be integrated in the costs of the overall project.

7.1. Biodiversity Management & Wildlife Conservation Plan

Biodiversity Management Plan will be implemented during operational phase, however, some aspects will be implemented during the construction phase too. The State Forest Department will be implementing the plan, in close relationship with the tribal inhabitants. The main objective of this plan is to conserve the crucial habitats which hold potentially shelters for several keystone species. The major activities under this plan are distribution of artificial trophies, incentive for the submission of guns, germplasm bank and seed centre, wildlife conservation and forest protection plan and strict safeguards measures. The total cost estimated for this plan would be would be **Rs. 141.00 Lakhs**.

7.2. Fuel Wood Energy Management & Conservation

In order to sustainably maintain wood resources and avoid over exploitation, the EMP suggests setting up Liquefied Petroleum Gas (LPG) depots, Kerosene depots and Community Kitchens in the project area. In addition locals would be encouraged to use solar cookers, pressure cookers and smokeless chullahs. Shared resources may be managed with the upstream project of Heo to ease the furniture of Kerosene and LPG, and to limit the number of storage tanks. The allocated budget for this plan would be **Rs 54.80 lakhs.**

7.3. Waste Management Plan

As it is essential to collect, treat and dispose of all types of wastes generated by native and immigrant populations on site, a proper waste management plan has been set up for Tato-I H.E. Project. This plan includes management of solid and liquid waste except muck. Based on several assumptions, the peak migrant population in the project area would be around 1 200 persons, producing a total amount of solid waste of around 200 tons per annum. Therefore septic tanks, community toilets, bathrooms and washing places, two sewage treatment plants, incinerators, dumpers and wheel barrows, and water and toilet facilities will be installed in the project colony and the estimated cost would be **Rs 224.30 lakhs.**

7.4. Management of Air & Water Quality and Noise Level

The main reason for the management of the quality of the aquatic, air and noise environments is to maintain the observed water and air quality properly within desirable limit. This section regroups additional measures for air and water quality which are not part of other environment managing plans. The report recommends the use of quality levels monitoring devices and first protection equipments such as dust masks. It also establishes a list of works habits that helps keeping pollution at acceptable levels. A special responsibility of sustainable work control would be given to a site officer. Overall budget should not exceed **Rs 36 lakhs**.

7.5. Catchment Area Treatment Plan

Catchment area treatment plan will be implemented during the construction phase and operational phase. The objective of this plan is to reduce and minimize soil erosion in the free draining area. Several engineering methods as well as biological measures will be adopted, especially the use of check dams that will rectify slopes while supporting vegetation growth. The total free draining area is about 7400 ha, and 2051 ha are concerned with severe to very severe erosion. The total surface to be treated would be around 579 ha. The State Forest Department will be in charge of the activities and the total budget estimated for this plan would be **Rs 305.85 lakhs**.

7.6. Public Health Delivery System

The main objective of the public health delivery system in Tato-I H.E. Project is not only to provide the medical facilities to project workers and staff but also to deliver effective and sustained health care to the project affected families and the local people of the region. The proposed Tato-I H.E. project is located in a remote area of Arunachal Pradesh, where existing medical facilities are in bad condition, insufficient and highly inadequate. The developer of the Tato-I H.E Project would participate in developing and strengthening the public health management by establishing new Hospital in the affected zone, opening up veterinary centre and immunization centres in the villages and labourer camps, providing services for pre-/ post-natal check up etc. Overall budget is expected to be **Rs. 337.36 lakhs**.

7.7. Fishery Development & Downstream Management plan

The main objective of the proposed plan is to conserve the native species and to improve the fisheries in the area. The plan includes training for fish farming and financial assistance for fish farms.

The downstream management plan aims at regulating the environmental flow along the downstream stretch of the reservoir. Besides, other mitigation measures related to river ecosystem were also suggested in various sections like Fishery Development, Waste Management and Environmental monitoring. The three major component of this plan are maintenance of river flow level, channelization of river stretch and maintenance of pools and tributaries.

Both plans of artificial fishery and managing downstream flows will be implemented during the operational phase and the dedicated budget is estimated to be **Rs. 70 Lakhs**.

7.8. Muck Disposal Plan

Muck would be excavated from the HRTs during the tunneling, construction of power house complex, approach roads etc. Even though some of the muck will be utilized for back filling, yet a large quantity of the excavated material will need to be relocated and dumped in such a manner that it does not impose any negative impact on terrestrial and aquatic environment.

The total amount of muck to be generated from the different project related activities would be estimated to 7,38,020 m^3. Afterwards, considering the swelling factor (10 to 20%) the total amount of muck generated would swell to 8,80,387 m^3, that would be rehabilitated in the muck disposal areas.

All the proposed dumping areas are susceptible to soil erosion, if not managed properly. Beside the loose soils are also prone to wind erosion and it would possibly blow in the air and may increase the concentration of suspended particulate matters in the air. Therefore to avoid and minimize such environmental impacts, engineering as well as biological measures have been adopted. The compaction of loose soil and construction of retaining wall are important engineering measures. Biological measures include plantation with geo textiles technology onto dumping slopes.

The total financial outlay for the relocation of muck and rehabilitation of dumping sites including engineering and biological measures would be **Rs. 148 lakhs** only.

7.9. Green Belt Development Plan

The green canopy has the inherent capacity to absorb pollution, increase water retention by soil and decrease sediment transport. In order to reduce different kind of pollutions and avoid land slips from the portion of catchment draining directly into the small pond, the green belt in and around the project areas is an obvious choice. Thus a green belt would provide the stability to immediate vicinity of the small pond and will contribute to the aesthetic and beautification of the project area. For the Tato-I H.E. Project, the areas to be treated are the areas around the intake and power house sites. Road side plantation is also included in this plan. All engineering measures will be developed during the first 18 months whereas plantation and maintenance will be carried out between 18-36 months from the date of inception of the project. The budget is expected to be around **Rs. 17.27 lakhs**.

7.10. Restoration of Construction Areas and Landscaping

Around 47.7 ha of land will be directly disturbed due to various construction activities of the proposed project, like access roads, muck dumping sites, quarry sites, colonies, offices, etc. Therefore, all areas disturbed by construction activity including access roads will be landscaped to reflect natural contours, suitable drainage paths will be restored and the reestablishment of vegetation will be encouraged. For this purpose, many biological methods would be employed, such as the removal of top nutritive soil before excavation for re implantation, and construction of retaining wall. Overall restoration project would cost approximately **Rs. 84.57 lakhs**.

7.11. Disaster Management Plan

Disaster management plan is prepared in case of worst case scenario that could occur under the Tato-I H.E. plant operation, a weir break flood situation. In order to prevent the loss of lives and property and to mitigate the negative impacts as a result of weir break a detailed Disaster Management Plan is proposed. This approach includes preventive measure, mitigation, preparedness, response, recovery and rehabilitation. An effective weir safety surveillance, monitoring and observation along with periodic inspection, safety reviews and evaluation must be put in place. A centralized siren alert system would be installed at all downstream flood prone effected village Panchayats. All the villages falling under the flood-prone zone or on the margins are required to be connected through wireless system backed by stand-by telephone lines.

In order to prevent the loss of lives and property and to mitigate the negative impacts as a result of dam break a detailed Disaster Management Plan is proposed. The package includes the cost of property lose, sustenance grant, livelihood grant, medical grant and rights and privilege grant on forest resources.

The total budget layout plan for disaster management is estimated to be **Rs 143 lakhs**, considering the low height of Tato-I weir. .

7.12. Rehabilitation & Resettlement Plan

The proposed R & R plan for the affected persons or families of Tato I project follows the guidelines of Rehabilitation and Resettlement policy of Government of Arunachal Pradesh (2008). The Rehabilitation and Resettlement Plan is framed out to minimize the negative impacts of the project, to provide relief measures and benefits to project affected families or persons, to compensate the loss of livelihood of people if any, to consider all cultural, traditional and social aspects and to furnish infrastructure development in the project area. The proposed plan for Tato I H.E. project has been formulated considering the cascade development. There are two other projects upstream which will be owned by the same agency. Therefore, any repetition in the implementation of R & R plan has been avoided.

Rehabilitation plan is based on the study of the socio economic profile of the neighboring population, and one of its purposes is to develop different skills and education. Relief and rehabilitation package for the affected families includes family grants, livelihood grant, schedule tribe grant, BPL family grant, pension for vulnerable persons and free electricity grant. A compensation for the loss on customary rights on Unclassified State Forest is also planned. Peripheral Development Plan is proposed to improve the quality life of the local inhabitants and infrastructure in the area. The provisions of the plan are education facilities, merit scholarship programme, communication facilities, Training on various courses for income generation, transportation facilities, construction of rain shelters and footpath, provision of sanitation facilities, adoption of a village and skill upgradation for handicrafts.

Total budget for the Rehabilitation and Resettlement Plan and Peripheral Development Plan would be about **Rs. 1207.12 Lakhs**

7.13. Good Practice

The good practice is a set of safeguard and precautionary measures, which do not require detailed management plan and high financial outlay but are decisive to keep sustainable ecological and social environments. As well, the good practice is a way to maintain respectful relationship between project authorities and local inhabitants. The project authorities would establish their Environment Cell and Corporate Social Responsibility cell which will execute and monitor all the good practices. A **Rs 25 Lakhs** budget is allocated to Good practice implementation.

7.14. Implementation & Monitoring program

Various plans and mitigation measures have been suggested in the EMP report to reduce the adverse impacts of proposed project on the environment and biodiversity of the area as well as socio-economic development of the region. The given plans will be executed by various agencies and departments of government of Arunachal Pradesh as well as project authorities. However, it would require a proper coordination among these agencies for smooth functioning. For this reason, two committees are suggested for the monitoring and evaluation i.e. the independent committee and project level committee. The committee will arrange the meetings between various sub committees and independent committee. Various environmental variables like water, noise, air, etc are critical and would require a regular monitoring. In addition, various other agencies are involved in the monitoring and evaluation of some mitigation measures. Running these groups and giving them the necessary means to monitor the EMP would cost **Rs 60 lakhs.**

7.15. Summary of Costs

S.No.	Plans	Amount (Rs in Lakhs)
1	Catchment Area Treatment Plan	305.85
2	Biodiversity Management and Wildlife Conservation Plan	141
3	Muck Disposal Plan	148
4	Restoration of Construction Areas and Landscaping	84,57
5	Green Belt Development Plan	17.27
6	Fishery Development and Downstream Management Plan	70
7	Public Health Delivery System	337.36
8	Waste Management Plan	224.3
9	Fuel Wood Energy Management and Conservation	54.80
10	Management of Air & Water Quality and Noise Level	36
11	Rehabilitation and Resettlement Plan	120712
12	Disaster Management Plan	143
13	Good Practice	25
14	Implementation & Monitoring Programme	60
	TOTAL	**2854. 27**

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DRAFT FINAL REPORT
JUNE, 2012

ENVIRONMENTAL IMPACT ASSESSMENT OF TATO-I HYDROELECTRIC PROJECT, Arunachal Pradesh

Volume-I
Baseline Data

Prepared for:
Siyota Hydro Power Pvt. Ltd., New Delhi

CENTRE FOR INTER-DISCIPLINARY STUDIES OF MOUNTAIN & HILL ENVIRONMENT
University of Delhi, Delhi

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Chapter 1

INTRODUCTION

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INTRODUCTION

1.1 GENERAL

Tato-I Hydroelectric Project is the most downstream project of a cascade of three projects developed by Velcan Energy Group across Mechuka and Tato circles. It is a run of the river scheme proposed on Yarjep (Shi) River near Tato and Heyo villages in West Siang district of Arunachal Pradesh (near the confluence of Yarjep (Shi) and Siyom rivers). The HEP will have an installed capacity of 186 MW of power potential by utilizing a gross head of 164m. It is immediately downstream of the Heo Hydroelectric Project and largely utilizes its discharged water (130.2 cumecs) along with additional discharge (2.8 cumecs) accumulated by the Yarjep (Shi) tributaries between Heo Dam and Power House.

Tato I project is directly connected to the outlet of Heo HEP project and is fed through a bypass valve provided aside of the Heo HEP turbines. The additional flow used to reach the design discharge of Tato I is tapped from the river banks into a transverse water intake. The water is then routed through an 1100 m long channel along the terrace of Meying village area. At the end of the channel, the flow is fed into a pressurized tunnel. The head race tunnels runs on 3.9 km up to the terminal part of the scheme. The flow is then routed to the turbines through a pressure shaft. All components of the project are situated on the left bank of the Yarjep (Shi) River with nearly 3.9 kilometers long head race tunnel followed by an open to sky surge shaft and a surface power house near Heyo village (opposite to Tato village). It is situated along side of the road connecting Aalo and Mechuka.

1.2 YARJEP (SHI) RIVER BASIN

The Tato-I HE project is proposed to harness the power potential of the Yarjep (Shi) River, which is a major tributary of River Siyom, forming a part of the Brahmaputra River system. Yarjep (Shi) River is a snow and lake fed River. In the upper stretch before confluence of Sae nallah it is known as Yargyap River. Downstream of this confluence it flows as Siet River and further downstream it is called as Yarjep (Shi) . After the confluence of Phipir Korong it flows as Shi Chhu and finally joins Siyom River on right bank at El 960 m. With many streams joining it on either of its banks, this is a well developed subsystem within the Siyom river system. In the Tibetan part of its catchment, in its headwater region, from northeast to southwest and southwest to northeast flowing streams feed the southeastward flowing Yarjep (Shi). These streams are snow and lake fed and flow in the altitudinal zone between 4000 to 4430 m. About 2 km downstream of this confluence another stream, flowing from a lake lying above 3400 m, drains into the Yarjep (Shi) on its right bank. Another lake fed stream flowing on the northern slope of 4418 m peak confluences with Yarjep (Shi) at 2440 m on its right bank. Further downstream, a stream flowing southward from 5003 m peak (the highest elevation in the catchment) and draining thick forest region confluences with Yarjep (Shi) on its left bank at 2320 m. This small stream is also fed by four lakes on its left bank, which lie above 4000 m. In the middle stretch, Yargyap Chhu runs from WNW to ESE and a number of tributary streams flowing from north to south and south to north join this river in the Indian part of the catchment.

The catchment area of the proposed schemes lies between Longitude 93°45’E to 94°20’E and Latitude 28°25’N to 28°50’N. The Tato-I catchment area up to the intake site is 1154 Sq.Km and the drainage network of the catchment area of Yarjep (Shi) exhibits a dendrite pattern. The river is called as Barpu Sikyo in the head water region of the catchment. Barpu Sikyo is joined by large numbers of the snow fed, spring fed, glacial fed and seasonal rivers. These streams flow in the elevational region between 4000 to 4430 m. The headwater region of the Yarjep (Shi) River is snowfed and springfed stream and its headwater region is covered with thick forests. It originates from the region above 4000 m. The gradient of main river channel of Yarjep (Shi) Chhu is 1: 22.65. Moderately steep class is prevalently spread in the catchment with 56% of the catchment area. The elevation bands from 2000-4000 m covers 82% of the total catchment area and the NW-N-NE facet is spread over an area of 289.89 Sq.Km i.e., 24.7 % of the catchment area. Open forest and dense forest are more commonly spread on the slopes of the catchment area.

1.3 PROJECT CONTEXT

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

The power from hydro projects in the North Eastern region would be in excess of the demand in the region and would have to be exported for utilization in other regions of the country through the Siliguri corridor. Presently there is no problem in the availability of transmission systems beyond the Northeastern power region for dispersal of power as the five power regions of the country are in the process of greater integration within a national grid.

1.3.1 Policy Initiatives

Several policy initiatives have been taken in the power sector, viz., 100% FDI in generation, transmission and distribution, long-term power purchase and fuel supply agreements, mandatory International Competitive Bidding (ICB), R&M schemes costing up to Rs. 500 crores are not required to be submitted for the concurrence of the Central Electricity Authority (CEA) etc.

The new Hydel Policy announced an objective of making investment more attractive hydro projects. Tariff dispensation and innovative financing mechanisms are expected to minimize the risks associated with hydro projects. The key GoI policy statements that guide hydropower development are National Policy for Hydropower Development and the 50,000 MW Hydroelectric Initiative (2003). The later sets a long term target for hydroelectric power to meet 40% national generation mix, and medium term target as 28.63% of generation mix by the end of the 10th five year Plan (the starting point being 25% in 2003. The policy statements describe the policy objectives of hydropower development as: (i) environmental benefits, in particular avoidance of pollution and emissions from thermal plant (ii) benefits for power system operation, especially for meeting peak demand (iii) energy security - reducing exposure to fuel price and supply risks. The policy statements also propose several policy actions to promote hydropower. A key feature of these policy statements is the concept of planning for the development of a 'shelf' (portfolio) of hydroelectric projects. India had adopted a portfolio approach to project development given (i) the scale of projected demand increases relative to individual project size (ii) the benefits of having a portfolio of projects in terms of diversifying project development and timing risks.

1.3.2 Initial Ranking

The CEA study on “Preliminary Ranking Study of Hydro Electric Schemes” identified potential hydroelectric sites at various river basins, which are prioritized in the order of their attractiveness for implementation. With the objective of expediting hydro power development in a systematic manner, Central Electricity Authority (CEA) completed the ranking study of the hydro potential sites for all the basins in the country during 2001-02 .The ranking of hydro sites has been carried out based on a weightage criteria for various aspects involved in the development of hydro schemes. Considering these aspects, the schemes have been graded in A, B and C categories in order of their priority development. Based on the Preliminary Ranking Study, 399 schemes with an aggregate installed capacity of about 106910 MW have been prioritized in the six major river systems of the country. Out of this, 98 schemes with probable installed capacity of 15641 MW fall under A category, 247 schemes with probable installed capacity of 69853 MW under B category and 54 schemes with probable installed capacity of 21416 MW under C category.

1.4 POWER POTENTIAL

1.4.1 Power Potential in India

India is endowed with a vast hydropower potential. As per the latest assessment carried out by the CEA, feasible hydro potential in India has been estimated as about 148700 MW which corresponds to a potential of about 84000 MW at 60% load factor, which can yield an annual power generation of over 440 TWh of electricity, and with additional seasonal energy, the total energy potential is about 600 TWh a year. Only 22.34% of this potential is under operation and 8.64% of the potential is under execution. Thus the bulk of the potential amounting to 69.01% is yet to be developed.

About 75% of the potential of the country comes from the Himalayan river systems (the Indus, the Ganga and the Brahmaputra) of that 39.6% is located in the North-Eastern region and 35.9% in the Northern region. The hydro potential of the NE region is approx. 32,000MW at 60% load factor, which is almost 95% of the Brahmaputra basin potential (Table 1.1).

Table 1.1 Status of Development of Hydro Power Potential (source As on 28/02/2009)

Sl. No.	Region	Feasible Potential/Projects identified	Potential already developed	Potential under development	Total Potential development	Potential yet to be developed

		MW	MW	%	MW	%	MW	%	MW	%
1	Northern	53395	13772	25.79	6734	12.61	20506	38.40	32889	61.60
2	Western	8928	5804	65.01	400	4.48	6204	69.49	2724	30.51
3	Southern	16458	9395	57.08	786	4.78	10181	61.86	6277	38.14
4	Eastern	10949	3049	27.85	2211	20.19	5260	48.04	5688	51.96
5	North-East	58971	1203	2.04	2724	4.62	3927	6.66	55044	93.34
Total(India)		148,701	33223	22.34	12855	8.64	46078	30.99	102622	69.01

1.4.2 Need of Hydro-power

About 75% of India's total installed capacity is thermal-based (Table 1.2). However expansion of this energy source is encountering difficulties because of the burden it places on the infrastructure for supply (mines) and transportation (railways) of coal. Considering that the capacity of Indian Railways to carry coal effectively is limited and the coal is of low quality which needs costly transportation over long distances, it appears logical to develop thermal projects in specific areas, e.g. coal- rich areas in Bihar, Orissa, Eastern Uttar Pradesh and surrounding areas, and gas-based power near the port belts of Gujarat and Maharashtra, and thus place total emphasis on hydropower in States such as Himachal Pradesh, Punjab, Haryana, Western Uttaranchal and far-East India - the Himalayan belt.

Table 1.2 Share of Hydropower in India's Installed Capacity (Source - Year)

Year	Total Installed Capacity (MW)	Hydropower Capacity (MW)	Share of Hydropower (%)
1962-63	5801	2936	50.6
1969-70	14102	6135	43.5
1979-80	28448	11384	40.0
1989-90	63636	18308	28.8
1991-92	69070	19189	27.8
1993-94	76718	20366	26.6
2001-02	105045	26268	25.0

Year	Total Installed Capacity (MW)	Hydropower Capacity (MW)	Share of Hydropower (%)
2006-07	135299	33776	25.0
2008-09	147965	36878	24.92
2009-10	159398	36878	23.14
2010-11	169798	37367	22.00

The declining share of hydropower also strongly advocates development of hydropower projects.

1.4.3 Power Potential in Arunachal Pradesh

Arunachal Pradesh along with the States of Assam, Meghalaya, Tripura, Manipur, Nagaland and Mizoram form part of the Brahmaputra Basin. This basin comprises four major rivers, viz., Siang, Subansiri, Lohit and Dibang. During 2001 to give fill up to the efforts for the development of hydropower potential, CEA under took 'Preliminary ranking studies of 'yet to be developed sites'. The study analyzed about 399 sites out of 845 identified sites to determine the priority for development of schemes identified in the re-assessment studies. This was followed by "50,000 MW hydro electric initiative" launched by Hon'ble Prime Minister of India. Under this initiative, preliminary feasibility reports (PFR) of 162 hydro sites were prepared. Out of 162, seventy two (72) projects were identified in North eastern region itself with total installed capacity of 31925 MW. The State wise distribution of the main schemes in NE region is as under:

- Arunachal Pradesh : 42 schemes (27293 MW)
- Meghalaya : 11 schemes (931 MW)
- Nagaland : 3 schemes (370 MW)
- Mizoram : 2 schemes (1500 MW)
- Sikkim : 10 Schemes (1469 MW)

1.4.4 Hydro Electric Potential of Siang Basin

As per the study on "Re-assessment of Hydro Electric Potential" carried out by CEA during 1978-87, Siang river system has a probable hydropower potential of about 10730 MW from 16 identified schemes at 60% load factor. These schemes are run of river and storage types. Initial survey and investigation works were taken up at Siang Upper/Intermediate (11000 MW), Siyom (1000 MW) and Siang Lower (2000 MW) by NHPC.

In addition to the above, other schemes have been identified by the Central Electricity Authority, the Government of Arunachal Pradesh or IPPs, including the following…

- Ringong HE Project 150 MW
- Tato-II HE Project 700 MW
- Naying HE Project 1000 MW
- Mirang HE Project 141 MW
- Hirong HE Project 500 MW
- Simang HE Project 90 MW
- Pauk H.E. Project 145 MW
- Heo H.E. Project 240 MW
- Tato-I H.E. Project 186 MW

1.5 POLICY, LEGAL & ADMINISTRATIVE FRAMEWORK

It is important, for the proposed project, to identify applicable environmental regulations and legislations of the country which necessitate compliance in respect to its nature, type, scale, area and region of the proposed development.

1.5.1 Policy Framework

The National Environment Policy (NEP) of 2006 is intended to mainstream environmental concerns in all development activities. It is built on earlier policies for environmental management, viz., the National Forest Policy (1988), National Conservation Strategy and Policy Statement on Environment and Development (1992), Policy Statement on Abatement of Pollution (1992) and on some sector policies like National Water Policy (2002), National Agriculture Policy (2000), and National Population Policy (2000). The NEP is intended to be a guide to act in regulatory reforms, programmes and projects for environmental conservation and to review and enactment of legislation, by agencies of the central, state, and local Governments. The dominant theme of this policy is that while conservation of environmental resources is necessary to secure livelihoods and well-being of all, the most secure basis for conservation is to ensure that people dependent on particular resources obtain better livelihoods from the fact of conservation, than from degradation of the resource.

In the course of its development, the Tato I HEP needs to adhere to all relevant policies and guidelines in general and the following, in particular.

i.) National Forest Policy (NFP), 1988

ii.) National Water Policy (NWP), 2002

iii.) National Rehabilitation and Resettlement Policy (NRRP), 2007

iv.) Rehabilitation and Resettlement Policy (RRP), 2008 of GoAP

1.5.2 Legal Framework

The legal environmental framework stems from the national commitment to a clean environment, mandated in the Constitution in Articles 48 A and 51 A (g) and strengthened by judicial interpretation of Article 21. The Ministry of Environment & Forests (MoEF) is the nodal regulatory agency of the Central Government for planning, promotion, co-ordination and overseeing the formulation and implementation of environmental and forest policy, legislations and programmes. Regulatory functions like grant of Environment Clearance (EC), Forest Clearance (FC) are part of the mandate of this agency.

The Environment (Protection) Act, 1986 is the national umbrella legislation that provides a holistic framework for the protection and conservation of environment. The Act, its associated Rules and their subsequent amendments require for obtaining environmental clearances for new or expansion of river valley and hydro-electric projects as addressed under the Environmental Impact Assessment Notification, 2006 and require for submission of an Environmental Impact Assessment (EIA) report as one of the pre-requisites for EC.

The Tato I H.E. project is proposed to be developed by meeting statutory environmental requirements of Arunachal Pradesh as well as the Central Government. The project is to be complied with applicable environmental regulations and guidelines. Some of the Acts, Rules, notifications and standards relevant for this project development are given as under.

i.) Water (Prevention & Control of Pollution) Act, 1974
ii.) Forest (Conservation) Act, 1980 and its amendments
iii.) Air (Prevention and Control of Pollution) Act, 1981
iv.) Environment (Protection) Rules, 1986 and its amendments
v.) Wildlife (Protection) Amendment Act, 2002
vi.) The Biological Diversity Act, 2002
vii.) Forest (Conservation) Rules, 2003 and its amendments
viii.) Noise Pollution (Regulation & Control) Rules, 2003 and its amendments
ix.) EIA Notification, 2006 and its amendments
x.) National Ambient Air Quality Standard, 2009
xi.) Supreme Court's Orders on Diversion Forest Land for Non-Forest Purpose
xii.) IS Codes & CPCB Guidelines for monitoring & analysis of air, water, soil, etc.

1.5.3 Administrative Framework

To ensure environmental and related compliance by project proponents, the administrative framework consists of following entities:

i.) MoEF, GoI and its Regional Establishments
ii.) Central Pollution Control Board (CPCB)
iii.) State Pollution Control Boards or Union Territory Pollution Control Committees
iv.) State Forest Departments
v.) Ministry/Department of Environment in respective States
vi.) Ministry of Tribal Affairs (MoTA)
vii.) Central/State Ground Water Boards (CGWB/SGWB)
viii.) Ministry of Social Justice and Empowerment (MoSJE)
ix.) Ministry of Power (MoP)
x.) Ministry of Water Resources (MoWR)
xi.) Ministry/Department of Water Resources in respective States

1.6 PURPOSE AND SCOPE OF EIA STUDY

Hydro-power is considered as 'green energy' as compared to other projects like thermal power, nuclear power, etc. However, it has some adverse impacts on the environment and social structure. An EIA study is always focused to identify the negative impacts and to ensure that development is sustained with minimal environmental degradation. The purpose of the identification of the negative impacts is to formulate the suitable mitigation measure in order to require the prior environmental clearance (EC) as per EIA Notification, 2006. The EIA is expected to serve one or more of the purposes, viz., (i) decision making during project development, (ii) choosing among various project design alternatives and (iii) integrating environmental cost into the project cost.

The scope of EIA study has been determined through scoping, the second stage of EC process. Hence, the scope of the present study is listed in the Terms of Reference (TOR) accorded by the MoEF during scoping and pre-construction clearance.

Chapter 2

PROJECT DESCRIPTION

2
PROJECT DESCRIPTION

2.1 LOCATION

The project is located (**Fig. 2.1**) in the Tato and Mechuka circles of West Siang district in Arunachal Pradesh. Tato-I is a central village of the area, which is about 140 km from Aalo (or Along), the district headquarters. The intake site near Meying village (opposite to Gapo village) is located between 28^0 32' 32''N latitude and $94^0$18'43''E longitude. Its power house site near Heyo village is located between 28^0 31'53''N latitude and $94^0$21' 31''E longitude.

The Tato-I hydroelectric project site is accessible through a motorable road from Aalo up to Gapo village, at a distance of about 158 km. The nearest road head to the intake site (there is no dam and no barrage) of the project is in Gapo village (right bank), approachable by road at approx. 8 km from Tato village on the way to Mechuka. After Gapo village a *kaccha* footpath of nearly 4 km is followed to access the intake site near Meying village (left bank). To access the power house, motor road on the way from Tato to Lungte village is followed for nearly 5 km, thereafter, a footpath of about 5 km is followed to access the proposed power house of Tato-I H.E. Project. The project site connected to National Highway-52 at Aalo via state road (Tato – Aalo), and is about 295 km from Akajan in Assam. For Tato-I project the nearest meter gauge rail head is at Silapathar (Approx. 296 km) and broad gauge at Naogaon (approx. 697km) in Assam. From the project site, the nearest operational airport is 441 km, located at Likhabali in North Lakhimpur district of Assam and the nearest international airport is 830 km located at Guwahati, the capital city of Assam.

2.2 BACKGROUND OF THE PROJECT

The Tato-I HE Project is one of the 3 schemes located on the Yarjep (Shi) River and entrusted to Velcan Energy Holdings (Dubai) Ltd by the Government of Arunachal Pradesh for implementation of the Project vide MoA signed on 30.06.2007 on BOOT basis for an installed capacity initially estimated at 90 MW as per CEA preliminary rankings studies. The two other projects on the Yarjep (Shi) River are Pauk HEP and Heo HEP. Siyota Hydro Power Pvt. Ltd, a member of Velcan Energy Group, is now the Special Purpose Vehicle dedicated to the development of the Tato-I HEP on B.O.O.T. basis.

A Pre-feasibility Report for Tato-I H.E. project has been prepared and submitted to the State of Arunachal Pradesh in March 2008. Due to interference of upstream Rapum HEP on Pauk HEP, the initial project had to be modified, and a new PFR was submitted accordingly in November 2008. The interference of upstream project has however continued after this second PFR, and was finally cleared by the Government of Arunachal Pradesh on 31st July 2009, through the signature of an amendment to the Memorandum of Agreement. Hence, the final stretch of river available for Project development was finally determined by the Government of Arunachal Pradesh on 31st July 2009, through the signature of such Amendment. In addition, the first two years of Hydrological and Meteorological studies and data collection showed more available water than initially estimated and the installed capacity of the Project was increased to 170 MW accordingly, through the aforesaid Amendment dated 31st July 2009. Following the signature of this Amendment, involving new features, the Tato-I H. E. Project had to be thoroughly designed again in order to arrive at a new PFR which was submitted in November 2009.

Water Availability Studies have been approved by the (Central Electricity Authority (CEA) / Central Water Commission CWC) in July 2010. The Power Potential Studies have been submitted in July 2010 to the CEA, which finally requested the Project developer, in April 2011 to increase again the installed capacity from 170 MW to 186 MW. Hence, the Power Potential Studies have been approved with a capacity of 186 MW.

The Ministry of Environment and Forests, Govt. of India, granted to SHPPL the revised TORs and clearance of preconstruction activities, updated with the new project capacity and features in April 2010 for the first increase and then in October 2011 for the second increase.

VELCAN Group has set-up multiple camps and guest houses in order to conduct the surveys. One guest house is located in Mechuka and the local head office is at Aalo. Locally, VELCAN Group is employing a team depending on site works requirements from time to time. Local tribal population has been integrated to the project development through employment and/or welfare activities. In addition, all the daily / temporary labour contracts have also been awarded to local tribal people, in order to provide support to field investigations and various works depending on requirement.

Since June 2007, SHPPL has performed surveys and investigations for project reconnaissance and then for DPR preparation:

- Hydrological and climatic surveys of the area
- Topographical Surveys
- Geological mapping
- Sub-surface geological investigations
- Environmental surveys for EIA/EMP preparation.

Tato-I H.E Project is proposed to be developed by meeting statutory environmental requirements of Arunachal Pradesh as well as the Central Government. The Ministry of Environment & Forests (MoEF) is the nodal regulatory agency of the Central Government for planning, promotion, co-ordination and overseeing the formulation and implementation of environmental and forest policy, legislations and programs. Given the installed capacity of the Project, regulatory functions like grant of Environment Clearance (EC), Forest Clearance (FC) are part of the mandate of the Ministry of Environment & Forests (MoEF).

2.3 SALIENT FEATURES AFTER SURVEY AND INVESTIGATIONS

The catchment of the proposed project is nearly around 1154 sq. km. The Project lies just downstream of the Heo H.E. Project, which is also allotted to and developed by Velcan Energy Group. The project does not have a dam, but only a small diversion weir to divert the additional water of the river instead. It directly utilizes the desilted water of Heo project in upstream. It is proposed to construct an open box shaped channel of 6 m x 6.6 m in dimension and 1100 m. in length starting from outlet of Heo Power house site before Meying village up to the headrace tunnel portal downstream of the Meying village. This channel will have discharge capacity of 133 cumecs out of which 130.2 cumecs will come from Heo and 2.8 cumecs additional discharge will come from the tributaries of Yarjep (Shi) River which join it between Heo dam and Heo power house. It is followed by a headrace tunnel (HRT) which is 3.9 km long and has 6.4 m diameter in horse shoe shape. The HRT is concrete lined. The HRT passes through a maximum vertical cover of approximately 425 m. It crosses a major intermittent cross drainage named Pirpir Korang Nala where low cover conditions are likely to be expected. The head race tunnel ends up in a circular 14 m dia, 85 m high, open to sky surge shaft. The penstock is 5.75 m dia, roughly 633 m long, steel lined structure. The power house complex, measuring 42 m (L) x 72 m (W) x 37m (H) is located at surface near Heyo village which also falls opposite to Tato village. It will host three units of Francis vertical turbines, 62 MW each to generate 186 MW power at a gross head of 164m. A detail of salient features of Tato-I H.E. Project is given in Table 2.1. Detailed layout plan of Tato-I H.E. Project indicating the location of various project components is given in **Fig. 2.2**.

Table 2.1 Salient features of Tato-I H.E. Project in West Siang district of Arunachal Pradesh

LOCATION	
State	Arunachal Pradesh
District	West Siang
River	Yarjep (Shi)
Geographical Coordinates of Water Intake	
Longitudes	94°18’43’’E
Latitudes	28°32’32’’N
Geographical Coordinates of Power house	
Longitudes	94°21’31’’E
Latitudes	28°31’53’’N
Nearest Airport	Dibrugarh
Nearest Rail Head (Broad gauge)	Nagaon
HYDROLOGY	
Catchment area at the water intake (km^2)	1154
PMF (m^3/s)	4100
SPF (m^3/s)	3400
WATER INTAKE	
Type	Trench weir Intake coupled with Heo PH outlet
Length (m)	55
Max discharge (m^3/s)	10
RESERVOIR	
Full Reservoir Level at the water intake (m)	1195.2
Full Reservoir Level at HRC (m)	1189
Submergence area (ha)	3
WATERWAYS	

HEAD RACE CHANNEL	
Length (m)	1100
Shape & Size	rectangular 6x6.6 m
Design discharge (m3/s)	133
Slope	0.1%
HEAD RACE TUNNEL	
Length (km)	3.9
Diameter (m) & Shape	6.4 Horse shoe, 300mm concrete lined
Design discharge (m^3/s)	133
Head Pond Level (m)	1187.9
SURGE SHAFT	
Type	Vertical Orifice
Diameter (m)	14
Vertical height (m)	85
PRESSURE SHAFT	
Number	1
Diameter (m)	5.75
Length (m)	633
POWER HOUSE	
Type	Surface
Head (m): Gross / Design Net	164 / 153.4
Size of power house L x W x H (m)	42 x 72 x 37
Installed capacity (MW)	186
Type of Turbine	Francis vertical
Number & Capacity (MW)	3 x 62 MW

2.4 ALTERNATIVES

2.4.1 Intake

Regarding the intake site, various locations for weir site have been worked out in the preliminary stages. Two sites have been particularly investigated. The selected site is the most upstream one. The selection of site is mainly based on the geological and economical reasons. In the alternative option located 500 m downstream, a landslide has been identified in the weir site area leading to important excavations and soil consolidation. In the upstream option, geological and geotechnical investigations showed that bed is apparent at the surface on the right and left banks. Moreover, a technical and economical optimisation leads to the selection of the most upstream solution. The submergence is also less, and almost totally confined within the river bed of the river. The upstream option presents quite limited impact on both local activities and environment.

Additionally, the valley at the intake site of upstream option is much narrower than the valley at the downstream option. Thus, topography and geological constraints are favourable to the upstream option. The upstream option is the better one regarding geological, socio-environmental and cost effective issues. Both local topography and geology allow the construction of a concrete weir with overflowing spillway. Construction schedule has been worked out in order to minimize the cost of diversion works. Main structures shall be constructed during lean season, work area being protected from the flows by rock and earthfill cofferdams. In this way, no diversion tunnel is required.

2.4.2 Power House

Regarding the power house site, there is only one option for location of a surface power house due to topographical reason. The power house is located nearby Heyo village area, on the left bank, with no impact on houses and habitation. The head race tunnel is located on the left bank valorising the natural available head between the Meing and Heyo villages. The Head Race Tunnel is crossing various layers of suitable rocks, mainly banded gneisses.

2.5 CONSTRUCTION METHODOLOGY

2.5.1 General

Despite its significant installed capacity, Tato-I project has been conceived in such a manner that its construction will limit the technical risks and planning of execution. Therefore, the diversion structure is a transverse intake weir with a crest, 9.0 m above riverbed. The most strategic and critical part of the work will be tunneling. A horse shoe shaped head race tunnel of 3.9 km in length and 6.4 m diameter is a key point in the planning as well as in the budget. The main construction components are described below.

- Power house on the left bank, as well as 2 smaller elevated platforms for tunnel and surge shaft works

- Intake weir and flush gate near Meying village.
- Tunnel intake at 1192 m. downstreal of Meying village.
- Tunnel Intermediate adit no 1 after 1.5 km of the HRT

Before the commencement of the work, access roads will be built from the existing Tato to Mechuka road. The access roads preparation will be awarded in an advanced stage once all clearances are obtained, so that this preliminary activity will not jeopardize the tunnelling work start date.

2.5.2 Material Sources

a) *Concrete*

20 km upstream of the site, the Mechuka valley is filled with a deep layer of alluvium and sandy material. A quarry site for sand will be developed in the vicinity of the construction sites and the required quantity of sand will be transported from Mechuka to the construction sites. During investigation stages, various quarry sites for coarse aggregates have been identified in the vicinity of the construction sites. Based on direct availability of rock in situ and construction sites proximity, 2 locations have been selected

- Upstream of Heyo village, on the left bank, along the Adit access road
- Downstream Gapo village on the right bank

Crushing plant will be directly located at the construction sites. According to test results (see Geology chapter), aggregates extracted from these quarry sites are suitable for concrete production. Cement has to be brought by road from the closest cement factory (most probably from Assam).

b) *Steel and Equipment*

Due to site specific conditions, almost all equipments and steel parts will have to be brought from remote factories, either in other districts of Arunachal Pradesh or even from other States of India. For heavy equipment delivery, alternative solutions over Brahmaputra River as well as rail transport up to Dibrughar are investigated.

2.5.3 Contract Packages

The entire project is envisaged to comprise the following five main contract packages:

a) PACKAGE-I – Civil works - Head Works including diversion, weir and allied hydro-mechanical works;
b) PACKAGE-II - Civil works - Tunnelling works of the headrace tunnel (HRT) including adit and drainage galleries;
c) PACKAGE–III – Civil works – Powerhouse,
d) PACKAGE–IV - Hydro-mechanical equipment including steel lining supply and erection
e) PACKAGE-V - Hydro-electrical equipment.

Contractors eligibility for each Package mentioned above shall be fixed suitably based on the working experience under similar conditions. The auxiliary works of the river diversion including coffer dams shall be part of the civil works. However, depending on the basic site facilities available such as storage facilities for contractor, site offices, testing laboratory, staff colony, plant and access roads at power house and diversion weir sites, some or all of the related works will have to be taken up by the Contractor departmentally to enhance the pace of work and cost recovered from the contractors. Package-IV and V listed above being equipment packages, they shall be contracted earlier so that by the time civil contractors mobilize site facilities and manpower, minimum equipments are made available for furthering the work on site.

2.5.4 Schedule of Work

As per plan, underground works such as headrace tunnel, adit and the related works would not be hampered by the restricted working season. The intake weir will be built over 2 periods of 5 months each corresponding to lean season, from November 1st to March 31st. First lean season will be used for the flush structure on the right bank that will be used as diversion channel during the second lean season. Second lean season will cater to construction of the weir itself and intake gallery. The peak workforce is expected to reach up to around 340 people during the construction period.

2.5.5 Construction Activities

Following construction activities for various components of the H.E.Project are described herein:

2.5.5.1 *Diversion of river – flush gate and intake structure*

Construction activities for structures located on the left and right banks are highly impacted by the water level seasonal variation. Therefore, the work sequence shows 4 phases, each of which corresponding to either lean or monsoon time.

Phase 1**:** Diversion structure is proposed to be built during the first lean season. The construction site will be isolated from the river through a lateral coffer dam built out of suitable fill material excavated from the tunnel. First step will consist in an overall cleaning of the area, which includes tree and spoil removal. Excavation methodology and plant for flush structure depend on geological specificities of the existing material. Soft and weathered material will be excavated down to sound rock level with hydraulic excavators and loaded on trucks to be stockpiled for later *in-situ* re-use, either in coffer dams or working platforms, or as concrete aggregates after crushing and screening. Excavation in hard rock will involve drill and blast process in 3 to 4 m high benches. After spoil evacuation, each bench is stabilized with appropriate shotcrete and rock bolts pattern and steel mesh layer as per design by appointed geologist, before carrying on to the next bench down to bottom level. A pass will then be built and left fully opened in order to serve as diversion channel in the second construction period. It consists in two reinforced concrete lateral walls (90m and 120m long) that will be erected in 2 to 3m high lifts up to 1202 m. or top level if possible.

Phase 2**:** The lateral coffer dam may be removed in the monsoon time so that the occasional flood will be routed with maximum section available. Meanwhile, if necessary, both walls are to be completed up to top level.

Phase 3: During the second lean season, the site will be isolated from the river course through a large cofferdam of about 12,000 m^3. Water flow will be diverted through flush gate walls. Excavation in riverbed shall go down to 2 m below existing ground level. Grouting in riverbed – if revealed necessary - will then be performed. The main weir consists in a 9.0 m high concrete structure, followed by a gated concrete gallery on the left bank that conveys water from HEO PH tail race basin. A 120m long retaining wall protecting it from the river will be erected at the same time and backfilled after concrete works completion.

Phase 4: Once the main weir is completed, the cofferdam is removed and spoil evacuated to Meying platform. As water is diverted back to its natural bed, the pass on the right bank may be converted into a flush gate. To allow work in this area, a concrete stop log will be erected in the upstream part. Secondary concrete will be cast to reduce section and accommodate embedded parts. Packages IV and V contractor will be able to proceed with equipment installation such as gates, trashracks, gantry crane and start testing and commissioning process for this part of the project.

2.5.5.2 *Head Race Channel*

Water from Heo tail race is discharged into a reinforced concrete channel that follows the course of the Yarjep (Shi) River. Foundation level ranges from 1100 to 1200 m. Excavation works will start from Heo PH Side, where hard rock may be encountered. It will involve drill and blast process as well as slope stabilization with appropriate rock bolts, steel mesh and shotcrete. However, the rest of the channel is mostly founded on medium hard material that will be excavated with hydraulic excavators. A service road runs on the side of the channel, so that the global width of the excavation is about 10m.

Concrete structure will be cast in 12 m long bays: A 75 cm thick raft slab will be cast on compacted soil with kickers for the walls. After stripping, walls will then be cast independently with conventional 2 face shutters. All construction joints have to be treated with PVC Water stop joints. Overall progression rate is reckoned to be 1 bay per week, which corresponds to 150m^3 of concrete. Two Nallahs cross the channel layout. Plan is to locally cover the channel with a roof slab with guide walls on top. After backfilling, the water from the tributary will overflow on top of the channel to reach the Yarjep (Shi) River. These two structures have to be built during the lean season to facilitate works.

Right before crossing the last Nallah, the channel is fitted with a 60 m long crest spillway that allows excessive water to overflow into a side channel if needed. This side channel conveys water into the river through a ski-jump. On the last 50 m, the channel deepens to form a head pond that feeds water into the head race tunnel intake structure. For access reasons, the concrete intake structure has to be built only after tunnelling works completion on section A.

2.5.5.3 *Tunnelling*

The HRT is horizontal with a horse shoe shape section having 6.4 m finished inner diameter and an overall length of about 3.9 km. For sequencing purposes, it is divided into 3 sections referred to as Section A, B and C going downstream. Tunnelling works will start with the construction of one adit with the same section that will provide access and start point for further excavation activities.

A 206 m long intermediate adit starts from a platform located at the fist third of HRT length. It lays perpendicular to the Head Race Tunnel and joins it at about 1500 m downstream of intake site. This is the meeting point of section A and B. A 124 m long intermediate adit starts from a platform located at the second third of HRT length. It lays perpendicular to the Head Race Tunnel and joins it at about 2500 m downstream of intake site. This is the meeting point of section B and C. A 124 m long downstream gallery starts from a platform located above PH site at 1150 m.

Three excavation fronts will be operating simultaneously to minimize work duration. Section A and C will be excavated from and tunnel beginning and tunnel end, whereas section B works will be carried out from downstream intermediate adit only. Chosen boring technology is conventional "drill and blast" method using two or three boom jumbos, excavators, loaders and dumpers. As per international standards, vault reinforcement solution shall depend on geological conditions and progress rate will be affected consequently:

<u>Rock class II</u>: 50 mm of shotcrete and 4 anchors (dia 25 mm, 2.5 m long, 1.5 m spacing) in crown
<u>Rock class III</u>: 100 mm of shotcrete and 9 anchors (dia 25 mm, 2.5m long, 1.5 m spacing) in crown and walls
<u>Rock class IV</u>: 150 mm of shotcrete and 9 anchors (dia 25 mm, 2.5 m long, 1.5 m spacing) in crown and walls

Owing to preliminary geological survey, most part of the encountered material consists in quartzite and banded gneiss, 75 to 80% of which is supposed to be class II rock. Although it is not necessary from a structural point of view, the use of steel arches may be considered to ensure workforce safety in areas with poor rock quality. The completion time of tunnelling including access preparation is expected to be 27 months based on 3 excavation fronts, each working in 2 shifts 6 days a week. That is the critical path of the construction programme.

Concreting will start after tunnel breakthrough of section C, while excavation continues on Section A and B. A 30 cm thick concrete lining will be cast in 12 m long bays using two formworks on wheels. Both will work backwards from the midpoint of the tunnel in order to facilitate access and material supply to each work station. After tunnel breakthrough on section A, concreting will start as well using the same methodology and another set of formworks. When concreting is completed on section A, the 2 formworks will be transferred to section B. Batching Plant and aggregate processing plant installed for the intake site shall supply concrete that will be transported by mixer trucks and pumped. Peak demand when the 4 formworks are in use is reckoned to reach up to 600 m^3 per week.

2.5.5.4 *Intake structure*

Intake structure for HRT is built at the location of Elevation 1192 m. The structure will be concreted once the HRT is completed and no access into the tunnel is needed from that point.

2.5.5.5 *Surge shaft and pressure shaft*

A 5.75 m diameter steel lined pressure shaft terminates the HRT, consisting in a 70 m upper horizontal section, followed by a 85 m vertical section and another 170 m lower horizontal section. The first 2 parts will be bored through an access gallery starting from the same platform as the HRT at 1345 m. On the other hand, the last horizontal part can be excavated from the power house platform at 1191 m and is therefore, an independent site. Once all sections are completed, steel lining will be put in place in 3 m segments, welded and backfilled with concrete. A 85 m high surge shaft will be implemented at the starting point of the pressure shaft. It is designed with a 14 m diameter and a 50 cm concrete lining. Works will be carried out from the top at 1429 m where a dedicated platform will be set up. These sites are independent from the HRT works and corresponding works will be carried out simultaneously in order to be ready to be connected to the HRT upon its completion.

2.5.5.6 *Power house site*

The powerhouse is designed to accommodate 3 x 62 MW turbine units and all equipment required for their operation. Excavation of the power house and tailrace basin shall use standard method deploying Drill and Blast machinery and jack hammers. Rock faces will be stabilized with steel mesh, shotcrete and/or rock bolts wherever needed. Mucking of the excavated soil and rock will be carried out through site roads to appropriate dump site. Approach to the powerhouse on the left bank of the river is planned from the existing road on the right bank and by crossing the River Yarjep (Shi) through a bridge to be built for this purpose. The left bank will be treated by grouting so that the site will have limited water infiltration from the river. Concreting of the powerhouse will be carried out in 2 major phases.

- A substructure that accommodates machinery and several specific embedded parts such as draft tube and spiral case.
- A superstructure that is similar to conventional industrial building works.

Tailrace channel walls will be concreted in 3 m lifts with appropriate number of shutters. Erection, Testing and Commissioning of the three TG units shall be a parallel activity to the entire scope of works described here above. However, commissioning may only be completed after impounding of the whole installation, which requires work completion of the other project components (weir, intake, HRT).

2.6 LAND REQUIREMENT

Total land required for the various components of Tato-I H.E. project is 52.8 ha, in which 50 ha is surface land and remaining is underground. In the surface land, 2.3 ha of the river bed. The entire land is categorized as Unclassified Forest land (Table 2.2). The total submergence area is 3.0 ha including 1.8 ha of river bed and 1.2 ha of surface land. The impacted surface, excluding river bed, is 47.7 ha.

Table 2.2 Project component wise break up of land in Tato-I H.E. Project

Purpose wise break-up of total land Required for TATO-I HEP					
S. No.	**Project Component**	**Surface Area (Ha)**		**Underground Area (Ha)**	**Total Area (Ha)**
		Surface Land	**River Bed**		
1	Submergence area	1.2	1.8		**3.0**
A	**Surface Structures**				

Purpose wise break-up of total land Required for TATO-I HEP					
S. No.	**Project Component**	**Surface Area (Ha)**		**Underground Area (Ha)**	**Total Area (Ha)**
		Surface Land	**River Bed**		
2	Intake complex area	8.2	0.5		**8.7**
3	Intake Muck Disposal area and construction platform	3.2			**3.2**
4	Intake Storage and Colony area	1.7			**1.7**
5	Intake Quarry site	0.3			**0.3**
6	Power House Area (including penstocks and Tail Race)	8.8			**8.8**
7	PH Construction Platform and Muck Disposal	3.2			**3.2**
8	PH Storage Area, Office and Colony	1.4			**1.4**
9	PH Quarry Site	0.5			**0.5**
10	PH Access Road	10.7			**10.7**
11	Adit Area	1.9			**1.9**
12	Adit Access Road	6.6			**6.6**
	Total of surface area	47.7	2.3		**50.0**
B	**Under Ground Structures**				
13	Head Race Tunnel (including Adit tunnels)			2.8	**2.8**
	Total	**50.0**		**2.8**	**52.8**

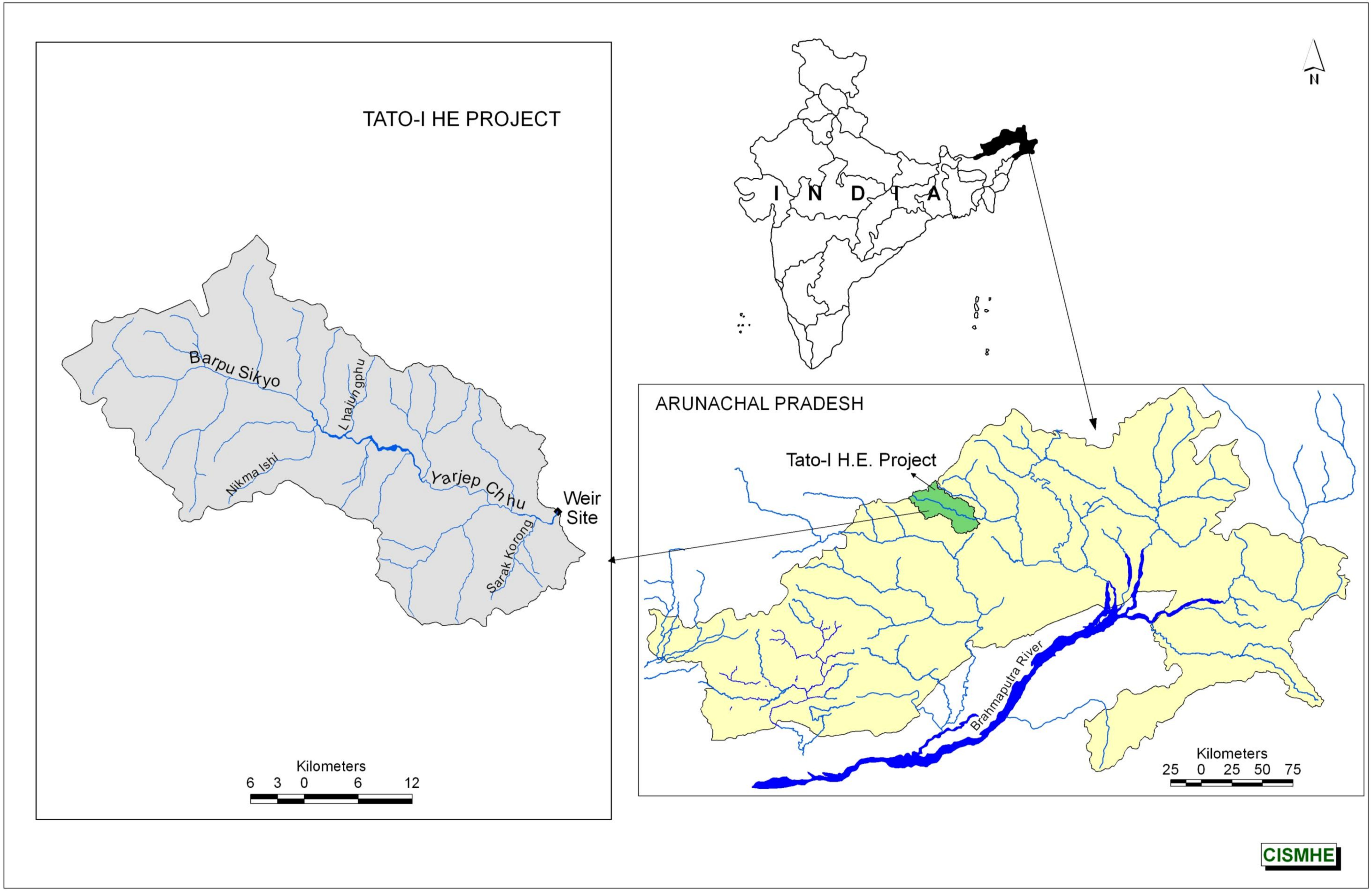


Fig.2.1 Location map of Tato-I H.E. Project

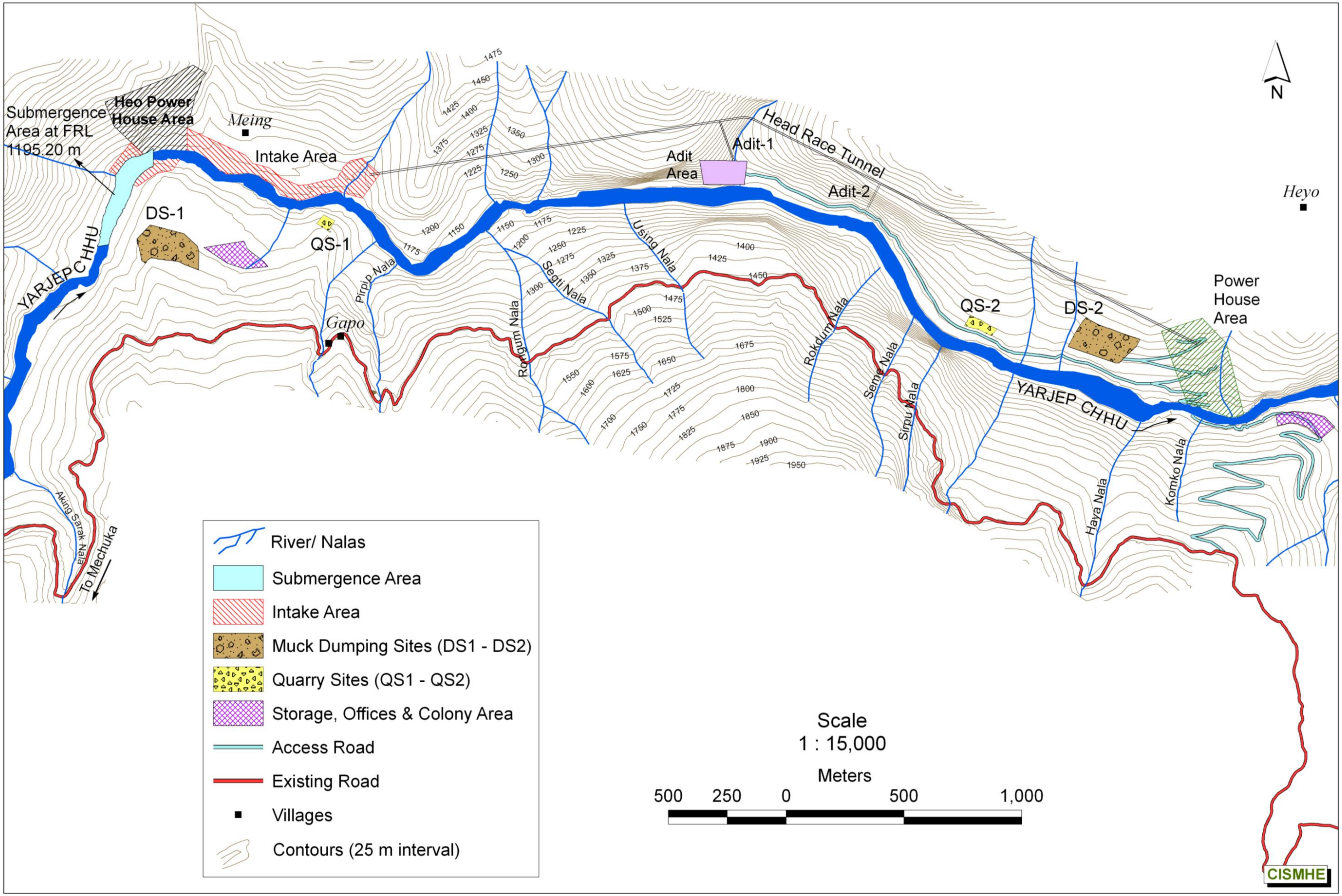


Fig.2.2 Layout map showing the different components in the stretch of Tato-I H.E. project area (Source : Velcan Energy)

Chapter 3

BASELINE DATA

3
BASELINE DATA

3.1 CONCEPTS & METHODOLOGY

3.1.1 CONCEPT

Environmental Impact Assessment (EIA) is a process that examines the environmental consequences of development actions in advance with an emphasis on environment protection. The idealized EIA process is flexible, iterative, proactive and based on accurate, consistent, transparent and defensible methods. This is only achievable if EIA forms a part of integrated systems of environment regulation, based on strategic planning and regulation of environmental quality and operating standards in relation to quality standards. Thus EIA can provide a basis for environmentally sound decision making, the designing and planning of developmental projects, monitoring, management and audit, mitigation and application of EIA process.

EIA includes the study of various baseline parameters *viz.* Air, Land, Water, Flora, Fauna, Social aspects. Based on baseline environmental status and proposed project activities potential impacts have been assessed and predicted. The environmental status of project area was based on detailed field survey and secondary data review. Besides these components the impact on quality of life of the people living in the vicinity of the proposed project is important to arrive at the informed decision as to the environment feasibility of the project. More recently a number of new dimensions like ethnic diversity, cultural sensitivity of human communities and issues such as displacement, resettlement and rehabilitation were added to the EIA studies.

The United Nations Environment Programme (UNEP) has defined the goals and principles of EIA for the analysis and assessment of planned activities to ensure environmentally safe and sustainable development (UNEP, 1980). The nature of the EIA systems (e.g., mandatory or discretionary) vary widely in different countries. However, the concept of EIA has been accepted due to its central role in environmental protection and its validity as a proactive planning tool. With reference to hydropower development within India, it is worth mentioning that EIA is now a mandatory requirement and is to be carried out according to the terms of reference (ToR) defined by the Environmental Appraisal Committee (EAC) of Ministry of Environment and Forests (MoEF), Government of India. Furthermore, it is interesting to note that what began as an EC directive on environment assessment (CEC, 1985) regarding impact of development on *flora* and *fauna* has today developed into a major concern for the conservation and management of ecosystems and biodiversity in the environmental, financial and techno-commercial appraisals of developmental projects. International financial institutions have also laid down stringent environmental guidelines for developmental projects and financial closures are possible only after the borrowing agency has fully committed itself to adopt adequate provisions for environmental conservation, management and impact minimization or mitigation. The developmental actions may have impacts not only on the physical environment but also on the biological, social and economic environment. It requires a suitable and feasible management plan which emphasize to avoid the action which has negative impacts on the resources or to minimize or compensate the potential adverse impacts. In general the purpose of EIA is to provide an aid to decision making, formulation of development actions and instrument for sustainable development.

3.1.2 METHODOLOGY

In the present study standard methods, either developed at the Centre or published elsewhere, such as CISMHE (1993, 1998, 2000, 2002, 2005, 2008), Clark, *et al.* (1981), Leopold, *et al*. (1971), Sassaman, (1981), Lohani & Halim (1987), Biswas & Geping (1987), etc. were followed for Environment Impact Assessment of Tato-I HE project. Studies on water resource development projects by various authors viz. Bisset (1987); Dee, *et al.* (1973), Duke, *et al*. (1979) and LEUP, (1979) were particularly consulted for the present study. A brief account of the methodologies and matrices followed in the present study is given below under different headings. All the methods were structured for the identification, collection and organization of environmental impacts data. The information, thus gathered, has been analyzed and presented in the form of a number of visual formats for easy interpretation and decision-making. The detailed methodology followed for the EIA report of Tato-I H.E. Project is described in the following paragraphs.

3.1.2.1 Study Area

Tato-I Hydroelectric Project is a run of the river scheme proposed on Yarjep River near villages Meying (Intake site) and Heyo (Power House), in the West Siang district of Arunachal

Pradesh. It is immediately in the downstream of the Heo Hydroelectric Project and largely utilizes its discharged water (130.2 cumecs) along with additional discharge (2.8 cumecs) accumulated by the Yarjep tributaries between Heo Dam and Heo Power House. The study area was bifurcated into areas of direct and indirect impacts. The area of indirect impact includes the free-draining catchment area of proposed Tato-I HE Project, which comprises nearly 74 sq. km and the catchment area itself, of 1154 sq km. The indirect impacts on the various aspects include a 10 km periphery of proposed intake and power house sites and river bed, referred to as influence area, which covers an area of around 435 sq. km. The areas of direct impacts are made of the project's land requirement, which includes all project components like reservoir, weir site, HRT tunnel, proposed power house, dumping areas, quarry sites, etc. They are referred to as Project Area.

3.1.2.2 Surveys and Samplings

Primary surveys were conducted in different seasons of the year to collect data related to geology, flora, fauna, forest types and ecological parameters including soil and water. During these surveys data and information were collected on geophysical and biological attributes of the catchment and free-draining areas in brief, influence area (10 km radius) and Project Areas in details. In addition, detailed surveys and studies were also conducted for understanding aquatic ecology and fish life of Yarjep 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, forest and vegetation types were recorded on the ground in the catchment area, in project and in study area. A detailed schedule of the survey and samplings is given below.

S.No.	Duration of Survey	Parameters studied
1	February, 2009	Water, Fauna, Flora, Geology, soil, Air, Noise, Fish and Fisheries
2	May, June, 2009	Water, Fauna, Flora, Geology, Soil, Ground truthing
3	Aug., September, 2009	Water, Fauna, Flora, Geology, soil, Fish, Air, Noise, Ground truthing, Socio-economic survey
4	May, June 2010	Fauna, Flora, Geology, Soil, Fish, Noise
5	December 2010	Socio-economic Surveys

3.1.2.3 Physiography

Spatial database on physiographic features were taken from various sources including Survey of India (SOI) toposheets, satellite data and analyzed with the help of Geographic Information System (GIS) tools. These data were collected, arranged and thematic maps were prepared according to the EIA methods used in the study. The thematic maps are presented in the form of general drainage map of catchment and its sub-watersheds, relief map, aspect map, slope map etc. In addition, river gradient profile of the Yarjep River was calculated from its upper reaches to the proposed intake site.

3.1.2.4 Geology & Seismicity

The regional geology around project area highlighting geomorphology, stratigraphy and structural features were based on the existing information, viz., i) Detail Project Report (DPR, 2011), ii) Geology of Arunachal Pradesh (Kumar, 1997), iii) Geodynamics of Northeastern India and adjoining region (Nandy, 2001), iv) Seismotectonics of South Asia (Kayal 2008), v) Indian Meteorological Department (IMD) earthquake data in the vicinity of the project area and vi) published literatures (Verma and Kumar, 1987; Kayal, 1996, etc.). The discussion on project geology has been based on the data available in DPR of Tato-I (2011) and field observation in the selected sites.

3.1.2.5 Soil

The soils of project sites (proposed intake site to power house site) and catchment are described in this section. The soils are classified by using the standard method of NBSS (1998). In order to analyze physical, chemical and biological characteristics, the soil samples were retrieved from various locations of downstream area, proposed power house area, intake site area and the catchment area. Description of the sites is given below. The sampling sites are mentioned in the **Figure 3.1.1**.

Site S1 (near Gapo village) – Right bank of Yarjep river – Forest Area

Site S2 (near Tato village) – Right bank of Yarjep river – Agricultural land

Site S3 (near Hiri village) – Right Bank of Yarjep river – Old Jhum

Site S4 (near Rego village) – Left bank of Yarjep river – Forest area

For each site replicate samples were retrieved for three seasons (winter, pre-monsoon and monsoon). The soil samples were collected with the help of auger. Soils were removed from upper temporary layer (5cm or more according to the soil profile) with help of digger; soil samples were retrieved from a depth of about 10 - 30 cm and about 10 x 10 sq cm in width. The physical properties included moisture content, water holding capacity, bulk density and pore size measurement (soil texture) while chemical characteristics included pH, organic carbon, organic matter, phosphate, nitrate, and chloride. Soil moisture was calculated by evaporating moisture from pre-weighed soil, at 105^{o}C for 24 hours in an oven and reweighed the soil. Standard methods for the soil analysis were followed as given in Jackson (1958) for bulk density, soil texture and water holding capacity. The soil was divided into 6 textural classes – very coarse, coarse sand, medium sand, fine and very fine sand, coarse silt and fine, medium silt and clay by using the sieve of different mesh sizes viz. very coarse and coarse sand, 200-500 µm for medium fine sand and 50 - 200 µm for very fine sand and 20-50 µm for coarse and medium silt and < 20 µm for fine silt and clay.

Soil pH and conductivity were measured by the instruments pH Scan and TD Scan 3 (Oakton, Eutech Instruments), respectively. Nitrate and phosphate were determined by the icon specific meter (Hanna Instruments). Chloride estimation was done by colorimetric analysis given by Adoni (1985) while organic matter was calculated by Walkley's method (Walkley, 1947).

Microbial analysis was carried out by the Serial Dilution Technique. Microbes were isolated at 10^{-6} dilution on Potato Dextrose Agar (PDA, Himedia) and Nutreint Agar (NA, Himedia) for fungal and bacterial populations, respectively. Media were prepared by dissolving the ingredients in distilled water and heated till agar was completely dissolved. The pH was maintained at 5.4 (± 0.2) and 7.2 (± 0.2) for fungal and bacterial cultures, respectively. Finally, media were autoclaved at 15 lb/inch^2 for 15 minutes and allowed to cool at about 40-45 ^{o}C to pour into sterilized Petri plates. Inoculated Petri plates were incubated at 27 ^{o}C (± 2.0) for fungal and at 34 ^{o}C (± 2.0) for bacterial colonies. Five to seven days old Petri plates were used for population counting and expressed as CFU (Colony Forming Units) for fungi and MPN (Most Probable Number) for bacteria.

3.1.2.6 Land Use & Land Cover

Land use and land cover was prepared for the Tato-I H.E project area. Remote sensing and GIS spatial functionalities were used in the preparation of land use and land cover map for the whole catchment, with area coverage of 1154 sq. km. Satellite imageries of IRS-P6 LISS-III was used and it was radiometrically corrected using dark pixel subtraction technique before the land use/ land cover map was generated. Nine land use/ land cover classes were generated for the catchment. The land use and land cover maps were prepared for the catchment area, influence area and project area.

3.1.2.7 Hydrology

The data on rainfall are available from 7 rain gauge stations namely, Mechuka, Monigong, Raying, Kaying, Along and Tato sourced from various third parties (IMD, Brahmaputra Board and other private project developers) and have been used along with the developer's own Gauge stations, to assess the water availability. Two data sources were acquired for Mechuka (i.e. external data source and rain gauge stations installed by Velcan Energy Group).

In 2007, the developer of the Tato-I HE Project has undertaken daily-discharge measurements (three measurements per day). Two gauges have been installed on the Yarjep River: one in Purying village (1065 km^2 of catchment area), and the other one in Mechuka village (686 $km^2$of catchment area). Discharge data collected by external agencies have also been analyzed. Based on the data described above, the detailed water availability studies have been conducted to arrive at the 10 daily discharge data of Yarjep river from June 1978-79 to May 2008 - 2009 (DPR, 2011), monthly and annual water discharge and 90% and 50% dependable years for Tato-I H.E. Project. The Central Water Commission has approved the water availability studies of the DPR in July 2010.

3.1.2.8 Aquatic Ecology & Water Quality

The water sampling was conducted at different locations in the 10 km river stretch of Yarjep River. These locations were grouped into three sampling sites namely W_1, W_2 and W_3. Sampling site W_1 involved river stretch upstream of proposed intake site while W_2 site covered the continuum around the proposed intake site. Site W_3 included proposed power house site.

The sampling was carried out for three seasons (winter, pre-monsoon and monsoon). A total of 19 physical and chemical parameters including Cd, Cu and Hg of heavy metals and 5 biological parameters were studied to assess the river water quality. The discharge data provided in the DPR of Tato I (2011) was used for analyzing the seasonal variation in the flow of Yarjep River. The water current velocity at all sites was measured with the help of float method. A 20 m stretch of the river was measured and marked at both ends. A float was thrown at upper end and the time taken by the float to travel the marked distance was recorded by a stop watch. The water temperature was recorded with the help of graduated mercury thermometer. Care was taken in measuring the temperature as it was recorded from surface, column and near the bottom of the river. Average value of these readings was computed.

The pH was recorded with the help of pH Scan (Eutech) and pH meter (EI – 132 E) in the field. For the turbidity of water, samples were collected in sampling bottles from different sites in the field and brought to the laboratory for analysis. The turbidity was recorded with the help of Nephelometer or turbido meter (EI – 331 E). The total dissolved solids were measured with the help of TDScan 1 (Eutech) at each site. Similarly conductivity was recorded with the help of TDScan 3 (Eutech) at the site. Dissolved oxygen was measured by using digital DO meters (Eutech ECDO 602K). BOD was recorded with the help of DO meters (Eutech ECDO 602K) using a field incubator. Total alkalinity, alkalinity as carbonates and bicarbonates, total hardness, Ca and Mg contents, chloride and heavy metals were measured with the help of APHA (2005) and Adoni (1985). Nitrate (NO_3 – N) and phosphate (PO_4 – P) were measured using HAANA instruments namely HI 93728 and HI 93713, respectively.

Biological characteristics involved the status of total coliforms, zooplankton, suspended algae, phytobenthos and macro-invertebrates. A presumptive test (presence/absence test) was performed for the estimation of total coliforms. The method described by Central Pollution Control Board (CPCB), New Delhi was adopted for this purpose. For the quantification of zooplankton and suspended algae 50 liters of water for each community was filtered at each site by using plankton net made up of fine silk cloth (mesh size 25 μm). The study was repeated three times at each site and the samples were pooled. The filtrate collected for suspended algae was preserved in the Lugol's solution while unpreserved samples of zooplankton were brought to the laboratory. Epilithic phytobenthos were obtained by scrapping the surface of rocks and boulders (4 x 4 cm^2) with the help of a hard brush. Three replicates, obtained from each site were pooled and preserved in Lugol's solution for further analyses. Before going further for other analysis of the plankton and benthic samples the density was estimated by using drop count method. The suspended algae and phytobenthos were identified with the help of Sarod and Kamat (1984), Hustedt and Jensen (1985) and Edmondson (1959). The zooplankton was identified by using literatures of Edmondson (1959) and Battish (1992).

The macro-invertebrates were obtained with the help of a square foot Surber's sampler or a square foot quadrate. The substrate, mainly stones were disturbed and immediately transferred to a bucket underwater and later rinsed thoroughly to dislodge all the attached macro-invertebrates. The organisms trapped in the Surber's sampler were also transferred to the bucket. The material was sieved through 100µm sieve. Samples were collected in three replicates and pooled for further analysis. The samples were preserved in 3% formalin or 70% ethyl alcohol. The organisms obtained were then counted after identifying them up to family level by the procedure described by Pennak (1953) and Edmondson (1959). Bhatt and Pandit (2010) macro-invertebrate index was assessed to measure the water quality of Yarjep River.

3.1.2.9 Fish & Fisheries

The study of fish fauna was carried out in the Siyom River, Yarjep River and small tributaries as these streams fall in the catchment, influence and project areas. Common fishing methods were used to land fish from Yarjep River and its tributaries. The fish were landed with the help of local fisherman using cast nets and hooks. The fish were identified with the help of Talwar and Jhingran (1991). In addition, literature of Sen (2006) was consulted to make an inventory of fish fauna of Yarjep River.

Conservation Assessment Management Plan of Biodiversity Conservation Prioritization Project Workshop (CAMP-BCPP, 1997) and IUCN (2011) criteria were followed to know the conservation status of fish species inhabiting river Yarjep and its tributaries.

3.1.2.10 Air Environment & Noise Level

The sampling for weather condition, ambient air quality and recording of traffic density and noise pollution data was carried out based on the availability of facilities. Sampling was carried out for three seasons for all parameters.

Climatic Attributes: Using pocket weather tracker (KESTREL 4000), primary data on climatic attributes like wind speed, wind chill temperature, humidity etc were recorded for three seasons in the project components areas. These attributes were recorded at three sites namely Gapo village (site S1), Heyo village (S2) and Tato town (S3). The data was collected for three seasons namely pre-monsoon (May), monsoon (August) and winter season (February). Replicates samples were recorded at each site. An average value for each parameter was calculated for the interpretation

Air pollution: To assess the level of pollutants in the air sampler (high volume, respirable dust sampler APM 460 BL and its attachment APM 411 TE) was run to record the concentrations of SPM, NO2 and SO2. Due to lack of electricity in the surroundings it was run at Aalo. Aalo is major town in the area and was considered as control.

Traffic density: Number and types of vehicles plying on (i) Tato intake site (Tato-Mechuka Road) and (ii) Tato power house (Tato-Lungte Road towards BB camp) were recorded.

Noise Level: Sound levels were recorded at various sites in and around the project area by using Sound Level Meter D 2023 (Cygnet), a TYPE 2 instrument (IS 9779, 1981). Noise levels were recorded at upstream village (Meying-Sd1), proposed intake site (Sd2), powerhouse site (Sd3), nearest stretch of national highway (Sd4) and Tato town (Sd5).

3.1.2.11 Forest Types and Floristics

i) *Study area*

The details on forest types and forest cover in the catchment area were based on our primary surveys in the area supplemented with the working plans and records of Aalo Forest division, West Siang. The forests present in the Tato-I and adjoining areas have been grouped into different forest types following the classification of Champion & Seth (1968), Kaul and Haridasan (1987), Negi, (1989, 1996), Chowdhery (1996) and Muddgal & Hajra (1999).

Influence area (i.e. 10 km radius from power house site, intake site and HRT) was selected for the description of vegetation in the area. In the influence area, the surveys were carried out along the altitudinal gradient (900 - 2000 m). The important sites for the primary surveys were:

i) Area between B Camp and Tato village

ii) Area between Tato village and Gapo Basti

iii) Area between Gapo Basti and Menying village

iv) Area beyond Menying village and its surroundings

Floristic study in the project area was undertaken with the objectives of preparing a checklist of flora in the submergence area and locations where project components (i.e. intake site, power house site, dumping sites and quarry site) are proposed. Listing of rare/ endangered, economically important and medicinal plant species was prepared by conducting primary surveys along all project components.

ii) *Samplings*

The detailed account of ecological study and plant communities has been described based on the primary surveys in the project area. During our surveys in 2009 and 2010, two sites viz., intake site (Meyning, left bank of Yarjep) and powerhouse site (Tato, right bank of Yarjep) were selected for vegetation structure study on the basis of the presence of forest patches in the area. Considering the difficult terrain, quadrat method was used for vegetation sampling. Tree layer was analysed by sampling ten randomly placed quadrats of 10 x 10 m size in each site. The size and number of quadrats needed were determined using the species area curve (Misra, 1968). Circumference at breast height (cbh at 1.37 m from the ground) of all trees with > 31.5 cm was recorded individually per species. The shrub and sampling strata were analysed by sampling ten quadrats of 5 x 5 m randomly on each site. The herbs were analysed by placing ten quadrats of 1 x 1 m on each site during different seasons.

The data on vegetation were quantitatively analyzed for abundance, density, frequency (Curtis & McIntosh, 1950). The tree basal area was determined as an index of dominance as:

$$\text{Basal area} = \pi r^2 = C^2/4\pi$$

Where, $C = 2\pi r$

(C = Circumference at breast height; r = Radius)

The Important Value Index (IVI) for trees was determined as the sum of relative density, relative frequency and relative dominance (Curtis, 1959).

The index of diversity was computed by using Shannon-Wiener information index (Shannon Wiener, 1963)

$$H = -\Sigma\ (ni/n) \times \ln\ (ni/n)$$

Where, ni is individual density of a species and n is total density of all the species.

3.1.2.12 Fauna

In order to collect the information on the fauna (mammals, birds, herpetofauna, and butterflies) in the catchment area of Yarjep River, primary as well as secondary sources were utilized. Following methods were adopted during the survey of fauna.

i. The Forest Working Plans of the Forest Divisions falling in the project area were referred to for secondary information on the wildlife of the catchment area.
ii. ZSI (2006) publications were referred to make an inventory on mammals, avifauna, herpetofauna, butterfly and other invertebrates.
iii. Interviews of local villagers for the presence and relative abundance of various animal species within each locality.
iv. Data collection on habitat condition, animal presence by direct sighting and indirect evidences.
v. Direct sighting and indirect evidences such as calls, signs, tracks and fecal pellets of mammals were recorded along the survey routes taking aid from Prater (1980).
vi. Detailed household surveys were carried out to collect the information on trophies and hunting patterns.
vii. A detailed survey of birds was carried out in the project sites and catchment area using the literatures of Ali & Ripley (1983), Grewal et al. (2002) and Dutta and Basu (2006) as field guides. The invertebrates inventory was made with the help of Das and Chattopaddhyay and 2006; Mondal, 2006.
viii. The criteria of IUCN (2010), Wildlife (Protection) Act (1970) and Zoological Survey of India (1994) were followed to describe the conservation status of the species.

A detailed survey was carried out for the mammals, birds, reptiles and butterflies for three seasons, namely winter, pre-monsoon and monsoon. We selected various sites which are likely to be disturbed by the various activities of the project. The surveyed sites were proposed colony site, power house site, intake site, tracks from Tato to Meying villages and B Camp to Tato village and B Camp to the Lungte Way. The birds were surveyed in the morning hours while butterflies in noon hours. Standard methods were followed to sample the bird and butterfly species.

3.1.2.13 Socio-Economic & Cultural Aspects

Socio-economic profile includes brief descriptions of Arunachal Pradesh, West Siang district and the circles in which project components are located. History, cultural aspects, ethic values and tribal life of Arunachal Pradesh and West Siang district are also 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 households was carried out for the proposed project. A detailed questionnaire was prepared for this purpose and the same is placed at Annexure-I&II. The surveys and preparation of the plan included following procedure:

i) Due to non availability of revenue records, the land for acquisition was identified by the project authority and submitted to district administration for discussion with authorized people of the concerned villages.
ii) Door to door socio-economic survey of the project affected families was conducted to collect the base line data. Data was collected on various parameters e.g. Demography, Occupation, Education, Quality of life, Income patterns, Land holdings, Amount of land loss due to this project, etc. The detailed information has been used in preparation of the R & R plan.
iii) Discussion was held with all project affected families/persons. It resulted that all the interviewed persons have expressed their willingness to accept project.
iv) The existing socio-economic profile of the project-affected area has been given in the EIA report.

3.1.2.14 Impact Prediction

The main objective of entire EIA process is the identification, prediction, evaluation and monitoring of the impacts. The ecosystem like terrestrial, aquatic, air, social etc based approach has been followed for the identification and prediction of impacts. Evaluation of the impacts was assessed on the basis of nature (positive/negative, reversible/irreversible, direct/indirect, long term/short term), magnitude and other dimension (local/strategic, small/large) of impacts. Evaluation included an assessment of the relative significance of the impacts. The outputs and inputs related to evaluation of impacts are given in **Figure 3.1.2**. Generally, evaluation method ranges from simple to the complex, qualitative to quantitative, checklist to matrices etc.

In order to predict the impacts of Tato-I H.E. project, a modified Leopold index has been used. The index comprises of rows and columns, represented by actions and environmental variables. Each cell of the index was assigned with a relative score indicating an impact. After, weighing the nature, magnitude or other dimension of impact, a suitable score has been assigned. The totaling of rows and columns were evaluated and a suitable mitigation plan was prepared.

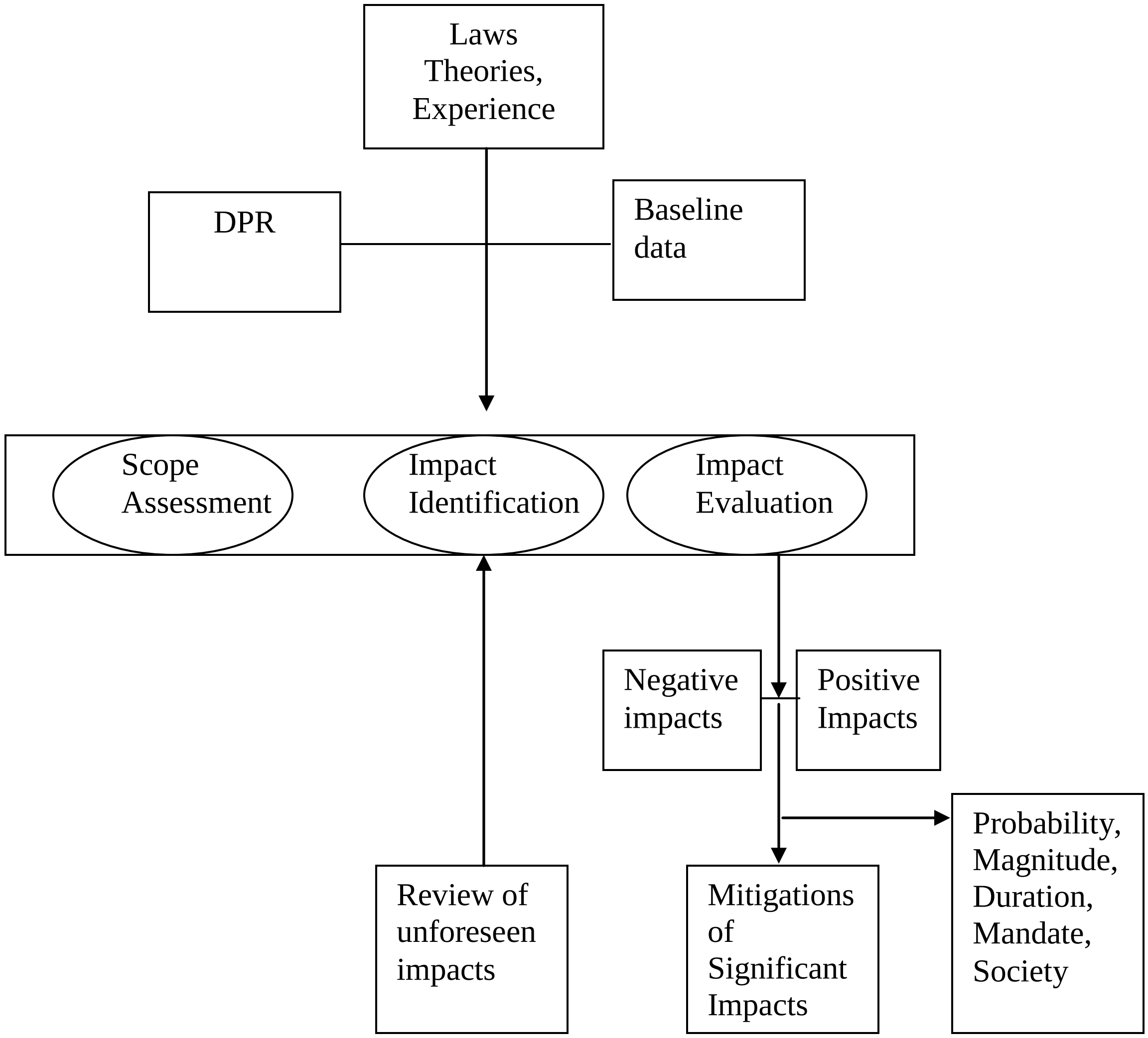


Fig. 3.1.2 Inputs and outputs related to evaluation of impacts

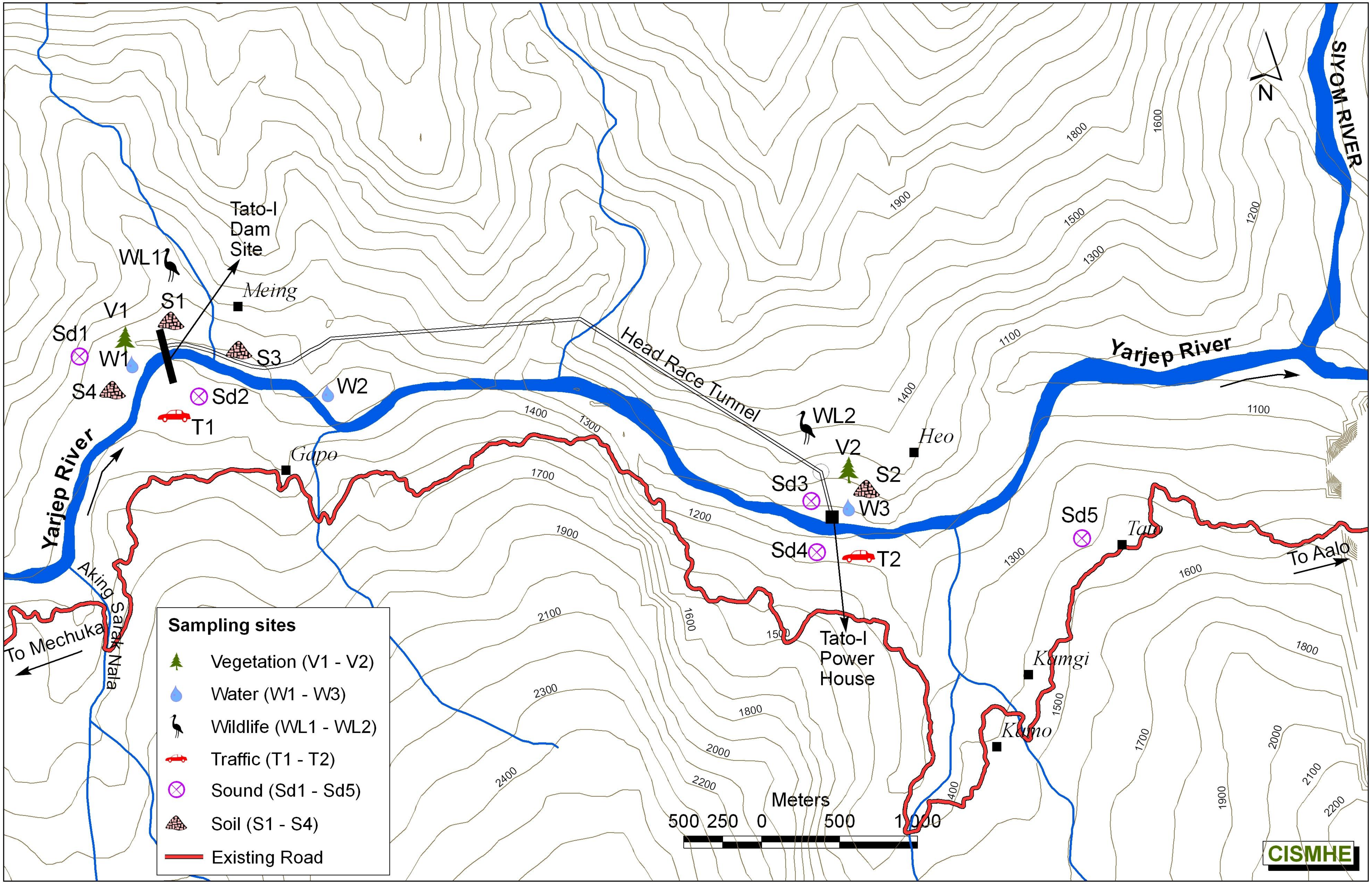


Fig.3.1.1 Map showing sampling sites of the proposed Tato-I H.E. project

3.2 LAND ENVIRONMENT

3.2.1 PHYSIOGRAPHY

The physiographic condition of a region refers to the sculptures on the natural landscape and ongoing changes by several natural processes of geomorphic agents like water, glacier, wind etc. Many of these agents are controlled by the prevalent climatic conditions of the region and the internal dynamic functional mechanism of the earth system. Therefore, for any hydroelectric project, the study of physiographic condition of the river catchment is very crucial as it has a strong control on water availability and sediment load supplied to the river. The present chapter deals with physiography of the Yarjep Chhu catchment area in the upstream of the proposed Tato-I H.E Project intake site.

The geographical region of the proposed dam site is spread in the West Siang district of western Arunachal Pradesh. The catchment area is confined between 28° 25′ N to 28° 49′ N latitudes and 93° 45′ E to 94° 20′ E longitudes. The proposed intake site is located on the Yarjep Chhu near Meying village. A comprehensive physiographic database of Yarjep Chhu catchment was carried out for this study. Physiographic parameters were analyzed through the spatial analysis of Geographical Information System (GIS). Databases of different aspects were developed for all constituent sub-watersheds of the catchment. The Survey of India (SOI) toposheets were used to generate the contours and consequently contours were spatially interpolated in GIS to generate raster topographical data. Satellite data were utilized in preparation of different thematic maps. Analysis and interpretation of this spatial database were achieved by using GIS techniques. The results were confirmed after ground truthing at specific locations in the catchment. The outcome of this study is discussed in the following sections. In this section drainage system, DEM, relief, aspect and slope are presented. For each of the parameters two maps were prepared, catchment and the influence area. As per Terms of Reference, a base map developed to demarcate the influence zone was projected for Tato-I H.E project.

3.2.1.1 Drainage System

The Yarjep Chu catchment up to Tato I intake site is 115400 ha, the drainage network of the catchment area of Yarjep Chu is shown in **Fig. 3.2.1.1**. The river is called as Barpu Sikyo in the head water region of the catchment. Barpu Sikyo is joined by large numbers of the snow fed, spring fed, glacial fed and seasonal rivers. These streams flow in the elevational region between 4000 to 4430 m. The headwater region of the Yarjep River is snowfed and springfed stream. It originates from the region above 4000 m. Yarjap chhu is mainly snow fed and lake fed river. In Tibetan part of its catchment (headwater region), two northeast to southwest and southwest to northeast flowing streams feed the southeastward flowing Yarjap Chhu. About 2 km downstream of this confluence another stream, flowing from a lake lying above 3400 m drains into the Yarjep on its right bank. Another lake fed stream flowing on the northern slope and originates at 4418 m peak confluences with Yarjep Chhu at 2440 m on the right bank. Further downstream, a stream flowing southward from 5003 m peak (the highest elevation in the catchment) and draining thick forest region confluences with Yarjep Chhu on the left bank at 2320 m. This small stream is also fed by four lakes on its left bank, which lie above 4000 m. In the middle stretch, Yarjep Chu runs from WNW to ESE and a number of tributaries flowing from north to south.and join this river in the Indian part of the catchment. Besides, there are number of glacial lakes in the northern part of the catchment and southern part of the catchment. The drainage characteristics of these subsystems are discussed in detail with the left and right bank of the Yarjep Chhu in the following sections. In Table 3.2.1.1 catchment characteristics, place of confluence with the main channel is given and the sub-tributaries associated are given along the left and right banks.

a) Left Bank Streams

The streams joining the Yarjap (Yarjep, Shi) Chhu on its left bank are as follows and detail is given in the map.

Lungkhor Dem

It is a small springfed stream which flows from 3200 m to 2240 m. Most part of its catchment is barren. It flows for approximately 5.3 km before it drains into the Yarjep Chu.

Sheshirong Ishi

It is larger tributary as compared to former one. It flows approximately for 12.3 km before it is joined with the main channel of Yarjep Chhu. Sheshirong originates from the Damchen range and it is fed by several large and small rivulets along right and left banks. The largest sub-tributary of the Sheshirong flows from the N-E for 4.2 km approximately before it drains into Sheshirong Ishi.

Netsrang Gongphu Chhu

It is a snowfed and springfed stream which originates from 4053 m peak in Damchan range and flows southward for 13.3 km approximately and confluences with Yarjap Chhu at 1990 m near Nachonggong Village. In its middle stretch it drains the region covered with fairly dense mixed forest. The tributary shows dendrite pattern with large number of tributaries along both banks (see **Fig. 3.2.1.1**).

Nangso Sokang

It is a small springfed stream which flows from Changkaria (2400 m) and confluences with Yarjap Chhu at 1940 m near Nangso village. The tributary flows approximately for 3.5 km before it drains into Yarjep Chu near the Nangso village. The catchment of this stream is barren.

Gaptse Chhu

Gaptse Chhu is a snowfed and springfed stream. This stream is separated from the stream in its east by the Puiling Pik ridge. It originates at south of Damchan range at 3900 m. In the elevational range of 2200-3900 m there are five streams which join and together form Lhalungphu Cho. Of these five streams major discharge is contributed by Nukmaphu Chhu, and Sharba Sakong Lhalungphu Cho in its downstream stretch is known as Gaptse Chhu. Lhollne village is situated on the right bank of Gaptse Chhu. The upper catchment of Gaptse Chhu is covered with thick vegetation. Gaptse Chu flows for 9.2 km and drains into Yarjep Chu near Lhollne village (see **Fig. 3.2.1.1**).

Endashokong

The tributary is a short traversed tributary system and it flows for 2.8 km of length. The river flows from 2800 m to 1930 m. In its upper reaches it drains the fairly mixed jungle and in the lower reaches there are cultivable terraces around Beehenthang. It also drains the swampy land in the downstream before joining Yarjep Chhu.

Nyangapa rang

It is a small springfed stream with a length of 2.7 km drains the region around Nangso and confluences at 1940 m with Yarjep Chhu. Entire catchment of this stream is barren.

Teden

It is also a small stream approximately 3 km long, the catchment area is characterized with barren land. Draining the Galling Gompa region it meets the Yarjep Chhu upstream of Shinghir village.

Chanajung

The river traverses for 2.4 km southwards draining the catchment of barren land. It flows from 2320 m and meets Yarjep Chhu at 1920 m in Chanajung village after taking a sharp bend.

Dutangphu Chhu

Dutanphu Chhu is one of the largest tributary of the Yarjep Chhu. It is drained by six snowfed and springfed streams namely Phushung Jang, Dorlingphu Chhu, Yarduphu Chhu, Tsarok Sakong, Tenrik Sokong and Shunuphu Chhu. It flows through the slopes where land cover is fairly dense mixed forest region and later altogether forms the large Dutangphu Chhu. These six streams drain a bowl shaped region bounded by Dam Chan range in the north, Sengang range in the southwest and Sharcho Rego-Ranchenling range in southeast. The river flows for a distance of 14 km of length and joins the Yarjep Chhu at 1880 m, upstream of Sheker village (see **Fig. 3.2.1.1**).

Dohak Sokang

The river flows south-eastwards along the Ranchenling range for 5.7 km and confluence with Dohak Sokang. It is a springfed stream, drains the slopes with fairly dense mixed forest and joins the Yarjep Chhu at 1700 m. In its upper reaches it is also known as Darigyap Chhu.

Dasong Siding

It is a small springfed stream which flows from the steep southern slope of Shing Duk range. There is thick forest cover on these slopes. The stream course is marked by a 61 m high waterfall. The river flows for 1.6 km before it drains into Yarjep Channel before the intake site.

Songshi Bu

Songshi Bu is one of the largest tributary along the left bank and drained by several seasonal and perennial sub-tributaries. Moreover, it is the last major tributary along the left bank. This is a snowfed and springfed stream which flows in the east of Shing Duk ridge and Renchen Ling ridge and later flows towards south. The stream flows for 16.7 km before it drains into Yarjep Chu upstream of Purying. Its right bank is very steep and most part of its catchment is covered with dense forest. Shoriong Sokang and Libang Sokang are two important headwater tributaries of Sangshi Bu.

b) *Right Bank Streams*

Most of the streams joining the Yarjap Chhu flow northwards. Most of them are small and short traversed river channels with narrow gorges. The tributary on its right bank are as follows.

Bum Chhu

It is one of the largest drainage systems originating from the western part of Great Himalayan range. Evidently the river system is a snowfed, which drains northeastern slopes of Singyang range. The river flows for a distance of approximately 14 km eastwards before it drains into Yarjep Chhu near Nachonggong village. Nikma Ishi is a major tributary stream of Bum Chhu which flows northwards for 14.3 km. Further Nikma Ishi is joined by a small tributary system from the south called as Chirukishi stream. The catchment area of both these streams is covered with dense mixed forest (see **Fig. 3.2.1.1**).

Segang Shuru

Segarang Chu flows through a narrow channel for 5.2 km and drains into the main channel of Yarjep Chhu. This is a snowfed and springfed stream which flows northwards from 3400 m and drains the dense forest on the northern slopes of Singkyang ridge and confluences at 1940 m with Yarjep Chhu near Segang village.

Jenrang

This is a small snowfed stream which flows for 4 km. It is a springfed stream which flows northward and turns towards east to confluence with Yarjep Chhu, downstream of Segang. The upper parts of its catchment are covered with dense mixed forest.

Enda Sokang

This is a small snowfed and springfed stream which drains the slopes with dense mixed forest in its upper part and cultivable terraces in the lower part before it confluences with Yarjep Chhu at 1920 m. The river has a length of 5.2 km from its point of origin.

Shuru Phuja

Shuru Phuja is large river system and it is a snowfed and springfed stream which flows in the west of Dungzugong ridge in the north of Singkyang range. The headwater region is composite of streams of Shuru Ishi, Enda Sokang, Talling Tongkok and Lingchonyg Tukuk. All these streams drain the slopes covered with thick forests in north of Singkyang ridge. The main channel of the Shuru Phuja flows for 10 km before it drains into the main channel of Yarjep Chhu (see **Fig. 3.2.1.1**).

Tamding Phujo

This is a small snowfed and springfed stream which drains the dense forest region between Barung Gong and Dungzu Gong ridge, flows through Mechukha and joins Yarjep Chhu on its right bank at 1880 m. The river flows for 9.6 km towards north and drains into the Yarjep Chhu downstream of Phocegy.

Tachenpaogo Sokang

It is a small springfed stream which flows for 2.6 km towards northeast on the northern slope of Barang Gong ridge draining along the dense forest and cultivable terraces. It confluences with Yarjep Chhu at 1920 m downstream of Churling.

Kangdang Sila

It is also a smaller springfed stream which flows for 3.6 km before it drains into the main channel of Yarjep Chhu. The tributary traverses through the thick forest region on the western slopes of Barang Gong ridge.

Siligomang

It is a larger drainage system and flows north-eastwards for 6.6 km and drains into Yarjep Chu. It is a springfed stream which drains the western slopes of Barang Gang ridge and confluences with Yarjap Chhu downstream of Kangdangshiri. The slopes are covered with thick forest.

Kartesho Kong

This is a snowfed and springfed stream which flows towards northeast on the eastern slope of 4008 m peak on Singkyang range and confluences with Yarjap Chhu at 1720 m. The tributary shows dendrite pattern and it flows for 7.7 km before it drains into the main channel of Yarjep Chhu.

Namrangong

It is one of the smallest tributaries of the Yarjep Chhu which is more a seasonal stream. The tributary has a length of 2.4 km before it drains into the main river channel.

Ering Sokang

This is a springfed stream which flows on the northeastern slope for 3.2 km from a peak of 2845 m. Upper reaches of its catchment are covered with dense mixed jungle.

Sae Chhu

As shown in the map given in **Fig. 3.2.1.1** Sae Chu is one of the largest tributary systems of the Yarjep Chhu and moreover the largest tributary along the right bank of the Yarjep Chhu. It is a snowfed and springfed stream which flows towards northeast and confluences with Yarjep Chhu at 1428 m. In its upper stretch it is also known as Chechi Tso. The river traverses an approximately 16 km stretch before it drains into the main river channel of Yarjep Chhu near Rego village before the Dam site at Pauk. Mane Sokong, Gyara Sikyo, Shichi Sikyo, Sheh Sikyo and Sheti Sokang are important tributary streams of Sae Chhu. All these tributary systems form a large catchment of Sae Chu in the south-eastern part of the Pauk catchment. The Northern slopes of Sae Chhu are almost vertical cliffs whereas the southern slopes are gentle.

Shene Korang

It is a small springfed stream which flows from 2945 m peak on Hedomera ridge and confluences with Yarjep Chhu at 1400 m. The stream flows for 5 km towards north and joins into Yarjep Chu upstream of Purying village. The watershed is covered with barren land and open forest.

Sarak Korong

Sarak Korong flows from the south-eastern part of the catchment for 7.9 km towards north and joins with Yarjep Chu near Pungsi village. It is a small springfed stream which flows on the northern slopes from 2625 m peak, drains through a narrow gorge and joins Yarjep Chhu at 1320 m in the downstream of Ling Pung.

Sarak Korong

The next river is also called as Sarak Korong and it is the last river along the right bank. The catchment of this tributary is predominantly covered with dense forest. The river flows for 5.7 km towards north and drains into Yarjep upstream of the intake site.

3.2.1.2 Drainage System in the Influence Zone

Drainage thematic layer was generated within a 10 km radius of power house and intake site. The influence zone map was generated using the distance map calculation in GIS from the point maps of intake site and Power house site. The area of the influence zone is around 43525.4 ha. In the influence zone map as shown in the **Fig. 3.2.1.2** main streams are Sae Chu, Songshi Bu, Sarak Korong, Pirpu Korong and Shou nadi. Besides, within the influence zone Yarjep River confluences with Siyom River downstream of Tato. Siyom is one of the major tributary of Siang river. Siyom River is joined by Shiper Nala and Shishi nala near Hirong village. After the confluence of Yarjep and Siyom, river popularly known as Siyom. In the downstream stretch iyom River is joined by a large tributary - Tagurshit nadi near Tadugiru. There are several small streams downstream of the power house site joining the main Siyom Nadi.

3.2.1.3 Stream Gradient

The longitudinal profile of Yarjep Chhu including its headwater where the river is known as Barpu Sikyo to the proposed intake site is given in **Fig 3.2.1.3**. The river covers a distance of 67.1 km. It flows from 4300 m in the Great Himalaya range to 1182 m to the intake site at Meying.

Table 3.2.1.1 Tributaries of Yarjep Chhu and its catchment characteristics

Major Tributaries	Right Bank/Left Bank	Place of confluences with the Yarjep Chhu	Major streams joining the tributary	Catchment Characteristics

Netsang Gongphu Chhu	Left bank	Upstream of Nachonggonh	Left Bank; Unnamed small nalas joined at both the banks	Netsang Gongphu Chhu is a left bank tributary of the Yarjep Chhu. The catchment area is covered with farily dense mixed forest Drainage pattern is characterized by dendritic.
Gaptse Chu	Left bank	Upstream of Dalgaling,	Composite of Nukmaphu Chhu,, Lhajungphu Chhu, Shama Sokong and Mimraga	This tributary flows southwards traversing a length of 9.2 km. Drainage network shows dendritic pattern. Catchment area is occupied by mixed forest, agricultural land etc. .
Dutangphu Chhu	Left bank	Shekar	Phushung Jang, Dorlingphu Chhu, Yarduphu Chhu, Tsarok Sakong, Tenrik Sokong, Shunuphu Chhu	The tributary flows towards south traversing a distance of 14 km. The catchment area is covered with alpine meadows in the head water regions and mixed forest along the lower elevation area.
Dohak Sokong	Left bank	Downstream of Shekar	Several seasonal streams	It flows from north to south. The river flows for 5.7 km of length. It is covered with mixed forest.
Songshi Bu	Left Bank	Upstream of Purying	Showang Sokong Libong Sokong	Flows from the dense forest with a large catchment. The tributary flows for 16 km.
Bum Chhu	Right bank	Upstream of Nongso	Several large streams from the both the banks.	This tributary flow north-eastwards and the catchment is partly covered with glaciers in the upper elevation of the catchment where as the lower part of the catchment is covered with mixed forest. The main channel flows for 14.7 km upto the point of confluence.

Shuruphujo Chhu	Right Bank	Shingbir	Shuru Ishi, Enda Sokang, Talling Tongkok and Lingchonyg Tukuk	The catchment is covered with slopes of thick forests in north of Singkyang ridge. The drainage shows dendritic pattern.
Tamding Phujo	Right Bank	Downstream of Phocegy	Seasonal streams	The river flows for 9.6 km and it drains into the main channel. There are several streams which are some of the
Kartesho Kong	Right Bank	Downstream of Sheker	Komrong Sokong	The catchment is small and it is represented by mixed forest. The stream flows for a length of 7.7 km.
Sae Chhu	Right bank	Downstream of Kangiaghi	Mane Sokong, Gyara Sikyo, Shichi Sikyo, Sheh Sikyo and Sheti Sokang	It is one of the largest catchment in Yarjep Chhu . The Northern slopes of Sae Chhu are almost vertical cliffs whereas the southern slopes are gentle. Land cover is characterized with mixed forest type.
Sarak Korong	Right Bank	Upstream of Dam site	Several seasonal and perennial streams	Catchment has dendritic pattern of drainage system and much of the area is covered with barren land and open forest.

The Yarjep Chhu spans an elevation of 3118 m in 67.1 km of its flow. Thus, the gradient of main river channel of Yarjep Chhu is 1: 21.52. A knick point was observed at 0.77 km from the head water region where the elevation drops from 4300 m to 4000 m. in a span of less than 1 km. One of the prominent tributaries is Bum Chu which flows for 15 km within the elevation range of 4000 to 2000 m. This channel has the gradient of 1: 7.35. One of the prominent knick points was observed along Bum Chhu lies at 31.35 km from the headwater region. Here, the river elevation drops down from 4000 to 3700 m in a span of about one kilometer distance. The presence of knick points indicates major structural discontinuity across the stream. High knick points were observed along the head water region of Sae Chhu where river elevation drops to 300 m within a span of 1 km. The stream gradient for this river is 1:8.35. Other streams Songshi Bu, Dutangphu Chu, Gaptse Chu and Sarak Korong have stream gradient of 1:7.41, 1:7.36, 1:5.57 and 1:5.29 respectively. Therefore, lower gradient indicates that the river is in its advanced evolutionary stage and hence has low erodibility potential. The higher channel gradient indicates lower equilibrium stage and therefore, high erodibility potential. As evident from gradient values, the main Channel of Yarjep Chhu has the highest gradient (1:21.6), while others have less than 1:10 gradient (Table 3.2.1.2). Therefore, the Yarjep Chhu has little higher erodibility potential as compared to its tributaries.

Table 3.2.1.2 Gradient profiles of the Yarjep Chu and its major tributaries in the upstream of Dam Site

S.No.	Stream	Length	Gradient
1	Yarjep Chu	67.1	1:21.52
2	Sarak Korong	12.7	1:5.29
3	Songshi Bu	16.67	1:7.41
4	Sae chu	18.37	1:8.35
5	Dutangphu Chu	14.71	1:7.36
6	Gaptse Chu	10.31	1:5.57
7	Bum Chu	15.06	1:7.53

3.2.1.4 Digital Elevation Model

Topographical data and its aspects are the main input in much of environmental models. Most of the environmental models such as the soil erosion susceptibility model, geomorphologic and land cover mappings rely on topographical data as one of the major input (Zomer and Ives, 2002). Topography in GIS is usually termed as Digital elevation model (DEM). DEM as the term indicates is a digital description of the terrain relief. A DEM can be stored in different forms: contours lines, TIN (triangulated interface network), raster based array of cells. DEM stores the surface height by means of array of elements which are called as pixels. Generally DEM (**Fig.3.2.1.4**) formed the basis for generation of elevation-relief, slope and aspect maps which are shown in **Fig. 3.2.1.6**, **Fig. 3.2.1.8** and **Fig. 3.2.1.10**, respectively.

Raster based DEM was prepared from the toposheet of Survey of India. The toposheet was scanned and digitized in GIS platform. Similarly, thematic maps for elevation-relief and aspect were also generated using the base map of the DEM. The mountain ranges of Tibet Himalaya range in the NW, Damchen range in the north and Singkyang range in the south of catchments are elevated at a height above 4900 m (see **Fig. 3.2.1.4**). The low lying valley from Bum Chu confluence to the intake site is elevated at a gradient height of 1800 m to 1200 m.

In the influence zone of 10 km radius area, it is spread over of 43525.4 ha of land. The area of the Singkyang range in the south and Damchan in the north extends up to 3911 m However, the lower lying valleys of Siyom i.e., d/s of the power house goes to 772 m a.s.l. **Figure 3.2.1.5** shows the influence zone within the 10 km radius of the study area both from the intake site and power house site.

3.2.1.5 Relief

The DEM was classified into 11 elevation bands in the catchment area up to the intake site. The lowest elevation band is classified up to 1200 m whereas the highest elevation band was classified above 4800 m.. The five elevation bands from 2000-2400 m, 2400-2800 m, 2800-3200 m, 3200-3600 and 3600-4000 covers 82.5% of the total catchment area. The largest area falls under the elevation band of 2400-2800 m with an area coverage of 18.90% of total catchment area (see **Fig. 3.2.1.6**). Lower elevation band 1600-2000 m covers 5.13% of the catchment area, this elevation band is prevalently spread in the downstream of Yoprdunchu Chu to the Intake site. Higher elevation bands are prevalent in the Singkyang range, Damchen range and Great Himalayan range. Please refer to Table 3.2.1.3 for further details.

Table 3.2.1.3 Elevation range and corresponding area of Tato I H.E. Project catchment.

S.No.	Elevation	Area	Percent
1	Up to 1200	0.04	0.00
2	1200-1600	842.42	0.73
3	1600-2000	5920.02	5.13
4	2000-2400	16502.2	14.30
5	2400-2800	21810.6	18.90
6	2800-3200	19387.2	16.80
7	3200-3600	18129.34	15.71
8	3600-4000	19364.12	16.78
9	4000-4400	11874.66	10.29
10	4400-4800	1546.36	1.34
11	> 4800	46.16	0.04
	Total	**115400**	

As shown in the influence zone in **Fig. 3.2.1.7**, three elevation band classes 1600-2000 m, 2000-2400 m and 2400-2800 covers 60.2% of the total area of 43525.4 ha of the influence zone. These classes are spread in the head water region of Tagushit Nadu, Shene Korong and many seasonal streams. The consequent elevation bands 2800-3200 m, 3200-3600 m and above 3600 m form the head water region for Sarak Korong and Shou Chu along the right bank and Sittin Korong and Pirpu Korong along the left bank of power house and intake site. These three bands accounts for 24% of the total influence area. Apparently the lower elevation bands forms the valleys and they accounts for 15.8% of the influence zone. These bands are more prevalent along the downstream of the confluence of Sae Chu and Yarjep Chu.

3.2.1.6 Slope

Moderately steep class is prevalently spread in the catchment with more than 56% of the total catchment area. This class is more prevalent along the right bank of the Yarjep Chu. Moreover, this class is predominantly spread in the catchment of Sarak Korong near the intake site. Moderately steep is classified under the slope ranging from 15% to 30 %. Steep class is second predominant slope class in the catchment with an area coverage of 29498.32 ha i.e., 25% of the total catchment area up to the intake site (see **Fig. 3.2.1.8**). Steep class is more prevalent along the higher ridges of the Damchen and Singykyang ranges. Strongly sloping is more prevalent on the right bank on the ranges of hills along the watersheds of Tamding Phujo, Sae Chu, Kartsesho Korong and Shuru Phujo. Strongly sloping class covers an area of 14705.18 ha which accounts for nearly 13% of the total catchment area. Other slope classes represent about 5% in the catchment. Please refer to the Table 3.2.1.4 for further details.

Table 3.2.1.4 Slope range and corresponding area of Tato-I H.E. Project catchment

S.No.	Slope Class	Area	Percent
1	Gently Sloping	911.66	0.79
2	Moderately Sloping	4592.92	3.98
3	Strongly Sloping	14759.66	12.79
4	Moderately Steep	64900.96	56.24
5	Steep	29600.1	25.65
6	Very Steep	634.7	0.55
	Total	**115400**	

Within the influence zone moderately steep is prevalently spread on the right bank of the intake site and power house site. Perversely, steep is more prevalent along the left bank of the intake site and power house site. Most of the tributaries have their head water region within steep class and moderately steep. These both classes are spread on an area of 88% of the total influence zone. The remaining classes are spread on the rest of the 12% of the influence area (see **Fig. 3.2.1.9**).

3.2.1.7 Aspect

As shown in the aspect map of **Fig. 3.2.1.10** all the facets Flat, NW-N-NE, NE-E-SE, SE-S-SW and SW-W-NW are more or less equally distributed. Moreover NW-N-NE facet is spread over an area of 28584.58 ha i.e., 24.77 % of the catchment area. For further details of area coverage please refer to Table 3.2.1.5.

The facet SW-W-NW is prevalently spread in the influence zone moreover on the right bank of the power house and intake site. This facet is spread in an area of 10690.91 ha which forms 24 % of the influence zone. Flat lands are also widely spread with in the 10 km radius of the intake site and power house site. For details see **Fig. 3.2.1.11** and Table 3.2.1.5. Other classes such as NW-N-

NE, NE-E-SE and SE-S-SW are spread in an area of 21.01%, 16.14% and 18.09% of the influence zone.

Table 3.2.1.5 Aspect and corresponding area of Tato I H.E. Project catchment

S.No.	Aspect Class	Area	Percent
1	Flat	23530.06	20.39
2	NW-N-NE	28584.58	24.77
3	NE-E-SE	19444.9	16.85
4	SE-S-SW	21822.14	18.91
5	SW-W-NW	22018.32	19.08
	Total	**115400**	

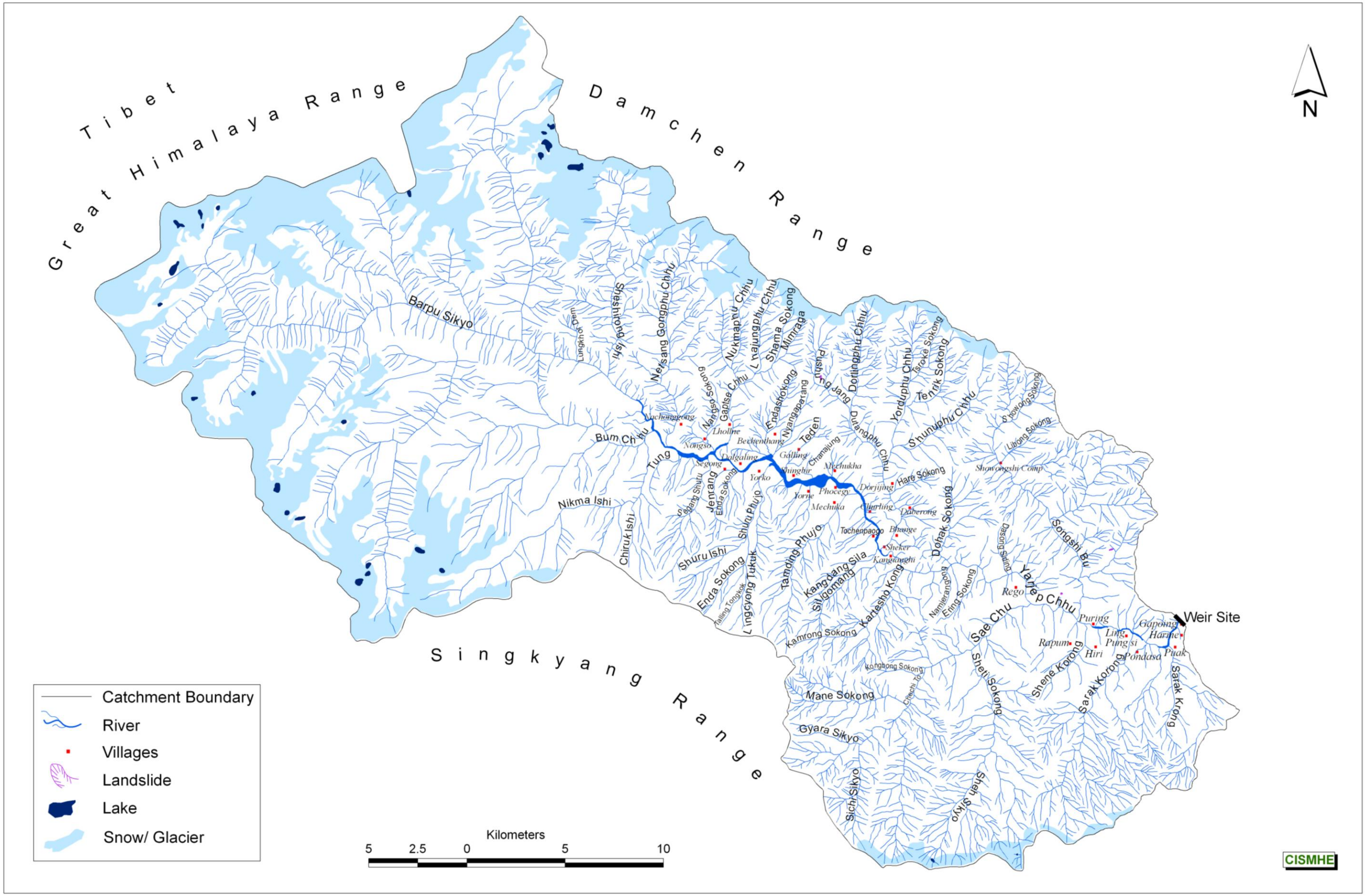


Fig. 3.2.1.1 Drainage map of Yarjep Chhu in the catchment area of the proposed Tato-I H.E. project up to the proposed Weir site

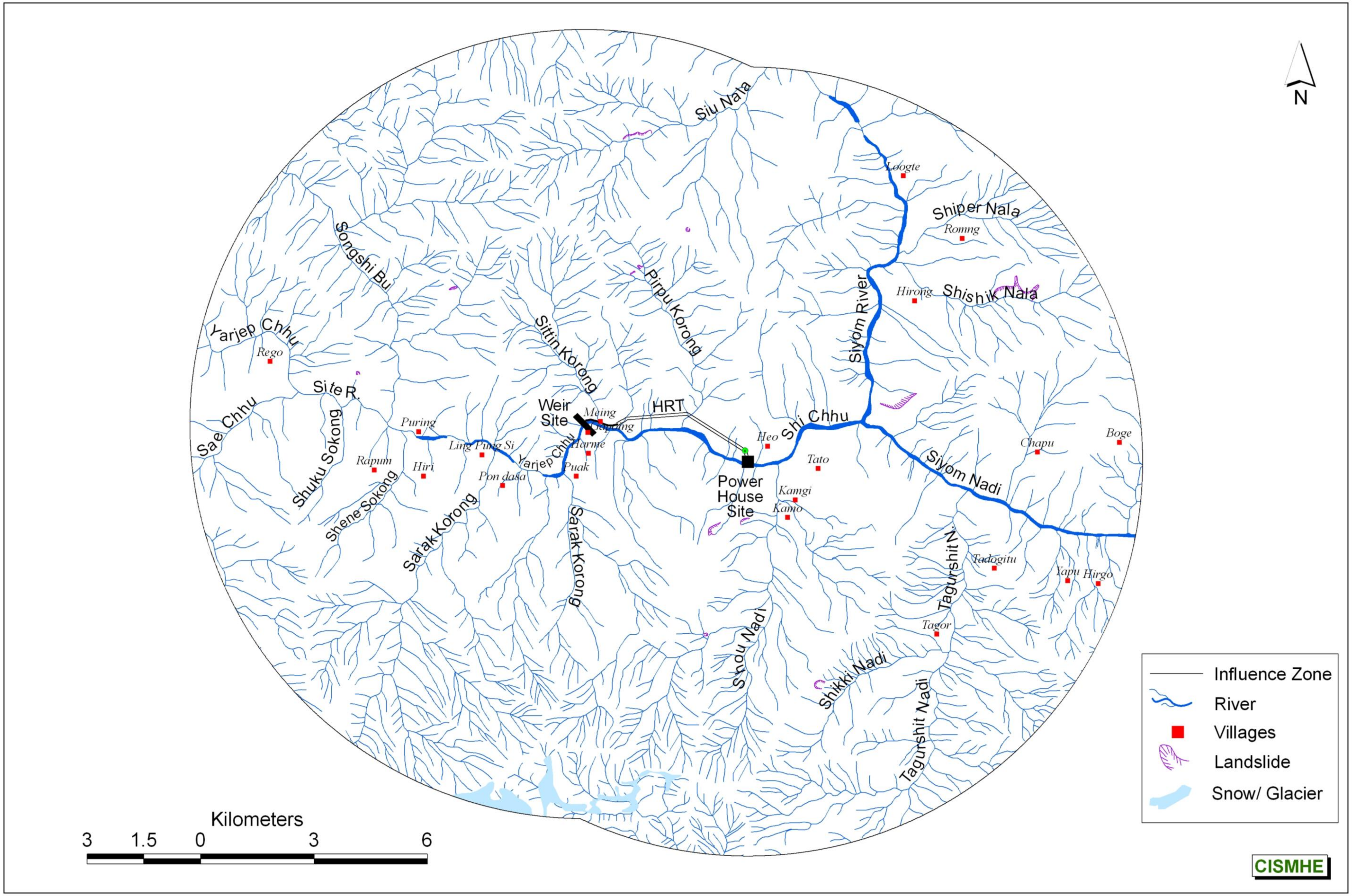


Fig.3.2.1.2 Drainage map of Yarjep Chhu in the influence zone of the proposed Tato-I H.E. Project

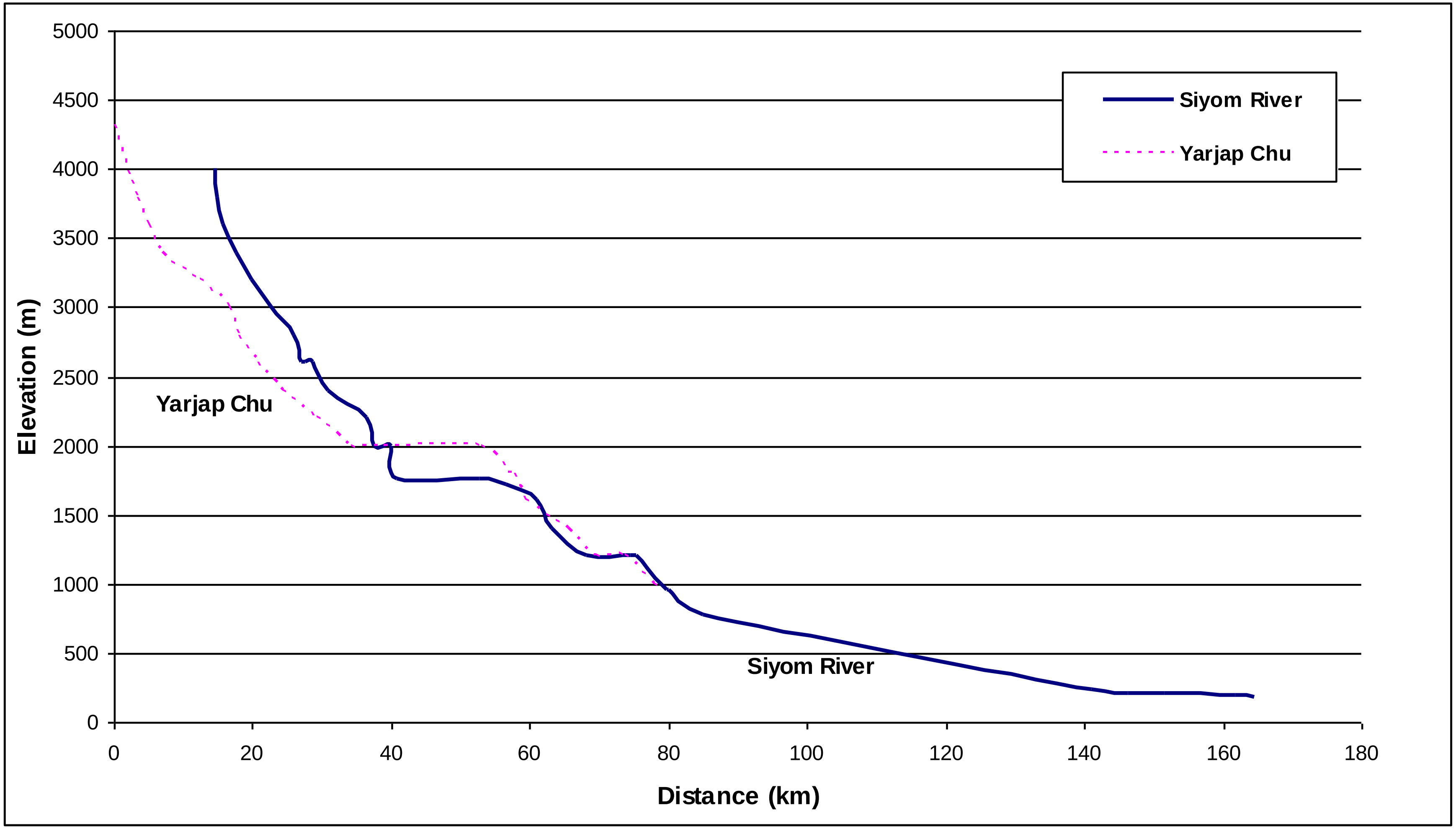


Fig.3.2.1.3 Gradient profile of Siyom river of the proposed Tato-I H.E. Project

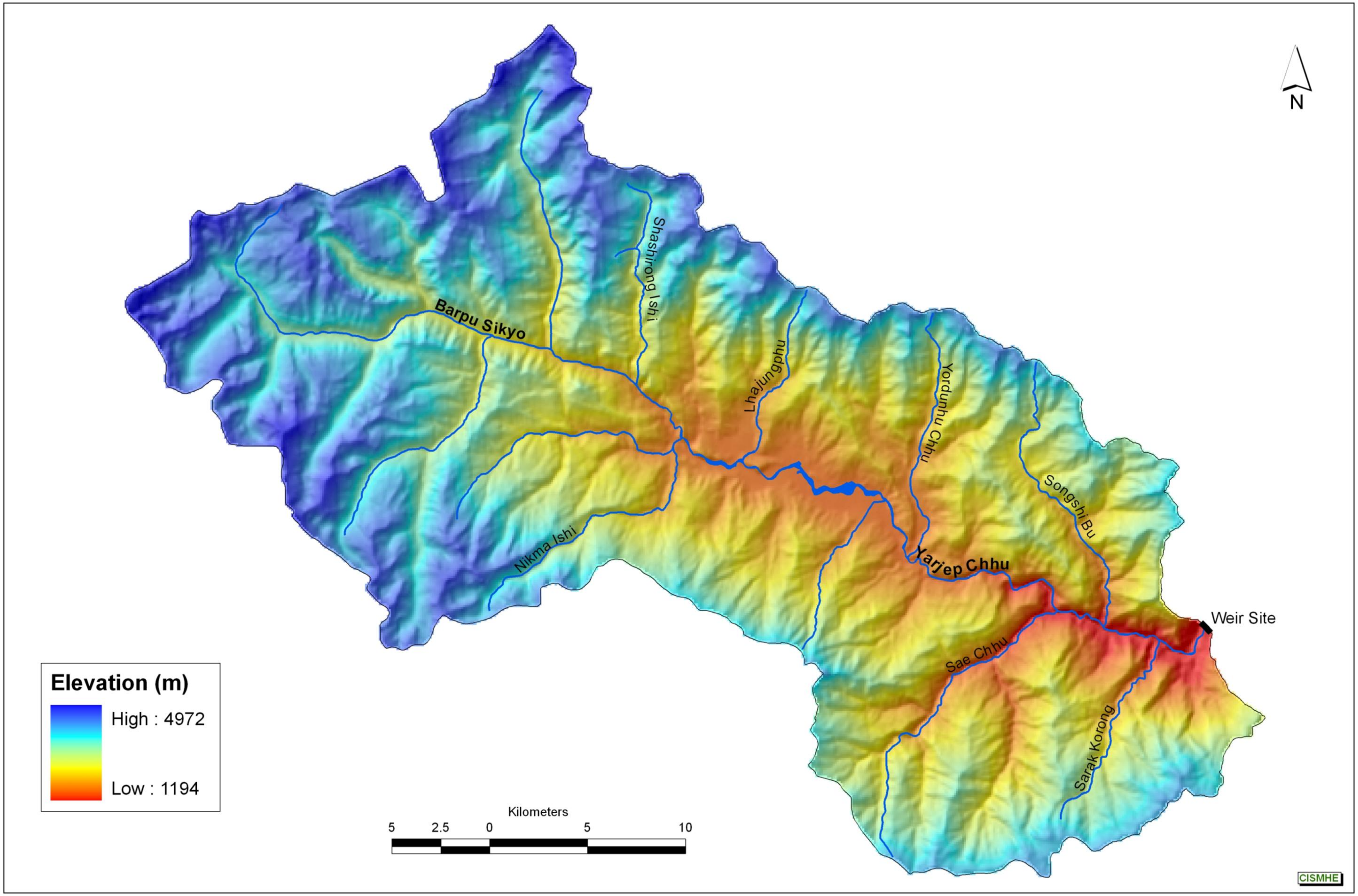


Fig.3.2.1.4 Digital Elevation Model (DEM) map of the catchment area of Tato-I H.E. project up to the proposed Weir site

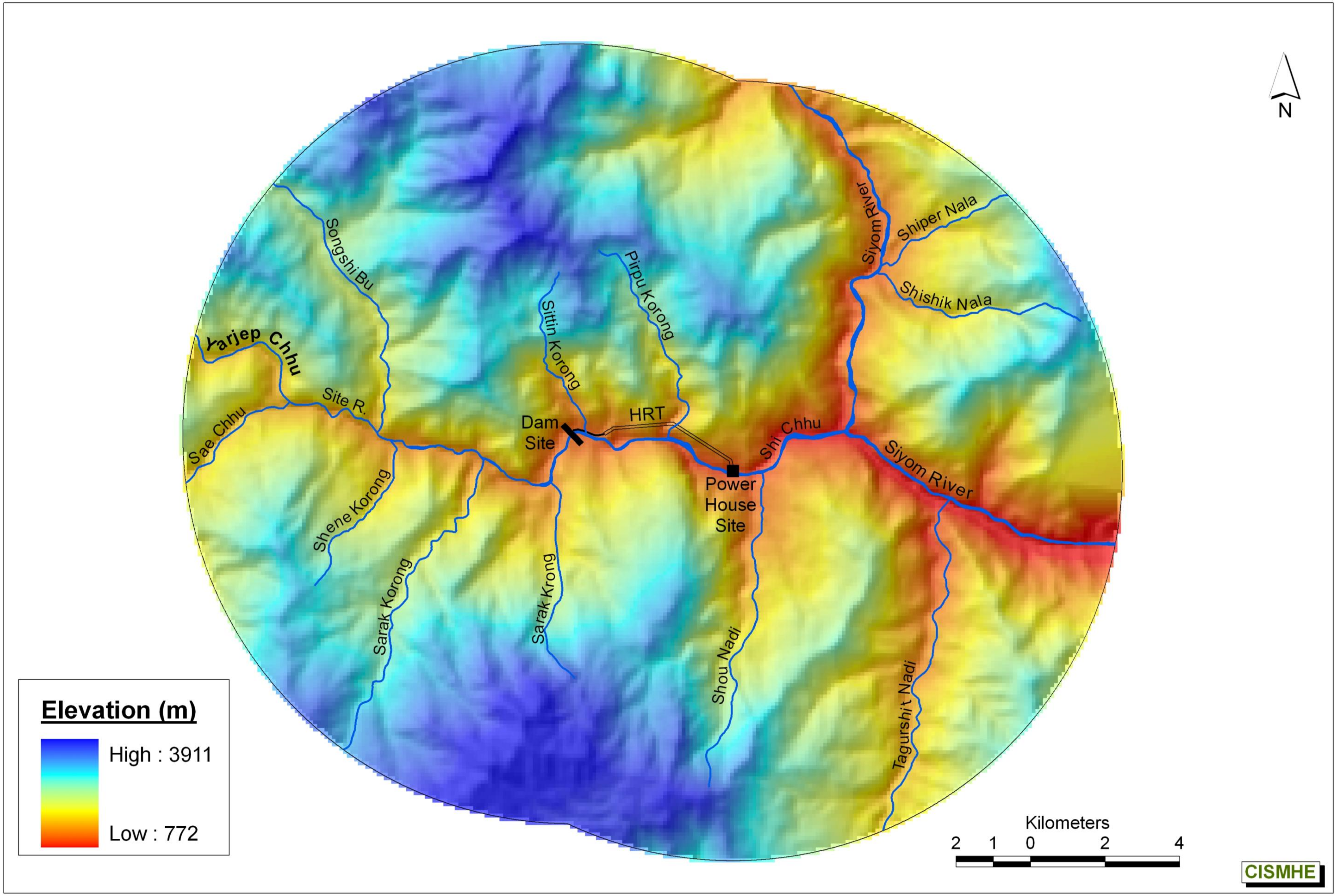


Fig.3.2.1.5 Digital Elevation Model (DEM) map of Yarjep Chhu in the Influence zone of the proposed Tato-I H.E. project area

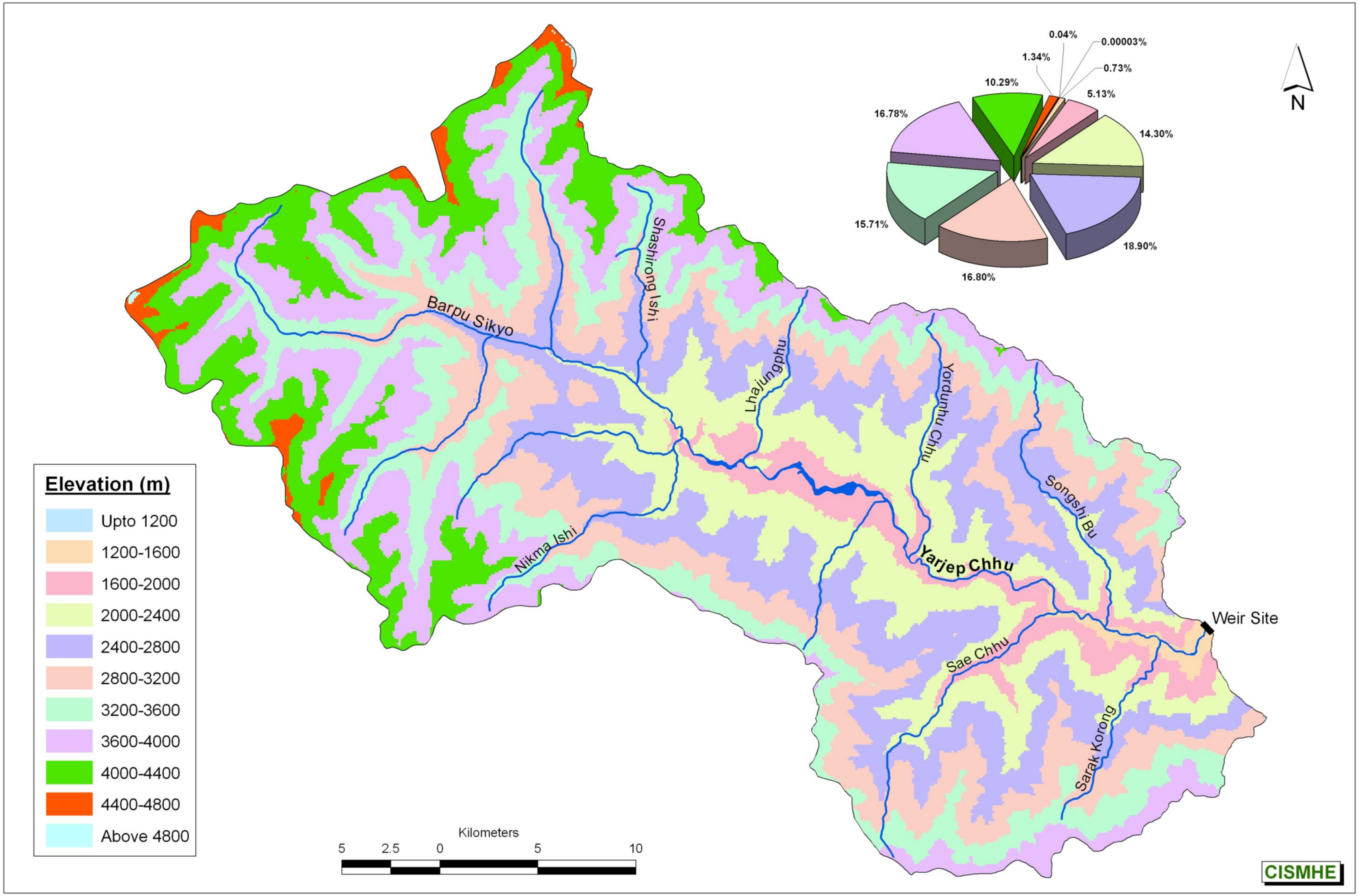


Fig.3.2.1.6 Relief map of the catchment area of Tato-I H.E. project up to the proposed Weir site

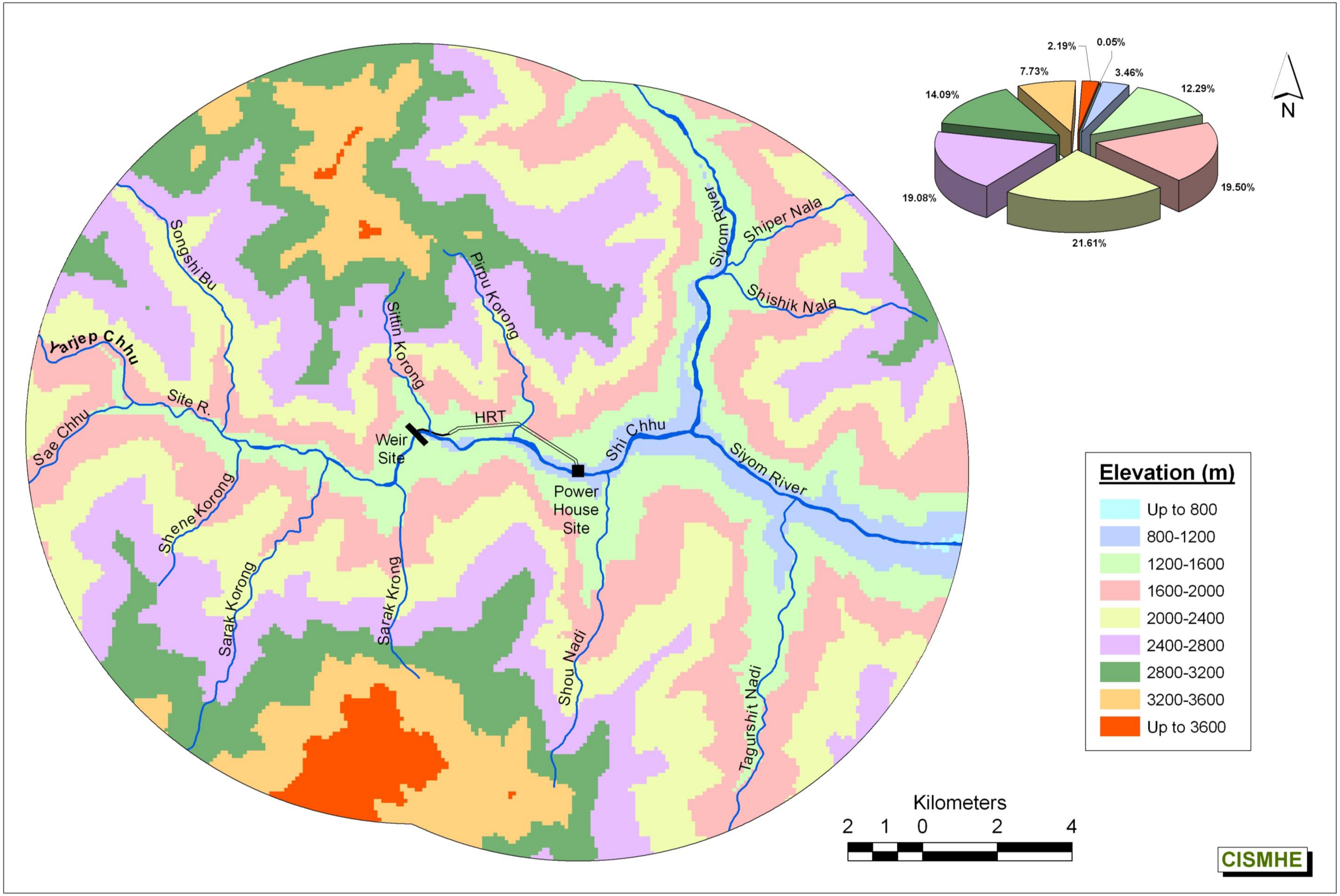


Fig.3.2.1.7 Relief map of Yarjep Chhu in the influence zone of the proposed Tato-I H.E. Project

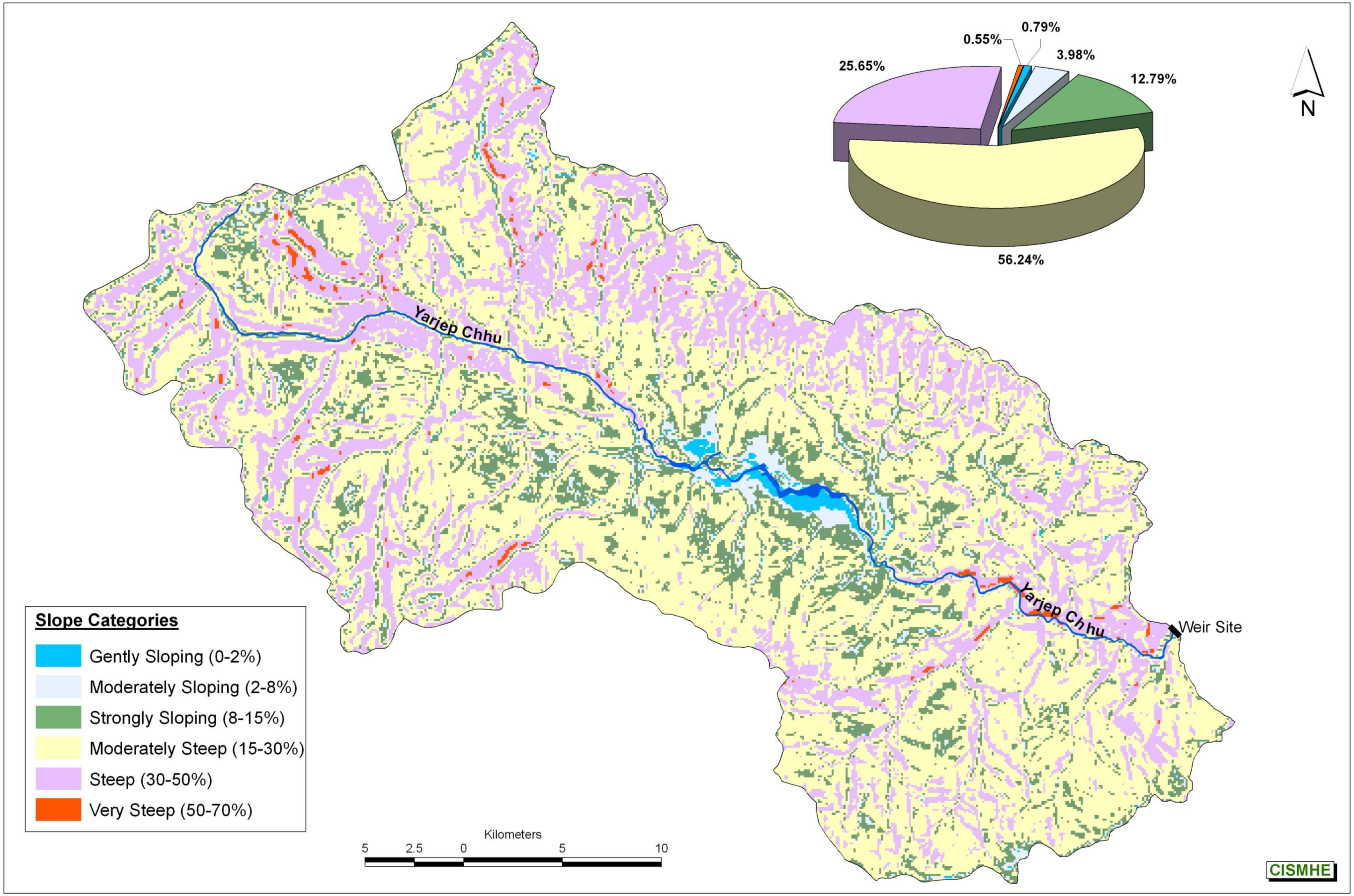


Fig. 3.2.1.8 Slope map of the catchment area of Tato-I H.E. project up to the proposed Weir site

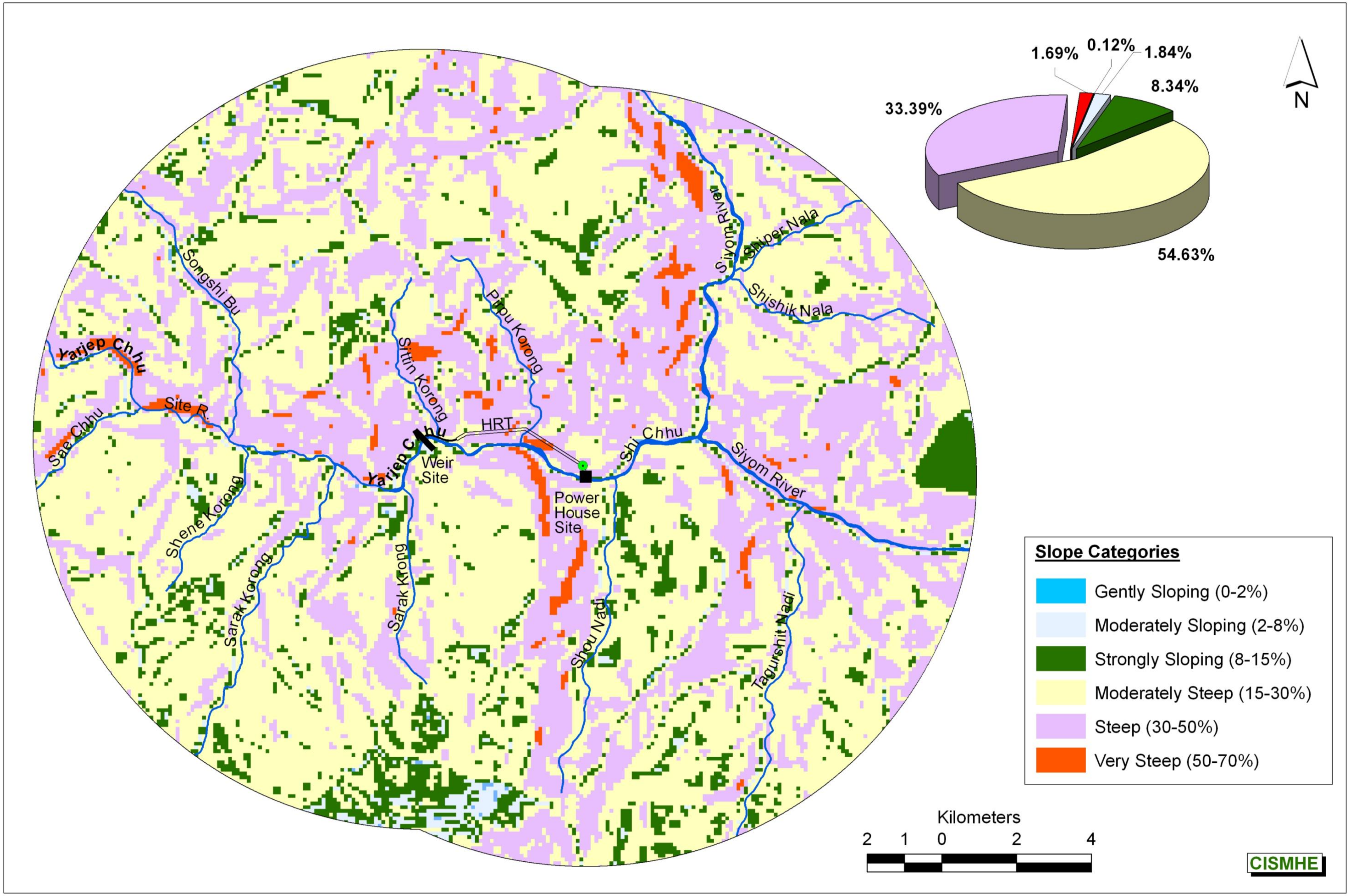


Fig.3.2.1.9 Slope map of Yarjep Chhu in the influence zone of the proposed Tato-I H.E. Project

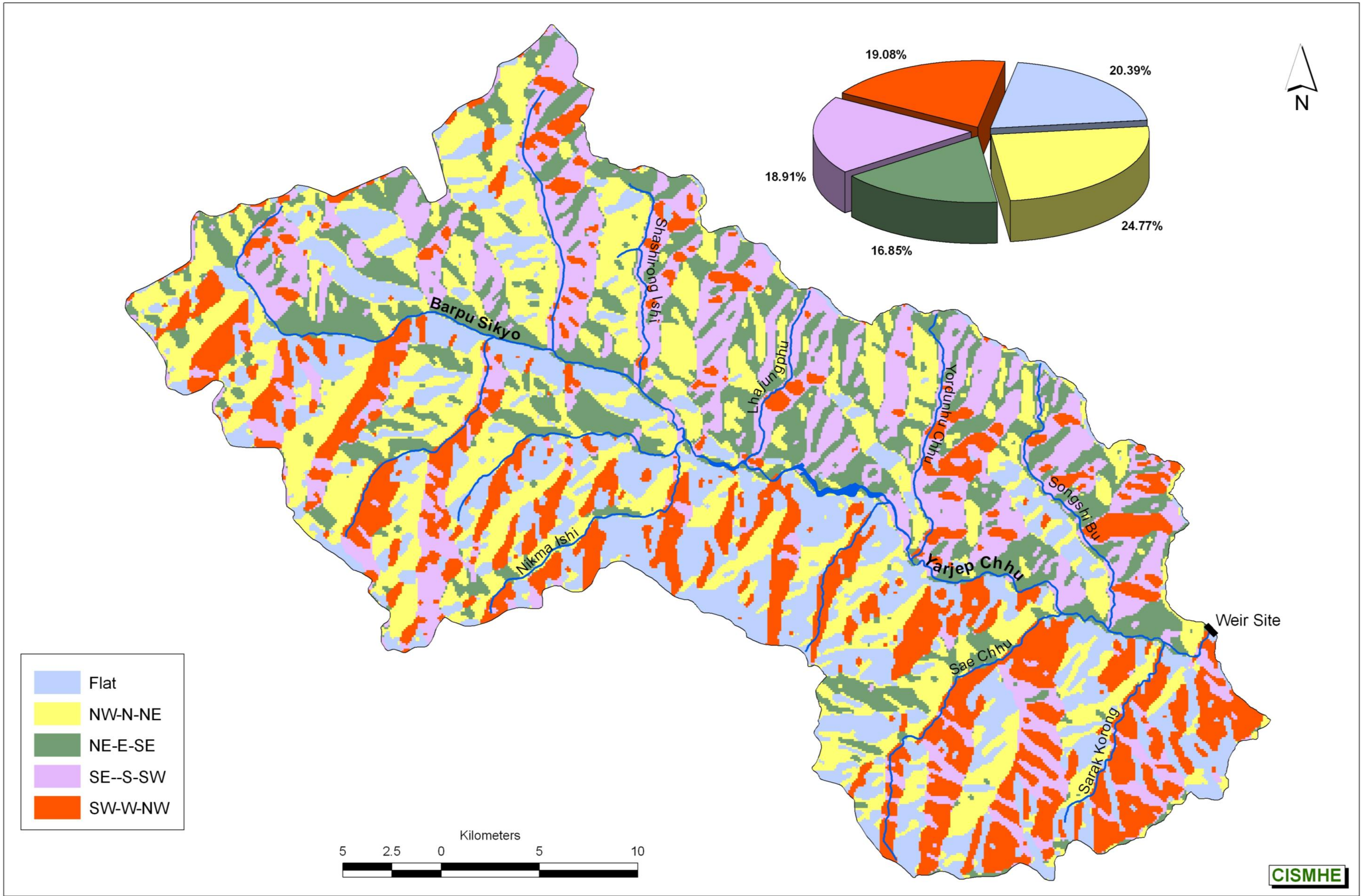


Fig.3.2.1.10 Aspect map of the catchment area of Tato-I H.E. project up to the proposed weir site

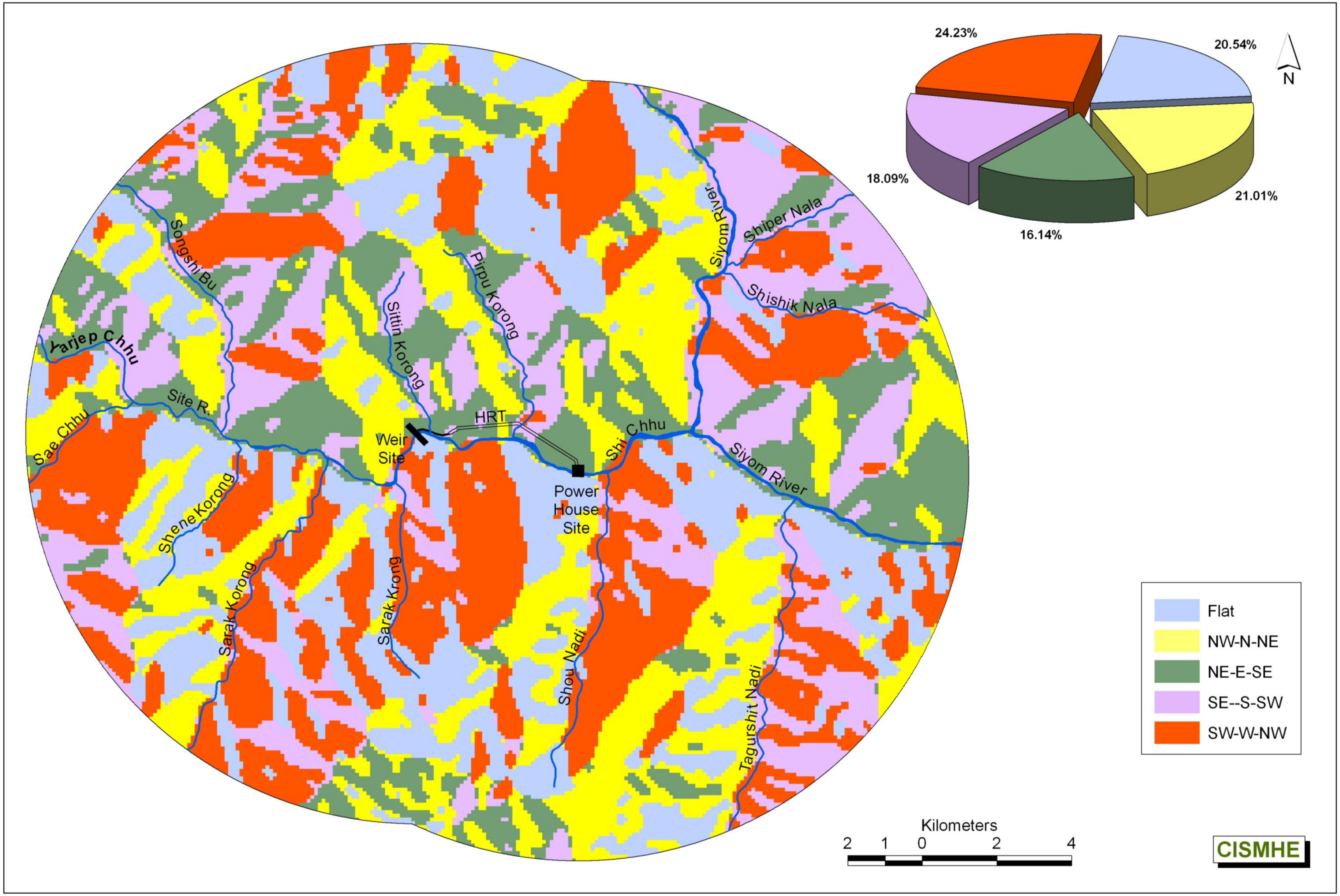


Fig.3.2.1.11 Aspect map of Yarjep Chhu in the influence zone of the proposed Tato-I H.E. Project

3.2.2 GEOLOGY AND SEISMICITY

Tato-I Hydroelectric Project is a run of the river scheme proposed on Yarjep River near village Tato-In West Siang district of Arunachal Pradesh near the confluence of Yarjep and Siyom rivers to generate 186 MW of power potential through utilizing the gross head of 164 m. It is immediately downstream of the Heo Hydroelectric Project and largely utilizes its discharged water (130.2 cumecs) along with additional discharge (2.8 cumecs) accumulated by the Yarjep tributaries between Heo Dam and Heo Power House. It is proposed to run in tandem with the Heo Project. All components of the project are situated on the left bank of the Yarjep River with a nearly 3.9 kilometer long head race tunnel followed by an open to sky surge shaft and a surface power house near Heyo village (opposite to Tato village). It is situated along side of the road connecting to Along and Mechuka. The river bed gradient is about 1 in 33 in the project area between channel intake (Meying village) and Power House site (near Heyo village). The project area falls on Survey of India topo sheet No. 82 L /6.

3.2.2.1 Regional Geology

Arunachal Pradesh, the northeastern most State of India falls between latitudes 26° 40’ and 29° 25’ N and longitudes 91° 35’ and 97° 25’ E. The State could be divided into four distinct physiographic segments such as i) Himalalayan Ranges ii) Mishmi Hills iii) Naga-Patkoi ranges and iv) Brahmaputra Plains from North to South. Each unit has a distinct geology and tectonic history (Kumar 1997) (**Fig. 3.2.2.1**). Admittedly, geologically and tectonically this is one of the most complex region in view of the palaeo and contemporary tectonics besides being one of the most difficult terrain due to ruggedness, accessibility and potential local hostile weather. Geological information has to be gathered, in general, through investigative account of various workers and in such an area naturally there is difference of opinion on several of the tectonic features location, demarcation of lithological boundaries and geological grouping. However, here an attempt has been made to present a balanced geological frame work of the region for better appreciation of the geology and tectonics of the region for its application of assessment of the project envisaged.

i) Stratigraphy

The Himalayan ranges continuing from NW India to NE India occurs as a “gigantic crescent” in this part of the country with its convex side towards south and extends from the Western border of Bhutan to Lohit valley in the east and is divisible into four linear zones namely the Tibetan

Himalaya, Higher Himalaya, Lesser Himalaya, and Sub Himalaya abutting against the Trans Himalayan range, and the Mishmi Hills famously known as the Eastern Syntaxial Bend. The Himalayas constituting the northern fringe of the Indian Plate abuts against the Tibetan Plate along Indus-Tsangpo suture in the north and in the east by Indo-Burmese Plate along the Tiding Suture. Mishmi hills are considered to be part of the Burmese Plate, an extension from Mayanmar. The Naga-Patkoi ranges defines the southern limit of the Upper Brahmaputra plain abut against the Mishmi Hills along Mishmi thrust in the part forms part of Assam-Arakan basin. The ophilite belt of Nag-Chin separates it from the Naga metamorphics in the east. The Brahmaputra plain lies between Shillong Plateau and Naga-Patkoi ranges in the south and Himalaya in the north, Mishmi Hills in the east. This is essentially made up of quaternaries and rest over the basement of Precambrian or Paleogene-neogene sediments.

Rocks of Arunachal Pradesh belong to Proterozoic. Based on stratigraphy, degree of metamorphism and associated igneous activities they have been classified into three sequences (**Fig.3.2.2.2**) as enumerated below:

Supersequence –I Sela Group of rocks –Early Proterozoic

Supersequence-II Bomdila - Middle to late Proterozoic

Supersequence–III Dirang and Lumla Formations –Mesoproterozoic age

The general Proterozoic succession is provided in the Table below:

<table>
<tr><td>Proterozoic</td><td>Neo Proterozoic</td><td></td></tr>
<tr><td></td><td>Meso Proterozoic</td><td>Granite Gneiss
Dirang Formation; Lumla Formation</td></tr>
<tr><td colspan="2">Palaeo Proterozoic</td><td>Biotite granite gneiss
Ultramafic dykes/sills</td></tr>
<tr><td colspan="2"></td><td>Bomdila Group
Chillepiam Formation
Tenga Formation</td></tr>
</table>

	Ketabari Formation **Se La Group** Galensiniak Formation Tahila Formation

The Sela Group is the oldest, comprises polyphase deformed metasediments varying from green schist to amphibolite facies and well exposed in Se La pass and occurs in the higher Himalayas close to the border with Bhutan. The southern limit is defined by Main Central Thrust which separates it from the younger Dirang Formation. The Bomdila group extensively developed and exposed in the Lesser Himalayas from Siang Valley in the east to Kameng Valley in the West and further continues into Bhutan. Dirang formation unconformably overlains the Bomdila Group. As the sequence has been differently classified different nomenclature has been adopted by different workers and correlated differently. In view of the unconformable relation the Dirang formation is distinguished as a different identity from the upper most formation Chilliepam Formation of the Bomdila Group and is not considered part of the sequence.

The Mesoproterozoic rocks unconformably overlie the Bomdila Group of Rock and Ziro gneisses in Lesser Himalayabto constitute Dirang formation and over the Se La group in Higher and Tethyan Hiamalayas to form Lum La Formation. The project area falls in Dirang formation resting over the Sela group of rocks. The formation comprises a thick sequence of low grade metasedimentaries comprising garnet-muscovite schist, phyllite, sericite- quartzite, calc silicate and tremolite-actinolite marble, truncated in the north by MCT.

3.2.2.2 Geology of Project Area

i) Weir site

The Weir site is located 50 m upstream of the Heo Power house site and therefore the geology of the Weir site is almost the same as that of the Heo powerhouse site. The rocks exposed at the Weir site are predominantly quartzite with sub-ordinate quartzo-feldspathic gneiss with some schist bands. The foliation trend varies from N30-60E- S30-60W with dip varying from 30 to 40 towards Northwesterly. While in the left flank the rock crops out up to considerable elevation the outcrops on the right flank are limited to 6-7m from the riverbed level. The thickness of overburden inferred in the river bed may vary from 5m to 10m. The major discontinuities recorded in the rockmass of the country rocks are as follows.

Description	Strike/Dip	Persistence	Frequency	Roughness
Foliation/Foln.jt	N30-60E-S30-60W/30-40 N30-60W	Medium (3 to 10m)	15cm to 50cm	Smooth planar
Oblique Joint	N45W-S45E/70 NE	Low (1m to 3m)	30cm to 50cm	Smooth Planar
Steep	N30W-S30E/80 S60W	Low (1-3m)	Occasional	Curvilinear smooth

Based on the morphological feature on the left flank, particularly presence of several cliffs aligned in near E-W direction, a relatively gentler foot slopes indicating variation in abrupt slope characteristics probably due to rock mass variation characteristics and presence of released large sized debris strewn in considerable stretch of the river bed portion points to a probability of a E-W trending fault. Although an alternative explanation by way erosion by Yarjep River could be put forth, it is desirable to unequivocally establish presence or otherwise of the fault to observe the nature and type of material and their behaviour by pitting is contemplated. The exploration will be taken up since this information may also be needed for determination of seismic parameters of the site.

ii) Intake

The proposed intake structure will be located in gray to off white quartzite hard and compact. Preliminary estimates of Q value shows that the rockmass can be classified as fair to good and the RMR values based on GSI is of the order of 55 at the surface. No serious problems are anticipated at this stage of the investigation. The permeability tests have indicated that the joints in the foundation rock are tight in nature and values vary from 3.65 to 10.71 lugeons

iii) Water conductor system

The water conductor system consists of a channel section from the head works and the tail race pond of the Heo project powerhouse up to a distance of 1100m on the left bank of Yarjep River parallel to river flow, after which the system consists of the Head Race Tunnel. A geological account of these is given in the following paragraphs.

a) Head race channel

The head race channel or the power channel is primarily located in reaches covered by riverine deposits and zone of accumulation of palaeo-slide debris. Formation of channel will be essentially in cut reaches. There are two drainage crossings and it is intended to cross these reaches as Super passage by providing a box work. The Channel is 1100 m long with a base width of 6.6 m is intended to be lined in the entire reach. The depth of excavation varies from 4 m to more than 22 m and in general the excavation is of the order of 10m. FSL is 1189m± and the bed of the channel starts from ± 1183 m with a slope of 0.15%.

The bedrock is quartzite and is traversed by three sets of joints including foliation. The foliation trends NE-SW dipping 25^0 to 30^0 NW and the other two joints are oblique joint trending NE-SW dipping 60 NW and NW-SE dipping 70^0 to 80^0 towards SW. The foliation joints set and the first oblique joint set dip into the hill while the third joint set dip towards the valley as depicted in the sections. The preliminary stability analysis indicate that the dip of foliation and the other joints set will not be exposed into the cut of the channel on the left bank while on the right bank they will daylight in the right bank slope of the channel.

b) Head race tunnel

The HRT route was earlier foreseen on the right bank. Potential landslides identified in the area of the outlet-penstock-powerhouse lead to considering different options. The alternative with all conveyance system and powerhouse on the left bank was retained for investigations. Earlier PFR considered the locations on the right bank and in course of the field visit led to following observations:

- Morphological signature typical of slided loose materials
- Thick soft loose deposits and strongly disturbed (displaced) rock masses with open fractures observed along the access road and it was felt that presence of deep instability cannot be disregarded at this stage

In view of above all the project features other than the diversion structure are located on the left flank where rocks crop out prominently.

The proposed Head Race Tunnel (HRT) alignment passes through a rough and rugged terrain with very difficult access on the left bank of Yarjep River. The tunnel alignment is presently inaccessible where neither any approach road/track exists nor is there is any crossing arrangement and entire HRT area consists of steep to near vertical slopes with thick vegetation.

The tunnel as per the earlier proposals was studied for being located either on the right or left banks of the river but in view of number of cross drainages and salesladies on the right bank it was preferred to locate the tunnel on the left bank. The proposed tunnel on the left bank is about 3.9 km long with a diameter of 6.4 m, horseshoe and has a gradient of 1 in 150. The tunnel is aligned in ENE direction for a length of 1.6 km before being aligned in ESE direction for the remaining length of 1.9 km up to the Surge shaft a length of about 2.4 km.

The Head Race Tunnel crosses a number of cross drainage systems and one of them is Pirpit Korang nalah falling on the alignment just before the second bend and first major bend where low cover is expected, as per the available data is around 96m (1153.3-1250), or 1.4H. Don Deere rules are respected. Some seepage problems may occur for which the alignment is suitably modified and will be tackled during the actual surveys. The HRT passes through a maximum vertical cover of about 425 m and is expected not to pose much problems.

In view of inhospitable terrain and also due to scarcity of outcrops and thick forest cover along the actual alignment, the geological details gathered based on high resolution image interpretation data, nalah sections and on the mapping details of road section on the right bank and photo imagery studies and few outcrops map of the tunnel alignment area had to be inevitably relied upon for interpreting the anticipated geological setting along the tunnel alignment; rock mass characteristics have been worked out to design the support system Mapping details at the Heo powerhouse site and results of explorations have supplemented to develop the geological section along the tunnel alignment to make a forecast of the rock groups to be met along the tunnel alignment and the probable rock mass characteristics have been worked out to design the support systems. With the availability of more data during the tender and detailed engineering studies of the project and pre-construction stage of the project necessary modifications and refinement of the forecast will be made. Of course, as in all tunneling operations the short-term prognosis has to be made with the progress of tunneling and necessary modifications in the support system which may be more realistic. The proposed design is made based on the most conservative assumptions.

The imagery studies and geological mapping carried out at the structural sites and correlation of other data indicates that the tunnel will encounter the following rock units/groups in general.

I. Composite Gneisses with bands of quartzites

II Quartzites with interbedded layers of augen, streaky gneisses and bands of schist and amphibolite's bands

III. Migmatites

a) Gneisses:

Gneisses are mostly banded variety along with augen and streaky gneiss variety. They are light grey to dark grey in color with banding hard and compact and they are interbedded with schists (qtz.mica schists) from a few cms to a metre thickness. They are comparable with similar rocks in other Himalayan areas with a compressive strength of 120-140 Mpa.

The streaky gneisses under the microscope indicate the presence of quartz mainly with plagioclase felspar, amphiboles, biotite/chlorite and pyrite and magnetite as accessory minerals. They occur with bands/lenses of quartzites.

b) Banded gneiss with schist

The term 'schist' designates schistose, mafic-rich, thin bands generally strongly deformed as shear zones. Near surface, alteration of such bands can result in clayey fill. However, it is estimated that in confined conditions, such bands are mostly sealed and tight, as observed in drill cores.

Gneiss with schist intercalations can be assimilated with heterogeneous rock masses. There is a dedicated GSI chart for such rock masses. For the purpose of characterizing this rock mass, we can consider gneiss and schist in comparable ratios, which is quite conservative in light of actual observations which shows gneiss predominant.

The schist rock is mostly a dark grey rock, medium to coarse grained consisting of quartz, mica (both muscovite and biotite) in preferred orientation and define the characteristic schistocity and magnetirte occurs as an accessory mineral mostly (**Plate 3.2.2.1**).

c) Quartzites:

Quartzites white skin color, hard and compact, and at places it is grey in color. These quartzites are also associated with gneisses and schistose layers and amphibolite bands of variable thickness but not exceeding a few meters.

d) Migmatites

A prominent migmatite zone has been mapped beyond the mid reach of the tunnel length which is mostly a mixed rock made from two different sources, the host rock and invading rock material and can be termed as injection gneiss and show development of flow folds and is hard and foliated in character (**Plate 3.2.2.2**).

Structurally, the rock type structure is complicated with foliation joints and sheared along schist zones. The foliation in these gneisses shows low to moderate dips (25 to 40) in northwesterly direction mostly though locally they are dipping towards southwesterly direction. A detail of joints in composite gneisses is given in Table 3.2.2.1.

The rock types are well jointed and following major sets of joints have been recorded.

Table 3.2.2.1 Joints in Composite Gneisses

Joint Direction Strike and Dip	Type	Continuity	Roughness	Frequency
N50-70E with dip of 25-40 towards NW	Foliation Joint	Long continuity up to more than 5m	Smooth Undulating	Very frequent
N80W-S80E with dip of 15 to N10E	Oblique Joint	Generally 3m long but may be up to 5m	Smooth Undulatinmg	Frequent(Spacing 20-50cm)
N85W-S85E with dip of 50-60 toS05W	Cross joint	3-4m,	Smooth planar	Occasional (spacing 20cm to one metre)
N40E-S40W dip of 60 towards S50E		2-3 metres	Smooth planer	Often (Spacing 30cm to 2m)

In the tunnel alignment, as detailed above, the following is broadly the distribution of the rock units starting from the inlet side:

In the initial reaches, the tunnel is aligned in E-N-E direction from the channel section end and in this stretch the tunnel will be excavated through composite gneisses followed by Quartzites with gneisses and schist bands for a length of about 0.5km followed by a kilometre length in Quartzites to be followed again by gneisses with schist bands with a zone of quartzites and migmaties in between. It is expected that a number of shear zones in the poorer schistose zones are anticipated and may be filled with clayey and other rock flour material.

The stereographic contour plot of joints recorded in the project area is shown in **Figure 3.2.2.3**. wherein, Joint Plane corresponding to maximum concentration of points (Plane I) is that of the foliation plane which is northerly oriented at gentle angles (13).This shows the predominance of foliation. The other important joint set is plane No.2 oriented towards N55W and dipping at 40 the third one is nearly southerly dipping at moderate angles (51:S9W)

The tunnel is aligned across the foliation by about 30^0 in the initial 1.6 km reach and then later on it is aligned about 45 degrees with regard to foliation. These both indicate a favorable direction for tunneling and should not pose problems

iv) Adit to Head Race Runnel

In order to facilitate excavation of HRT, two intermediate adits have been proposed in the reaches of the tunnel alignment of the head race tunnel for excavation and lining purposes and quick progress which will be further assessed and finalized with the availability of better physical control.

v). Surge Shaft/Tank

A 85m deep and 14 m diameter Surge Shaft/Tank is proposed from the top surface level at 1225m with the bottom level at 1140m for the project. The area around the Surge Shaft is occupied mostly by gneiss exposures with a cover of overburden and thick forest cover on the surface. The gneiss exposures are inter bedded with schist bands of variable thickness.

The rock exposures indicate a foliation trend of almost East-West with low dips of 10 to 30 degrees towards North i.e. into the hill. No major joint systems have been evidenced at top level but lower levels the rock mass is dissected by three to four prominent systems/ sets.

The northern surface slope of the Surge Shaft location is rising and occupied by rocky outcrops and southern lower slopes are steep up to 1300m and below that it is steep. The Surge Shaft is to be sunk through gneisses with thin schist bands and in view of the fair quality of the rock no problems should occur. However, if the rock falls occur from the sides the same will be suitably stabilized with anchors and shotcreted before final lining with concrete. The all round lateral cover for the Surge Shaft is considered adequate.

The drainage system around the location indicates presence of a nalah towards eastern side and seepage along this may be anticipated during excavation for which necessary measures for dewatering will be made.

vi) Access Gallery

Excavation of the Surge Shaft is to be achieved through the access gallery about 155 m long at 1220 m from the face of the hill i.e. the southern slope of the hill to be constructed from the access road to Surge Shaft top. This adit will be excavated through the banded gneisses with schist bands falling under Class III Fair rock mass and should not pose any major geotechnical problems.

The access gallery will be driven through the ridge in westerly direction from the access road to Surge Shaft. Since the gallery is to serve as a permanent entry for good part of construction works and latter stage it will be provided with anchors/shotcreting during the construction phase of the project and lined with concrete at a later stage.

vii) Pressure Shaft

Mapping details

Surge Shaft and turbines in the Powerhouse are proposed to be connected through a main Pressure Shaft having diameter of 5.75m that will be trifurcated near the powerhouse and connected to the MIVs and is in two segments, a vertical one and a horizontal portion.

The alignment of vertical section is about 80 m in length from 1140 m top to 1020 m and horizontal section about 380 m long of the shaft falls along the ridge line extending from top of the ridge towards river Yarjep. The vertical section of the Pressure Shaft takes off about 20md/s of Surge Shaft for a length of about 80 m and then it is proposed to be extended horizontally for a length of about 380 m. The location of the Pressure Shafts ensures enough rock cover all around and is placed deep inside the hill surface. The surface ridge outline is occupied by fine to medium grained banded gneisses with thin schist bands. The rock exposures indicate a foliation trend of almost East-West with low dips of 10 to 30 towards North i.e. into the hill and rock mass is dissected with two prominent sets of joints in addition to foliation joints.

The Pressure shaft is to be excavated from the adit for a length of 270 m above the powerhouse on the hill slope at 1130m through gneisses with schist bands across their foliation and should not pose any geotechnical problems except for rock loosening by the system of joints dipping at 45 degrees towards the powerhouse as they will be undercut during excavations The normal system of protection for the Class II rock mass will be provided for.

viii) Power House

Current design contemplates surface power house on the left bank of the river near Heo village opposite to Tato village at location 28° 31’ 53”:94° 21’ 31”. Very steep cliffs covered by thick forest cover dominate the site (**Plate 3.2.2.3a,b**).

Physiographically, the Powerhouse is located on the left bank and a small nalah is joining the main river on this bank. A suitable crossing arrangement has been made at appropriate levels so that the nalah does not foul the construction activity and running of the power house and to prevent debris carriage and water in rainy season. The location of the powerhouse is considered favorable taking advantage of the flat surface available on the left abutment. The back slopes are rising steeply at about 50 degrees and it is presumed that the bed rock may not be deep and outcrops of gneisses is found along the slope in this area and shallow dips around 10 deg have been recorded towards NNW forming a stable setting .Above 1075m the slope becomes suddenly gentler but no outcrops are noted on the slope .One isolated outcrop of gneisses was noted at El 1125m in the small nalah which discharges near the powerhouse Apart from this outcrop the narrow stream is cut into slope wash deposits which form 10-12m high slopes.

The predominant rock type at selected site is banded gneisses which are exposed on both the banks of the Yarjep around powerhouse site. At the elevation of 1020 m where the Yarjep is joined by a nalah exposed rocks on the left bank are coarse grained and banded Biotitic hornblende gneisses interbedded with garnet quartzo feldspathic gneisses

However the rock exposures on the right bank are highly disturbed and weathered. And powerhouse location on this bank has not been preferred. The actual powerhouse location on the left bank is covered by overburden. The thickness of overburden is established by geophysical surveys and drilling which are described later

The foliation in this gneissic rock dips generally in a northerly direction. With 4 to 6 degree swings on both the sides at low to moderate angles (10-30) i.e. into the hill. The rock mass is jointed and prominent sets recoded are in Table 3.2.2.2.

Table 3.2.2.2 Characteristics of joints recorded near powerhouse site

Joint Direction Strike and Dip	Type	Continuity	Roughness	Frequency
N80W-S80E toN85E-S85W with dip of 10-30 to North	Foliation Joint	Long continuity up to more than 5m	Smooth planer	Very frequent Spacing 10 cm to 50 cm
N50W-S50E with dip of 20-25 to NE	Oblique Joint	1-2m	Smooth planer	Frequent , Sp 30-50 cm
N47E-S47W with dip of 45 to SE		1-2 m	Smooth curvilinear	Occasional Sp 50 cm -1m

3.2.2.3 Seismo-Tectonics and Seismicity

Himalayas as a whole has undergone intense folding and faulting during different phases of Himalayan Orogeny. The Northeast India in particular has witnessed sedimentation from Paleozoic to Tertiary and has undergone subsequent tectonic events. Four physiographic divisions namely Tethys, Higher, Lesser and Sub Himalayas of Arunachal Pradesh described above have imprints of different tectonic episodes and differ markedly in their intensity. The important structural features of Arunachal Pradesh are described below.

i) Folds

Each division has witnessed different tectonic episode and depict different patters of folding. A brief description of various generation folds described in literature is given below:

1. The first generation folds (F1) are isoclinal to reclined parallel to bedding (S_0) and of local extent which were developed during first generation of metamorphism (garnet – amphibolite facies) and are largely recorded in Se La Group of rocks.
2. The second generation folds (F2) are superimposed over F1, moderately tight to open and of regional dimension. These are conspicuously developed in Se La and Bomdila Group of rocks and trend in ENE – WSW direction if not refolded during subsequent episodes. These are not traceable in younger rocks e.g. Dirang and late successions and therefore, are believed to be associated with late Palaeo - Proterozoic orogenic movements. Further, these are associated with large scale acid intrusions which gave rise to various granitic gneisses i.e. tourmaline gneiss, biotite granite gneiss etc. in this region. One such axis of regional fold, overturned plunging anticlinal is found running between MCT and MBF following same regional trend i.e. ENE – WSW within Palaeo – Proterozoic gneisses occurring between both tectonic features.
3. The third generation folds (F3) are isoclinal, reclined or asymmetrical with axial plane running in NNE – SSW or NE – SW and plunging towards north. Their imprints are found in Bomdila Group, Dirang Group and younger sequence of rocks.
4. The fourth generation (F4) is asymmetrical upright to overturned folds having ENE – WSW trending axial plane and dipping towards north. These folds are recorded in Lower Gondwana sequence, west of Siang valley. Eastern Syntaxial Bend is the result of this tectonic event of deformation. Their imprints are well traceable in Bomdila Group as well.
5. The last and final phase of deformation resulting in fifth generation (F5) folds which are generally open, broad asymmetrical with axial plane trending NNW – SSE to NW-SE. These folds have affected Yingiang Group and older succession but have not affected MBF and Siwalik Group of rocks. It therefore, seems that they are result of strong compression forces possibly during initiation of Himalayan orogeny when

Gondwana Plate collided with Asian Plate along Indus Tsangpo Suture on one side and Central Burmese Plate along Tiding Suture on the other side along Tidding Suture.

ii) Fault / Thrust

1) *Main Central Thrust*

The word “Main Central Thrust” (or MCT) was first used by Heim and Gansser (1936) to define tectonic boundary between Central Crystalline (in Arunachal its equivalent rocks are Se La Group) and Garhwal Group (Bomdila in Arunachal Pradesh) in U P Himalaya (now Uttarakhand). The MCT is so pronounced that later it has been traced to Arunachal Pradesh through Nepal, Darjeeling - Sikkim and Bhutan (Ravi Shankar *et al*. 1989) and finally it abuts against Tidding Suture (see **Fig. 3.2.2.4**).

The MCT separates the high grade metamorphic rocks (Se La Group) with low to medium grade metamorphic rocks (Dirang Formation). It is traceable in Diggin valley near Rama Camp, upper reaches of Kamla River and near Taliha in Subansiri River section.

2) *Main Boundary Fault*

The Main boundary Fault is northerly dipping, steep fault which demarcates Main Himalaya in the north and Sub Himalaya in the south. In Arunachal Himalaya, it is traceable (**Fig. 3.2.2.4**) from near Bhutan border in the west. Through north of Itanagar, it extends in ENE – WSW direction up to Roing in Dibang valley and abuts against Roing Fault.

3) *Bame Fault*

Bame Fault runs N – S in central Arunachal Pradesh and separates Bomdila Group of rocks and Lower Gondwana rocks. Along this fault, Yang Sangchu Formation which occurs between Lohit Thrust and Tidding Suture terminates in Siang valley. This fault is traceable from Siang valley in the north to near Basar in the south and it terminates against MBF.

4) *Roing Fault*

Roing Fault runs parallel to Tiding Suture and Lohit Thrust in central Arunachal Pradesh in the NW – SE direction and like them it also abuts against Mishmi Thrus in the SE. Main Boundary Fault also gets terminated near Roing along this fault.

5) *Tidding Suture*

The word suture is normally referred to plate boundaries and therefore is important regional lineaments. The Tidding suture is NW – SE trending suture zone or the zone of subduction where Indian Plate is believed to be subducting beneath the Burmese plate along this lineament. It extends from Dhapa Bum (southern part of Lohit valley) to south of Tuting in Siang valley in northwest. It abuts against Mishmi Thrust in the south

6) *Lohit Thrust*

It is also NW – SE trending feature which separates Tiding and Mishmi Formations. It was first identified by (Nandy, 1976). It is traceable from north of Tuting in Siang valley till Mishmi Thrust in the south where it is abutting against it.

7) *Mishmi Thrust*

It is located in the south east part of the Arunachal Pradesh near Myanmar boarder. The western part of this thrust trends E – W. It takes NW – SE trend as it moves towards eastern side following the trend of Naga Patkoi Hill ranges.

Figure 3.2.2.5 shows the important tectonic structure near proposed project site. Main Central thrust passes Yarjep river in upstream and Siyom in the downstream. The distance from project site to MCT in downstream and upstream is approximately 30 km.

3.2.2.4 Seismicity and Earthquakes

i) ***General***

The intake weir site is defined by co-ordinates 28^0 32’ 32” N latitude and $94^{\,0}$ 18’ 43” E longitude and lies in West Siang district, Arunachal Pradesh. The area falls in Seismic Zone V of the Seismic Zoning Map as adumbrated in the Indian Standard Criteria for Earthquake Resistant Design of structures IS: 1893-Part I, 2002 (**Fig. 3.2.2.6**). The Zone corresponds to Intensity IX of the MSK scale (1964). IS code quoted above also iterates that detailed site specific studies are to be carried out for determination of design earthquake parameters based on the seismotectonics of a given area, the response at site and seismogenic capability of the tectonic elements etc, a review of the past and present earthquake incidences etc.

The catalogue of earthquakes of the region containing information of source parameters, size, focal mechanism, time of occurrence are gathered through the published information of the Geological Survey of India (Seismotectonic Atlas of India-2000) and the table is appended with this report. (Table 3.2.2.3).

ii) Seismotectonic Milieu

Regionally, Arunachal Pradesh comprises four geotectonic blocks viz., 1) The Himalaya 2). The Mishmi Hills 3) Naga-Patkoi ranges of the Arakan Yoma Mountain and 4) The Brahmaputra Plain separated from each other by major tectonic fabric, characterized by distinct stratigraphy with different orogenic episodes and geological history (G. Kumar, 1997). This is inferred due to fragmentation and accretion of Gondwanaland and collision of plates, convergent margin tectonics and consequential uplift of the Himalaya. In Arunachal Pradesh, the Himalayan mobile belt constitute the prominent geotectonic block and is limited by Indus-Tsangpo Suture Zone in the North (ITSZ)- the collision boundary of Indo-Tibetan Plates, by the Main Central thrust (MCT) in south segregating the high grade metamorphics from cover sequences. The Main Boundary Thrust separates the Siwaliks from the pre-tertiary rocks. Further south the Main Frontal Thrust, separates the lofty mountain chains from the Brahmaputra Plains.

The Mishmi geotectonic block considered to be part of central Burmese Plate rather than Indian Plate. Comprising of metasediments the block has undergone polyphase of deformation with profuse granitic intrusions and abut against the Indian Plate along the Tiding Sututre. The Mishmi Hill massif comprising crystallines is thrust along Mishmi Thrust in the south.

The Naga-Patkoi geotectonic block occupying part of Arunachal Pradesh is made up of cover sediments of Paleogene-neogene age over a pre-cambrian basement. The basement is inferred to be extension of Shillong plateau. Sedimentation in Shillong Plateau was reported to have occurred during Permian in response to Himalayan Orogenic movements.

The foredeep that formed between the Sub-Himalayas and the Indo-Burma mountain chain led to huge continental fluvial deposition during the Quaternaries and this has evolved as Brahmaputra Plain.

The major structural elements of the region are the MCT, which lies to the north of the project site (See drawing TVIPL-TAT-D-02 Seismotectonic Map of Project Area.) , Baume–Tuting Fault in the east, Mishmi Thrust, Tiding Suture and the Lohit thrust. The Main Boundary Thrust and the Main Frontal thrust occurs to the South east part of the project complex. As reported by the GSI (Seismic Atlas 2000), variable pattern of seismic incidences have been registered in different tectonic domains and the Himalayan domain is considered sparsely seismic contrary to Indo-Burmese convergent margin tectonics. The Project area falls very close to Himalayan domain**.** A perusal of the appended drawing indicates that the project area manifests relatively fewer incidences of earthquakes and the focal mechanism of two fault plane solutions of two nearby events to the south indicates strike slip mechanism. A regional assessment also indicates thrust mechanism for deeper events and normal and strike slip mechanism for relatively shallow events (GSI).

A detailed Site Specific study for Design Earthquake Parameters for Pauk HEP, Arunachal Pradesh has been carried out by the Department of Earthquake Engineering, IIT, Roorkee and is appended in Volume II Geology “Appendix List, “APPENDIX 7 – Roorkee report on seismic factor estimation”.

This project is just upstream of the Heo Project and falls in the same geotectonic block having similar geomorphological features, lithology and seismogenic sources. Besides as in the Heo site no additional major structural element such as river bed fault or neotectonic fault has been observed calling for exclusive seismic analysis. In view of proximity, size of the structure, similarity of lithological/ tectonic features including falling in same geotectonic block, absence of additional features call for a consideration that the seismic analysis carried out for Pauk HEP and the horizontal seismic co-efficient arrived at can be adopted for Tato-I i.e. 0.31g and the vertical acceleration can be as two thirds of horizontal seismic co-efficient.

Table 3.2.2.3 Chronological listing of earthquake data for magnitude > 4.9 in Arunachal Pradesh

SI. No.	YY	MM	DD	Hr	Min	Sec	Lat	Long	Ms	Mb	Depth Km	Source
1	1927	3	15	16	56	32.0	24.50	95.00	6.50	6.00	130.00	GR
2	1930	9	22	14	19	11.0	25.00	94.00	6.30	5.90		GR
3	1932	8	14	4	39	32.0	26.00	95.50	7.00	7.00	120.00	ABE

4	1934	6	2	5	54	29.0	24.50	95.00	6.50	6.00	130.00	GR
5	1935	4	23	16	45	41.0	24.00	94.75	6.30	5.90	110.00	GR
6	1938	5	6	3	41	8.0	24.50	95.00	5.80	5.70	100.00	GR
7	1939	5	27	3	45	44.0	24.50	94.00	6.70	6.10	75.00	GR
8	1941	5	22	1	0	32.0	27.50	93.00	5.60	5.50		GR
9	1943	10	23	17	23	16.0	26.00	93.00	7.20	7.40		ABE
10	1950	8	26	6	33	6.0	26.80	95.00	6.00	5.80		ISS
11	1950	9	25	12	25	28.0	24.00	93.00	5.50	5.50		ISS
12	1951	2	8	21	14	15.0	27.50	95.60	5.80	5.70		ISS
13	1954	3	21	23	42	11.0	24.50	95.25		7.40	180.00	ABE
14	1955	9	8	4	45	26.0	25.00	95.00	5.70	5.60	150.00	ISS
15	1956	12	30	21	59	6.0	24.00	94.50	5.00	5.20		CGS
16	1957	5	28	5	31	68.0	25.42	95.03	5.80	5.70	61.00	ISS
17	1957	7	1	19	30	22.0	24.38	93.76	6.80	6.20	41.00	ISS
18	1959	4	9	17	8	33.0	25.70	94.76	5.10	5.30		ISS
19	1960	5	26	20	5	7.0	27.00	93.00	5.00	5.20		CGS
20	1961	2	4	8	51	48.6	24.80	95.30	5.40	5.40	135.00	CGS
21	1961	6	14	0	41	17.0	24.55	94.69	5.80	5.70	91.00	ISS
22	1963	6	26	17	21	57.3	24.30	95.10		5.40	79.00	CGS
23	1963	10	14	2	1	23.5	25.20	95.30		5.30	33.00	CGS
24	1964	3	27	4	30	36.1	25.82	95.71	4.70	5.30	115.00	ISC
25	1964	6	3	2	49	17.2	25.88	95.69		5.40	121.00	ISC
26	1964	7	12	20	15	58.8	24.88	95.31		5.50	152.00	ISC
27	1965	2	18	4	26	34.7	24.97	94.21		5.40	45.00	ISC
28	1965	5	30	8	48	19.7	25.93	95.80		5.30	101.00	ISC
29	1965	6	18	8	17	38.1	24.94	93.67		5.20	48.00	ISC
30	1966	9	11	15	55	19.4	26.90	95.60		4.90	26.00	ISC
31	1966	10	2	4	31	49.5	24.41	94.81		4.90	75.00	ISC
32	1966	10	18	20	34	37.4	24.28	94.87		4.90	86.00	ISC
33	1969	4	28	12	50	17.2	25.93	95.20		5.00	68.00	ISC
34	1970	2	19	7	10	61.5	27.40	93.96		5.40	12.00	ISC
35	1970	7	29	10	16	20.4	26.02	95.37		6.40	68.00	ISC
36	1970	7	29	10	30	47.4	26.04	95.33		5.00	33.00	ISC

37	1970	7	29	10	31	11.0	26.24	95.10		5.30	52.00	ISC
38	1971	6	26	2	16	36.9	24.60	94.78		5.00	74.00	ISC
39	1971	7	17	15	0	55.8	26.41	93.15	5.1	5.40	52.00	ISC
40	1971	12	29	22	27	3.5	25.17	94.73		5.60	46.00	ISC
41	1973	5	31	23	39	52.4	24.31	93.52	5.7	5.80	1.00	ISC
42	1973	10	9	4	1	47.4	27.69	93.60		4.90	33.00	ISC
43	1974	12	2	1	8	45.9	24.44	95.31		4.90	107.00	ISC
44	1975	11	4	19	27	58.5	24.09	95.11		5.20	98.00	ISC
45	1976	12	25	1	7	10.9	26.12	95.18		4.90	55.00	ISC
46	1977	11	13	21	2	31.8	26.51	93.00		5.10	52.00	ISC
47	1978	1	8	6	10	58.5	24.73	95.20		5.00	97.00	ISC
48	1979	5	29	0	39	52.1	24.50	94.74	4.6	5.20	82.00	ISC
49	1979	7	13	23	20	8.8	24.88	95.22	4.3	4.90	108.00	ISC
50	1979	8	11	20	32	7.9	24.20	94.93	3.9	5.00	113.00	ISC
51	1980	8	12	16	44	1.5	24.80	94.62		4.90	52.00	ISC
52	1981	4	25	11	32	23.0	24.89	95.34	5	5.70	146.00	ISC
53	1982	9	14	6	1	28.5	25.93	95.31		5.00	88.00	ISC
54	1982	11	26	13	26	29.1	27.78	94.87	4.4	5.10	29.00	ISC
55	1983	1	3	11	28	15.1	24.23	94.45		5.10	82.00	ISC
56	1983	1	13	23	0	11.9	24.67	95.00		5.40	109.00	ISC
57	1983	1	31	3	26	4.2	24.72	95.04		5.00	70.00	ISC
58	1983	8	23	12	12	17.5	25.55	95.12		5.20	126.00	ISC
59	1983	8	30	10	39	27.2	25.04	94.67		5.70	64.00	ISC
60	1983	9	23	20	18	8.5	24.77	95.12		4.90	115.00	ISC
61	1984	2	19	9	29	50.6	24.99	94.79		5.00	50.00	ISC
62	1984	3	5	21	26	42.6	24.52	94.62		5.20	70.00	ISC
63	1984	3	21	23	6	24.0	26.76	93.30		5.00	35.00	ISC
64	1984	4	25	14	58	41.5	26.03	95.70		5.00	107.00	ISC
65	1984	5	6	15	19	11.3	24.22	93.53	5.8	5.70	54.00	ISC
66	1985	3	5	10	10	58.4	27.72	94.08	4.9	4.30	52.00	ISC
67	1986	4	17	13	15	57.3	24.42	94.74		5.00	89.00	ISC
68	1987	4	29	5	15	34.6	24.07	94.64		5.00	106.00	ISC
69	1987	5	18	1	53	51.3	25.23	94.21	5.9	5.70	55.00	ISC

70	1987	9	6	23	38	54.1	26.64	93.41	4.3	5.20	49.00	ISC
71	1987	12	1	8	50	41.4	26.33	93.22		4.90	59.00	ISC
72	1988	2	17	17	52	14.0	24.33	94.40		4.90	111.00	ISC
73	1988	7	10	3	31	30.2	25.03	95.38		4.90	128.00	ISC
74	1988	8	6	0	36	25.5	25.13	95.15	7.2	6.60	108.00	ISC
75	1988	8	13	19	59	51.0	25.29	95.13		5.00	87.00	ISC
76	1988	8	21	13	16	30.2	25.27	95.10		4.90	89.00	ISC
77	1989	4	3	19	39	31.5	25.15	94.66	4.8	5.30	69.00	ISC
78	1989	8	9	16	1	24.6	24.51	94.55		5.10	80.00	ISC
79	1990	1	9	18	51	29.2	24.74	95.26		6.10	118.00	ISC
80	1990	1	10	6	37	54.9	26.46	94.63		5.30	82.00	ISC
81	1990	11	29	10	20	33.0	24.37	94.64		4.90	82.00	ISC
82	1991	1	23	6	7	8.6	24.72	95.22		5.40	114.00	ISC
83	1991	1	28	22	24	43.5	26.08	95.39	4.9	4.60	0.00	ISC
84	1991	3	11	10	24	39.0	25.80	94.70		5.00	33.00	ISC
85	1991	5	11	2	15	22.2	24.26	93.68	4.5	5.00	64.00	ISC
86	1991	6	23	10	4	1.7	26.59	93.19	4.4	5.40	35.00	ISC
87	1991	12	7	13	57	38.9	24.00	93.83	4.5	5.10	64.00	ISC
88	1991	12	20	2	6	5.2	24.69	93.12	4.9	5.30	41.00	ISC
89	1992	3	25	22	32	34.2	24.82	95.25		5.20	106.00	ISC
90	1992	4	15	1	32	11.3	24.27	94.93		5.50	116.00	ISC
91	1992	6	15	2	48	56.1	24.00	95.97	6.3	5.80	14.00	ISC
92	1992	3	27	9	42	58.5	24.64	95.02		4.90	117.00	ISC

3.2.2.5 Geotechnical Assessment

1. *Trench Weir*

Although the proposed trench Weir can also be founded on overburden/river borne material rocks are exposed almost from the centre of the river bed portion up to entire left flank. Occurrence of bed rock in the other part of the Weir is also expected to be in rock. Therefore it is opined that no further exploration may be necessary at this stage. In case of necessity explorations can be carried out. No serious geotechnical problems are apprehended for the proposed intake as well. Exploration for suspected fault on the left flank based on geomorphic expressions will be taken up by trenching to prove or otherwise of the suspected fault as this has a bearing on the seismological design input.

The rocks exposed on the Weir site are quartzites with RMR value of the order of 60 falling in fair rock category as confirmed by the exploratory drilling carried out in the left flank.

2. *Water Conductor System*

i) Open channel section

Based on the Seismic Refraction studies carried out geological sections have been prepared and appended with this report. Most of the Channel reach is expected to be excavated in quartzites except in one section where the channel section will be completely excavated in terrace deposits and landslide debris as established by a borehole drilled beyond the bed level of the Channel. SMR rating obtained as advocated by Romana (1991) has indicated that majority of the slopes are partially stable with a probability of failure 0.4. The mode of failures likely to be planar and formation of certain wedges. The recommended remedial measures such as spot/systematic rock bolting, spot/systematic shotcreting will be carried out concurrently with excavation in order to render the slope completely stable.

The permeability tests carried out in the borehole MCDH-1 in bed rock portion has indicated the permeability value to be around 2 lugeons only indicating the tight nature of joints in the bed rock.

A preliminary slope stability analysis as per Romana was carried out for the sections against planar, topple and wedge failures and the results are as indicated below.

Of the three sets of joints enlisted at the Weir site are likely to occur in the Channel sections too. For the foliation joint set as the plane dips into the hill, the stability is worked out for the Southern slope of the Channel where it daylights into the slope. The values as per Romana are F1= 0.15, F2=1.0 and F3= -6.0 and as the excavation will be by normal blasting F4=0 and SMR= 55 + (0.15 X1.0 X6) + 0 =54.1 which falls under Class III. The rock mass fall under normal class and the stability condition is partially stable, and modes of failure will be planar along some joint planes and formation of several wedges. Probability of failure is 0.4. The recommended treatment measures are spot/systematic bolting, spot shotcreting, toe ditch and or nets.

The oblique joint F1=0.15, F2 =1.0 and F3=-10. Substituting the values SMR= 55+ (0.15 X 1.0 X -10) + 0 = 53.5. This also falls under the same class and the treatment measures are provision of Spot/systematic bolting, spot shotcreting, toe ditch and or nets.

The vertical or steep joint the possibility of toppling failure F1=0.15, F2=1.0 and F3 = -25 and the SMR= 55 + (0.15 X 1.0 X-25) + 0 = 51.25. The SMR of this joint set also falls in the same Class III and the treatment measures required are the same. The preliminary analysis can be up dated as and when additional data is available and the recommended treatment measures will be carried out.

The Wedge failure by modified Romana method works out to F1=0.15 F2=0.4 and F3=10 and the SMR= 55 + (0.15 X 0.4 X -10) + 0=49. This falls under class III and the support measures required are systematic bolting and systematic shotcreting with toe ditch and or nets.

ii) Head race tunnel

The imagery studies and geological mapping carried out at the structural sites and correlation of other data indicates that the tunnel will encounter the following rock units/groups, in general

i. Gneisses
ii. Quartzites
iii. Banded gneisses with schist bands..
iv. Migmatites

Estimation of rock mass characteristics

The engineering properties of the main rock types to be encountered in the tunnel length as per IS1123:1975 is as follows:

1. Gneiss Sp. Gravity 2.5-3.0, Compressive strength-500-2000kg/cm2, Tensile strength-50-200kg/cm2 Modulus of Elasticity 2.0x103 to 4.9x103 kg/cm2 and Porosity 0.5-1.5
2. Quartzites Sp. Gravity, 2.55-2.65 Compressive strength.1500-2000kg/cm2 Shear strength 200-400kg/cm2, Tensile strength.. 100-300kg/cm2 Porosity 0.2-0.5
3. Migmatites. No specific values given in the above code but can be assumed as similar to Gneisses
4. Schists. Sp. Gravity 2.37-3.04 Compressive strength 400-900kg/cm2

5. Banded Gneiss No specific values are given for this rock group but can be assumed to be at the lower levels of Gneisses.
6. Migmatitic Gneisses. No specific values given in the above code but can be assumed as similar to Gneisses

Estimated distribution of rock mass classes

At this stage, due to high uncertainties on in situ stress, Bieniawski's RMR classification seems preferable to Barton's Quality index classification. The RMR distinguishes 5 classes of rock.

RMR	81 -100	61 -80	41 -60	21 -40	<20
Class	I : Very good	II : Good	III : Fair	IV : Poor	V : Very poor

The active tectonics characterizes regional geology. Among other consequences, it can be expected that this results in general decrease of rock mass condition due to fracturing and micro-fracturing. Ultimately, this judgment leads to shifting the estimation of rock mass condition to lower ranges, and this adjustment is included in the following distribution of rock mass classes.

The following table shows the estimated distribution of rock mass classes for the Head Race Tunnel.

Rock class	**Type of rock**	**Percentage**
I – Very Good	Gneiss, weakly fractured, with sealed schistosity.	10
II -Good	Gneiss, weakly fractured, Quartzite.	50
III – Fair	Gneiss moderately fractured.	25
IV – Poor	Banded gneiss with schist, schistosity joints not sealed. All rocks strongly fractured, slightly to moderately weathered. Local tight folding.	10-12
V – Very poor	All rocks highly weathered near surface or near fault zones, fault zones.	3-5

One more practical way for the tunnel excavation is by classifying the rock mass as per (the Geological Strength Index -GSI) The GSI for fractured gneiss is estimated around 35 to 50 at outcrop; it should be around 50-55 for deep rock masses Banded gneisses and schists, the rock mass can be assimilated with class ‘C’ of the chart and corresponding GSI is around 40 The typical marble rock mass can be described as generally blocky to massive, with good joint condition for which GSI 60 can be adopted as a conservative estimate.

The distribution of the rock types based on the surface geological studies and assessment from the drill hole cores in the area leads one to conclude that along the tunnel alignment the excavation details of rock varieties can be estimated to be as follows:

The tunnel is expected to be excavated through gneiss weakly fractured for 10 per cent (Class I Very Good Rock)), Gneisses, banded gneiss weakly fractured for about 50 percent length (Class II Good rock)),Gneiss banded with schist moderately fractured for 25 per cent (Class III Fair rock)) banded gneiss with strongly fractured rock (Class IV Poor rock) for about 10 percent length and balance (Class V Very poor rock) for rocks highly weathered or sheared fractured zones As per the Guidelines for excavation and support of Rock Tunnels in accordance with the Rock Mass Rating System (Bienawski 1989), the support system will be as follows.

- Very Good rock 81-100 Generally no support required except for occasional spot bolting
- Good Rock RMR 61-80. Locally bolts in crown 3m long spaced 2.5m with occasional wire mesh 50mm shotcrete (or fiber shotcrete) on crown where required

- Fair Rock RMR 41-60 Systematic bolting 4m long spaced 1.5-2.5m in crown and walls with wire mesh in crown.50-100mm shotcrete (or fiber shotcrete) on crown and 30mm on sides
- Poor Rock RMR 21-40 Systematic bolting 4.5 m long spaced 1-1.5 m on crown and wall with wire mesh Shotcrete 100-150 mm on crown and 100 mm on sides. Light steel set ribs spaced 1.5m where required.
- Light steel set ribs erected immediately after excavations
- Very poor rock RMR 4-20 Systematic bolting 5-6m long spaced 1-1.5 m in crown with wire mesh. Bolt invert.100-200 mm in crown 150mm on sides and 50mm on face or Medium to heavy ribs spaced 0.75 m with steel lagging and forepoling if required close invert/.

Based on Grimsted and Barton (1993) on the tunneling quality index (Q) the support system for this 6.4m diameter tunnel, could be

- Systematic bolting or
- Systematic bolting with 40-100mm unreinforced shotcrete/fibre reinforced shotcrete

iii) Adits

Adits provided along the length of the head race tunnel for excavation and lining purposes will be assessed in details after they are decided and marked ground. Necessary stabilization measures will be detailed based on site conditions.

3. *Surge Shaft*

The area around the Surge Shaft is occupied mostly by gneisses exposures with a thin cover of overburden and bushy vegetation. The gneisses bands exposures are interbedded with occasional schist bands of variable thickness.

In view of the fair quality of the rock no problem should occur during the excavations of the shaft. However, if the rock falls occur from the sides particularly the western wall the same will be suitably stabilized with anchors and shotcreted before final lining with concrete. The all round lateral cover for the Surge Shaft is considered adequate.

An access gallery about 155m long is provided on the southern slope of the ridge for facilitating excavation of this shaft. The portal of this access gallery however will be excavated through overburden and rock mass and suitable stable slopes will be evolved based on site conditions and stabilization measures like anchoring and shotcreting will be evolved in the construction phase.

The drainage system around the location indicates presence of a nalah towards eastern side and seepage along this may be anticipated during excavation for which necessary measures for dewatering will be made and this nalah has to be diverted at higher levels.

4. Pressure Shaft

The surface ridge outline is occupied by fine to medium grained gneisses with thin schist bands RQD values indicates the quality of the rock mass to be Class III type and it may be of Class II for some stretch in the horizontal section.

Excavations of the pressure shaft should not pose problems both in the vertical as well as in the horizontal section taking precautions during excavations and providing rock bolts and shotcrete as dictated.

5. Power House

The hill slopes are moderate to steep at the powerhouse site. The predominant rock type at selected site is Banded gneisses which are exposed on both the banks of the Yarjep around powerhouse site. At the elevation of 1020 m where the Yarjep is joined by a nala exposed rocks on the left bank are coarse grained and banded Biotitic hornblende gneisses interbedded with garnet quartzo feldspathic gneisses and few layers of augen and streaky gneisses. Bands or lenses of dark green to blackish schist are subordinate.

Geological mapping and evaluation of explorations by geophysical surveys and drilling have proved that gneiss rocks are exposed at the level of 1020 m and below overlain by mixed overburden consisting of boulders, pebbles, cobbles and sand and clay material. Since the foundation level of the powerhouse is around 101m banded gneisses rock with schist bands will be encountered at the foundation grade. Geophysical exploration by seismic Surveys along the longitudinal direction of the powerhouse has indicated the rock profile to be at the same level of around 1020 m which indicates the area may mark a river terrace on the left bank of Yarjep river which could be considered as a perfect platform for the power house structure. Excavations for reaching the foundation grade will be through overburden of about 10m meters and the river terrace material will have to be removed towards the river side.

The foliation strike of the gneisses on surface indicates that the powerhouse is aligned in East-West along the longer direction making an angle of a few degrees only with the strike of the gneisses. The water loss during drilling has varied; varies from complete loss up to 14 m, and from 14 m to 37 m it is nil below which it is complete loss up to the end of hole. The detailed log of the drill hole is appended as Appendix 2 with the report. The water loss indicates the rock mass and needs grouting to improve the seepage problems. Point load strength of one of the core samples between depths of 19.0 to 26.50 corresponding to Elevations of 1005 to 1012 m is 4.65 MPA. The Safe Bearing Capacity (SBC) of the foundation rock can be estimated based on the geotechnical characterization of the hard rock proved by drilling and study of the drill cores; and methods based on these are the a) RQD value b) Based on RMR values and c) based on strength of rock cores. A number of test studies in practice have indicated that methods based on RQD values and strength of rock cores give very high allowable bearing capacity. The method based on RMR values estimates reasonably allowable bearing capacity for the hard rock at the foundation grade. This will ensure settlement of raft foundation up to 6m thickness to be less than 12mm.

The allowable bearing capacity of the foundation rock gneisses and schists is estimated from following Table 3.2.2.4 as per IS12070-1987

Table 3.2.2.4 Net Safe Bearing Pressures Based on RMR value

Classification	I	II	III	IV	V
Description	Very Good	Good	Fair	Poor	Very Poor
RMR	100-81	80-61	60-41	40-21	20-0
Qm (t/m^2)	600-448	440-288	280-155	145-90-15	55-45-40

The rock mass gneisses with schist and considering the foliation along the longer direction of the powerhouse from data available are classified under Class III Fair rock to poor Rock and equivalent allowable bearing pressure capacity for the foundations rock for estimated RMR value varying from 10-20 will vary from 0.4 to 1.45 MPA but safely can be reckoned to be around 0.5 MPA unless *in situ* tests on the foundation rock indicate better values for design purposes. The foliation joint patterns also indicate a favorable loading direction. But since the dip is towards north at shallow angles can be considered as satisfactory.

The modulus of elasticity value for the rock mass is 30-40 GPA and as per the tests conducted it is 32.91 GPA and this value can be adopted for the designs.

No permeability tests have been conducted in the borehole done at powerhouse site but the water loss during drilling at powerhouse grade is nil but at lower depths indicated that the joints in the foundation are open in nature and to seal effectively the joints and weak zones consolidation grouting on a regular pattern will have to be provided for in the designs.

Since the powerhouse wall falls close to the river on one side curtain grouting to prevent the river water entering the powerhouse pit will be provided in the rock mass to seal all the joints along with necessary drainage measures at the pit in the powerhouse.

Slope cuts of the hill slope behind the powerhouse are a prerequisite for stabilization of the back slopes. The rock slopes behind the northern side of the powerhouse will be stabilized by designed slope cuts with anchors and shotcreting in the detailed design stage. A suitable diversion arrangement will be made at appropriate levels for the nalah so as to not to foul the construction activity and running of the powerhouse will be made at higher levels to prevent debris carriage and water in rainy season.

Stability

The backslope of the power house stability has been arrived by Romana's Slope Mass Rating. The RMR value arrived at Powerhouse is taken as 55 and the Slope Mass Rating is arrived by the formula SMR=RMR + (F1 x F2 X F3) + F4. Substituting the values for the foliation joint F1= 0.15, F2= 0.15 F3= -10 the SMR =52.5 and this falls under class normal and the stability of the slope is partially stable, the mode of failures some planar failures and formation of many wedges. The support measures recommended are spot bolting and spot shotcreting with toe ditch and or nets.

For the second set of joints F1=1.0, F2=1.0 and F3= -10 and the SMR=45. The recommended corrective measures are systematic bolting, systematic shotcreting with toe ditch and net.

For joint set 3 F1= 0.15, F2= 0.85 and F3= -6. the SMR = 47.5. In all the above calculations excavation is taken to be normal blasting and therefore F4=0. The recommended corrective measures are systematic bolting, systematic shotcreting with toe ditch and net.

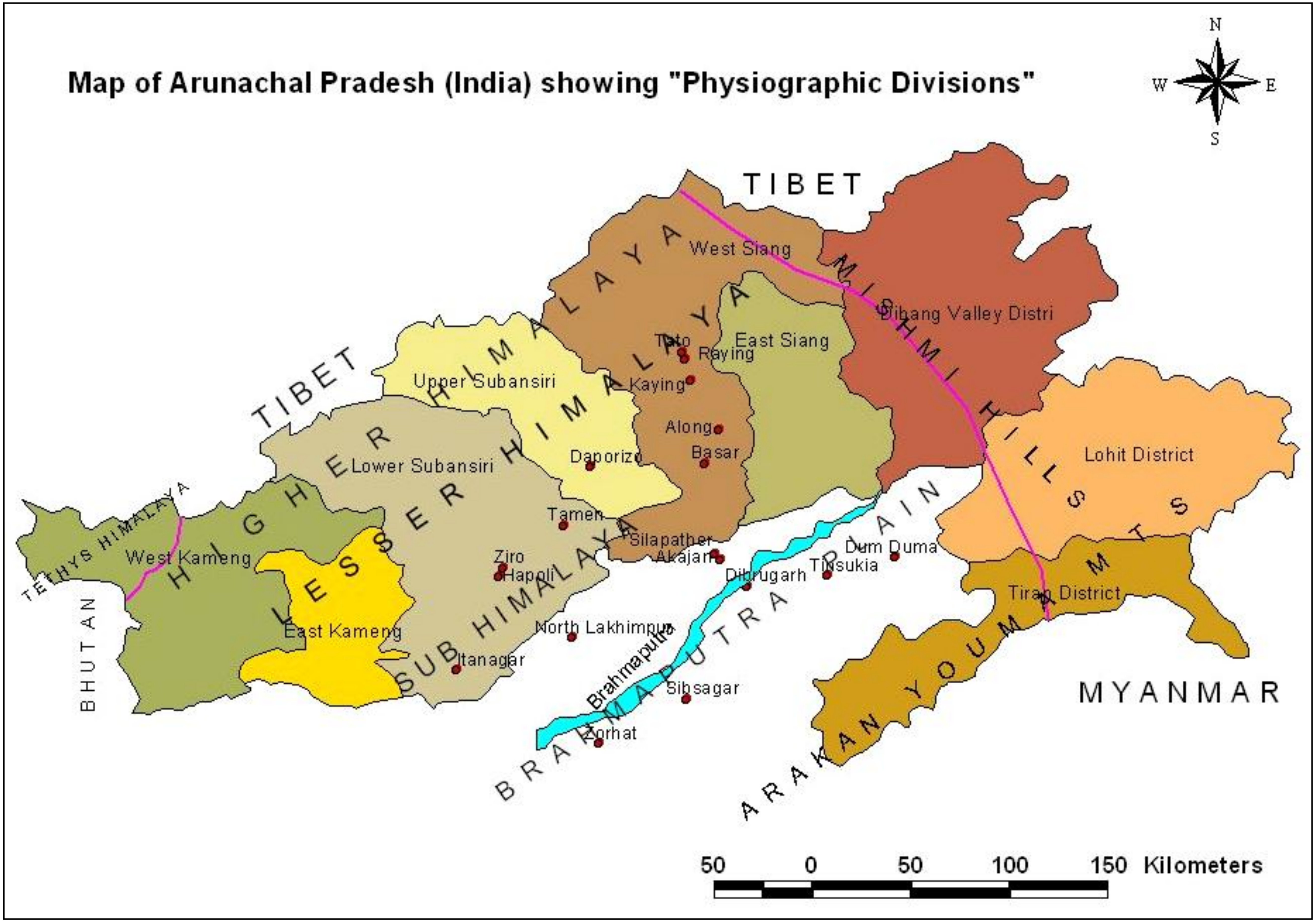


Fig. 3.2.2.1 Physiographic Features of Arunachal Pradesh

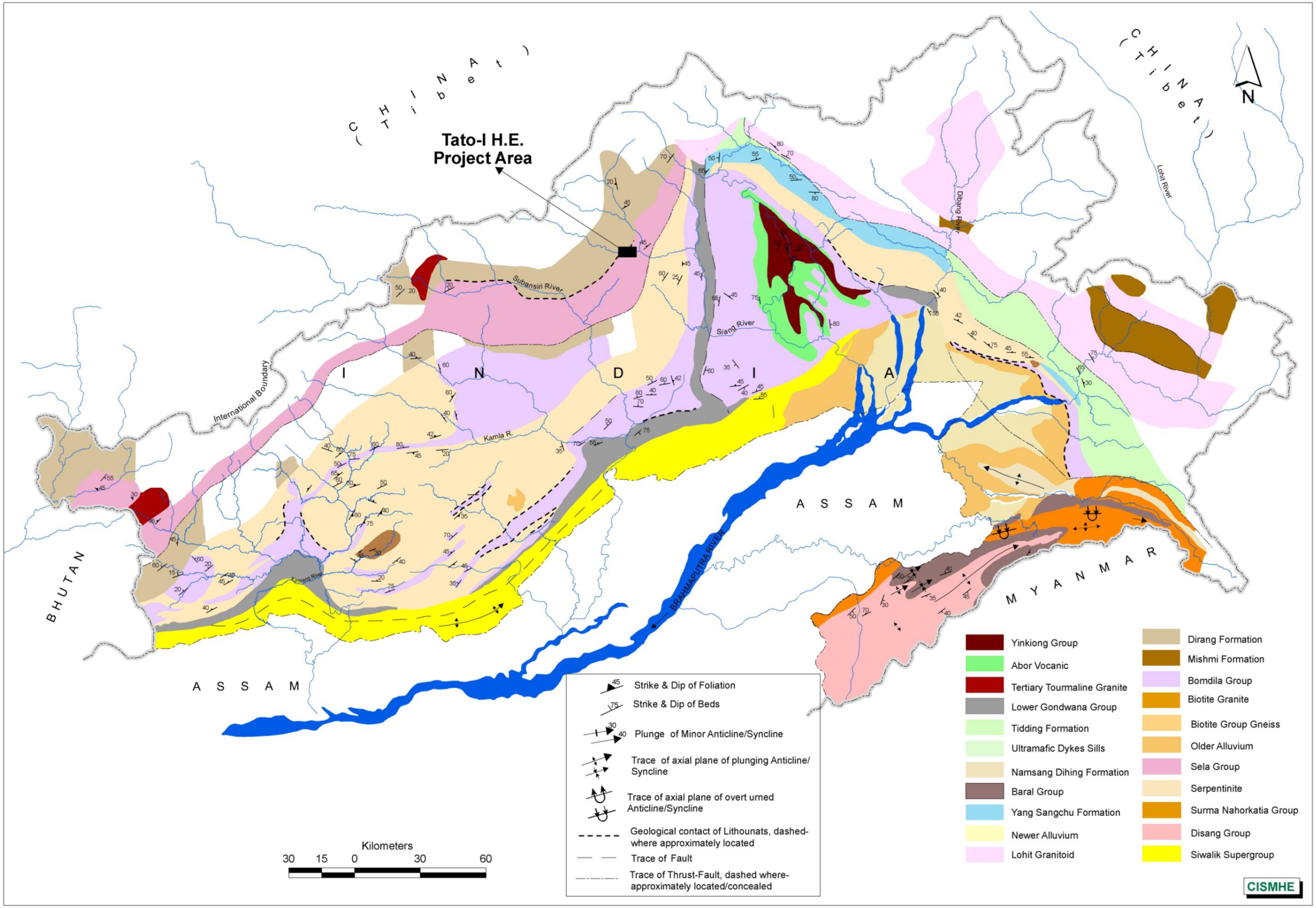


Fig.3.2.2.2 Regional geology of the Arunachal Pradesh showing Tato-I H.E. project area

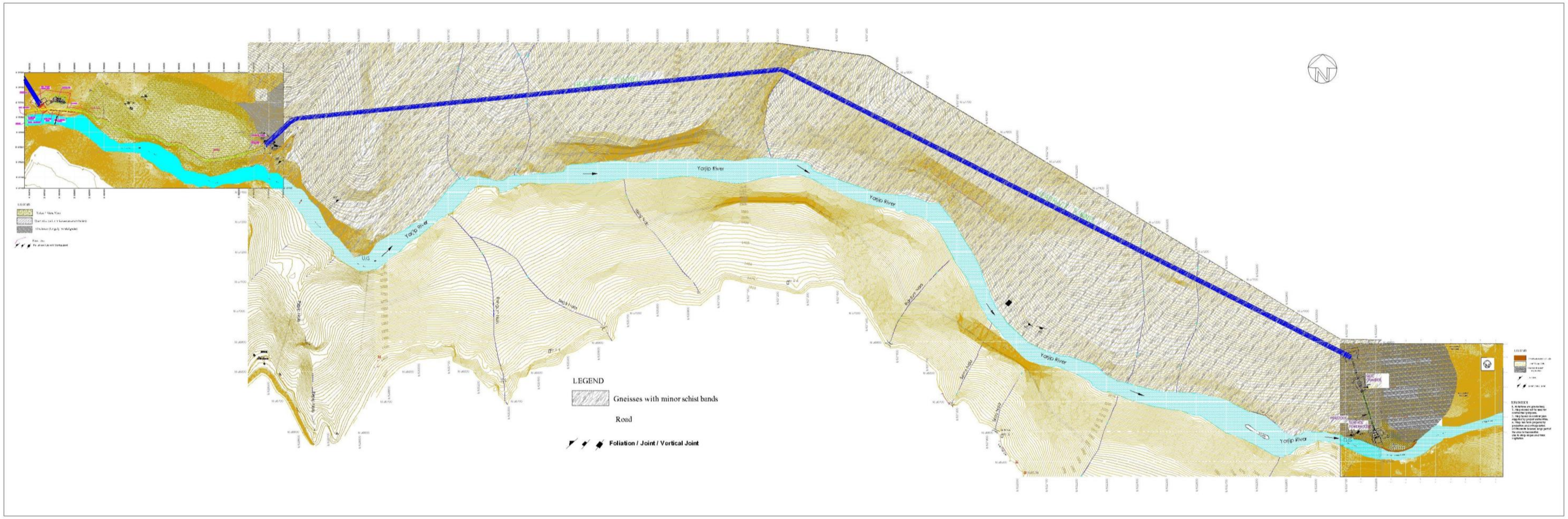


Fig.3.2.2.2. Geological map of Tato-I H.E. Project area

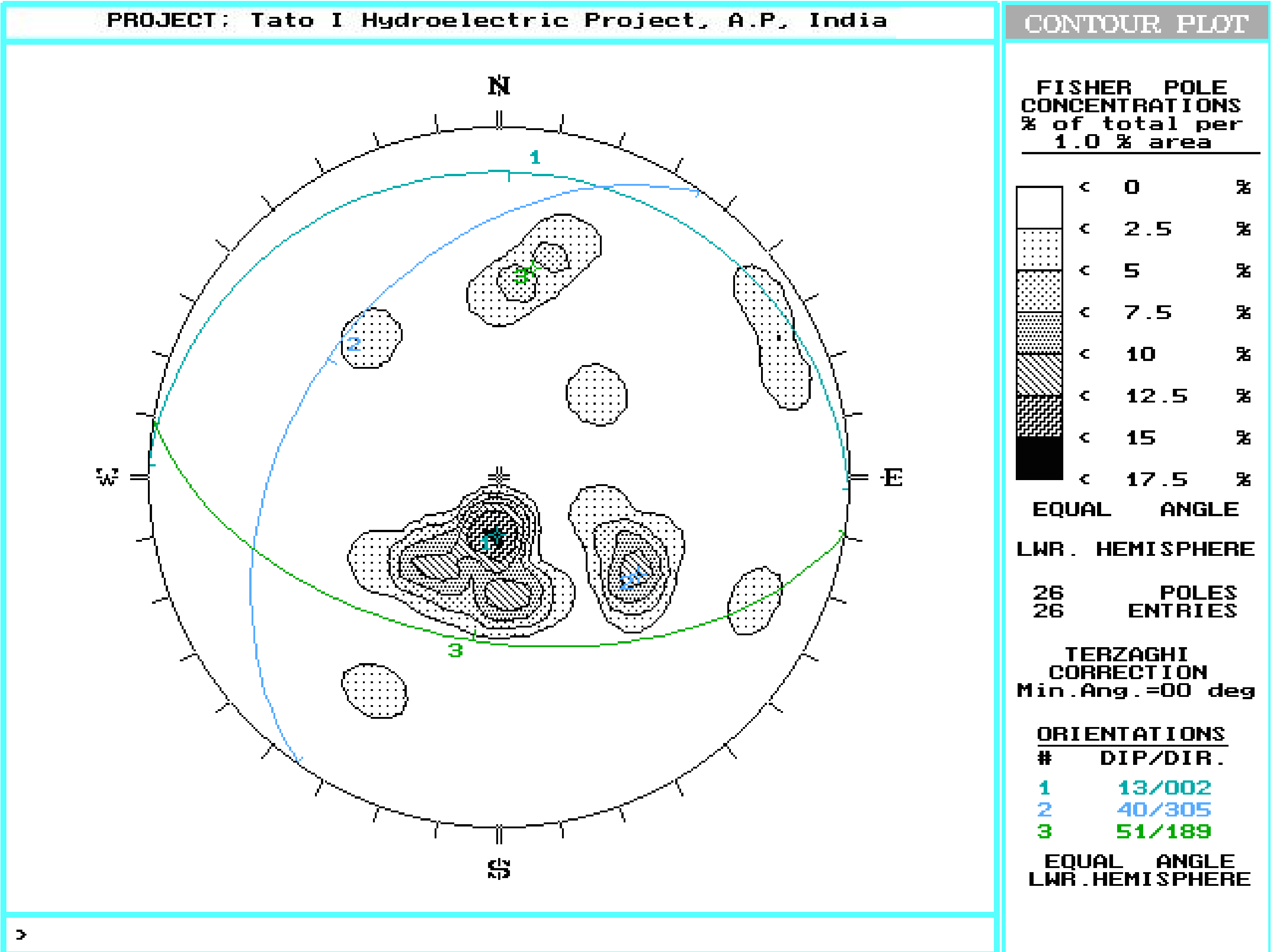


Fig. 3.2.2.3: Stereographic plot of joint planes occurring around Tato-I Hydroelectric Project area

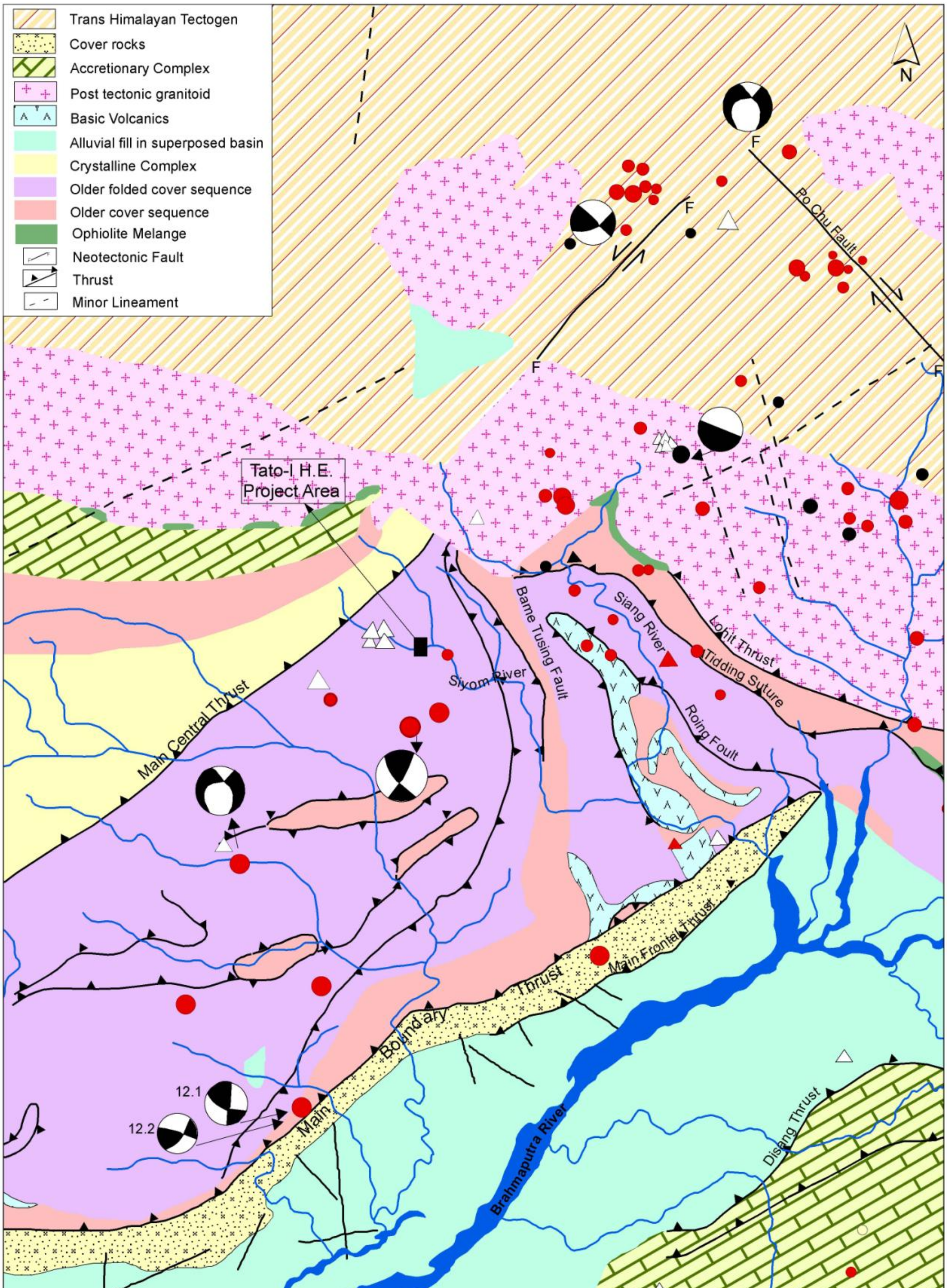


Fig.3.2.2.4 Seismotectonic map of Northeast India showing Tato-I H.E. Project area

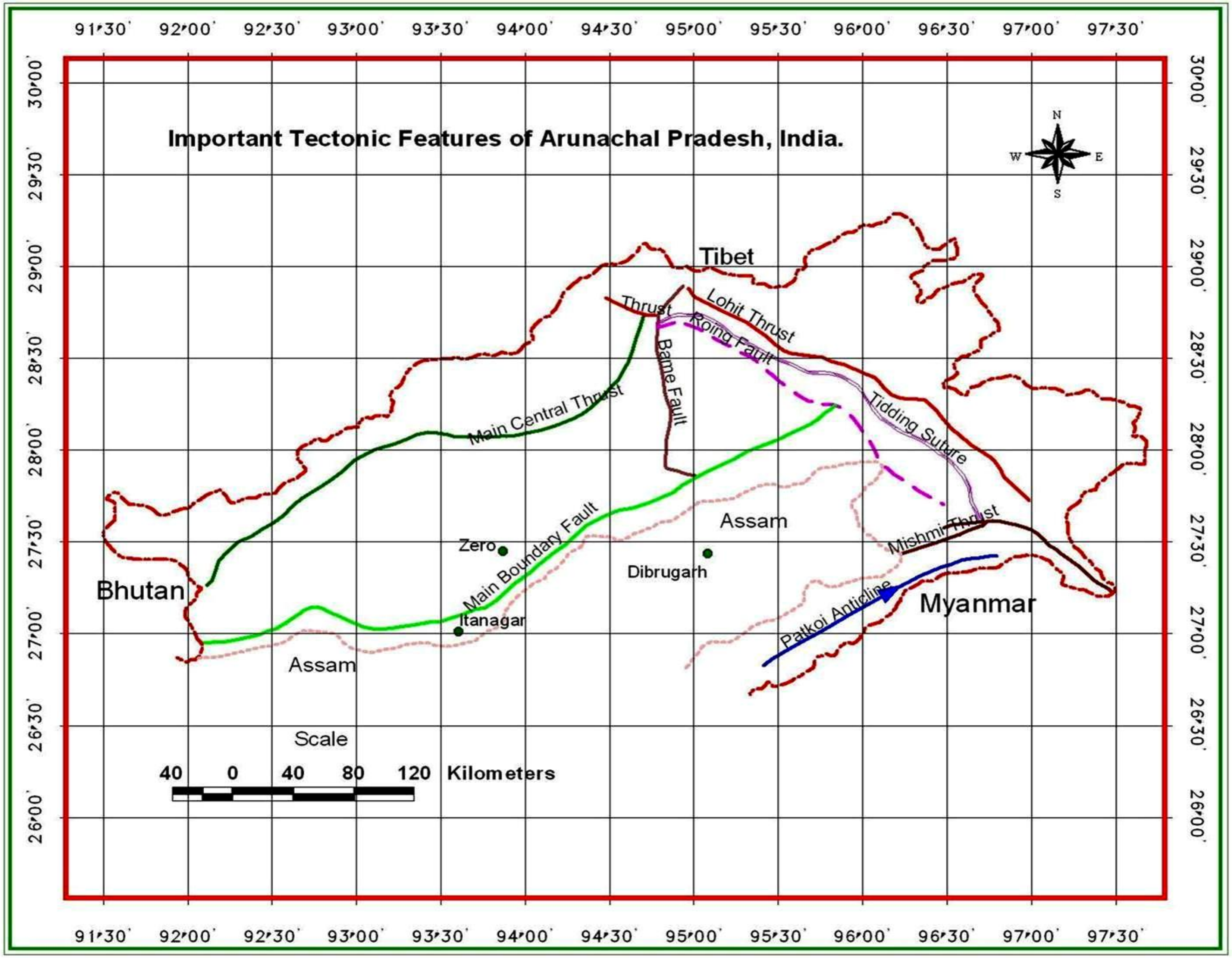


Fig. 3.2.2.5 Important tectonic features of Arunachal Pradesh

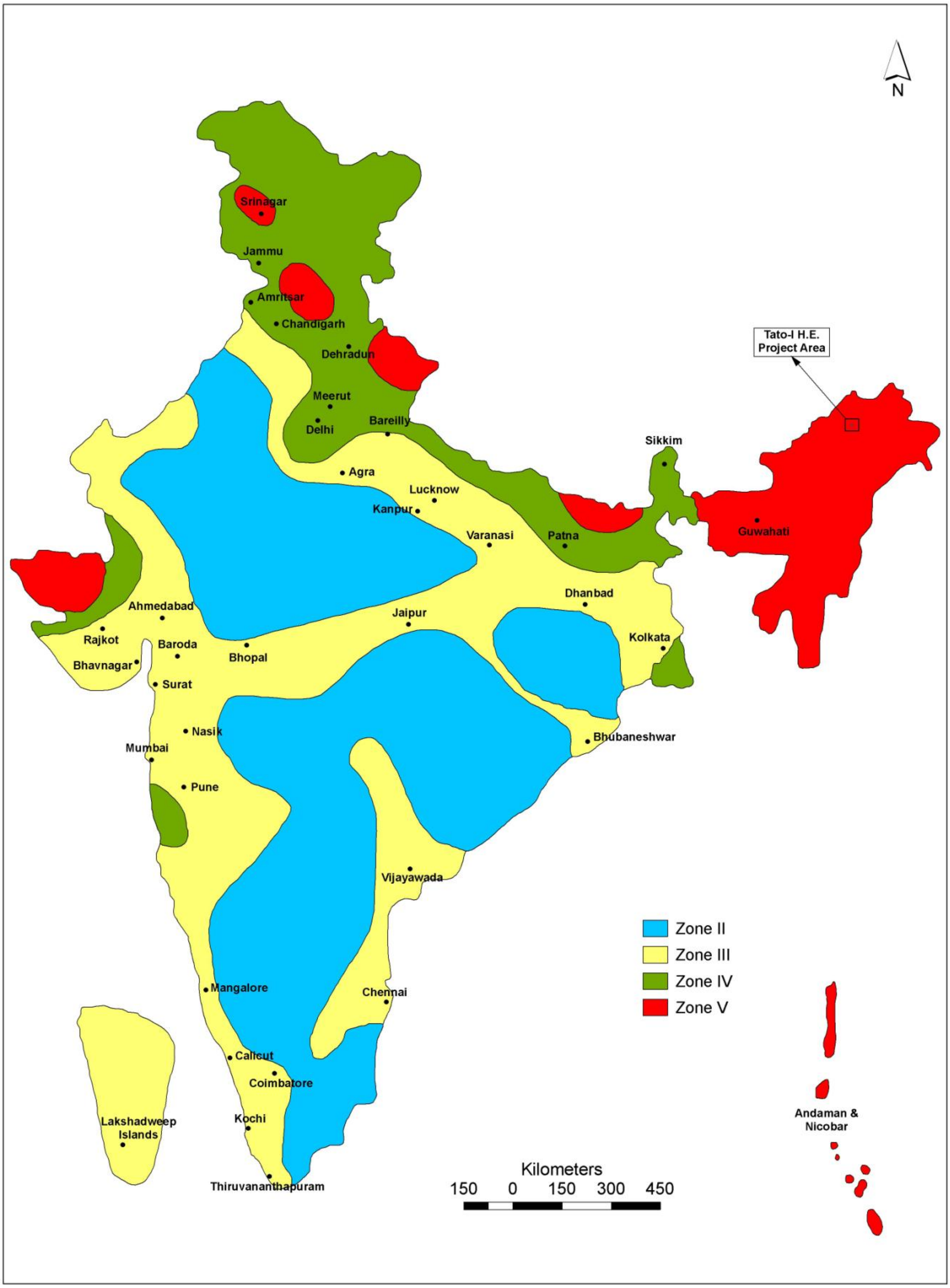


Fig.3.2.2.6 Seismic zoning map of India (Source : BIS, 2002, New Delhi)

Plate 3.2.2.1 Banded gneiss exposed at HRT intake

Plate 3.2.2.2 Migmatitic Gneiss exposed to HRT

(a) 

Facing upstream

(b) View of the location of PH

Plate 3.2.2.3 Location of proposed power house

3.2.3 SOIL

Soil is a natural body of mineral and organic constituents and generally, it is differentiated into horizons usually unconsolidated, of variable depth, which differs among themselves as well as from the underlying parent material in morphology, physical makeup, chemical properties and composition and biological characteristics. The process of weathering by the natural forces such as heat, rain, ice, snow, wind and other environmental factors from the parent materials, i.e., rocks, forms soil. Soil is one of the basic resources for sustaining all life forms on this earth. Soil characteristics and properties are the determining factors mainly for the growth of plants.

In addition to the natural events in the form of wind and water movements, soil properties are largely affected by the human induced activities resulting in the deterioration and degradation of soil quality. Soil is one of the important aspects of EIA study because a large scale of developmental activities involved in the construction of hydropower projects leads to the deterioration of air and water qualities and health hazards. In hydroelectric projects, soil erosion in the project area and its surroundings is also an essential aspect to be addressed as it determines the life of the project. Baseline data on the soil is useful in preparing the Catchment Area Treatment Plan including both engineering and biological measures. In this section, we describe the soil classes and their properties for catchment and the project influence areas, and the physical, chemical and biological characteristics of soils from the project component areas have also been documented.

3.2.3.1 Soil Types

i) ***Catchment Area***

We identified six classes of soil associations based on the report of NBSS & LUP (1998) for the Catchment area of Tato-I H.E. project which has a total geographical area of 1154 sq. km. Among these soil associations, soil association of Lithic Udorthents – Dystrict Eutrochretps (Category S3) is predominant in the catchment area covering nearly 50% of the total area (**Fig. 3.2.3.1**). The soil is predominantly of loamy skeletal and shallow and it is prone to severe erosion, which is associated with moderately deep and light stoniness (Table 3.2.3.1). The Yarjep River flows through the major part of this soil association. The soil association of Typic Udorthents – Typic Eutrochretpts covers the minimum area of the catchment area (0.15%). The snow cover area with rock outcrops is limited at the upper catchment area mainly on the right bank of the river. Rocky mountains and snow cover an area of 13.1% of the total catchment.

ii) ***Influence Area***

For the influence area of Tato-I H.E. project we identified four different classes of soil associations covering an area of 435 sq km (**Fig. 3.2.3.2**). Soil association of Lithic Udorthents – Typic Udorthents occurs predominantly in the influence area of the project covering 53.7% of the total area. Soil is predominantly of loamy skeletal and shallow to moderately deep which is prone to very severe to severe erosion (Table 3.2.3.1).

iii) ***Project Component Area***

All the project components like weir, HRT, powerhouse colony area, etc. of the Tato-I H.E. project are located on the soil association of Lithic Udorthents – Typic Udorthents. Soil is characteristic of loamy skeletal and shallow to moderately deep and it is prone to severe to very severe erosion.

Table 3.2.3.1 Soil groups and their characteristics in Catchment and influence areas of Tato I H.E. Project

Soil Series	Description	Sub-Group
S1	Shallow, excessively drained, loamy-skeletal soils on very steeply sloping hill summit having loamy surface with very severe erosion hazard and moderate stoniness: associated with:	Loamy-skeletal, Lithic Udorthents
	Moderately deep, somewhat excessively drained loamy-skeletal soils on moderately steeply sloping side slopes with severe erosion hazard and moderate stoniness	Loamy-skeletal Typic Udorthents
S2	Deep, somewhat excessively drained, loamy-skeletal soils on moderately steeply sloping summits having loamy surface with severe erosion hazard and moderate stoniness: associated with;	Loamy-skeletal, Entic Haplumbrepts
	Moderately shallow, excessively drained, sandy skeletal soils on steeply sloping summits with	Sandy-skeletal,

	very severe erosion hazard and slight stoniness.	Typic Udorthents
S3	Shallow, excessively drained, loamy-skeletal soils on steeply sloping summits having loamy surface with severe erosion hazard and slight stoniness: associated with;	Loamy-skeletal, Lithic Udorthents
	Moderately deep, somewhat excessively drained, loamy-skeletal soils on moderately steeply sloping side slopes and slight stoniness	Loamy-skeletal, Dystric Eutrochrepts
S4	Shallow, excessively drained, loamy-skeletal soils on very steeply sloping summits having loamy surface with severe erosion hazard and strong stoniness: associated with;	Loamy-skeletal, Lithic Udorthents
	Moderately deep, somewhat excessively drained, sandy-skeletal soils with very severe erosion hazard and moderate stoniness	Sandy-skeletal Typic Udorthents
S5	Moderately shallow, somewhat excessively drained, loamy-skeletal soils on moderately steeply sloping side slope of hills having loamy surface with severe erosion hazard and strong stoniness: associated with;	Loamy-skeletal, Typic Udorthents
	Moderately deep, somewhat excessively drained, fine-loamy soils with moderate erosion hazard	Fine-Loamy, Typic Eutrochrepts
S6	Rocky mountains covered with perpetual snow and glaciers	

3.2.3.2 Soil Properties

i) ***Physical and chemical properties***

Soil texture affects the physical and chemical properties of the soil. Generally, the texture of soils determines the permeability, porosity and intensity of aeration of the soil particles. Presence of high percentage of silt and clay in soils is considered as nutrient rich soils. In the present study, coarse sands accounted for the maximum percentage of the soil texture, followed by the medium sands indicating high porosity and permeability of the soil (Table 3.2.3.2). The percentage of silt and clay ranged from 1.09 to 3.54% for all season, this amount is considered to be optimum in forested area. Moisture contents ranged from 12.72 to 39.21% with maximum at Rego (S4) and minimum at Tato village. Bulk density ranged from 0.67 to 1.23 g/cc indicating loose compaction of soils. Water holding capacity was recorded to be maximum for the pre-monsoon period and minimum for the monsoon period. The electrical conductivity was recorded high in the soil for the pre-monsoon season and it is directly related to the total solids and ions in the soils. Higher values of electrical conductivity indicate ion rich soils.

The pH of soil plays an important role in the growth of plant species. Values of the pH in soils depend on the presence of organic matter contents and plant nutrients and are found generally at neutral or around neutral pH 6 to pH 8. We recorded slightly acidic soils, ranging from 5.13 to 6.79. The pH values were found to have considerable effects on the concentration of the nitrates, phosphates and organic matters (Table 3.2.3.2). Among the nutrients, the concentration of phosphate was relatively high as compared with chloride and nitrate in general. Soils were generally rich in organic matters and organic carbon.

ii) ***Soil Microbes***

Microorganisms in soil play an important role in nutrient cycling, soil structure and plant health and help in improving soil structure by the humus they create while digesting organic matter. Generally, populations of microbes in soil are numerous as many as one billion and about 13,000 species can reside in a single gram of soil. Different factors such as availability of water, soil pH, temperature, redox potential and the soil organic matter content not only influence the types of microbes colonizing the respective micro-niche but also their activity. Therefore, study of soil microbes forms an essential component of the EIA of hydropower projects.

Representative colonies of fungi and bacteria developed from the soil samples are illustrated in **Plates 3.2.3.1 (A) & (B)**. The bacterial colonies in the soil samples collected from the Tato-I H.E. project and catchment areas ranged from 2.32 x 10^4 to 3.12 x 10^6 cfu/ g^{-1} with maximum value recorded during monsoon season and minimum in winter season. (Table 3.2.3.3). Similarly, high density of fungal colonies (2.51 x 10^6) were recorded in monsoon season while minimum (1.50 x 10^3) in winter season. The results revealed that monsoon season when rainfall is maximum triggered the maximum growth of soil microbes in and around the project areas.

Table 3.2.3.2 Physical and chemical characteristic of soils retrieved from the project area of Tato-I H.E. project.

	Winter				Pre-monsoon				Monsoon			
Physical Characteristics	**S1**	**S2**	**S3**	**S4**	**S1**	**S2**	**S3**	**S4**	**S1**	**S2**	**S3**	**S4**
Soil Texture (%)												
Very Coarse sand	0.14	0.67	0.46	0.82	1.46	0000	1.25	0	2.19	06.14	1.17	1.19
Coarse sand	44.18	49.38	33.10	50.20	46.85	29.27	44.57	66.00	44.32	17.88	43.18	61.23
Medium sand	28.22	30.80	29.04	20.28	32.90	37.99	36.48	27.27	31.26	37.77	36.80	23.22
Fine and very fine sand	24.14	15.43	30.63	20.07	14.97	30.1	13.98	4.65	35.37	36.68	16.39	12.21
Coarse silt	2.23	0.66	2.71	6.30	1.65	1.33	2.41	0.22	1.99	0.96	1.88	1.12
Fine, medium silt and clay	1.09	3.03	3.54	2.33	2.17	1.28	1.88	1.20	1.39	0.54	1.75	1.77
Moisture content (%)	16.88	12.72	17.48	18.31	15.12	12.74	24.78	22.04	16.17	31.62	35.12	39.21
Bulk Density (g/cc)	1.01	1.00	0.99	1.11	1.07	0.67	0.73	0.93	1.04	0.73	0.75	1.23
Water Holding Capacity (%)	41.23	53.58	61.00	43.04	46.28	74.26	58.14	78.13	67.12	2.91	44.02	18.55
E. Conductivity (µs/cm)	120.00	59.00	53.21	105.00	144.00	105.50	102.50	98.10	83.19	83.00	111.00	98.11
Chemical Characteristics												
pH	5.26	5.52	6.25	6.17	6.00	5.63	6.79	6.27	6.43	5.42	5.60	5.13
Nitrate (mg/g)	0.07	0.05	0.01	0.06	0.03	0.09	0.09	0.08	0.10	0.02	0.43	0.09
Phosphate (mg/g)	0.25	0.52	0.33	0.53	0.021	0.113	0.111	0.041	0.03	ND	0.11	0.04
Organic Matter (%)	3.98	2.44	4.27	3.37	3.48	2.36	5.98	2.71	5.24	2.55	4.14	3.12
Organic Carbon (%)	2.14	1.44	2.47	1.95	2.01	1.37	3.56	1.75	0.2.47	1.48	2.83	1.66
Chloride (mg/g)	0.046	0.068	0.066	0.06	0.043	0.091	0.79	0.24	0.040	0.043	0.07	0.06

S1 = near Gapo village; S2 = Tato village; S3 = near Hiri village; S4 Rego

Table 3.2.3.3 Microbial communities in the soils of the proposed Tato-I H.E. Project

Soil characteristics	Project area		Catchment area	
	(S1)	(S2)	(S3)	(S4)
Winter Season				
Fungal colony (mpn/ g^{-1})	1.50×10^3	1.24×10^4	2.42×10^5	1.90×10^4
Bacterial colony (cfu/ g^{-1})	3.26×10^5	2.32×10^4	3.92×10^5	2.61×10^6
Pre-monsoon Season				
Fungal colony (mpn/ g^{-1})	1.2×10^4	2.56×10^4	2.79×10^4	3.56×10^4
Bacterial colony (cfu/ g^{-1})	3.29×10^4	2.32×10^6	4.22×10^4	3.67×10^5
Monsoon Season				
Fungal colony (mpn/ g^{-1})	3.21×10^5	1.89×10^5	3.00×10^5	2.51×10^6
Bacterial colony (cfu/ g^{-1})	2.40×10^5	3.12×10^6	1.21×10^6	2.68×10^5

S1 = Near Gapo village; S2 = Tato village; S3 = Near Hiri village; S4 Rego

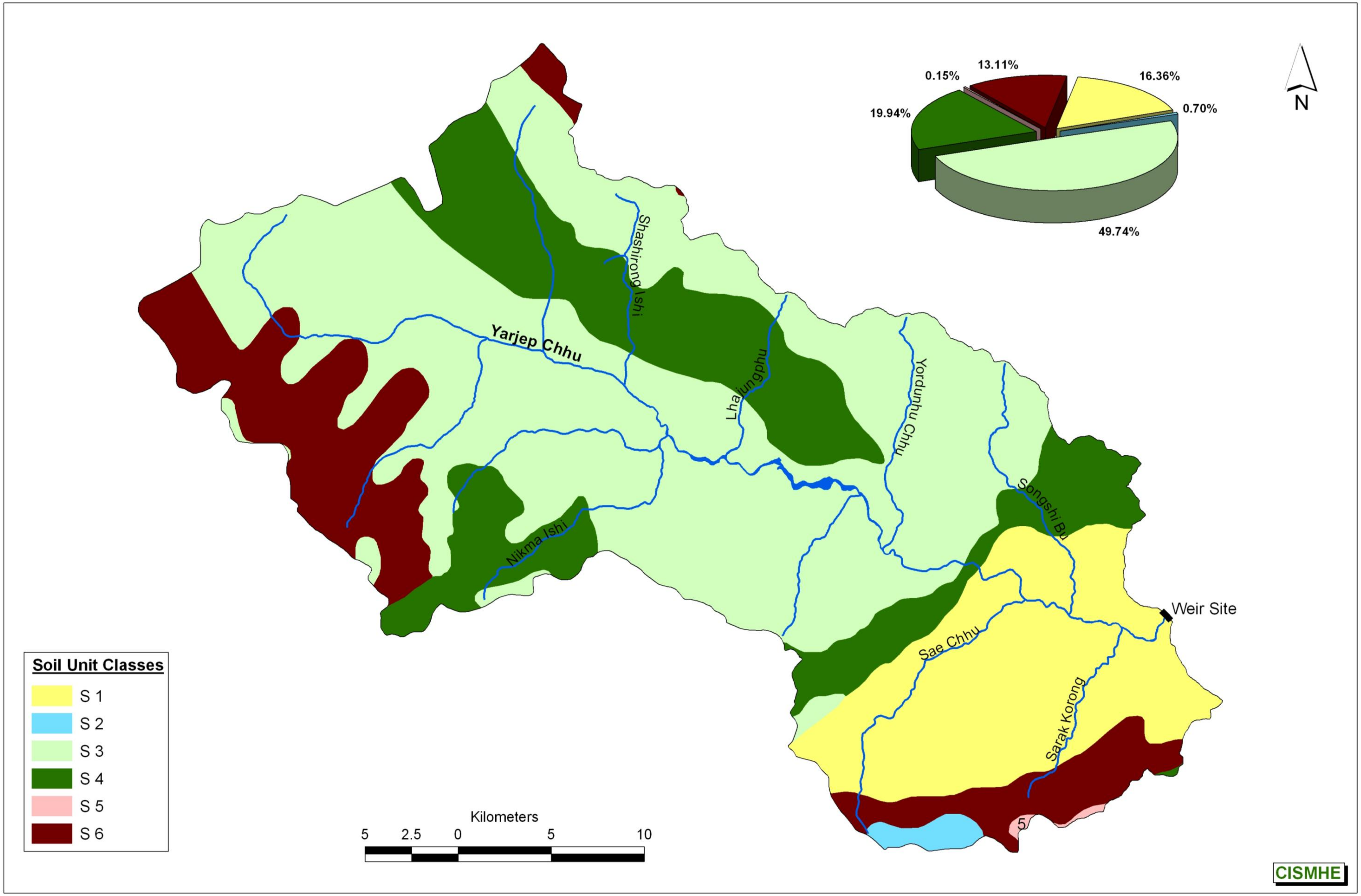


Fig.3.2.3.1 Soil map of the catchment area of Tato-I H.E. project up to the proposed Weir site

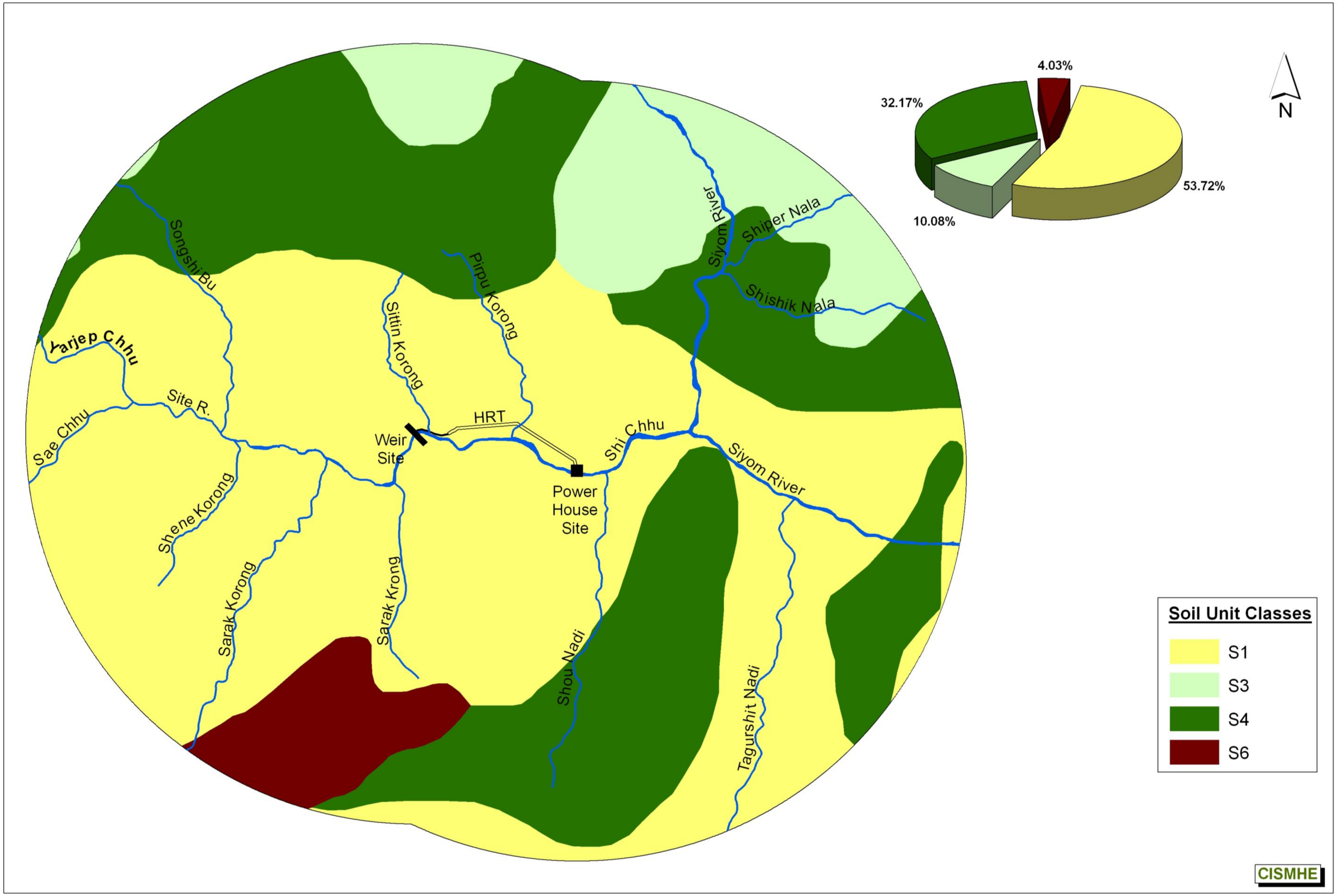
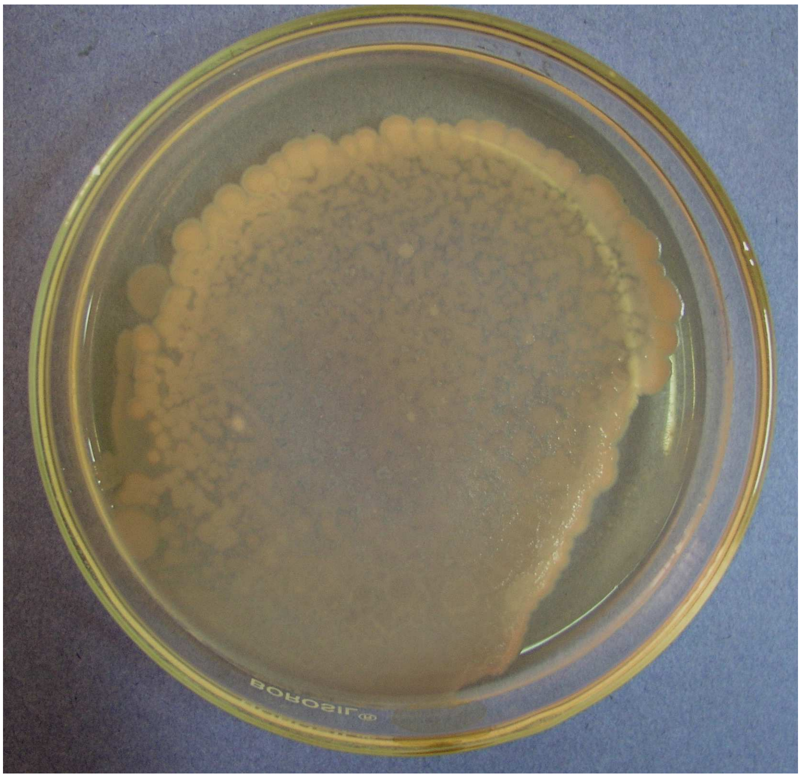


Fig.3.2.3.2 Soil map of Yarjep Chhu in the Influence zone of the proposed Tato-I H.E. project

(A)



(B)

Plate 3.2.3.1 Fungal colony (A) recorded from dam site and (B) bacterial colony recorded for powerhouse site of Tato-I HE, Arunachal Pradesh.

3.2.4 LANDUSE AND LANDCOVER

Land use and land cover mapping of an area with the help of satellite remote sensing technology contributes significantly in the baseline data while assessing the impacts on a developmental project. During the construction and after construction, changes in the land use and land cover is foreseen and the quantum and magnitude of changes can be assessed with the help of remote sensing technology. Since 1972, when Landsat -1 was launched, remote sensing technology and application has undergone a tremendous change in terms of sensor development, aerial flights with improved sensors, satellite design development and operations including data reception, processing, interpretation and utilization of satellite images. These developments have indicated that if satellite data is judiciously used along with the sufficient ground data, it is possible to carry out detailed forest inventories and monitoring of land use and vegetation cover at various scales such as local, regional and global scale.

Forests constitute the major proportion of Tato I catchment in Arunachal Pradesh and play an important role in maintaining the ecological balance and regulation of hydrological regime of Yarjep Chu system. Land use and land cover mapping of Tato I river catchment up to the proposed Tato I H.E. project Intake site was carried out by standard methods of analysis of remotely sensed data and land use./ land cover classification were undertaken which was followed by ground truth data collection of the classified land cover and land use units. Hence digital data on CDROMs was procured from National Remote Sensing Agency, Hyderabad. Digital image processing of the satellite data and the analysis of interpreted maps were carried out at the Computer Centre at CISMHE using ERDAS Imagine 8.7 of Erdas Inc.

3.2.4.1 Objective and Study Area

The study deals with assessing the land use/land cover in the catchment area and project area as baseline data so that can add to prediction of impacts due to construction of Tato-I H..E. Project. The region is characterized by sub tropical wet hill forest, wet temperate broad leaf forest and mixed coniferous forest. Besides the higher ridges of the catchment are majorly characterized with scrub and snow capped peaks. The catchment is also prone to landslides and changes in landscape features.

The study was aimed to produce a detailed Land cover / Land use map using hybrid digital classification technique. Besides the study focuses at producing land cover data set appropriate for wide variety of applications like Catchment Area Treatment (CAT) planning. The Study areas are the catchment area, the influence area and the project area.

3.2.4.2 Database

The details of primary data in the form of digital data on CDROMs procured from NRSA for interpretation and analysis are given in Table 3.2.4.1.

Table 3.2.4.1 Database used for land use/ land cover mapping of Tato-I H.E. Project

Satellite	Sensor	Path/Row	Date	Data type & Bands
IRS-P6	LISS-IV	112/51	05-12-2006	Digital (1,2,3,4)

For the secondary data, Survey of India topographic sheets 82L2–82L3-82L6-82L7 on 1:50,000 scale were referred to for the preparation of base and drainage maps.
The field information, collected by CISMHE and / or provided by Velcan Energy was also used in order to study the Project Area.

3.2.4.3 Methodology

Before processing any image for image enhancement, transformation or classification, pre-processing was done for band separation. Different bands were downloaded into the work station using ERDAS IMAGINE 8.7. The images were checked for occasional shortcomings in the quality of radiometric and line dropouts. Band separation and windowing of the study area with the help of Survey of India (SOI) toposheets was performed. The registration of image was performed using the nearest-neighbour resampling algorithm (Jensen, 1996). The scene was geometrically corrected with toposheets using proper identification of GCPs with a root-mean-square (RMS) error of 0.0002 to 0.003 pixels. IRS LISS-III was radiometrically corrected using dark pixel subtraction technique. They were then co-registered with SOI toposheets using Polyconic projection. Geo-referencing of the composite image was done using digital vector layer of drainage, road network, water bodies and other permanent ground features extracted from SOI toposheets. Distinguishable Ground Control Points (GCPs) both on image and vector database were identified and using these GCPs the image was resampled and geo-coded. Sub-pixel image to map registration accuracy was achieved through repeated attempts. The image enhancement was performed by using different combinations for best image contrast for the full dynamic range for each band employing enhancement techniques like edge detection, filters, manipulation of contrast and brightness, histogram equalisation, etc. False Colour Composite (FCC) was prepared using enhanced data of Bands 2, 3 and 4 of LISS-III, IRS-1D (**Fig. 3.2.4.1**). The image was interpreted digitally using various digital image processing techniques. All operations were carried out using ERDAS IMAGINE 8.7 software. The general procedure for classification involved the following important steps viz. enhancement of scene, rectification and classification technique, etc. is given in **Figure 3.2.4.2** in the form of flow chart.

In order to utilize the higher resolution of panchromatic image of IRS-ID, image fusion was done to enhance the lower multispectral LISS. For this purpose a portion of high resolution PAN image that corresponds with an area of interest in the multispectral LISS image was extracted. Thereafter, both the images were co-registered and LISS and ETM+ images were resampled for merging with PAN image. Merging or image fusion was done by spatial enhancement module of ERDAS Imagine 8.7.

The digital vector layers of state of Yarjep river catchment up to the Tato I H.E. project Intake site as well as the administrative boundaries of different sub-watersheds of free-draining catchment were prepared from the Survey of India (SOI) toposheets at 1:50,000 scale. These vector layers were used as masks to extract the sub-watersheds from the images for further processing. A mosaic image was prepared from four different PAN scenes. It was from these mosaic images, that the mask of above mentioned study area was extracted. From this mosaic image, different districts and watersheds were extracted.

In the preliminary analysis, image classification was done by unsupervised classification technique by performing ISODATA training. It helped in assigning the classification of the image into land use units. Later on, the boundaries of water bodies were separately mapped using SOI toposheets and merged with classified image. The doubtful areas or wrongfully interpreted areas owing to various physical features controlling the study area were marked for ground truthing. The ground truth collected during the field surveys was used for the supervised classification for the preparation and identification of land uses resulting in accurate classification of the areas. The classified map was regrouped and merged. Unsupervised classification technique is also complimented by supervised classification technique where the classification of Pixels is classified and Maximum likelihood classifier technique is used. The classified raster map, thus prepared, was then converted to vector format for GIS analysis and the preparation of required thematic maps using ArcGIS 9.0 and GeoMedia Professional 5.2. Reconnaissance surveys of different parts of the study area were conducted to collect ground truthing.

3.2.4.4 Classification Scheme

With the objectives of preparation of environment management plan and an action plan for watershed management and Catchment area treatment, the classification scheme adopted for the preparation of land use/land cover maps and related thematic maps on 1:50,000 scale is as follows. Vegetation density classification was done by Normalized Difference Vegetation Index (NDVI) technique. NDVI values are derived from the band 2 and band 3, i.e.

$$NDVI= (\lambda_{1-} \lambda_2) /(\lambda_{1+} \lambda_2).$$

Where λ_1 is near infrared channel and λ_2 is near visible band channel. In NDVI algorithm vegetated areas will generally yield high values because of their relatively high near-infrared reflectance and low visible reflectance in contrast to water, clouds, and snow have larger visible reflectance than near-infrared reflectance. Thus, these features yield negative index values. Therefore NDVI values are a measure for the presence and condition of green vegetation density (Lillesand and Kiefer, 1999).

From the NDVI assessment two forest density classes were interpreted for the forest cover mapping. The forests with >40% canopy cover were delineated as dense forests and between 10% and 40% crown density as open forest. Furthermore, degraded forests and scrubs were also delineated for the purpose of erosion mapping. The cropland was also delineated. The non-forest land cover in the form of barren/ rocky land, glaciers, lakes, etc. was also classified for the calculation of erosion intensity classification in Catchment area treatment plan.

An interpretation key was prepared based on the relationships between ground features and image elements like texture, tone, shape, location, and pattern. Image interpretation was done for the entire Yarjep river basin. Interpreted details (polygons) were then transferred to base map. Since satellite data is geo-coded there was not much error in the geometry of the data and wherever necessary, local matching was done while transferring the details.

3.2.4.5 Landuse/ Landcover in the Catchment Area

The Tato-I H.E Project catchment has good forest cover. Major part (37.86%) of the catchment area up to the proposed barrage site is covered with dense forest (Table 3.2.4.2, **Fig. 3.2.4.3**). However, Open forest and degraded forest account for a mere coverage of about 13.83% of the total catchment area. A large part (12.53%) of the catchment is under Scrub and Alpine Scrub land covers. Barren land and moraines covers an area of 10874.98 ha i.e., 9.70% of the total catchment area. However snow and glaciers covers a larger area in the catchment with an area of 17134.74 ha of land i.e., 15.01% of the total catchment area. Cultivation and settlement covers a total area of 4.34% of the total catchment. Lakes and water bodies accounts for only 0.27% of the total catchment area.

Table 3.2.4.2 Area under different land use/ land cover categories in the Tato-I H.E. Project catchment area up to the barrage site

Land use/ Land cover	Area (Ha)	Percent
Dense Forest	43152.57	37.86
Open Forest	9815.8	8.65
Scrub	13171.5	12.53
Degraded Forest	5729.58	5.18
Cultivation	5345.8	4.34
Moraines	7847.88	6.45
Barren	11662.81	9.70
River	298.00	0.27
Snow	18376.05	15.01
Total	**115400**	

3.2.4.6 Landuse/Landcover in the Influence Zone

Land use/ land cover of Influence zone is given in **Fig. 3.2.4.4** with an area of 43525.39 ha of land. As seen from the figure, dense forest is the most dominant type of land cover and land use patches in the influence zone on either bank of the Yarjep chhu and Siyom River, accounting for 37.78% of the total influence zone within the 10km radius of both the intake site and power house site. In addition open forest is also widely spread with the radius with area coverage of 24% of the total influence zone area. Scrub and degraded forest accounts for 17.68% and 17.29% of the influence zone respectively. Other land use and land cover patches accounts for the rest of the area coverage i.e., 3.16% of the total influence zone area.

3.2.4.7 Project Area

The intake area, located in the vicinity of Meying and Gapo villages, is mostly covered by open to degraded forest and scrubs. The area under dense forest or cultivation and settlement is very small compared to the rest of the land use. The adit site is located on the left bank of the river, in an area covered by dense to open forest, while the power house area, located in a community land of Heyo and Tato villages. This area is covered with mostly dense to open forest.

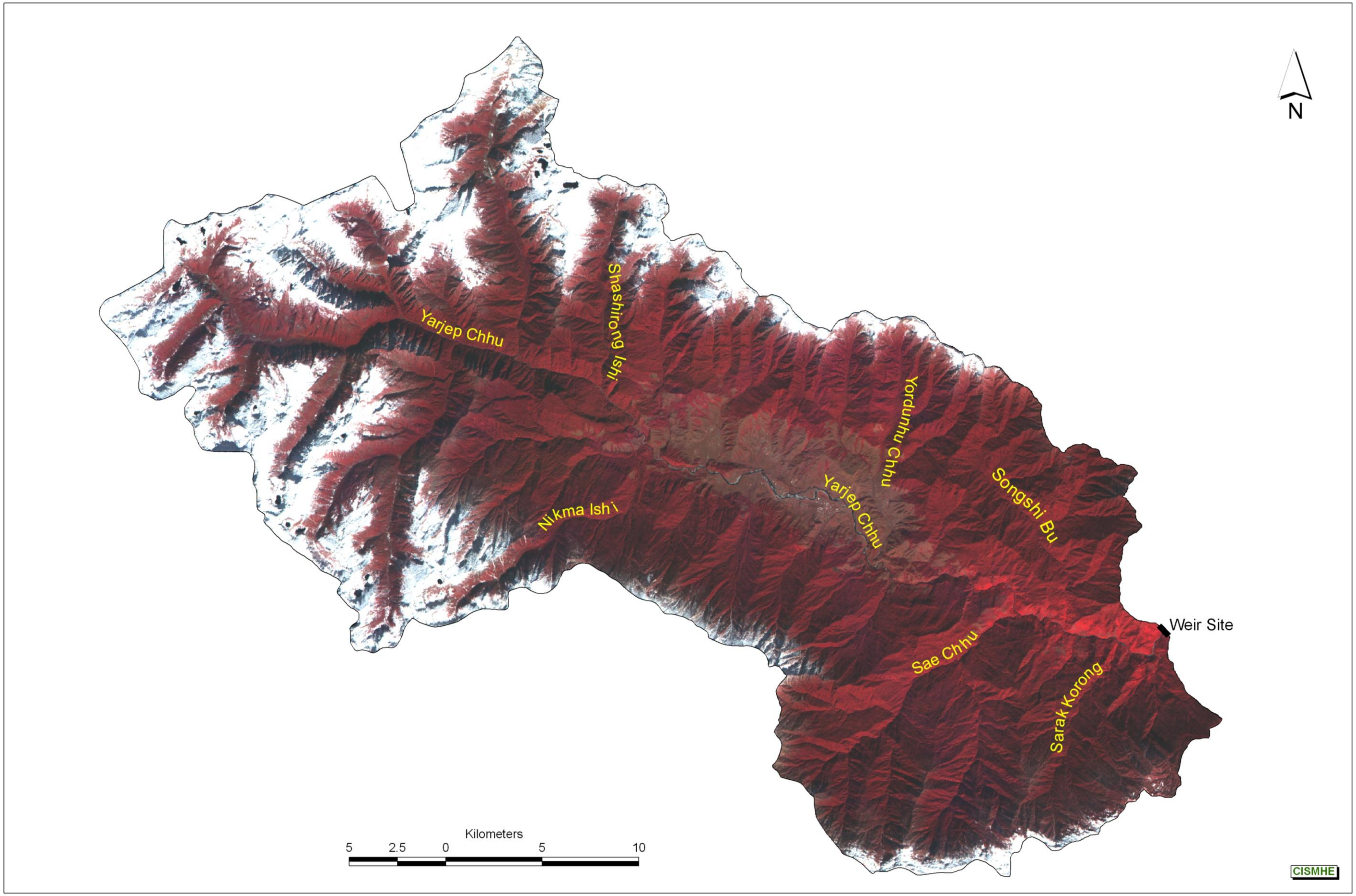


Fig.3.2.4.1 False Colour Composite (FCC) generated from IRS-P6 LISS-III, 2006 of the proposed Tato-I H.E. project

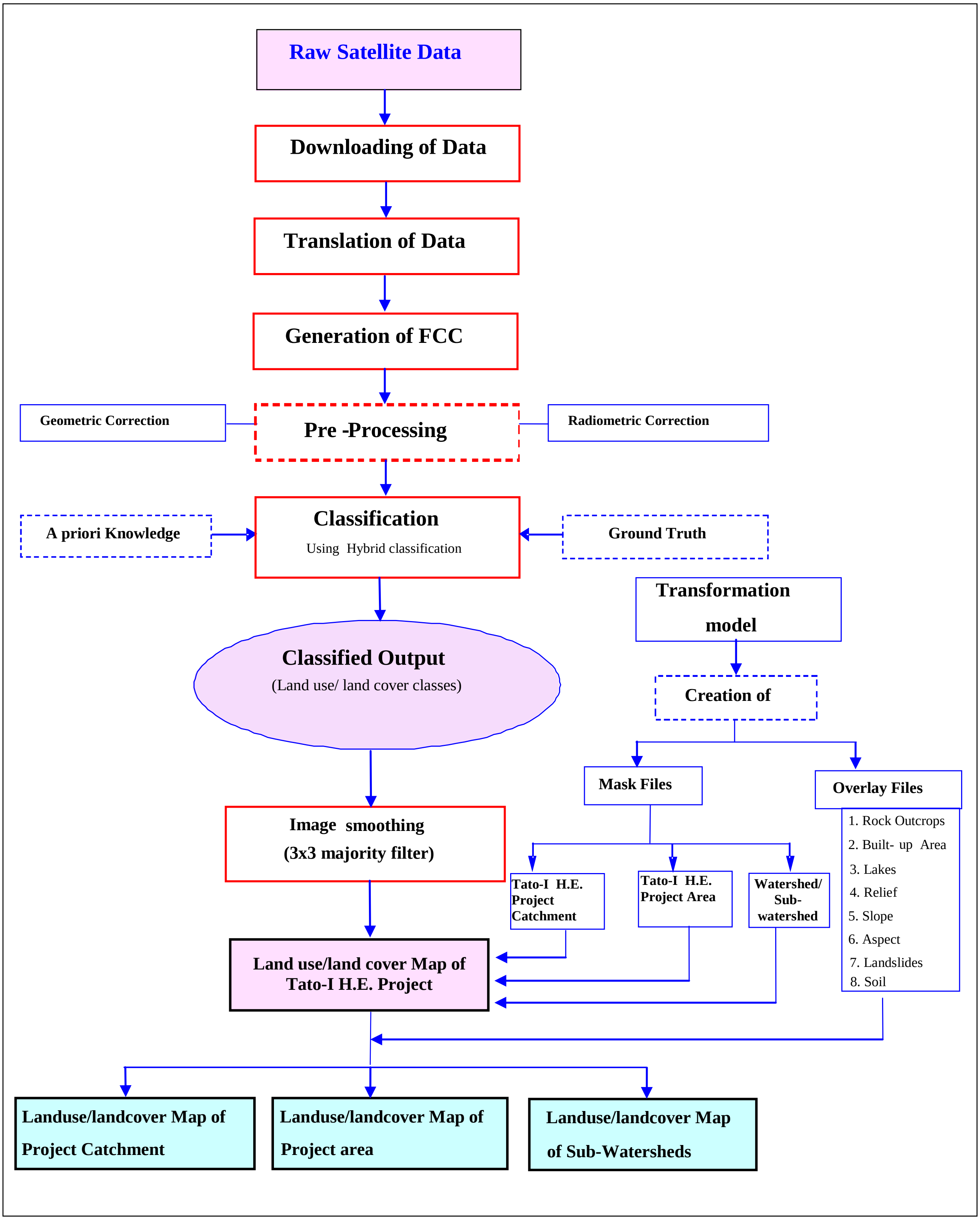


Fig. 3.2.4.2 Flow diagram for land use / land cover classification

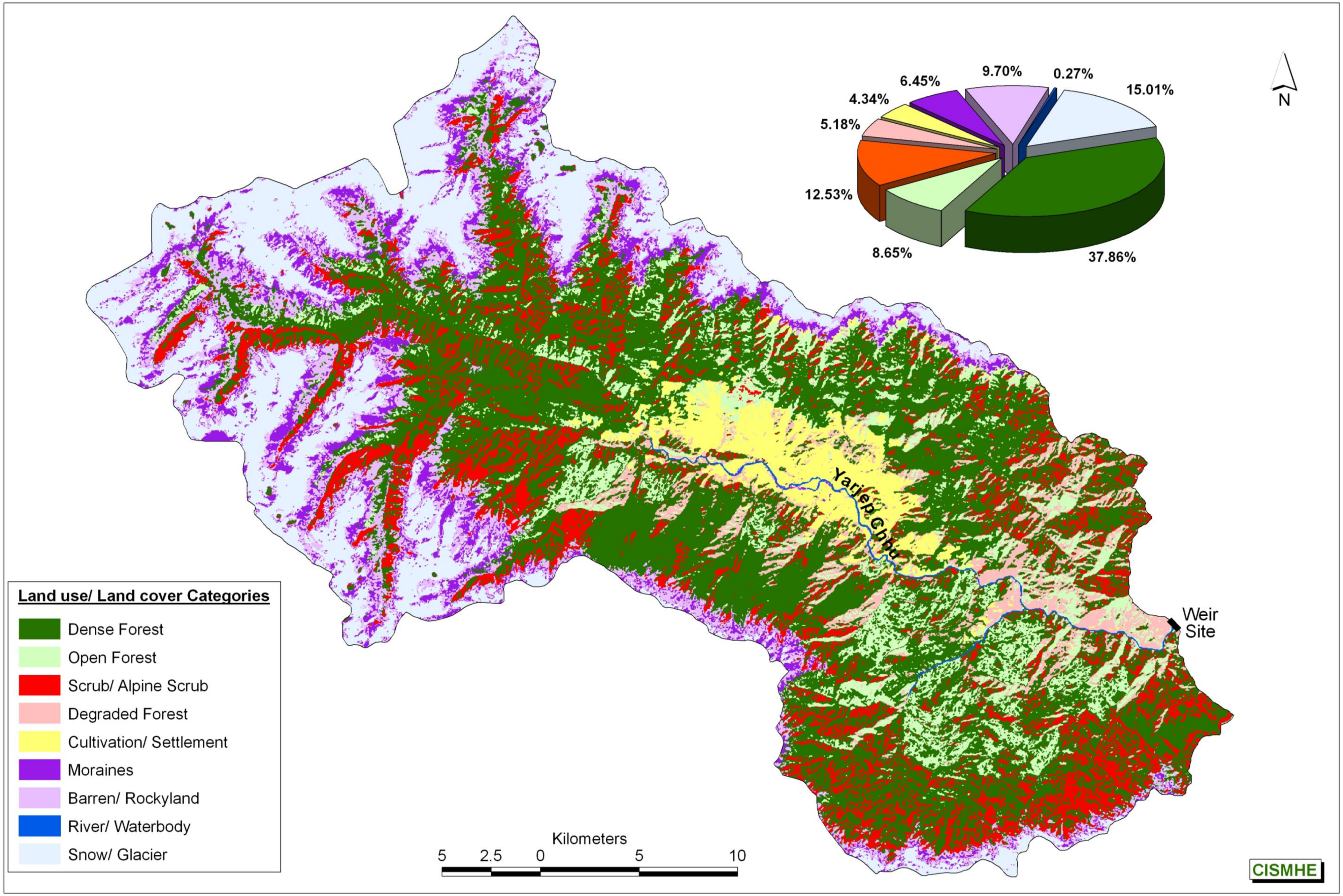


Fig.3.2.4.3 Land use/ Land cover map of the catchment area of Tato-I H.E. project up to the proposed Weir site

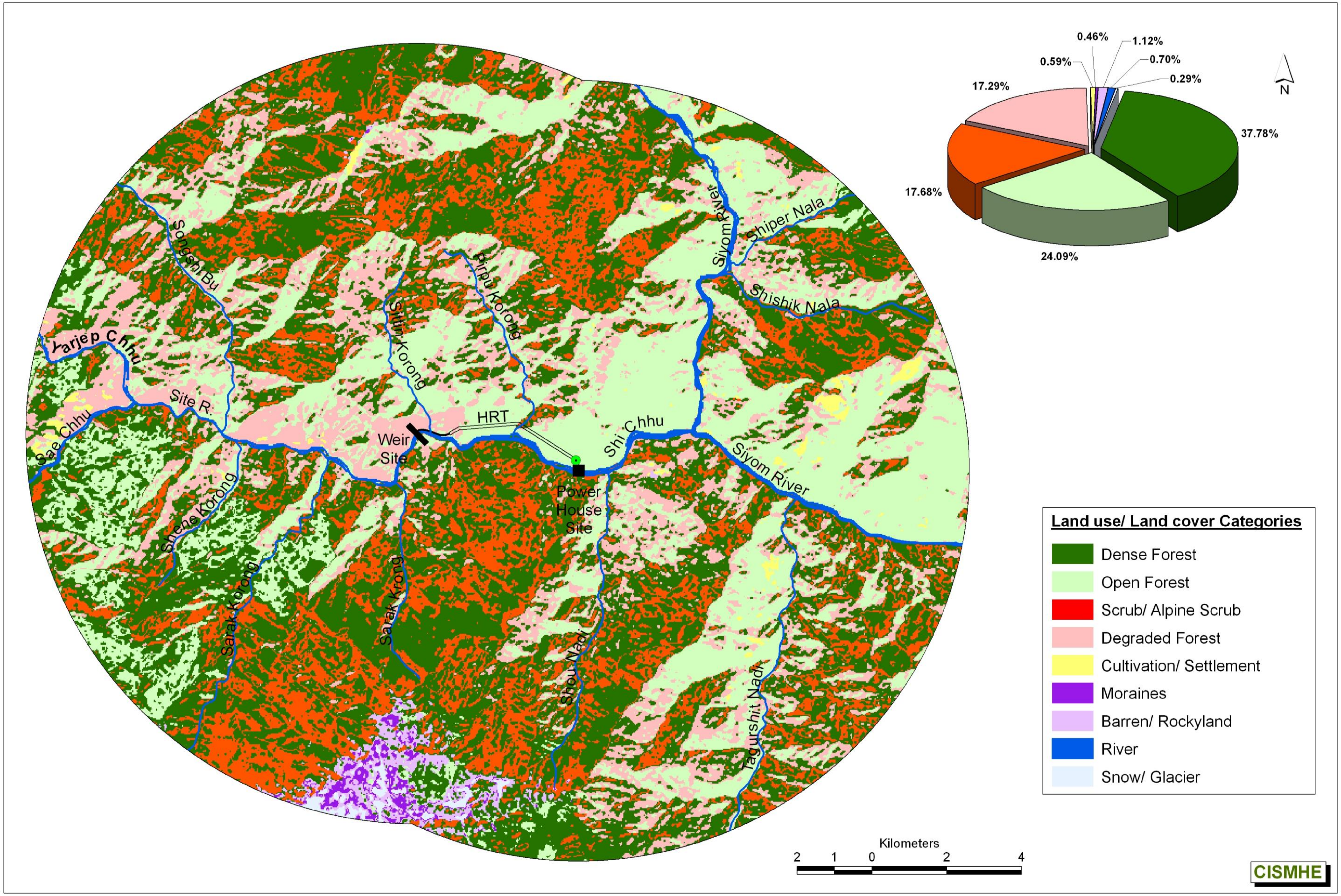


Fig.3.2.4.4 Land use/ Land cover map of Yarjep Chhu in the influence zone of the proposed Tato-I H.E. Project

3.3 WATER ENVIRONMENT

3.3.1 HYDROLOGY

3.3.1.1 General

The power potential studies of the hydro-electric project solely depends on the hydrological attributes, thus, availability of the water in a basis is the power of hydro-electric project. The hydrology of a particular basin is controlled by several meteorological and hydrological factors such as rainfall, temperature, direction of wind, evapo-transpiration, drainage network, sediment load etc. The important drivers of hydrological parameters are geographical position and topography of the basin. The baseline data on hydrological parameters are helpful not only in the power potential studies but play vital role in assessing the impacts while rivers are under regulation. The likely impacts associated with river regulation are changes in flow regime in upstream and downstream, environmental flow, etc. The changes especially in water discharge and sedimentation are permanent and long term. This contribution attempts to discuss some aspects of hydro-meteorological system in the Yarjep basin with reference to the development of the proposed Tato-I HE Project near Meying village.

3.3.1.2 Rainfall

The locations of the rain gauge stations are shown in **Figure 3.3.1.1**. The average monthly rainfall data for rain Gauge stations at Mechuka, Monigong, Raying, Kaying, Aalo and Tato are shown in **Fig. 3.3.1.2** and Table 3.3.1.1. The rainfall data for various rain gauge stations are used from the detailed project report (DPR) provided by Velcan Energy. Two data sets of Mechuka have been used for the interpretation of data in Tato-I H.E. Project. Data developed from the external sources, which is named as Mechuka (ext) and the measurements of data acquired through Velcan Energy has been named as Mechuka (int). Maximum rainfall was recorded at Raying and Kaying with an annual precipitation of 4658 mm and 4374 mm. Tato also receives an annual rainfall of 3031 mm. The intensity of the rainfall is high during the monsoon period (June-September) whereas it is low during the lean season (December-March). There is no clear correlation of the rainfall level with altitude as well as distance along the Siyom Valley. As in most of the mountainous field, the rainfall is concentrated in specific pocket (as the one of Kaying-Raying) where the level of precipitation can be 2 or 3 times the average one measured around. For instance, Kaying and Aalo are closed sites (30 km) and at a comparable altitude, however, the level of rainfall measured at Kaying is twice the one measured at Aalo. This indicates sudden change of rainfall system most probably due to the specific orography of the area.

The monsoon rain decreases at the end of September. The rainfall received during October ranges from 104 to 288 mm and it is gradually reduced up to onset of winter in December. During the lean season maximum rainfall is received in the month of March, ranging from 104 mm to 325 mm. The maximum rainfall received during monsoon (July) is 908 mm at Raying.

i) Seasonal Distribution of rainfall

The seasonal distribution of rainfall is given in Table 3.3.1.1. During monsoon the rainfall is high in Kaying, Raying, Tato and Aalo. These four stations record around 60% of the annual precipitation during the monsoon season at their respective stations (June-Sept). At Monigong and Mechuka (int) the monsoonal precipitation amounts to 54% and 50% of the yearly rainfall. The precipitation during the post-monsoon (Oct-Nov) season amounts to 7 to 12% of the total annual precipitation, where maximum of 12% at Monigong and Minimum of 7% at Aalo were recorded. During lean season minimum precipitation is received at Aalo with 11% of the total annual precipitation. Kaying receives maximum precipitation during lean season scaling up to 325 mm, and Tato receives maximum lean seasonal precipitation which amounts to 16% of the total annual rainfall there. A fifth (~13-25%) of the total annual rainfall is received during the pre-monsoon months (Apr-May) at most of the stations. Tato is nearest rain gauge station of Tato-I H.E. Project.

3.3.1.3 Water Discharge and Water Availability

i) Average *discharge pattern at intake site*

The average of 10-daily discharge at intake site is shown in **Fig. 3.3.1.3**. The discharge starts increasing in the month of May. The onset of monsoon is in the beginning of June. The average 10-daily flow series at Tato I intake site (June 1978 to May 2009) was computed on the basis of flow series data from Hydrology chapter of the DPR of Tato-I H.E Project. Average 10-daily discharges computed at the intake site has been plotted and the same is shown in **Figure 3.3.1.3**. The month of July records maximum average water discharge in Yarjep river. The average water discharge in Yarjep River during the monsoon months (June to Sept) varies from 151 to 228 cumec at intake site. In the time span from 1978 to 2009, minimum and maximum water discharge were 75 cumec in the middle of September 2005 and 482 cumec in the end of July, 2007, respectively.

Table 3.3.1.1 Seasonal distribution of rainfall (in mm) in and around the Yarjep basin

Station/Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mechuka (ext)*	69	97	153	198	338	460	373	342	316	188	66	27
Mechuka (int)*	21	157	125	244	383	220	431	393	186	224	40	35
Monigong	42	85	146	170	188	250	287	285	195	174	45	16
Raying	111	193	250	363	470	688	908	641	632	288	63	51
Kaying	156	153	325	353	396	712	755	624	535	246	69	50
Aalo	41	58	104	158	196	411	397	229	298	104	33	17
Tato	21	66	248	132	249	533	683	469	237	180	73	140

The corresponding water discharge for post-monsoon (Oct-Nov) period were minimum 18 cumec at the end of November in 1992 and middle of November in 2004 and maximum 278 cumec at the beginning of October, 2003. In lean season (Dec-Mar) water discharge varies from 11 cumec to 71 cumec. For the same time span Pre-Monsoon (Apr-May) water discharge varies 17 cumec in the beginning of April, 1994 to 291 cumec in the end of May, 2006.

ii) ***Water availability and Optimization study***

The changing pattern of total annual yield at the proposed Tato-I intake site for the water years 1978-79 to 2008-2009 is shown in **Fig.3.3.1.5** and Table 3.3.1.3. The optimization studies for the Tato-I H.E Project have been conducted on the basis of the 10 daily discharge data for 25 years i.e., from year 1978-79 to 1993-1994 and from 2000-2001 to 2007-2008. The criteria of dependable years signify the maximum quantum of energy which could be generated in a 90 % dependable year. The 90% and 50% dependable year was calculated using standard methodology. The 90% and 50% dependable years are the years in which the annual energy generation has 90% and 50% probability to occur over the considered period of 25 years, respectively. Monthly variation in 10-daily water discharge in Yarjep River at the intake site for 90% dependable year (1978-1979) and 50% dependable year (2003-2004) is shown in **Figure 3.3.1.4**. The peak discharge in the 90% dependable year was 215 cumec in the mid of July. On the other hand, the peak discharge in the 50% dependable year was 346 cumec in the beginning of July. The minimum discharges were 13 cumec in the 90% and 50% dependable years, respectively.

3.3.1.4 Flood Peaks in the River

The variation pattern of flood peaks shows that the peaks attain high level every 5 to 6 years for intake site axis. The data for the flood variation was available for 25 years (1978-1979 to 1993-1994 and from 2000-2001 to 2008-2009) provided by Velcan Energy, DPR. As seen in **Figure 3.3.1.5** maximum discharge at the intake site was attained in the 2007-08 with a total cumulative discharge of 3960 Mcum, it was again followed by precedent year i.e., 2006-07 with an annual discharge of 3896 Mcum. In 2000-2001 the discharge attained a peak of 3887 Mcum.

Table 3.3.1.2 Monthly and seasonal variation in 10 daily average water discharge at intake site of Tato-I H.E. Project

Annual Mean		99	53	176
Monsoon Mean		169	90	295
Non-Monsoon Mean		29	16	57
Year		**AVERAGE**	**MIN**	**MAX**
Jun	I	151	105	267
	II	172	112	289
	III	193	131	327
Jul	I	215	117	373
	II	225	114	323
	III	228	134	482
Aug	I	195	112	307
	II	198	79	411
	III	208	85	393
Sept	I	197	86	301
	II	190	75	352
	III	159	97	233
Oct	I	147	77	278
	II	118	49	171
	III	97	44	131
Nov	I	41	21	82
	II	34	18	65
	III	31	18	54
Dec	I	27	16	49
	II	24	15	42
	III	22	14	41
Jan	I	19	12	36
	II	18	11	32
	III	17	11	28
Feb	I	17	12	33
	II	17	12	27
	III	20	13	28
Mar	I	22	13	46
	II	27	13	57
	III	32	17	71
Apr	I	39	17	108
	II	49	21	98
	III	57	25	122
May	I	107	57	168
	II	117	63	211
	III	132	82	291

Table 3.3.1.3 Monthly variation in the water discharge for 50% and 90% dependable years

		50% Dependable 2003-04	90% Dependable 1978-1979
Jun	I	107	137
	II	150	189
	III	233	263
Jul	I	346	160
	II	283	173
	III	171	168
Aug	I	143	165
	II	245	128
	III	159	85
Sept	I	217	152
	II	169	190
	III	161	157
Oct	I	278	130
	II	115	99
	III	91	87
Nov	I	39	42
	II	36	35
	III	37	42
Dec	I	24	29
	II	31	25
	III	29	22
Jan	I	14	18
	II	13	17
	III	14	17
Feb	I	13	15
	II	13	13
	III	15	19
Mar	I	21	20
	II	21	20
	III	33	28
Apr	I	19	30
	II	25	34
	III	35	36
May	I	57	115
	II	63	105
	III	91	82

3.3.1.5 Sedimentation

The slopes on both banks of the reservoir are very steep. It has been assessed that the Mechuka plain plays a critical role in a sediment point of view. Since the valley at Mechuka is very wide and slopes of the flanks gentle on their lower levels, the valley acts as a desilting basin. Water is cleared from silts while it flows through the Mechuka plain. Even during high flood events, hydraulic model shows that sand and silt deposits are not put in motion again: water velocity does not increase significantly even during extreme flood event.

3.3.1.6 Environmental Implication

The stretch up to intake site requires special attention for the purpose of catchment area treatment in case of soil erosion and high siltation during the monsoon period. In addition instantaneous flood peaks are expected. PMF has been taken into account for the design. PMF determination is based on critical heavy rainfall calculated by IMD. An appropriate disaster management plan is necessary and proposed under appropriate section of the EMP (Chapter 5.12) for the purpose of catastrophic events like weir break failure or upstream dam break failure. Continual release of certain cumec into the downstream stretch will help to maintain and sustain the ecological functions in this region. The project has no impact on the high peak in discharge occurring every day of the monsoon season. Then, flood regime of the river will be maintained during the entire monsoon season, allowing the ecological regeneration of the river life.

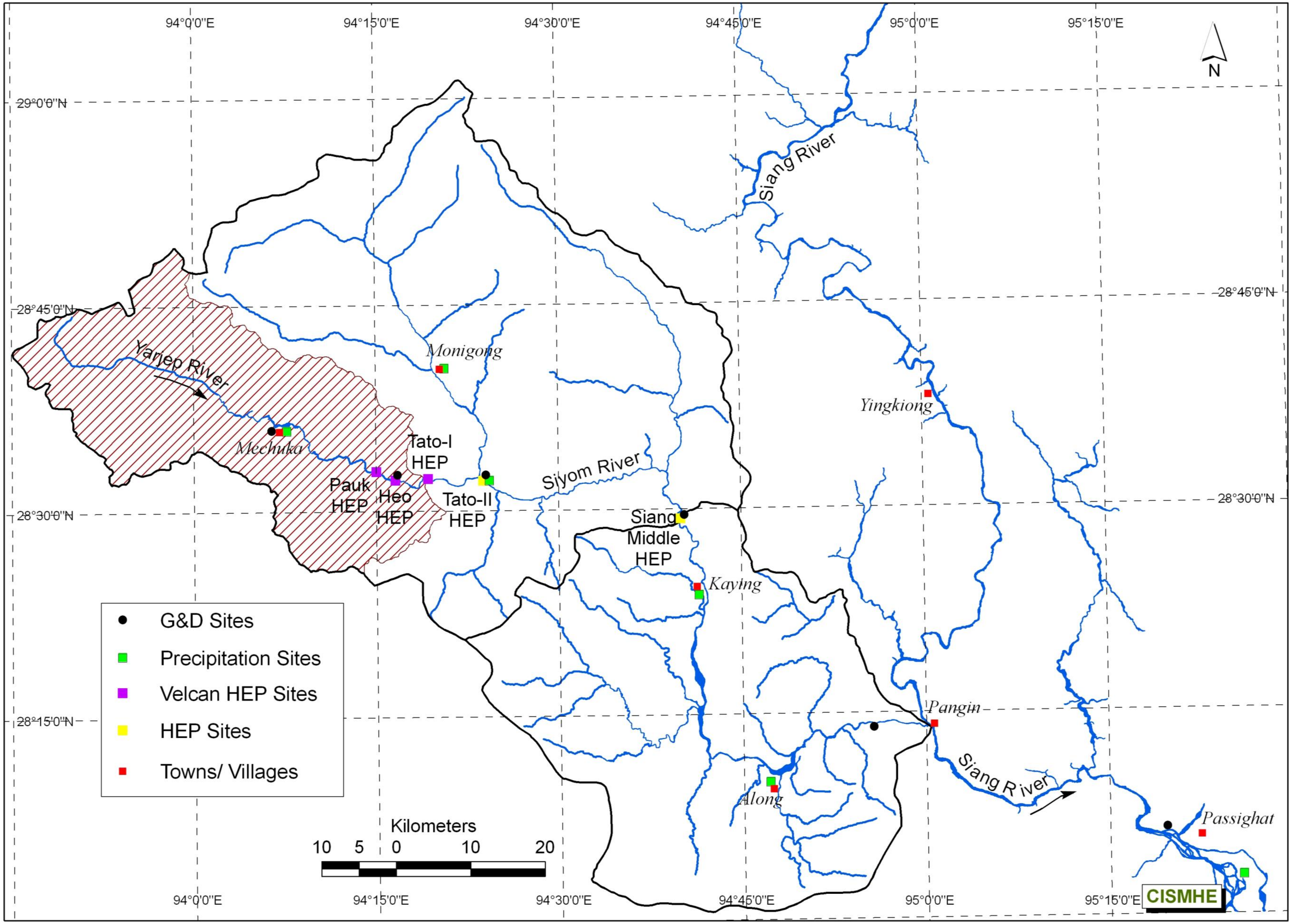


Fig. 3.3.1.1 Locations of G&D sites and Rain Guage Stations

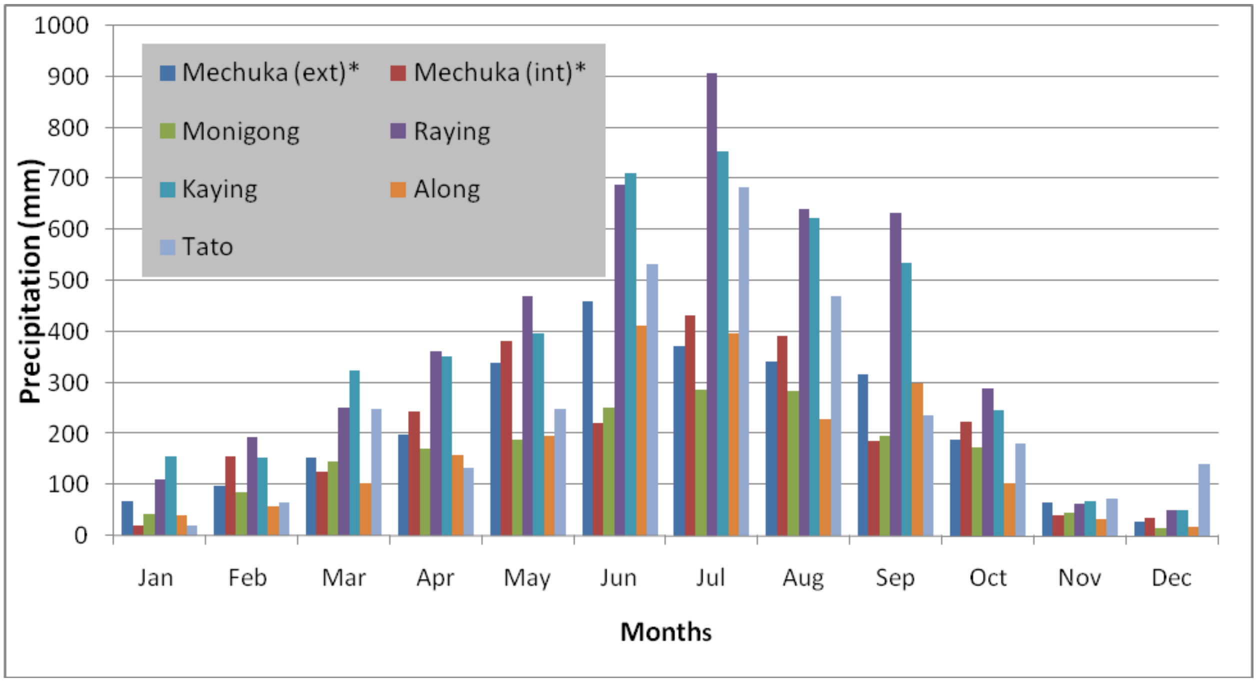


Fig. 3.3.1.2 Precipitation for seven rain gauge station

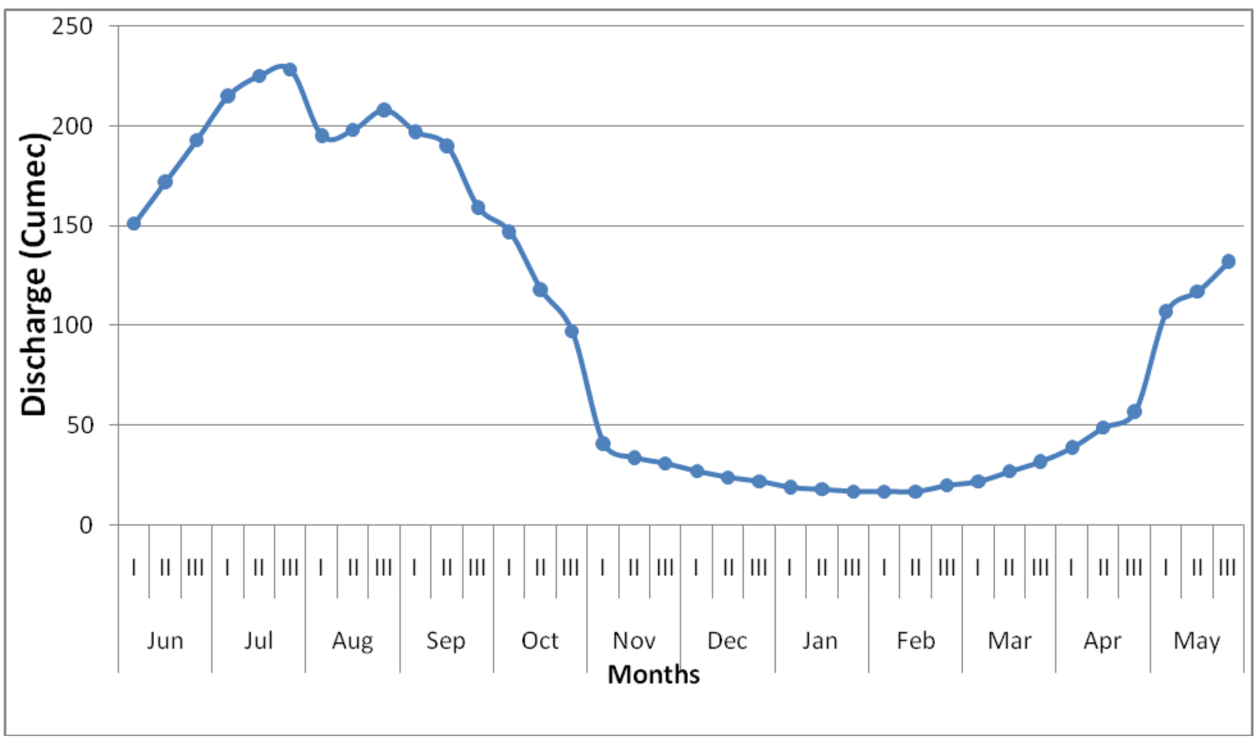


Fig. 3.3.1.3 Average 10-daily discharges at intake site

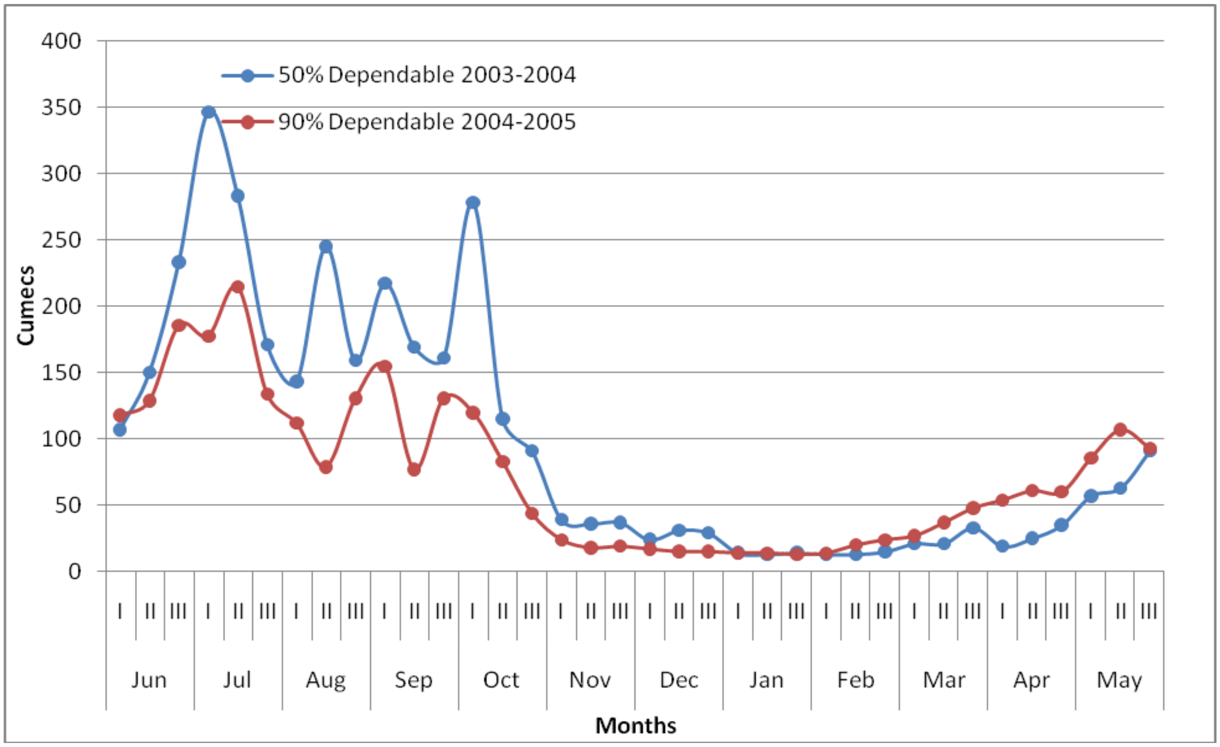


Fig. 3.3.1.4 Monthly variation in 10 daily discharge for the dependable years of 50% and 90%

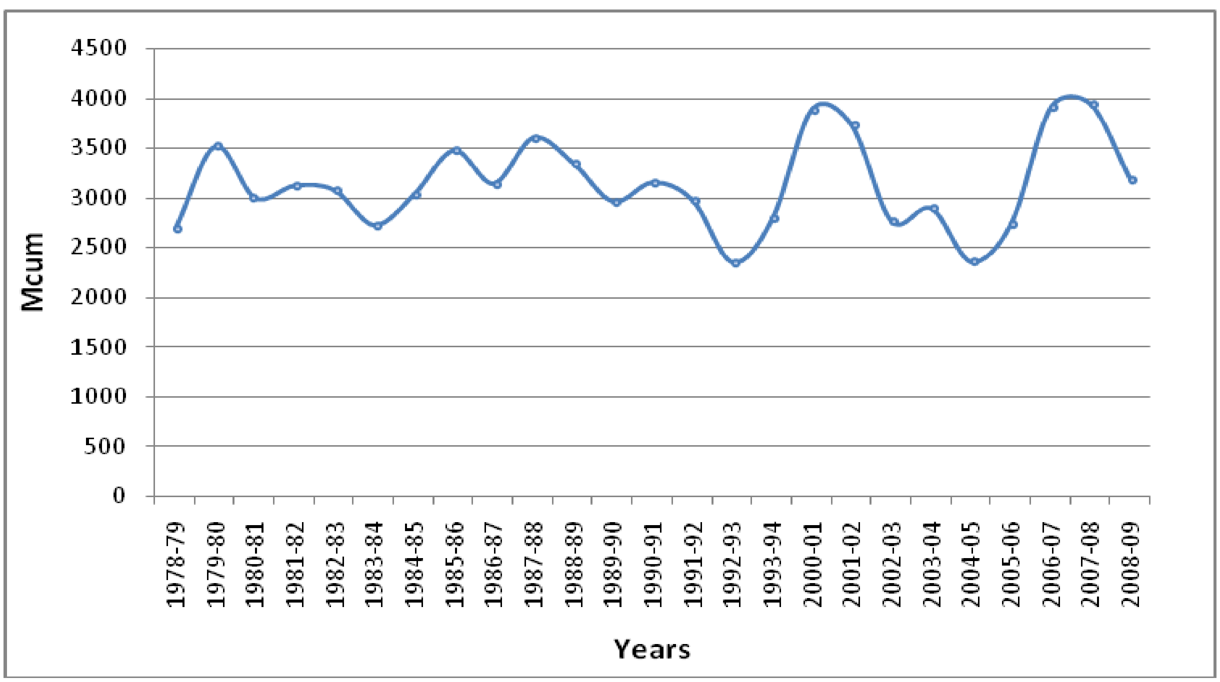


Fig. 3.3.1.5 Variation of annual yield in Mcum for 25 years

3.3.2 AQUATIC ECOLOGY & WATER QUALITY

Generally, hydropower is considered as relatively less polluting and reliable source of energy, however, this concept seems true for land environment and air environment. Water ecosystem is directly affected due to the hydroelectric project in various way. A dammed river leads to dearth of water in downstream, impoundment and changes in flow rhythms in downstream and upstream stretches. These physical modifications trigger the changes in quality of water in chemical as well as biological terms. Thus, aquatic fauna and flora are most and directly affected while developing a hydro- project as damming a river will have immense effects on both downstream and upstream stretches, viz. habitat degradation and habitat fragmentation (Berkamp et al., 2000); Smith *et al*., 2003). In addition, dammed water looses it self purifying capacity while flowing in downstream (Mason, 2002), decreases export of water, sediments, and nutrients to marine systems (Postel *et al*. 1998, Ittekkot *et al*. 2000). In the upstream river impoundment is characterized by thermal and flow buffering (Hannan, 1979) and a reservoir act as annual sink of organic and inorganic chemical (Soltero *et al*., 193).

River water is also considered as source of livelihood as people engage in fishing activities, use water for irrigation and drinking purpose, therefore, some socio-economic impacts are also foreseen while rivers are regulated. In view of above anticipation, baseline data on the water quality and aquatic bio communities have been assessed prior to river regulation. Yarjep river is free flowing and free of pollution as no point source of pollutants has been located in the catchment area. The study on impact assessment helps in formulating methods to avoid or mitigate the adverse environmental impacts caused by the project.

3.3.2.1 Aquatic Ecology

i) ***Yarjep Chu and Sampling sites***

Yargyap Chhu is a snow fed and lake fed river, originating from Tibetan territory from an elevation of 4000 - 4430 m. The river flowing in the most upper reaches before confluence with Sae Chu is called Yargyap Chhu. Downstream of this confluence it flows as Siet River and further downstream it is called as Yarjep Chhu. After the confluence of Phipir Korong it flows as Shi Chhu before joining Siyom River at 960 m. With many streams joining it on its either bank this is a well developed subsystem within the Siyom river system. Snow has major contribution to total discharge of river, thus, physical, chemical and biological characteristics greatly influenced by the seasonal variation in the snow melting and discharge.

ii) ***Physical and chemical characteristics***

The water quality affecting the physical, chemical and biological characteristics of the lotic systems depend on the seasonal fluctuations in the water discharge. One of the most important factors governed mainly by water discharge is the water current velocity. Water current velocity ranged from 0.61 m/s at site W_3 (near proposed power house site) in winter to 2.55 m/s in monsoon season at site W_3 (Table 3.3.2.1). Water temperature was minimum in winter season at site W_3 sites (11ºC) and maximum in monsoon season at sites W_2 (proposed intake site) and W_3 (17 ºC). The pH of river is an important factor for the aquatic fauna living within them. It ranged from a minimum of 6.48 at W_3 in pre- monsoon season and maximum of 7.56 at site W_1 (upstream of intake site) in monsoon season. With a few exceptions pH was alkaline and indicating good water quality. Dissolved oxygen (DO) is the most important characteristic, which support the aquatic flora and fauna in the water body. Turbulent flow and aquatic flora are main sources of dissolved oxygen in the water while water temperature is a main controlling factor (Hynes, 1970). Dissolved oxygen ranged from 8.56 mg/l in pre-monsoon season at site W_2 to 9.90 mg/l at site W_3 during winter season. Electrical conductivity ranged from a minimum of 16.33 µS/ cm in pre- monsoon season at W_3 to 75.66 mg/l at sites W_1 and W_3 in winter season. Minimum total dissolved solids were recorded at site W_3 in pre- monsoon season (11.33 mg/l) and maximum were recorded in winter season at site W_1 (40 mg/l). Total alkalinity ranged from 12 mg/l at sites W_1 and W_3 in winter season to 30 mg/l at site W_3 in monsoon season. Total hardness ranged from 8.00 mg/l at sites W_1 and W_3 in pre-monsoon season to 48.00 mg/l in winter season at site W_3 site. Thus, water of Yarjep River is soft. Calcium hardness was recorded lowest at site W_2 in monsoon season (nil) and highest at site W_1 in winter season (31.50 mg/ l). Calcium ions were also nil at site W_2 in monsoon season. Calcium ions followed the similar trend and seem to be main controlling factor of hardness of water. Magnesium hardness was not detected in pre- monsoon season at site W_1. Minimum Magnesium hardness recorded to be 2 mg/l at sites W_2 and W_3 in pre- monsoon season and maximum at site W_3 in winter season (24.9 mg/l). Low alkalinity and hardness in monsoon season can be correlated to the rain fall in the basin, which triggers the high discharge and leads to dilution of ions in the water (Hynes, 1970). Among the nutrients, chloride ranged from 5.99 mg/l to 12.99 mg/l. It is an optimum range of chloride, however, the concentration of other nutrients like Nitrate and phosphate were very low. The concentrations of nutrients largely depend on the land use and land cover in the catchment. The point source (factories, etc) and diffuse source (farming, settlement, etc) of nutrients are almost nil in the surroundings, which is reflected in low nutrient concentrations. Similarly, concentrations of heavy metal on Yarjep water were non detectable.

Table 3.3.2.1 Physical and chemical characteristics of Yarjep River from the Intake to the Power House sites of Tato-I H.E. Project

	W1			W2			W3		
Parameters	**W**	**PrM**	**M**	**W**	**PrM**	**M**	**W**	**PrM**	**M**
Physical Characteristics									
Water current velocity (m/s)	1.37	1.28	NR	1.43	1.66	1.86	0.61	2.08	2.55
Water Temperature (ºC)	11.00	14.00	16.00	11.00	14.00	17.00	11.00	15.60	17.00
Chemical Characteristics									
pH	7.32	7.14	7.56	7.29	7.34	7.20	6.64	6.48	7.21
Dissolved Oxygen (mg/l)	9.80	8.76	8.57	9.40	8.56	8.83	9.90	8.57	9.01
BOD (mg/l)	1.23	2.21	1.31	0.46	ND	0.99	1.23	2.38	3.12
Conductivity (µS/cm)	75.66	21.00	24.33	73.00	21.66	33.00	75.66	16.33	30.33
Total dissolved Solids (mg/l)	40.00	14.00	20.00	36.66	15.33	20.00	33.33	11.33	20.00
Total alkalinity (mg/l)	12.00	22.00	22.00	14.00	20.00	24.00	12.00	24.00	30.00
Total hardness (mg/l)	48.00	8.00	12.00	48.00	10.00	10.00	48.00	8.00	12.00
Calcium hardness (mg/l)	31.50	8.00	8.40	23.20	8.00	0.00	23.10	6.00	4.20
Calcium ion (mg/l)	12.61	3.20	3.36	10.10	3.20	0.00	9.25	2.40	1.68
Magnesium Hardness (mg/l)	16.50	0.00	3.60	24.80	2.00	10.00	24.90	2.00	7.80
Magnesium ion (mg/l)	4.00	0.00	0.87	6.02	0.84	2.43	6.05	0.84	1.89
Chloride (mg/l)	9.99	12.99	6.99	7.99	10.99	5.99	11.99	10.99	8.99
Nitrate (mg/l)	0.11	0.18	0.00	ND	ND	0.00	0.09	0.15	0.00
Phosphate (mg/l)	2.49	0.25	0.13	1.88	ND	0.93	1.81	0.07	0.57
Heavy metal (Cd, Hg, Cu)	ND	ND	ND	ND	ND	ND	ND	ND	ND

W_1 = upstream of proposed intake site; W_2 = proposed intake site; W_3 = proposed power house site.

iii) *Biological characteristics*

The biological community in a river is a function of the various physical and geomorphologic forms and processes of the river. Biological communities reflect overall ecological integrity (i.e., chemical, physical, and biological integrity) as the very existence of these communities represents the integration of conditions around them. Therefore, biological assessment is useful in assessing the ecological quality of aquatic ecosystems. River water is rich in planktonic, benthic and macro invertebrates' populations. Among the biological components, coliforms were absent and can be attributed to absence of outfall of deteriorated water and effluents in the river water. Zooplanktons formed a minor portion of planktonic community. Zooplankton density ranged from 8 individuals/l to 429 individual/l (Table 3.3.2.2). Zooplankton density was recorded highest in pre- monsoon season at site W_3. Phytoplankton density showed seasonal variation and was recorded minimum (28 cells/lit.) in monsoon season and maximum was recorded (87062 cells/lit.) in winter season. Phytobenthos density was also recorded minimum in monsoon season (19 cells/cm²) and maximum (732564 cells/cm²) at site W_1 in winter season. Macro-invertebrate density ranged from 77 individual/ m² at site W_3 in winter season to 2310 individual/m² at site W_3 in pre- monsoon season. In general biotic communities showed their minimum presence in the monsoon season because high water discharge and surface runoff wash out major portion of the biotic communities. The biotic communities appear to restore themselves in post monsoon season and peak in winter season.

Table 3.3.2.2 Densities of various biotic communities in Yarjep River flowing in Tato I H.E. project area.

Biological Characteristics	W1			W2			W3		
	W	**PrM**	**M**	**W**	**PrM**	**M**	**W**	**PrM**	**M**
Total coliforms	NA	NA	NA	NA	NA	NA	NA	NA	NA
Zooplanktons (indiv/lit.)	35	36	9	21	8	9	18	429	19
Phytoplankton (cells/lit.)	87062	208	29	56946	561	28	28959	42	44
Phytobenthos (cells/ cm²)	732564	103	32	440294	381	19	16632	80	23
Macro- invertebrates (indiv / m²)	365	178	266	1610	89	854	77	2310	355

W_1 = upstream of proposed intake site; W_2 = proposed intake site; W_3 = proposed power house site.

iv) *Community Characteristics*

Chlorophyceae included *Rhizoclonium* sp. *Spirotaenia* sp. and *Ulothrix* sp., while a single species of *Anabaena* of Cynophyceae was recorded from these rivers. Peak diatom (Bacillariophyceae) biomass and species composition are considered to be valuable parameters of environmental disturbances in freshwater ecosystems. Among the diatom community, 13 taxa were found exclusively in benthic form, 34 taxa were found in planktonic form and 31 taxa were common to both benthic as well as planktonic form (Table 3.3.2.3). Taxa found exclusively in benthic forms are *Gomphonema olivaceoides, Tabellaria flocculus, Synedra ulna* var. *amphirhynchus, Gomphonema olivaceum* var. *calcarea, Navicula cari, Gomphonema intricatum* var. *bohemicum, gomphonema lanceolatum, Fragilaria construens, Cocconeia placentula* var. *euglypta, Achnanthidium austriaca* var. *helvetica* and *Achnanthidium linearis* var. *pusila* (**Plate 3.3.2.1a,b**). Taxa found exclusively in planktonic forms include *Achnanthidium boyei, Achnanthidium exigua, Acghnanthidium holsti, Achnanthidium lapidosa* var. *lanceolata, Achnanthidium nodosa, Cyclotella* sp., *Cymbella tumidula, Diatoma hiemale var. mesodon, Didymosphenia geminata, Eunotia arcus, Fragilaria leptostauron, Fragilaria pinnata, Gomphonema nagpurensis, Gomphonema olivaceum, Navicula microcephala, Navicula radiosa* var. *minutessima, Synedra ulna* var. *amphirhynchus, Tabellaria* sp. and *Tetracyclus lacustris* (**Plate 3.3.2.1c,d**). Taxa common to both planktonic as well as benthic forms include *Achnanthidium affinis, Achnanthidium austriaca, Achnanthidium conspicua, Achnanthidium exilis, Achnanthidium linearis, Fragilaria vaucheriae, Gomphonema bohemicum, Gomphonema intricatum* var. *pumila, Gomphonema longiceps* var. *subclavata, Gomphonema parvulum,* and *Planothidium lanceolata. Achnanthidium linearis, Planothidium lanceolata, Cymbella* sp. and *Gomphonema parvulum* were the few taxa found in monsoon season.

Axhnanthidium linearis and *A. exilis, Gomphonema bohemicum*, are most common species of algae in planktonic and phytobenthic communities. *A. linearis, A. suchlandti, Fragilaria vaucheriae, Gomphonema intricatum* var. *pumila, G. intricatum* var. *bohemicum, G. logiceps* var. *subalavata* are dominant species in the phytobenthic community, constituting more than 10% of total density at different sites. In phytoplankton, predominant species are *A. exilis, A. minutissima and F. vaucheriae* are predominant species.

Macro- invertebrates' community was represented by six orders (Ephemeroptera, Plecoptera, Tricoptera, Diptera, Coleoptera and Acari) with Diptera as the largest order with five families

(Chironomidae, Tipulidae, Rhagionidae, Simuliidae and Calonidae) (Table 3.3.2.4). Ephmeroptera (Heptageniidae, Baetidae and Ephemerillidae) was represented by three families. Plecoptera (Perlidae and Perlodidae), Tricoptera (Hydroptilidae and Hydropsychidae) were represented by two families each. Coleoptera (Gyrinidae) and Acari (Limnocharidae) were represented by a family each. *Ablabesmyia*, *Cinygmula* and *Baetis* were the most abundant genera found in almost all seasons. *Cinygmula* sp., *Baetis Acroneuria* sp. and *Ablabesmyia* sp. (**Plate 3.3.2.2**) were common species, appeared at most of the sites. Bhatt and Pandit (2008) macro-invertebrates index showed a range of sensitivity score from 0.56 to 0.89 indicating water quality of good to excellent classes in Yarjep River.

3.3.2.2 Water Quality

Water quality of the river water can be assessed using physical, chemical and biological characteristics of the water. Among the physical and chemical parameters, dissolved oxygen (DO), Bio-chemical Oxygen Demand (BOD), pH and concentration of heavy metal are important parameters for the water quality monitoring. High concentration of DO, low concentration of BOD, non detectable heavy metal and optimum alkaline range of pH in Yarjep waters indicate a good water quality. River water was rich in the biotic communities. The majority of the species was pollution intolerant. The present investigation reveals that quality of surface water and drinking water is good and stand under the desirable limit as per IS:10500 except turbidity (Table 3.3.2.5).

There was no point source triggering the organic pollution in the vicinity. None of the effluent was recorded that measured the various parameters as per Table 3.3.2.6. Inland surface water standards indicate that the water of Yarjep and its tributaries are conducive for drinking, agricultural and fisheries purpose.

Table 3.3.2.3: Diatom assemblage composition in benthic and plankton forms of Yarjep River

	Phytobenthos						Phytoplankton					
	Winter			Pre- Monsoon			Winter			Pre- Monsoon		
Taxa name	**W1**	**W2**	**W3**	**W1**	**W2**	**W3**	**W1**	**W2**	**W3**	**W1**	**W2**	**W3**
Achnanthidium affinis	-	1.16	7.04	-	-	-	-	-	-	3.34	2.01	-
A. austriaca	0.39	-	-	2.04	-	-	6.01	-	-	2.39	0.80	-
A. austriaca var. *helvetica*	3.12	-	-	-	-	-	-	-	-	-	-	-
A. boyei	-	-	-	-	-	-	-	-	-	0.47	-	-
A. conspicua	3.12	4.66	9.85	-	-	-	-	6.16	1.08	0.95	2.01	-
A. cranulata	-	-	-	2.04	-	-	-	0.28	-	-	1.61	-
A. exigua	-	-	-	-	-	-	-	-	1.08	-	-	-
A. exilis	1.27	3.50	1.40	-	17.85	6.25	4.62	5.60	1.08	2.39	15.72	16.66
A. Grimmei	4.29	-	1.40	-	-	-	-	-	-	-	1.20	-
A. holsti	-	-	-	-	-	-	-	-	-	-	-	7.40
A. hungarica	1.27	3.50	-	-	-	6.25	-	-	-	0.47	-	-
A. lapidosa	-	-	-	-	-	-	-	-	-	-	-	1.85
A. lapidosa var. *lanceolata*	-	-	-	-	-	-	-	-	-	-	0.80	-
A. linearis	2.54	2.33	22.53	10.2	21.42	25.00	46.29	37.81	25.94	34.93	15.32	14.80
A. linearis var. *pusila*	-	-	5.63	-	-	-	-	-	-	-	-	-
A. microcephala	1.95	-	2.81	-	-	-	-	-	-	-	-	-
A. minutissima	5.45	-	-	-	-	-	11.57	9.80	14.05	1.47	0.40	1.85

A. nodosa	-	-	-	-	-	-	-	-	-	1.47	-	-
A. plonensis	-	-	-	-	-	-	-	-	-	-	-	1.85
A. saxonica	1.17	-	1.40	-	-	-	1.85	4.20	3.78	1.47	1.20	-
A. suchlandti	1.27	-	11.26	-	-	-	-	-	-	-	-	-
Cocconeis placentula	-	1.94	-	-	-	-	0.46	0.28	2.70	1.47	2.41	-
C. placentula var. euglypta	-	-	5.63	-	-	-	-	-	-	-	-	-
Cyclotella sp.	-	-	-	-	-	-	-	-	-	0.47	-	-
Cymbella affinis	-	-	-	-	-	-	-	-	-	-	0.40	-
C. amphicephala	-	-	-	2.04	-	-	-	-	-	-	0.40	-
C. laevis	5.85	-	-	-	-	-	-	0.28	-	-	-	-
C. perpusila	-	-	-	-	-	-	-	0.84	-	-	-	-
C. tumidula	-	-	-	-	-	-	-	-	-	0.47	-	-
C. turgidula	-	-	-	-	-	-	-	-	0.54	-	-	-
C. ventricosa	-	-	-	-	3.57	-	-	-	-	-	1.20	-
Diatoma hiemale	8.20	-	-	2.04	3.57	-	0.46	1.40	2.70	0.47	2.82	1.85
D.hiemale var. *mesodon*	-	-	-	-	-	-	-	-	-	-	0.80	-
Didymosphenia geminata	-	-	-	-	-	-	-	-	0.54	0.95	0.40	-
Eunotia arcus	-	-	-	-	-	-	-	-	-	-	0.40	-
E. fallax var. *gracillima*	-	-	-	-	-	-	-	-	-	-	0.40	3.70
Fragilaria brevistriata	-	-	-	-	-	-	-	-	-	-	-	16.66
F. capucina	-	-	-	-	3.57	6.25	-	-	-	0.47	-	-
F. construens	0.78	-	-	-	-	-	-	-	-	-	-	-
F. leptostauron	-	-	-	-	-	-	-	-	2.16	-	-	-

F. olivaceoides	-	-	-	-	-	-	-	-	1.62	-	-	-
F. pinnata	-	-	-	-	-	-	2.31	2.24	-	1.99	-	-
F. rumpens	-	-	-	-	-	-	-	-	1.08	-	-	-
Fragilaria sp.	12.71	23.05	2.81	24.48	17.85	31.25	4.16	5.04	7.02	17.14	14.52	-
F. vaucheriae	9.76	4.28	7.04	36.73	-	6.25	10.64	10.08	7.56	4.78	8.46	5.55
Gomphonema bohemicum	-	4.28	1.40	2.04	3.57	-	0.46	2.80	5.94	0.47	0.40	-
G. gracile	1.95	2.11	2.81	-	-	-	-	-	-	-	-	-
G. intricatum	-	-	-	-	-	-	0.46	-	-	-	-	-
G. intricatum var. *bohemicum*	-	10.50	-	-	-	-	-	-	-	-	-	-
G. intricatum var. *pumila*	12.71	10.51	-	2.04	-	-	-	1.12	2.70	0.47	3.22	3.70
G. lanceolatum	-	3.50	-	-	-	-	-	-	-	-	-	-
G. logiceps var. *subalavata*	12.71	16.73	-	2.04	-	-	0.46	2.24	7.56	1.99	4.43	3.70
G. nagpurenses	-	-	-	-	-	-	-	-	-	0.95	-	-
G. olivaceoides	1.95	2.33	1.40	-	-	-	-	0.28	-	-	-	-
G. olivaceum	-	4.27	-	-	-	-	0.46	-	1.08	0.47	1.20	1.85
G. olivaceum var. *calcarea*	-	-	-	-	3.57	-	-	-	-	-	-	-
G. olivaceum var. *minutissima*	-	-	-	-	-	-	1.85	-	-	-	-	-
G. paruvlum	1.95	-	5.63	4.08	7.14	-	2.31	-	2.70	2.39	10.08	9.25
G. parvulum var. *exilissimum*	-	-	-	-	-	-	-	2.24	-	2.39	-	-
G. sphaerophorum	2.73	-	-	2.04	-	6.25	1.85	-	-	0.95	1.20	-
Hannaea arcus var. *amphioxys*	-	-	-	-	-	-	-	-	-	-	-	1.85
H.arcus var. *linearis*	-	-	-	2.04	-	-	-	-	-	-	2.81	-

Navicula cari	-	-	1.40	-	-	-	-	-	-	-	-	-
N. microcephala	-	-	-	-	-	-	-	-	-	-	0.40	-
N. minima var. *atomoides*	-	-	1.40	-	-	-	-	0.84	1.62	-	-	-
N. radiosa	-	-	-	2.04	-	-	0.46	2.80	1.62	-	-	-
N. radiosa var. *minutissima*	-	-	-	-	-	-	-	-	-	-	0.80	-
N. radiosa var. *tenella*	-	-	-	-	3.57	6.25	0.46	-	-	0.47	-	-
N. rostellata	-	-	-	-	-	-	-	-	-	-	-	1.85
Planothidium lanceolata	1.95	-	5.63	-	3.57	-	0.92	-	2.70	11.44	2.41	1.85
P.lanceolata var. *rostrata*	-	-	-	-	-	-	-	0.28	-	-	-	1.85
Reimeria sinuata	0.78	0.77	-	2.04	3.57	-	1.85	0.28	0.54	0.47	-	-
Synedra ulna	-	-	-	-	-	-	-	0.84	-	-	-	-
S. ulna var. *amphioxys*	-	-	-	-	-	6.25	-	-	-	-	-	-
S. ulna var. *amphirhynchus*	-	-	-	-	-	-	-	-	0.54	-	-	-
Tabellaria flocculus	-	-	-	-	7.14	-	-	-	-	-	-	-
Tabellaria sp.	-	-	-	-	-	-	-	-	-	-	-	1.85
Tetracyclus lacustris	-	-	-	-	-	-	-	2.24	-	-	0.4	-
Total	**24**	**16**	**18**	**15**	**13**	**9**	**21**	**24**	**25**	**29**	**31**	**19**

W1 = upstream of proposed intake site; W2 = proposed intake site; W3 = proposed power house site

Table 3.3.2.4. Macro- invertebrate composition in Yarjep River Stretch around the proposed Tato I H.E. Project

Taxa	W1			W2			W3		
	W	Pr	M	W	Pr	M	W	Pr	M
Ephemeroptera									
Heptageniidae									
Cinygmula	22	-	56	44	11	22	-	33	-
Heptagenia				-	-	-	11	-	-
Stenonema	-	-	-	-	-	-	-	44	-
Epeorus	-	-	100	-	-	44	-	-	-
Baetidae									
Baetis	11	-	33	78	78	22	-	667	11
Epehmerelidae									
Ephemerella	11	-	-	11	-	-	-	56	11
Ephemeroptera (Others)	33	-	-	44	-	-	-	-	11
Plecoptera									
Perlidae									
Acroneuria	11	167	22	56	-	-	22	56	-
Perlodidae									
Isoperla	-	-	11	-	-	-	-	-	11
Trichoptera									
Hydroptilidae									
Hydroptila	-	-	-	44	-	-	-	11	-

Ochrotrichia	-	-	-	-	-	-	-	44	-
Hydropsychidae									
Hydropsyche	-	-	-	89	-	22	-	-	-
Diptera									
Chironomidae									
Chironomus	-	-	-	-	-	-	-	244	-
Ablabesmyia	244	-	44	1233	-	744	44	1111	300
Tendipes Tentans	22	-	-	-	-	-	-	-	-
Tipulidae									
Antocha saxicola	-	-	-	11	-	-	-	-	-
Rhagionidae									
Atherix variegata	-	-	-	-	-	-	-	11	-
Simuliidae									
Simulium pictipes	-	-	-	-	-	-	-	33	-
Calanoidae	11	-	-	-	-	-	-	-	-
Coleoptera									
Gyrinidae									
Dineutus	-	11	-	-	-	-	-	-	-
Acari									
Limnocharidae									
Limnochares	-	-	-	-	-	-	-	-	11
Density (individual / m^2)	**365**	**178**	**266**	**1610**	**89**	**854**	**77**	**2310**	**355**

W1 = upstream of proposed intake site; W2 = proposed intake site; W3 = proposed power house site

Table 3.3.2.5. Drinking water quality standards (as per IS:10500)

Parameters	Desirable limit	Permissible limit
Color (Hz)	5.0	25
Odour	Unobjectionable	-
Taste	Agreeable	-
Turbidity (ntu)	5	10
pH	5-8.5	No relaxation
Total coliforms (MPN/100 ml)	0	-
TDS ((mg/l)	500	2000
Total hardness (mg/l)	300	600
Total alkalinity (mg/l)	200	600
Chloride (mg/l)	250	1000
Nitrate (mg/l)	45	100
Calcium (mg/l)	75	200
Magnesium (mg/l)	30	100
Copper (mg/l)	0.05	1.5
Iron (mg/l)	0.30	1.0
Lead (mg/l)	0.05	No relaxation
Cadmium (mg/l)	0.01	No relaxation

Table 3.3.2.6. Tolerance Limits for Inland Surface Waters (as per IS:2296)

SN	Parameter and Unit	Class-A	Class-B	Class-C	Class-D	Class-E
1.	Colour (Hazen Units)	10	300	300	-	-
2.	Odour	Unobject	-	-	-	-
3.	Taste	Tasteless	-	-	-	-
4.	pH (max) (min:6.5)	8.5	8.5	8.5	8.5	8.5
5.	Conductivity (μS/cm)	-	-	-	1000	2250
6.	Do (mg/L) (min)	6	5	4	4	-
7.	BOD (3 days at 27^{o}C) (mg/L)	2	3	3	-	-
8.	Total Coliforms (MPN/100 mL)	50	500	5000	-	-
9.	TDS (mg/L)	500	-	1500	-	2100
10.	Oil and Grease (mg/L)	-	-	0.1	0.1	-

11.	Mineral Oil (mg/L)	0.01	-	-	-	-
12.	Free Carbon Dioxide (mg/L CO_2)	-	-	-	6	-
13.	Free Ammonia (mg/L as N)	-	-	-	1.2	-
14.	Cyanide (mg/L as CN)	0.05	0.05	0.05	-	-
15.	Phenol (mg/L C_6H_5OH)	0.002	0.005	0.005	-	-
16.	Total Hardness (mg/L as $CaCO_3$)	300	-	-	-	-
17.	Chloride (mg/L as CI)	250	-	600	-	600
18.	Sulphate (mg/L as SO_4)	400	-	400	-	1000
19.	Nitrate (mg/L as NO_3)	20	-	50	-	-
20.	Fluoride (mg/L as F)	1.5	1.5	1.5	-	-
21.	Calcium (mg/L as Ca)	80	-	-	-	-
22.	Magnesium (mg/L Mg)	24.4	-	-	-	-
23.	Copper (mg/L as Cu)	1.5	-	1.5	-	-
24.	Iron (mg/L as Fe)	0.3	-	50	-	-
25.	Manganese (mg/L as Mn)	0.5	-	-	-	-
26.	Zinc (mg/L as Zn)	15	-	15	-	-
27.	Boron (mg/L as B)	-	-	-	-	2
28.	Barium (mg/L as Ba)	1	-	-	-	-
29.	Silver (mg/L as Ag)	0.05	-	-	-	-
30.	Arsenic (mg/L as As)	0.05	0.2	0.2	-	-
31.	Mercury (mg/L as Hg)	0.001	-	-	-	-
32.	Lead (mg/L as Pb)	0.1	-	0.1	-	-
33.	Cadmium (mg/L as Cd)	0.01	-	0.01	-	-
34.	Chromium (VI) (mg/L as Cr)	0.05	0.05	0.05	-	-
35.	Selenium (mg/L as Se)	0.01	-	0.05	-	-
36.	Anionic Detergents (mg/L MBAS)	0.2	1	1	-	-

Class-A:Drinking water source without conventional treatment but after disinfection.

Class-B: Outdoor bathing.

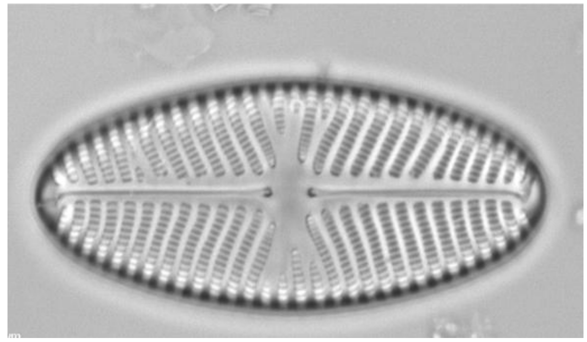
Class-C: Drinking water source with conventional treatment followed by disinfection.

Class-D: Fish culture and wild life propagation.

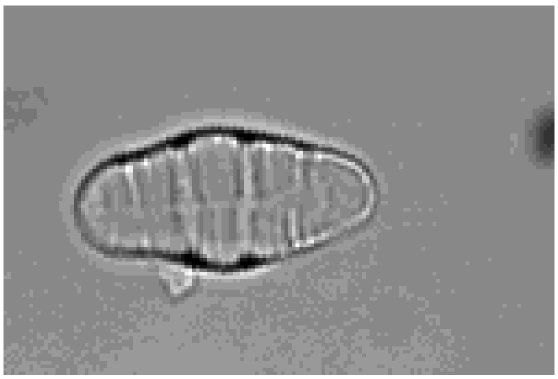
Class-E: Irrigation, industrial cooling and controlled waste disposal.

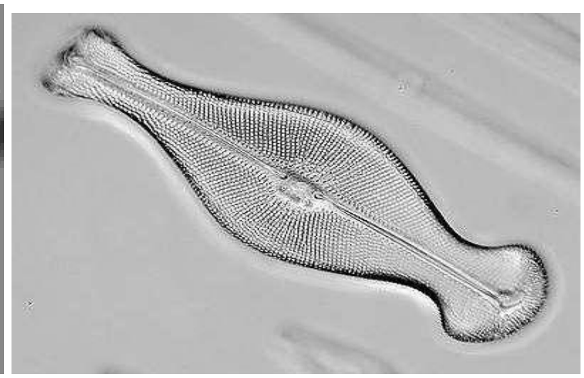
In the biological parameters coliforms were absent from the river and tributary waters at all the sites investigated during different seasons. It can be explained on the basis of sparse human population and absence of any point source of organic pollution in the catchment. Most of the algal species and macro-invertebrates species were intolerant of the organic pollution indicating the status of clear water.

Non-polluted water in the Yarjep River can be coincided with the absence of major sewage out fall in the river and very sparse population in the catchment and influence area. During the construction phase of Tato I H.E. project, the temporary deterioration of Yarjep river water can not be denied due to new temporary settlements alongside the river, disposal of the muck, diversion of the river water. In order to maintain the river water quality up to pre-construction status, it would require appropriate mitigation precautionary measures. These measures are provided in the EMP report of Tato I H.E. project.



(a) *Tabellaria flocculus* (b) *Navicula cari*



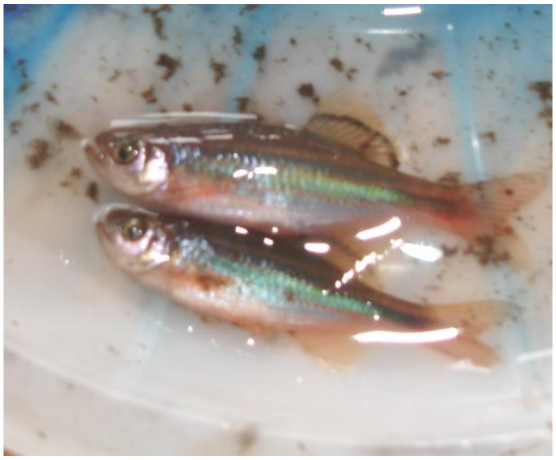


(c) *Diatoma hiemale* var. *mesodon* (d) *Didymosphenia geminata*

Plate 3.3.2.1 Diatom Species: (a,b) benthic species (c,d) plankton species, found exclusively in respective communities.

(a) *Baetis* (b) *Cinyigmula*

Plate 3.3.2.2 Common macro-invertebrate species of Yarjep river

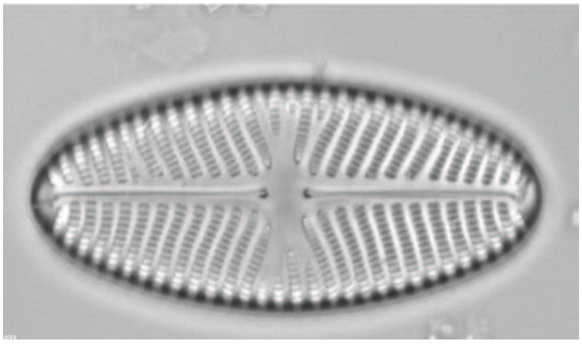


a) *Danio* species

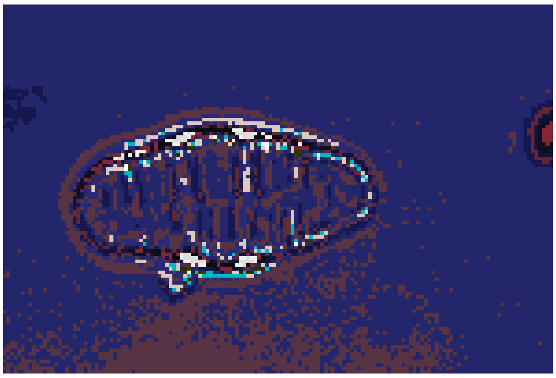
b) *Labeo calbasu* and *Garra naganensis*

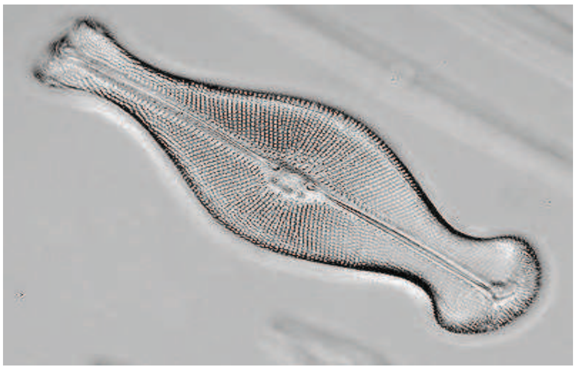
c) A native showing cast net

Plate 3.3.3.1 Common fish species in the influence area of Tato I H.E. project. Cast net is one of the important gears in the region



(a) *Tabellaria flocculus* (b) *Navicula cari*





(c) *Diatoma hiemale* var. *mesodon* (d) *Didymosphenia geminata*

Plate 3.3.2.1 Diatom Species: (a,b) benthic species (c,d) plankton species, found exclusively in respective communities.

(a) *Baetis* (b) *Cinyigmula*

Plate 3.3.2.2 Common macro-invertebrate species of Yarjep river

3.3.3 FISH & FISHERIES

Diversion of the river has direct impact on the river flow, physical structure of channel, riparian vegetation, water quality and fish, which determine and indicate the health of a river. Comparing the biotic communities of freshwater ecosystem fish are most dynamic, require adequate heterogeneity in the habitat, therefore, are most impacted by diversion of rivers.

Regarding the hydro-electric projects, ichthyofauna is the most vulnerable group so that fish need to be addressed primarily in the impact assessment and management planning. The present contribution highlights the impact assessment of Tato-I H.E. Project, located on Yarjep River (a tributary of Siyom) in West Siang district, on the fish fauna. This section comprises fish composition in the catchment and influence area, conservation status of fish, fisheries, fishing methods etc. On the basis of baseline data impacts on native fish identified, best possible mitigation measures are proposed in the report.

3.3.3.1 Fish Fauna of Siyom and Yarjep River Systems

Siyom is one of the largest right bank tributaries of Siang River, draining the West Siang district of Arunachal Pradesh. Major tributaries of Siyom River are Yarjep on right bank and Hirit on right bank. An account on fish diversity of West Siang district has been made by Sen (2006). In the area under discussion, a total of 12 species belonging to 5 families have been reported in water resources of West Siang district. In addition, we recorded *Danio* sp. from the area. Fishes of Siyom basin show strong affinities with Western Himalaya (*Labeo Calbasu*, *Puntius ticto*, *Schizothorax richardsonii*, *Nemacheilus multifasciatus*, *N. rupecola*), North East (*Garra Naganensis*, *Botia berdmorei*, *Ompok bimaculatus*) and Ganga and Brahamputra plains (*Mystus bleekeri*, *Glyptothorax annandeli, Chanda Nama*, *Glossogobius giuris*). The species like *Labeo calbasu*, *Nemacheilus* spp., *Chanda nama*) are confined to lower segment of the river (up to 500 M). Other species are widely distributed.

3.3.3.2 Fish Composition in Catchment and Influence Areas

Fish fauna of catchment and influence area comprises 10 species belonging to families Cyprinidae, Balitoridae, Cobitidae, Siluridae and Sisoridae. Out of 10 species 7 are common in the catchment area and influence area while three species namely *Labeo calbasu*, *Danio* sp. and *Puntius* *ticto* are confined to the lower fringe of influence area (**Plate 3.3.3.1a**). Notably *Danio* sp. was not mentioned in the earlier record of West Siang district. *Schizothorax richardsonii* and *Garra naganensis* are widely distributed in the catchment and influence areas. *Nemacheilus multifasciatus* and *Schistura rupecola* are also abundant in the study area. The loaches prefer to inhabit tributaries, however,they are rarely caught in tributaries because they dwell the river bed (Table 3.3.3.1).

During the primary survey *Labeo calbasu, Schizothorax richardsonii, Danio* sp. and *Garra nagenensis* were landed from Siyom river system in lower part of the influence area of Tato-I H.E. Project during winter and pre-monsoon seasons while in the catchment fish catch comprised of *Schizothorax richardsonii* and *Garra naganensis* (**Plate 3.3.3.1b**).

Table 3.3.3.1 Fish composition in the catchment and influence area of Tato-I H.E. Project

Scientific Name	Conservation Status
Cyprinidae	
*Schizothorax richardsonii**	VU
Garra naganensis	VU
Labeo calbasu	LRnt
Puntius tict	LRnt
Danio Sp.	-
Balitoridae	
Nemacheilus multifasciatus	EN
Schistura rupecola	LRnt
Cobitidae	
Botia berdmorei	EN
Siluridae	
Ompok bimaculatus	EN
Sisoridae	
Glyptothorax annandeli	-

EN = endangered; VU = Vulnerable; LRnt = Low risk near threatened

3.3.3.3 Conservation Status

Of the 10 fish species 8 have been assessed for their conservation status. Three species have been categorized as ‘endangered’ species while two are ‘vulnerable’ (CAMP, 1997). *Labeo calbasu, Puntius ticto* and *Schistura rupecola* are low risk- least concerned species. Schizothorax richardsonii has been categorized as 'vulnerable' species as per the criterion of IUCN (2011). None of the species is endemic to Siyom River and its tributaries, however, *Garra naganensis* is considered to be endemic to North-east region of India.

3.3.3.4 Fisheries

Capture fishery is not prominent in the influence area, however, fishing was carried out at Tato (BB Camp) (Yarjep River), lower area (at the boundary of 10 km radius – Siyom River), proposed weir site and 4 km upstream of weir site (Yarjep River and tributaries). During three season surveys 12 fishermen were observed, of which 4 were found to be involved in fishing while 8 were hired for the fishing purpose. Average fishing per fishermen per day (fishing hours 3) ranged from 1.0 kg to 4.5 kg, 1.5 to 4.0 kg. and 0.5 to 1.5 kg in winter, pre-monsoon and monsoon seasons respectively. However, this data can not be predicted for all days in this area because some of the fishermen were hired purposefully.

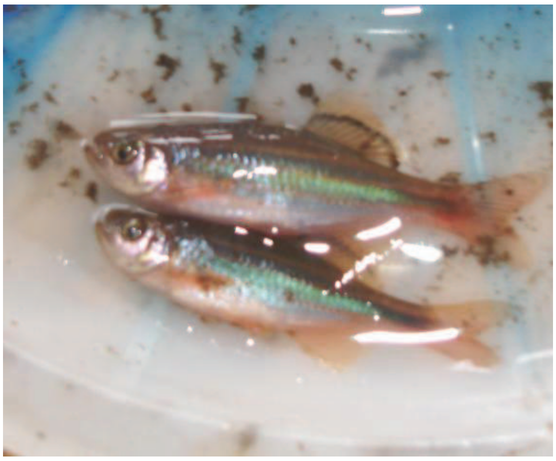
Labeo calbasu was predominant species in the fish catch from lower part of the influence area while *Schizothox richardsonii* (snow trout) accounted for maximum catch in upper part. The fish catch comprises of *Labeo calbasu*, *Schizothorax richardsonii*, *Garra naganensis* and *Danio* sp. Fishermen were found to land the fish with the help of cast nets and hooks (**Plate 3.3.3.1c**). In lower part cast net is an important gear while in upper part hook is used commonly.

3.3.3.5 Fish Migration

Schizotharax richardsonii, Labeo calbasu, and *Garra naganensis* are column feeder, thus, considered to move relatively longer distance as compared to other species dwelling the river bed. *Schizothorax richardsonii* and *Labeo calbasu* are considered to perform migration in river system. To cop the low temperature in peak winter season Snow trout moves downwards. It usually finds a tributary to spawn from May to September. *Labeo calbasu* ascends in monsoon season. In the region migratory pattern of *Schizothorax richardsonii* and *L. calbasu* are not well studied but other studies in Himalayan river show that they have not specific breeding grounds. *Labeo calbasu* was not spotted from the Yarjep river, thus its breeding habitat could not be confirmed in the Yarjep river system. In an another study carried out by CISMHE, juveniles and adolescents of *L. calbasu* were recorded from Hirit river, a tributary of Siyom in downstream, thus, Hirit river may be considered as spawning ground of this species.

3.3.3.6 Conclusion

Yarjep River and its tributaries are not rich in the fish diversity. In the influence area the fish species of fishery interest are *Schizothorax richardsonii* and *Labeo calbasu*. The culture fishery in the area is nil while capture fishery is undeveloped and disorganized. Inhabitants are not dependant on fish for their livelihood. None of the fish species inhabiting the Yarjep River is endemic to this region. The survey team did not come across the specific breeding grounds in the Siyom basin within 10 km of Tato I H.E. project. Out of the ten recorded fish species, three species are categorized as endangered. Those species are usually migrating in winter season, but can adapt to riparian environment, like a reservoir or a pond created by a dam.



a) *Danio* species

b) *Labeo calbasu* and *Garra naganensis*

c) A native showing cast net

Plate 3.3.3.1 Common fish species in the influence area of Tato I H.E. project. Cast net is one of the important gears in the region

3.4 AIR & NOISE ENVIRONMENT

3.4.1 METEOROLOGY

The Himalayan mountain region is observed by four distinct seasons: i) Pre-monsoon (April-May), ii) Monsoon (June-September), iii) Post-Monsoon (October-November), and iv) Lean season (December-March). The Himalayan climate is not similar to that of the plains of India (Das, 2002). A lull in rainfall over the plains of north and central India may be a period of 'active' or heavy rain over the eastern Himalaya. There is a phase difference in monsoon season between the eastern and western sectors of the Himalaya. The seasonal character of the climate is often reflected by the strength of upper winds over the Himalaya. During the lean season and the post-monsoon period, strong westerly winds blows over the mountains, but during the monsoon strong winds blow northward. On the individual peaks and adjoining valleys the anabatic winds and katabatic winds control the local climate. These mountain and valley winds blow at a speed of 50-100 km/h and control the diurnal variation in the rainfall pattern of a valley.

Undoubtedly, the mountain regions are the main hydrological and climatological triggers or pertubators of the water cycle as well as of complex meteorological patterns including phenomena such as the production or inhibition of rainfall. In terms of their role as water towers, mountain regions form an important supply of snow and/or rain-fed water to the lowlands. In terms of climate, mountain systems develop a considerably complex system of their own, influenced by the often characteristically narrow, deeply incised valleys. It is rare though, to find comprehensive work that combines both the hydrological and climatological aspects of mountain catchments. It is therefore very important to understand the hydro-meteorological conditions before carrying out any project in such a complex mountain topography area. This chapter attempts to discuss some aspects of hydro-meteorological system in the Yarjep basin with reference to the development of proposed Tato-I H.E. Project near Meying village.

3.4.1.1 Temperature, Humidity and Wind Chill

The temperature and relative humidity in high mountainous region like Himalaya is influenced by the change in altitude. At about 2,000 m, the average summer temperature is nearly 18°C. The summer temperature in valleys reaches between 32°C and 38°C. The latitudinal variation in Himalaya also has control on the rainfall, temperature and humidity. The Eastern Himalaya receives heavy rainfall, and therefore, the variation pattern of temperature and relative humidity of this region is different from that of Western Himalaya. The temperature and humidity data available for the project area are shown in the Table. 3.4.1.1.

Temperature, humidity, wind speed and wind chill were directly assessed by CISMHE team during the field visits in (2009) recorded at three sites. The Yarjep basin experiences low temperature during the winter months from December to January. The maximum temperature was recorded to be 27.80°C during monsoon season at site S1 site (Gapo village) whereas the minimum temperature was recorded at 12.9 ^{0}C during the winter at S3 site (Tato village). Relative humidity was highest during the pre-monsoon period for all the sites with 85.30% (S1), 88.10% (S2 – Heyo) and 95.10% (Tato village) respectively. The relative humidity during the winter scales downs to 56.00%, 44.30% and 76.70% at S1, S2 and S3 sites respectively. Wind chill were also assessed for all the three sites. The average wind chill was highest during the monsoon with an average of 24.03 ^{0}C. During the pre-monsoon period the average wind chill temperature was 18.97 ^{0}C. Eventually winter chill recorded was lowest with an average of 17.13 ^{0}C. The wind speed was maximum during the monsoon season at site S1 with a value of 13.80 km/h whereas the wind speed at S2 and S3 sites were 2.70 km/h and 2.20 km/h, respectively. The maximum wind speed during the winter was 4.5 km/h and the maximum wind speed during the pre-monsoon period was 3.7 km/h. In addition, heat index, dew point, wet bulb, barometer and density altitude were also directly assessed with the help of weather instruments. Details of the weather variables are given in the Table 3.4.1.1.

3.4.2 AIR ENVIRONMENT

A large number factors including natural and anthropogenic, storm, factories, vehicular movement, burning of fossil fuels, etc. affect the air quality adversely. The surroundings of Tato I H.E. project is characterized by the dense and open forests, sparse human population, sparse vehicular movement, slash and burning practices, etc. Thus, the area lacks the point source of pollutants of ambient air quality. Diffuse sources of pollutants occur mainly in the form of slash and burning, burning of fuel wood for domestic purpose and sparse vehicular movement.

Table 3.4.1.1 Meteorological data at various sites of Tato-I H.E. Project

	Pre- monsoon			Monsoon			Winter		
	S1	S2	S3	S1	S2	S3 (a)	S1	S2	S3
Wind (Km/h)	1.00	0.60	3.70	13.80	2.70	2.20	2.30	4.50	1.30
Temperature (ºC)	20.40	20.50	16.90	27.80	22.70	21.70	17.00	21.80	12.90
Wind Chill (ºC)	20.10	20.80	16.00	27.70	22.70	21.70	18.00	20.70	12.70
Humidity (%)	85.30	88.10	95.10	60.80	70.80	71.60	56.00	44.30	76.70
Heat index (ºC)	20.50	21.20	17.90	29.30	22.70	21.70	16.90	23.90	13.50
Dew Point (ºC)	17.80	18.90	16.90	19.20	19.50	16.10	8.00	9.20	9.80
Wet bulb (ºC)	18.80	19.90	17.00	21.50	19.20	18.20	11.60	14.90	11.30
Barometer (hPa)	914.70	916.30	928.70	885.40	910.80	887.90	916.70	920.60	937.60
Density Altitude (M)	1713.00	1744.00	1474.00	2320.00	1770.00	2077.00	1511.00	1675.00	1180.00

The hydro-electric projects are not considered as the major point source of pollutants especially during the operational phase. However, in the construction phase, various activities like excavation, dumping, transportation of muck, heavy vehicular movement, operation of machine, blasting etc would likely generate the polluting agents (like dust particles, smoke, high sound level, etc.) of air quality. These agents seem more prominent in the pristine ecosystem. Further, ambient air quality is the quality of open-air to which the public has access. Poor ambient air quality occurs when pollutants increase in high concentration. Also, air quality of a region up to some extent, determined by behaviour of air as a result of the interaction of topography such as mountains and valleys; weather such as wind, temperature, air turbulence, air pressure, rainfall and cloud cover; physical and chemical properties of pollutants; and by the emission sources themselves. The purpose of this assessment is to determine the concentrations of air pollutants, the sources of air pollutants, the impact of air quality on the environment and the risk to human health from air pollutants.

There is no earlier record of air quality in the catchment and project areas of Tato I H.E. Project. In order to collect the baseline data of air quality prior to the construction work the following parameters are highlighted, which would be useful in formulating the suitable management plan for air quality.

3.4.2.1 Sampling Strategy

The sampling for weather condition, ambient air quality and recording of traffic density and noise pollution data was carried out based on the availability of facilities.

Air pollution: To assess the level of pollutants in the air, a sampler (high volume, respirable dust sampler APM 460 BL and its attachment APM 411 TE) was run to record the concentrations of SPM, NO2 and SO2. Due to lack of electricity in the surroundings it was run at Aalo. Aalo is major town in the area and was considered as control. We assume that in any case the level of air pollutants in the surroundings of project area would be lower as compared to Aalo.

Traffic density: Number and types of vehicles plying on Tato intake site and (ii) Tato power house at BB camp roads were recorded. The Density was recorded for 2 hours in the morning, noon and evening time for three seasons. During thee survey sampling was repeated for three days in pre-monsoon and monsoon season and four times in winter season. The average value was calculated as density per hour.

Noise Level: Sound levels were recorded at various sites in and around the project area by using Sound Level Meter D 2023 (Cygnet), a TYPE 2 instrument (IS 9779, 1981).

Sampling was carried out for three seasons for all parameters. A detailed methodology for Air and Noise Environment has been given in Chapter Concept & Methodology (3.1) of EIA report.

3.4.2.2 Traffic Density

In the proposed Tato-I hydroelectric project area, national highway (NH 52) connects villages and towns of the region with Aalo (district headquarter) or with main city like Dibrugarh or Guwahati. Table 3.4.1.2 shows the traffic density in and around the project area. Different types of vehicles ply on the roads of project area. The maximum traffic density was recorded during monsoon period (Table 3.4.1.2). The annual average of vehicle plying in the project area was recorded to be 3, 5 and nearly 2 per hour for heavy, light vehicles and two wheelers on Tato - Mechuka road, respectively. On the Tato – Lungte road these values were less than 2 per hour for heavy, light and two wheeler vehicles.

Table 3.4.1.2 Traffic density in and around Tato-I H.E. Project

Location	Date and time Year 2009	Vehicular Traffic/ hour		
		Heavy vehicles	Light vehicles	Two wheelers
Winter Season				
Tato Mechuka Road	February, 9 - 13:00	3	3	2
Tato – Lungte Road	February, 9 – 12.00	0	2	1
Pre-monsoon				
Tato-Mechuka Road	22 May, 9 - 14:00	2	4	2
Tato – Lungte Road	24 May, 9 - 12:00	2	1	0.0
Monsoon				
Tato-Mechuka Road	28 Aug, 9 11:30 AM	04	08	1
Tato – Lungte Road	29 Aug, 9- 11.00 AM	1	01	0

3.4.2.3 Air Quality

Major sources of outdoor air pollution in the project area at Tato-I are vehicular traffic in and around, Jhum cultivation fire, and road construction activities. The only source of indoor air pollution is burning of fuel wood. The region receives high rainfall and is covered with dense vegetation. In addition, the open agricultural fields in the region are covered with vegetation during fallow seasons. Soils are not exposed and there is little possibility of any dust storms contributing in air pollution owing to the pervasive structure of vegetation cover. Different air pollutants are described as under the following headings.

i) *Suspended particulate matter (SPM)*

Concentration of SPM levels in and around project location is anticipated to be low as its values at Aalo vary from 83.61 to 311.00 μg/ m^3 (Table 3.4.1.3). Except in winter season, these values are generally lower than the standard values prescribed in NAAQS approved by the Ministry of Environment & Forests, GOI (Table 3.4.1.4). The average value of SPM was recorded lowest during the monsoon season, which may be ascribed due to settling down of the particles. The main sources of SPM in the region are vehicular traffic, occasional open degraded land areas and land slides. Forest fire was not observed in the region during the survey. The entire region is virtually covered with thick vegetation which plays a significant role in ameliorating the load of suspended particulate matters in air. Based on our field records of ambient air quality at Aalo we suggest that the levels of SPM, RSPM and NRSPM will remain much lower at the project site (Tato-I H.E.P.) than the values recorded at Aalo. Since the human population density of Tato HEP area is comparatively lower than of Aalo and the number of vehicles plying on the road is also low at the project site as a result the ambient air quality is at healthy level.

Table 3.4.1.3 Air quality for Tato- I H.E. Project area

Parameters	Winter(a)	Winter(b)	Pre-monsoon	Monsoon
SO_2 (µg/m³)	9.83	0.0	0.0	0.0
NOx (µg/m³)	0.0	1.79	1.22	1.35
TSPM (µg/m³)	311.00	272.60	92.13	83.61
RSPM (µg/m³)	137.61	79.24	13.75	31.25
NRSPM (µg/m³)	173.39	193.36	78.38	52.36

Note: Sampling was carried out twice in winter season, therefore, depicted as a and b

ii) *NOx*

NOx is the generic term for a group of highly reactive gases which contain compound of nitrogen and oxygen in varying proportions. Most of the nitrogen oxide gases are colourless and odourless gases except nitrogen dioxide (NO_2), which is reddish brown. These gases are produced during combustion especially at high temperature. The main sources of NOx are vehicles and industries. In Aalo region there is no industry and vehicles are the main source of

NOx. A very low concentration of NO_2 was recorded at Aalo (Table 3.4.1.3) which is negligible compared to the values of NAAQS approved by Ministry of Environment & Forests (see Table 3.4.1.4). Maximum level of NO_2 recorded at Aalo was 1.79 μg/ m^3 during winter season. Extrapolating the above observation we anticipate that NO_2 at the project site will remain lower than the recorded value of NO_2 at Aalo (1.79 μg/ m^3).

iii) *Sulphur Dioxide (SO_2)*

Sulphur dioxide is a colourless gas smelling pungent irritating odour. The main source of SO_2 is volcanoes, industrial processes and combustion of fuels such as oils and coal. Besides, coal and petroleum contain sulphur compounds and upon their combustion results in generating sulphur dioxide unless the sulphur compounds are removed before burning the fuel. SO_2 forms H_2SO_4 in the presence of a catalyst such as NO_2 that results in acid rain. Sulphur dioxide emissions are also a precursor to formation of particulates in air. The highest level of SO_2 recorded in the region was 9.83 μg/ m^3 (see Table 3.4.1.3). This value is significantly lower than the values of NAAQS approved by Ministry of Environment & Forests (see Table 3.4.1.4).

Table 3.4.1.4 National ambient air quality standards approved by Ministry of Environment & Forests

Pollutants	Time	Concentration in Ambient Air		Method of Weighted Measurements
		Ecological Sensitive areas	**Industrial, Residential , Rural & Other Areas**	
Sulphur Dioxide (SO_2)	Annual Average 24 hour	20 μg m^{-3} 80 μg m^{-3}	50 μg m^{-3} 80 μg m^{-3}	Improved West and Greek Method Ultraviolet flourescence
Oxides of Nitrogen (NO_x)	Annual 24hour	30 μg m^{-3} 80 μg m^{-3}	40 μg m^{-3} 80 μg m^{-3}	Modified Jacob Hochheises (Na-Arsenite) Chemiluminescence
Particulate Matter (size less than 10 μg)	Annual 24 hour	60 μg m^{-3} 100 μg m^{-3}	60 μg m^{-3} 100 μg m^{-3}	Gravimetric TOEM Beta attentuation
Particulate Matter Matter (Size < 2.5 μg)	Annual 24hour	40 μg m^{-3} 60 μg m^{-3}	40 μg m^{-3} 60 μg m^{-3}	Gravimetric TOEM Beta attentuation
Carbon Monoxide (CO)	8 hour 1 hour	2 mg m^{-3} 4 mg m^{-3}	2 mg m^{-3} 4 mg m^{-3}`	Non dispersive infrared spectroscopy

3.4.3 NOISE LEVEL

Noise pollution contaminants are generally waves that interfere with naturally occurring waves of a similar type in the same environment. However, noise pollution is defined as unwanted sound or sound that is loud or unpleasant. Sounds are considered noise pollution if they adversely affect wildlife, human activity or are capable of damaging physical structures on a regular basis. In addition, it is considered noise pollution if sound disturbs any natural process even if the sound does not occur on a regular basis. Noise from various sources intrudes unreasonably into the daily activities of human beings and animals creating adverse effects. Except the gurgling sounds of river there was no other unwarranted sound in the project area. The sound levels in the project did not vary much, which ranged from 48.6 ± 2.14 dBA during winter season to 76.5 ± 3.33 dBA during the pre-monsoon season (see Table 3.4.1.5). The high noise levels recorded at the proposed intake site and power house site due to the sound of the flowing water. Except at river sites the recorded noise levels in the project area were within the range limits as approved by the national standard, Government of India (Table 3.4.1.6).

Table 3.4.1.5 Noise levels at various sites in the vicinity of Tato-I H.E. Project

Location	Date and time	Sound level dB(A)
Winter		
Village at upstream (Sd1)	6 Feb, 2009; 2:50 PM	54.3 ± 3.85
Intake site (Sd2)	6 Feb, 2009; 12:10 PM	63.9 ± 2.37
Power House (Sd3)	7 Feb, 2009; 10:30 AM	48.6 ± 2.14
Tato Town (Sd5)	7 Feb, 2009; 2.00 PM	54.63± 3.10
Pre-monsoon		
Village at upstream (Sd1)	22 May, 2009; 12:40 PM	53.9 ± 3.54
Intake site (Sd2)	24 May, 2009; 11:30 PM	71.0 ± 4.56
Powerhouse site (Sd3)	24 May, 2009; 1:30 PM	76.5 ± 3.33
Road site (Sd4)	22 May, 2009; 11:00 PM	52.9 ± 5.31
Tato Town (Sd5)	22 May, 2009; 2:30 PM	55.9 ± 5.31
Monsoon		
Village at upstream (Sd1)	28 August, 2009; 9:20 AM	57.1 ± 0.56
Intake site (Sd2)	28 August, 2009; 11:45 AM	61.2 ± 0.42
Powerhouse site (Sd3)	29 August, 2009; 9:20 AM	58.1 ± 0.27
Road site (Sd4)	29 August, 2009; 2.00 PM	54.1 ± 0.27
Tato Town (Sd5)	29 August, 2009; 4.00 PM	56.1 ± 0.27

Table 3.4.1.6 Ambient noise levels as per CPCB

Area code	Category of Area	Limits in dB (A) Leq	
		Day time	Night Time
A	Industrial Area	75	70
B	Commercial Area	65	55
C	Residential Area	55	45
D	Silence Zone	50	40

3.4.4 CONCLUSION

The point sources of the air pollutants and noise are absent in the region. We did not find any source of pollution in the proposed project area except vehicles like civilian and army trucks, light motor vehicles and two wheelers which mostly ply in the town. Though, influence area is also under jhum cultivation and leads to air pollution. The present studies showed that the levels of SPM (TSPM, RSPM and NRSPM), NOx and SO_2 recorded at Aalo were within the prescribed limits and the air quality of the project area is presumed to be healthy compared to the ambient air quality at Aalo. During the construction of the project the significant increase in the vehicular movement, air pollutants and noise level is anticipated.

3.5 BIOLOGICAL ENVIRONMENT

3.5.1 FLORISTICS AND FOREST TYPES

Arunachal Pradesh is the largest state of Northeast India lying in the Eastern Himalayan ranges, covering an area of 83,743 sq km. It is situated between 26^0 28' and 29^0 30'N latitude and 91^0 30'and 97^0 30'E longitude. Physiographically the state is predominantly hilly and the elevation of hills ranges from 200m (Siwalik formations) to 7750 m above sea level (in the inner Himalayas), with climatic conditions varying from humid tropical, temperate to alpine. The northern ranges bordering Tibet are covered with perpetual snow, whereas on the southern side the low lying mountains gradually descend to the plains of Brahmputra valley. The wide range of altitudinal variation, unique phytogeographical position, topography, high degree of precipitation and microclimatic condition, have supported over 20 forest types in Arunachal Pradesh. Each forest type depicting its own its characterstic biodiversity, therefore, the area is considered to be one of the bio-diversity 'Hot Spot' of the world. Takhtajan (1969) has regarded it as the cradle of flowering plants. Over 4500 species of flowering plants and 400 species of pteridophytes have been identified from 60% area of the state explored.

In spite of its rich plant wealth, this region was not able to attract as many plant collectors, explorers in the past as compared to other regions in Eastern Himalaya, which may be attributed to its tough and inaccessible terrain. H. Wilcox for the first time explored the Mishmi Hills in 1826 and subsequently, Griffith in 1836 botanized this region and in "*Flora of Mishmi Hills*", he enumerated 900 species of flowering plants and 22 species of ferns and fern allies. With the advent of 20^{th} Century, plant explorations in this region gained momentum which resulted in the publication of some important floristic accounts such as "*On the Botany of Abor Expedition*" by Burkill (1924-25); "*Botanical Expedition in the Mishmi Hills*" by Kingdon-Ward (1929-1931); "*Lohit Valley*" by Kingdon Ward (1953) and "*A sketch of the vegetation of Aka Hills*" based on the collections of Bor (1931-1934) who enumerated 1,549 species of flowering plants, 9 species of gymnosperms and 58 species of ferns and fern allies. With the establishment of the Eastern Circle of Botanical Survey of India at Shillong, various parts of Arunachal Pradesh, viz. Kameng, Subansiri, Siang, Lohit, Tirap, etc. were surveyed for its vegetational wealth, of which Rao and Panigrahi (1961); Deb (1961); Rao (1974); Sahni (1981), Chowdhery (1996) have made important contributions. Apart from these, the plants of ethnobotanical significance were recorded by many workers Jain (1979), Haridasan et al. (1990) and Chowdhery (1996) from the area.

3.5.1.1 Forest Types in the catchment area

Arunachal Pradesh is reported to have 80.93 per cent of its total geographic area under forest cover, which includes very dense, moderately dense and open forest (FSI, 2005). The forest of Arunachal Pradesh fall under five major categories of vegetation viz., tropical, sub-tropical, temperate broad-leaved and temperate coniferous, sub-alpine and alpine forests. The type of vegetation met within a given locality depends on the climate, soil and past treatment. These major types are interlaced with subtypes and secondary forests depending upon local conditions. The catchment area of the proposed Tato-I HE Project covers almost all types of these forests. The forests in the project area fall in Mechuka range of Aalo Forest division.

The vegetation in these forests, particularly in lower valleys of project area comprises sub-tropical wet hill forests with many tropical semi-evergreen plant species. Wet temperate broad-leaved and dry temperate coniferous forests occur in the upper valleys. In the entire valley of the catchment, the area is either covered by dense forests along the river banks or degraded open forests interspersed with settlements in upper reaches. The forests present in the Tato-I and adjoining areas have been grouped into different forest types following the classification of Champion & Seth (1968), Kaul and Haridasan (1987), Negi, (1989, 1996), Chowdhery (1996) and Muddgal & Hajra (1999). The major forest types found in this catchment are discussed below.

i) 2B/C1a Assam alluvial Plains semi-evergreen forest

This type of forest occurs all along the low hills and river banks in all districts of Arunachal Pradesh. The top canopy consists of tall deciduous trees whereas the evergreen species are dominated in lower stories. The top canopy is represented by 30-40m tall trees viz., *Aglaia spectabilis, Altingia excelsa, Artocarpus lacucha, Bischofia javanica, Canarium strictum, Castanopsis indica, Cinnamomum glauscens, Dysoxylum gobara, Kydia calycina, Phoebe hainesiana, Syzygium cumini, Tetrameles nudiflora*, etc. Second storey consists of trees 15-25 m and represented by *Aphanamixis chittagona, Ficus semicordata, Gynocardia odorata, Magnolia hodgsonii, Saurauia punduana*, etc. Understorey consists of small trees and shrubs up to 10 m tall. Shrubs comprise the prominent species of *Ardisia, Boehmeria, Cappais, Clerodendrum, Luculia,* *Pinanga, Rubus* and *Strobilanthes*. Epiphytes and twiners are many. Epiphytes are represented by many species of mosses, ferns and orchids. Among climbers are *Cissus discolor, Entada phaseoloides, Pentapanax leschenaultii, Rubia sikkimensis, Rubus lineatus, Smilax aspera* and *Thunbergia coccinea*. The ground floor is occupied by some herbs and grasses like *Bidens pilosa*, *Carex cruciata*, *Colocasia affinis, Commelina paludosa*, *Lecanthus peduncularis, Pilea scripta, Viola pilosa*, etc.

ii) 8B/CI East Himalayan Sub-tropical wet hill forests

These forests occur on hilly terrain between 1000-2000 m and are largely dominated by a number of evergreen species, though some deciduous trees also occur in the top canopy. Many of the tropical genera like *Bischofia, Duabanga, Pterospermum, Tetrameles*, etc are absent and more temperate genera like *Alnus, Lithocarpus, Lyonia* and *Quercus* appear. These forests were observed in Gapo, Menying and Purying areas. The top canopy is comprised of *Albizia odoratissima, Alnus nepalensis, Altingia excelsa, Castanopsis indica, Engelhardtia spicata, Macaranga denticulata, Ostodes paniculata, Phoebe hainesiana, Schima wallichii,* etc. The second storey is represented by some evergreen tree species like *Alangium chinense, Brassiopsis aculeata, Ficus oligodon, Garcinia cowa, Gynocardia odorata, Oroxylum indicum, Rhus chinensis*, etc. The third storey consists of small trees and shrubs. Among shrubs are *Bambusa tulda*, *Boehmeria macrophylla, Clerodendrum griffithianum, Debregeasia longifolia, Dendrocalamus hamiltonii, Eurya acuminata, Leea asiatica, Maesa chisia*, *Oxyspora paniculata*, *Sida acuta*, etc. Epiphytes and climbers are many. Climbers belong to the species of *Canvalia*, *Cissus*, *Clematis*, *Dioscorea*, *Raphidophora* and *Stephania*. Epiphytes are represented by ferns viz., *Colysis*, *Lepisorus, Vittaria* and orchids such as *Bulbophyllum*, *Cymbidium*, *Dendrobium,* etc. The prominent herbs are *Ageratum conyzoides, Anaphalis busua*, *Anemone vitifolia, Aster mollisculus, Bidens bipinnata, Cardamine hirsuta, Crassocephalum crepidioides, Impatiens angustiflora, Persicaria capitata, P. barabata, Setaria glauca, Saccharum longisetosum, Spiranthes sinensis, Themeda arundinacea, Thysanolaena latifolia, Viola betonicifolia*, etc.

iii) 11b/C1 East Himalayan wet temperate forests

These forests occur between 1800-2700 m elevations on the higher hills of Mechuka range of West Siang district. The oaks contribute the greater part of top canopy with some laurels. The top canopy is represented by *Acer acuminatum, Castanopsis hystrix, Litsea sericea, Magnolia* *pterocarpa, Michelia doltsopa, Prunus cerasoides, Quercus semiserrata, Q. lamellosa* and *Tetradium fraxinifolium.* The middle storey is dominated by moderate sized trees and shrubs like *Eurya acuminata, Ilex dipyrena, Lyonia ovalifolia, Prunus cerasoides, Rhododendron arboreum, Symplocos theifolia, e*tc. Other associates of middle storey are *Berberis asiatica, Dichroa febrifuga, Myrsine semiserrata, Oxyspora paniculata, Rubus niveus, Spiraea canescens* and *Thamnocalamus spathiflorus*. Climbers and twiners are extremely rare except for the species of *Clematis*, *Rubus* and *Vitis*. These forests were observed in the upper reaches of Rapum and Rego areas. The ground flora consists of herbaceous species belonging to genera like *Anaphalis, Anemone, Cardamine, Campanula, Circium, Carduus, Fragaria, Ludwigia, Plantago, Persicaria, Potentilla, Pilea, Stellaria* and *Viola.*

iv) 12/1S1 Alder forest

These forests are pure forests present along the banks of streams and water courses. These forests are mostly the primary colonizers of degraded lands, particularly the landslides. The forests are very dense with very thin understorey. These forests were commonly observed near Meying, Purying and Rego areas.

v) 13/C6 East Himalayan dry temperate coniferous forest

This is a mixed coniferous forest type found in the inner valleys of Mechuka Reserve forest. These forests are characterized by the predominant conifer blue pine (*Pinus wallichiana*) as the principal species. The tall trees of blue pine are more or less open in nature. The top and the middle storey are composed of blue pine, whereas the lower storey and ground vegetation have the typical coniferous associates. These include *Acer acuminatum, Lyonia ovalifolia, Populus ciliata, Prunus cerasoides, Quercus lamellosa*, *Rhododendron arboreum* and *Salix wallichiana*. Shrubby layer is represented by *Berberis wallichiana, Cotoneaster microphyllus, Eurya acuminata, Indigofera heterantha, Rosa macrophylla* and *Rubus niveus*. The ground flora consists of some terrestrial ferns, herbs and grasses belonging to the genera such as *Anaphalis, Anemone, Artemisia, Circium, Dicranopteris, Digitaria, Dryopteris, Fragaria, Lycopodium, Potentilla, Pilea, Pteridium, Rumex, Stellaria*, etc.

3.5.1.2 Vegetation Profile in the Influence Zone

The description of vegetation of the project area has been presented in terms of zones which correspond to topographic/elevational class within the 10 km radius influence zone of the project. These are as follows:

i) Area between BB Camp and Tato village

ii) Area between Tato village and Gapo

iii) Area between Gapo and Meying village

iv) Area upstream of Meying village and its environ

i) Area between BB Camp and Tato village

This area covers tropical semi-evergreen forest in the lower reaches, while evergreen oak forest in the upper reaches. The lower reaches in this zone are characterized by degraded riverine semi-evergreen forest especially near confluence (Siyom River with Yarjep River). The prominent trees are *Alnus nepalensis, Brassiopsis griffithii, Ficus semicordata, Macaranga denticulata, Saurauia roxburghii* and *Terminalia myriocarpa*. The river terraces are being stabilized by *Albizia odoratissima, Oroxylum indicum, Rhus chinensis*, etc. The shrub layer is also open and represented by *Buddleja asiatica, Debregeasia longifolia, Desmodium triflorum, Phragmites karka, Rubus ellipticus*, etc. The notable parasitic plant species like *Cuscuta reflexa* and *Scurrula elata* were noted on *Maesa chisia* and *Ficus semicordata*. The trunks of few trees are often loaded with epiphytic ferns, vines and orchids. The ground floor is occupied by weeds and grasses like *Ageratum conyzoides, Artemisia nilagirica, Bidens bipinnata, Conyza japonica, Crassopcephalum crepidioides, Gnaphalium affine, Pteridium aquilinum, Saccharum spontaneum, Thysanolaena latifolia,* etc.

Tato village from the banks of river Yarjep is a gentle slope interspersed with terrace cultivation. The natural vegetation is sparse and comprises few trees like *Alnus nepalensis, Altingia excelsa, Beilschmiedia dalzellii, Brassiopsis aculeata, Erythrina arborescens, Ostodes paniculata* and *Saurauia roxburghii*. The vegetation from Tato village to Gapo consists of dense subtropical broad-leaved forest in lower reaches and patchy mixed sub-tropical forest along roadside with many semi-everrgreen plant species.

ii) Area between Tato village and Gapo village

The forests upstream of Tato village up to Gapo village along Yarjep and many adjoining tributaries are covered under this area. A fairly dense sub-tropical broad-leaved hill forest can be observed in the lower reaches on both banks of Yarjep River. The forest is dominated by tall evergreen species, but some deciduous tree species also occur in the top canopy. The trees are 20-30m in height with distinct second storey. *Altingia excelsa, Castanopsis indica, Dysoxylum procerum, Engelhardtia spicata, Kydia calycina, Phoebe hainesiana, Schima wallichii*, etc form the top storey. Other prominent trees are *Ficus semicordata, Gynocardia odorata, Magnolia hodgsonii, Michelia glabra, Saurauia roxburghii*, etc. Understorey consists of dense thickets of bamboos, *Musa* and many shrubs. The common shrubs are *Bambusa tulda, Boehmeria macrophylla, Buddleja asiatica, Debregeasia longifolia, Leea asiatica*, and *Rubus ellipticus*. The tree trunks are loaded with a number of epiphytic mosses, ferns and orchids. On *Engelhardtia* and *Castanopsis* there is abundance of orchids like *Bulbophyllum, Dendrobium, Eria, Liparis*, etc. Climbers are abundant. Tree fern (*Alsophila spinulosa*) is often seen on shaded and damp areas.

The vegetation around Gapo is characterized by open degraded forest interspersed with settlement in middle reaches and dense riverine forest in lower reaches. A few trees like *Alnus, Altingia, Exbucklandtia, Macaranga denticulata*, etc could be seen sporidically in the area. The shrubs are *Bambusa tulda, Boehmeria macrophylla, Leea asiatica, Leucosceptrum canum, Maesa chisia, Oxyspora paniculata, Rubus ellipticus* and *Sida acuta*. Herbaceous flora includes species of *Anaphalis, Anemone, Arenaria, Arisaema, Artemisia, Hydrocotyle, Malva, Rumex, Saccharum* and *Themeda*.

iii) Area between Gapo and Meying

Gapo area from the bank of Yarjep is a moderately steep slope interspersed with Jhum cultivation. On lower reaches, the natural vegetation comprises open degraded forest. *Albizia odoratissima, Alnus nepalensis, Altingia excelsa, Castanopsis indica, Lithocapus elegans, Macaranga denticulata*, etc could be seen in patchy population. Other trees observed in this area are *Brassiopsis aculeata, Carpinus viminea, Casearia glomerata, Eurya acuminata, Garcinia cowa, Lyonia ovalifolia, Rhus chinensis*, etc. Shrub elements are composed of *Boehmeria macrophylla, Debregeasia longifolia, Elaeagnus parviflora, Maesa chisia, Rubus ellipticus* and *Schefflera bengalensis*. Tree trunks are clothed with a number of epiphytic mosses, ferns and orchids.

Herbaceous flora includes *Ageratum conyzoides, Artemisia nilagirica, Brachystemma calycinum, Dicranopteris linearis, Dipteris wallichii, Pteridium aquilinum, Houttuynia coradata, Persicaria capitata, P. chinensis, Spiranthes sinensis,* etc.

Around Meing village patchy sub-tropical broad-leaved forest are seen at lower reaches. Some large trees such as *Actinodaphne obovata*, *Altingia excelsa*, *Albizia odoratissima, Engelhardtia spicata, Macaranga denticulata*, etc are seen along the river bank. This area has also fruit tree plantations of Citrus, Plums and Guava. Large area of forest is cleared for Jhum cultivation in the area. *Aconogonum molle, Bambusa tulda, Boehmeria rugulosa, B. macrophylla, Debregeasia longifolia, Hydrangea robusta, Leea asiatica, Leucosceptrum canum, Maesa chisia, Oreocnide frutescens,* etc. were found in the understorey. The herbaceous flora includes ferns, tall grasses and many herbs like *Begonia megaptera, Commelina benghalensis, Impatiens angustiflora, Imperata cylindrica, Lecanthus peducularis, Phragmites karka* and *Saccharum longisetosum*.

iv) Area upstream of Meying village and its environ

Beyond Meying village, the vegetation in upper reaches up to Mechuka is met with wet temperate broad-leaved and dry temperate mixed coniferous forests. Still higher mixed coniferous forest of *Tsugo dumosa, Cephalotaxus griffithii* and *Pinus wallichina* occur. In the area between Meying and Purying a dense broad-leaved sub-tropical forest is present. Beyond Purying and Rapum wet temperate broad-leaved forests occur. Important associates of the temperate forest are *Alnus nepalensis, Castanopsis hystrix, Litsea sericea, Lyonia ovalifolia, Magnolia campbellii, Michelia doltsopa, M. punduana, Prunus cerasoides, Quercus lamellosa, Q. semiserrata, Rhododendron arboreum,* and *Tetradium fraxinifolium*. Shrub elements are composed of *Ardisia macrocarpa, Berberis hookeri, Cotoneaster acuminatus, Gaultheria fragrantissima, Pieris formosa, Rubus ellipticus, R. niveus, Salix wallichiana* and *Thamnocalamus spathiflorus*. Climbers are rare. The trunks of the trees are often loaded with rich epiphytic flora viz., lichens, mosses, ferns and orchid species. Herbaceous flora includes species of *Agrostis, Anaphalis, Anemone, Calamagrostis, Circium, Conyza, Fagopyrum, Fragaria, Persicaria, Potentilla, Saccharum rufipilum,* etc.

3.5.1.3 Floristics of Project Area

The present ecological study in the project area of Tato-I HE Project 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, abundance and density of different vegetation components.

The field survey for all the above aspects of the ecological study pertaining to winter, premonsoon and monsoon season was conducted during different seasons of the year 2009 i.e. February, April and Aug - September, respectively. Besides the primary surveys in the catchment area of the project, we sourced our data on the floral diversity of this region from the literature cited above. The database has been pooled to present the results in terms of vegetation of submergence area, intake area and powerhouse area.

i) Vegetation in Submergence Area

The total submergence area in the proposed project is around 3.0 ha (0.03 sq km), including 1.8 ha of river bed. The proposed submergence site is located about 1 km downstream of Meying village in Mechuka Circle. The area in the vicinity of proposed submergence area comprised of fairly dense sub-tropical forest with few riverine semi-evergreen plant species. On the left bank the first storey is comprised of *Albizia odoratissima, Altingia excelsa, Castanopsis hystrix, Cinnamomum glaucescens*, *Engelhardtia spicata, Ficus semicordata, Saurauia punduana* and *Tetradium rutecarpa.* Second storey represented by *Acer thomsoni, Brassiopsis aculeata, Carpinus viminea*, *Casearia vareca*, *Eurya acuminata*, *Garcinia anomala*, *Lyonia ovalifolia* and *Trema politora*. Third storey consists of small trees and shrubs. Among shrubs are *Aconogonum molle, Arenga saccharifera, Boehmeria macrophylla, Caryota urens, Debregeasia longifolia, Hydrangea robusta, Leea asiatica, Luculia pinceana, Maesa chisia, Melocalamus compactiflorus, Oxyspora paniculata, Rubus ellipticus, Strobilanthes extensa* and *Schefflera venulosa*. Tree fern (*Alsophila spinulosa*) can also be seen in the understorey in shaded areas. The epiphytic flora comprises of large variety of lichens and ferns like *Asplenium ensiforme, Drynaria propinqua, Lepisorus nudus, Polypodioides wattii*, *Pyrrosia mollis, Vittaria flexuosa*, etc. (**Plate 3.5.1.1a**). The epiphytic orchids include species of *Bulbophyllum, Coelogyne* and *Dendrobium*. Climbers are represented by species of *Canvalia, Cissus, Dioscorea, Parthenocissus, Rhaphidophora, Rubia* and *Stephania* (Plate **3.5.1.1b**). Herbs are *Adiantum lanulatum, Ageratum conyzoides, Amomum subulatum, Artemisia nilagirica, Begonia palmata*, *Carex* sp., *Coniogramme caudata*, *Dicranopteris linearis*, *Elatinae ambigua, Equisetum ramosissimum, Hedychium spicatum, Impatiens angustiflora, Lecanthus* *peduncularis, Microstegium vagans, Molinera capitulata, Persicarea chinensis, Pteris pellucida, Saccharum longisetosum, Selaginella indica, Viola betonicifolia,* etc. A total of 85 species of angiosperms including trees, shrubs, climbers and herbs were recorded in the submergence area during survey (Table 3.5.1.1). Terrestrial ferns are few such as *Equisetum ramosissimmum*, *Coniogramme caudata*, *Pteris* spp., *Selaginella indica,* etc (Table 3.5.1.2) (**Plate 3.5.1.1c**).

The vegetation of right bank is denser in comparision to left bank. Dense musa (*Musa bulbisiana*) thickets can be seen in shaded and damp areas. Bamboo thickets (*Bambusa tulda*), Cane (*Calamus erectus*), palm (*Arenga saccharifera*) and tree fern (*Alsophila spinulosa*) are also seen scatteredly in the lower storey. The dominant trees are *Albizia odoratissima, Alnus nepalensis, Cinnamomum glaucescens, Ficus semicordata, Kydia calycina, Macaranga denticulata, Saurauia punduana, Schima wallichii* and *Tetrameles nudiflora*. The other riverine flora includes tall grasses such as *Miscanthus nepalensis, Saccharum spontaneum, Saccharum longistosum, Themeda arundinacea* and *Thysanolaena latifolia*.

Table 3.5.1.1 List of flowering plants in Submergence area

Species	Local Name	Family
Trees		
Acer thomsonii	-	Aceraceae
Albizia odoratissima	Kalo Siris	Mimosaceae
Alnus nepalensis	Utis	Betulaceae
Altingia excelsa	Singri	Hamemlidaceae
Brassiopsis aculeata	-	Araliaceae
Carpinus viminea	-	Betulaceae
Casearia vareca	Abuk-asing	Flacourtiaceae
Castanopsis indica	Hinguri	Fagaceae
Cinnamomum glaucescens	Gonsoroi	Lauraceae
Engelhardtia spicata	Tshos Shing	Juglandaceae
Eurya acuminata	Murmura	Theaceae
Ficus semicordata	Honaiyo	Moraceae
F. oligodon	KongmaShing	Moraceae
Gamblia ciliata	-	Araliaceae
Garcinia anomala	-	Cluciaceae

Kydia calycina	*Pichola*	Malvaceae
Lyonia ovalifolia	-	Ericaceae
Macaranga indica	Malata	Euphorbiaceae
Rhus chinensis	Bhakimilo	Anacardiaceae
Saurauia punduana	Paniposala	Actinidiaceae
Schefflera bengalensis	-	Araliaceae
Schima wallichii	Makrisal	Theaceae
Tetrdium rutecapum	-	Rutaceae
Tetrameles nudiflora	Bhelu	Combretaceae
Trema politora	-	Ulmaceae
Shrubs		
Aconogonum molle	Thothney	Polygonaceae
Arenga saccharifera	Sago Palm	Arecaceae
Bambusa tulda	Bijali	Poaceae
Boehmeria macrophylla	Kamli	Urticaceae
B. pendulifera	-	Urticaceae
Buddleja asiatica	-	Loganiaceae
Calamus erectus	Jeng	Arecaceae
Debregeasia longifolia	Tusare	Urticaceae
Hydrangea robusta	-	Hydrangeaceae
Leea asiatica	-	Leeaceae
Luculia pinceana	-	Rubiaceae
Maesa chisia	-	Myrsinaceae
Melocalamus compactiflorus	-	Poaceae
Neillia thyrsiflora	-	Rosaceae
Oxyspora paniculata	-	Melastomaceae
Rubus ellipticus	Hisalu	Rosaceae
Strobilanthes extensa	-	Acanthaceae
Trevisia palmata	-	Araliaceae
Zanthoxylum acanthopodium	Yokhung	Rutaceae
Climbers		
Clematis smilacifolia	-	Ranunculaceae
Cissus repens	-	Vitaceae
C. javana	-	Vitaceae
Dioscorea bulbifera	-	Dioscoreaceae

Pothos cathcartii	-	Araceae
Rhaphidophora decursiva	-	Araceae
Rubia sikkimensis	-	Rubiaceae
Smilax aspera	-	Smilacaceae
Stephania glandulifera	-	Menispermaceae
Toddalia asiatica	-	Rutaceae
Herbs		
Abelmoschus moschatus	-	Malvaceae
Amomum subulatum	-	Zingiberaceae
Arisaema tortuosum	-	Araceae
Artemisia nilagirica	-	Asteraceae
Begonia palmata	-	Begoniaceae
Capillipedium assimile	-	Poaceae
Carex myosurus	-	Cyperaceae
Commelina benghalensis	-	Commelinaceae
Duschesnea indica	-	Rosaceae
Fagopyrum esculentum	-	Polygonaceae
Hedychium spicatum	-	Zingiberaceae
Houttuynia cordata	-	Saururaceae
Hypericum elodeoides	-	Hypericaceae
Imperata cylindrica	-	Poaceae
Impatiens angustiflora	-	Balsaminaceae
Impatiens tripetala	-	Balsaminaceae
Isachne albens	-	Poaceae
Lecanthus peduncularis	-	Urticaceae
Microstegium vagans	-	Poaceae
Miscanthus nepalensis	-	Poaceae
Oxalis corniculata	-	Oxalidaceae
Persicaria chinensis	-	Polygonaceae
Saccharum spontaneum	-	Poaceae
S. longisetosum	Elephant grass	Poaceae
Setaria palmifolia	-	Poaceae
Solanum nigrum	-	Poaceae
Sida rhombifolia	Boriala	Malvaceae

Thysanolaena latifolia.	Beyshawa	Poaceae
Urtica parviflora	Shisnu	Urticaceae
Viola betonicifolia	-	Violaceae
Zea mays	Ashom	Poaceae

Table 3.5.1.2 Some of the common pteridophytes of submergence area of Tato-I HEP project

Sl.No.	Species	Family	Habit	Altitude (m)
1.	*Equisetum diffusum*	Equisetaceae	herb	Up to 3000
2.	*E. ramosissimum*	Equisetaceae	herb	Up to 3000
3.	*Lycopodium japonicum*	Lycopodiaceae	herb	1200-3000
4.	*Selaginella indica*	Selaginellaceae	herb	1000-2800
5.	*Alsophila spinulosa*	Cyatheaceae	tree	Up to 1500
6.	*Dicranopteris linearis*	Gleicheniaceae	herb	Up to 1400
7	*Lygodium salcifolium*	Lygodiaceae	herb	Up to 2000
8	*Adiantum lunulatum*	Adiantaceae	herb	Up to 1500
9.	*Pteris vittata*	Pteridaceae	herb	1000-1500
10.	*Coniogramme caudata*	Hemionitidaceae	herb	1200-2100

ii) Vegetation around intake site

A fairly dense sub-tropical broad-leaved forest occurs around intake axis with many riverine semi-evergreen plant species at lower reaches. At the left bank, the top storey of the forest is dominated by few trees like *Albizia odoratissima, Alnus nepalensis, Altingia excelsa*, *Castanopsis indica*, *Cinnamomum glaucescens*, *Macaranga denticulata*, and *Saurauia punduana*. Second storey is represented by *Brassiopsis aculeata, Casearia vareca, Ficus semicordata, Lyonia ovalifolia, Trema amoboenis*, etc. Understorey is represented by some small trees and tall spreading shrubs. *Aconogonum molle, Arenga saccharifera, Boehmeria macrophylla, Buddleja asiatica, Debregeasia longifolia, Hydrangea robusta, Luculia pinceana, Maesa chisia, Melocalamus compactiflorus, Neillia thyrsiflora, Rubus ellipticus* and *Trivisia plamta*. A few large tree ferns (*Alsophila spinulosa*) were also present in the understorey. Climbers and epiphytes are not common. Among climbers are *Cissus repens, Cuscuta reflexa, Rhaphidophora decursiva, Rubia sikkimensis, Stephania glandulifera*, etc. Herbaceous flora is represented by some terrestrial pteridophytes, grasses and herbs. *Artemisia nilagirica, Arthraxon hispidus, Commelina benghalensis, Coniogramme caudata,* *Equisetum ramosissimum, Hedychium spicatum, Imperata cylindrica, Molineria capitulata, Oxalis corniculata, Pteris vittata, Saccharum longisetosum* and *Thysanolaena latifolia*.

The right bank has denser forest in the lower reaches. The dominant tree species include *Albizia odoratissima, Alnus nepalensis, Altingia excelsa, Castanopsis indica, Cinnamomum glaucescens, Ficus semicordata, Macaranga denticulata* and *Saurauia punduana*. Herbs are few dominated by herbs and tall grasses like *Saccharum spontaneum, S. longisetosum, Themeda arundinacea* and *Thysanolaena latifolia*.

iii) Power House site

A surface powerhouse has been proposed on the left bank of river Yarjep. A fairly dense mixed sub-tropical forest occurs in the vicinity of project area. The top canopy of the forest is represented by tall trees like *Albizia odoratissima, Alnus nepalensis, Altingia excelsa, Castanopsis indica, Erythrina arborescens, Ficus semicordata, Macaranga denticulata, Ostodes paniculata,* and *Saurauia punduana*. The lower storey is of small trees and shrubs like *Alsophila spinulosa, Boehmeria macrophylla, Buddleja asiatica, Clerodendrum bracteatum, Debregeasia longifolia, Ficus oligodon, Hydrangea robusta, Leea aequata, Melocalamus compactiflorus,* etc. Climbers and epiphytes are few. *Cissus repens, Edgaria darjelensis, Piper pedicellatum, Rhaphidophora decursiva, Thunbergia coccinea,* etc. are important twiners. Epiphytes are mostly represented by many species of ferns and orchids like species of *Bulbophyllum, Cymbidium, Dendrobium,* etc. The epiphytic ferns are represented by species of *Colysis, Lepisorus, Pyrrosia, Vittaria,* etc. The ground floor is occupied by few herbs and tall grasses like *Aconogonum molle, Carex logipes, Commelina benghalensis, Equisetum diffusum, Hedychium spicatum, Molineria capitata, Musa bulbisiana, Persicaria capitata, Pilea scripta, Saccharum longisetosum* and *Thysanolaena latifolia*.

3.5.1.4 Community Structure

Community is an assemblage of organisms living in a particular area or physical habitat or it is an aggregation of organisms which form a distinct ecological unit. Before going to expel any idea related to numerical strength of the species in the community, it is prerequisite to understand the community quantitatively. Thus the phytosociological data gives an idea about the numerical strength of the species in a particular community. For sampling of various strata of vegetation, Nested Quadrat Sampling method was followed.

i) ***Density and basal area***

The maximum number of tree species was recorded at intake site as compared to powerhouse sites (Table 3.5.1.3). Similarly, the herb layer was poorly represented in both sites and seasons except in monsoon (Table 3.5.1.4). Table 3.5.1.5 gives the seasonal accounts of herbaceous vegetation in each site in different seasons.

On the proposed intake site (Meying, left bank of Yarjep), the tree and sapling strata were dominated by *Schefflera wallichiana* having maximum frequency (40%) and density (40 trees/ha). The associated species in the tree canopy were *Ficus semicordata, Lyonia ovalifolia, Casearia vareca, Euonymus hamiltonianus, Altingia excelsa, Eurya acuminate, Eribotrya dubia, Castanopsis indica, Engelhardtia spicata, Erythrina arborescens, Garcinia anomala, Macaranga denticulata* and *Tetradium rutaecarpa*. In the shrub layer *Strobilanthes extensa* was found to be the most dominant species having maximum density. The dominance of *Strobilanthes extensa* may be due to its fast growing nature and capability to grow in shaded areas. Other competing species in the understorey were *Melocalamus compactiflorus, Oxyspora paniculata, Hydrangea robusta, Boehmeria macrophylla, B. pendulifera, Arenga saccharifera* and *Luculia pinceana*. The complete absence of seedlings of all dominant tree species in a forest is attributed to high human encroachment.

At the power house site (d/s of Heyo village, left bank of Yarjep), tree strata was dominated by *Macaranga denticulata* having maximum frequency (60%) and density (110 trees/ha). The associated species in the tree canopy were *Alnus nepalensis, Ficus subulata, Albizia odoratissima, Saurauia punduana, Altingia excelsa, Rhus chinensis, Milletia pulchra, Ficus semicordata* and *Castanopsis indica*. In the sapling layer *Alnus nepalensis* was the most dominant species having maximum density. It was followed by *Schefflera bengalensis*. In the shrub layer *Boehmeria macrophylla* was found as the most dominant species with high density. The dominance of *Boehmeria macrophylla* may be due to its non palatable nature and capability to grow in the shaded areas. Other competing species in the understorey were *Elatostema lineolatum, Hydrangea robusta, Leea asiatica, Melocalamus compactiflorus, Oxyspora paniculata, Debregeasia longifolia* and *Melastoma malabathricum* (see Table 3.5.1.3). The complete absence of seedlings of all dominant tree species in a forest is attributed to high human encroachment and shade in the area.

Table 3.5.1.3 Various ecological attributes of woody vegetation in Tato-I HEP Project

Species		Frequency(F%)	Density(ha^{-1})	TBC(m^2ha^{-1})	IVI
V1	**Intake site (near Meing, left bank of Yarjep), El 1110m**				
Trees					
1	*Casearia vareca*	20	30	8.523	17.750
2	*Tetradium rutaecarpa*	10	10	3.630	7.292
3	*Ficus semicordata*	30	40	24.316	30.186
4	*Engelhardtia spicata*	20	20	3.179	12.858
5	*Acer thomsonii*	10	10	0.779	6.086
6	*Macaranga denticulata*	10	10	5.539	8.099
7	*Saurauia punduana*	10	10	5.024	7.881
8	*Schefflera wallichiana*	40	40	9.499	27.044
9	*Cinnamomum glaucescens*	10	20	2.512	9.451
10	*Erythrina stricta*	10	10	3.630	7.292
11	*Castanopsis indica*	20	20	4.749	13.522
12	*Ficus oligodon*	10	10	0.855	6.118
13	*Lyonia ovalifolia*	20	40	12.266	21.964
14	*Gamblia ciliata*	10	10	0.779	6.086
15	*Eurya acuminata*	20	20	1.568	12.176
16	*Garcinia anomala*	10	10	8.008	9.143
17	*Altingia excelsa*	20	20	132.037	67.357
18	*Euonymus hamiltonianus*	20	30	6.368	16.838
19	*Eriobotrya dubia*	20	20	3.179	12.858
	Total	**320**	**380**	**236.439**	
Saplings					
1	*Schefflera wallichiana*	50	240	7.840	124.263
2	*Eurya acuminata*	40	200	5.970	99.247
3	*Tetradium rutaecarpa*	10	80	3.617	40.329
4	*Garcinia anomala*	10	40	1.256	21.974
5	*Castanopsis indica*	10	40	1.520	23.280
	Total	**110**	**600**	**20.203**	
Shrubs					
1	*Oxyspora paniculata*	30	240	2.197	25.835
2	*Melocalamus compactiflorus*	50	880	0.542	46.672
3	*Hydrangea robusta*	10	80	4.578	17.851
4	*Boehmeria macrophylla*	10	80	0.904	9.024

5	*B. pendulifera*	10	80	0.981	9.209
6	*Trevisia palmata*	10	80	1.413	10.247
10	*Strobilanthes extensa*	60	2800	25.165	155.272
11	*Arenga saccharifera*	10	40	3.018	13.175
12	*Luculia pinceana*	10	40	2.826	12.715
	Total	**200**	**4320**	**41.624**	
V2	**Power house site (d/s of Heyo village, left bank of Yarjep) 950m**				
Trees					
1	*Altingia excelsa*	10	20	15.700	24.985
2	*Ficus subulata*	40	40	14.095	41.480
3	*Saurauia punduana*	20	30	8.478	24.908
4	*Macaranga denticulata*	60	110	19.664	74.671
5	*Rhus chinensis*	10	10	0.779	7.702
6	*Millettia pulchra*	10	10	1.256	8.165
7	*Albizia odoratissima*	30	30	15.072	35.485
8	*Alnus nepalensis*	40	90	20.093	61.200
9	*F. semicordata*	10	10	0.794	7.716
10	*Castanopsis indica*	10	10	6.936	13.687
	Total	**240**	**360**	**102.868**	
Saplings					
1	*Schefflera bengalensis*	40	240	8.308	90.349
2	*Macaranga denticulata*	30	120	2.120	44.535
3	*Oroxylum indicum*	20	80	1.815	31.227
4	*Alnus nepalensis*	30	280	11.127	98.987
5	*Rhus chinensis*	10	40	1.256	16.947
6	*Saurauia punduana*	10	40	1.520	17.955
	Total	**140**	**800**	**26.146**	
Shrubs					
1	*Boehmeria macrophylla*	80	1200	13.565	114.248
2	*Elatostema lineolatum*	40	840	7.270	66.759
3	*Oxyspora paniculata*	20	80	0.732	13.824
4	*Hydrangea robusta*	30	240	6.104	38.267
5	*Debregeasia longifolia*	10	80	5.281	21.424
6	*Melastoma malabathricum*	10	40	0.314	6.773
7	*Leea asiatica*	20	160	4.069	25.512
8	*Melocalamus compactiflorus*	10	240	0.118	13.193
	Total	**220**	**2880**	**37.454**	

Table 3.5.1.4. Various ecological attributes of herbaceous vegetation in Tato-I HEP

	Winter		Pre-monsoon		Monsoom	
Species	**Density(ha^{-1})**	**IVI**	**Density(ha^{-1})**	**IVI**	**Density(ha^{-1})**	**IVI**
V1 Intake site (near Meing, left bank of Yarjep) 1110m						
Hedychium spicatum	11000	117.909	8000	77.603	5000	81.093
Setaria palmifolia	4000	17.362	8000	23.821	-	-
Equisetum ramosissimum	4000	17.067	4000	11.980	17000	18.433
Amomumm subulatum	3000	47.727	3000	50.742	-	-
Gerbera piloselloides	8000	27.031	-	-	-	-
Carex longipes	6000	29.685	4000	20.505	-	-
Begonia palmata	2000	12.513	2000	10.317	-	-
Selaginella indica	4000	17.009	2000	10.073	-	-
Bulbophyllum affine	2000	13.702	-	-	-	-
Elatine ambigua	-	-	90000	94.958	190000	57.160
Carex cruciata	-	-	-	-	1000	4.941
Polystichium sp.	-	-	-	-	8000	30.356
Muhlenbergia viminea	-	-	-	-	128000	46.390
Colocasia affinis	-	-	-	-	1000	5.320
Hydrocotyle nepalensis	-	-	-	-	20000	9.624
Schoenoplectus mucronatus	-	-	-	-	12000	7.734
Pteris vittata	-	-	-	-	8000	8.385
Dichrocephala integrifolia	-	-	-	-	7000	11.136
Anaphalis busua	-	-	-	-	11000	13.878
Conyza japonica	-	-	-	-	1000	5.553
V2 Power house site(d/s of Heyo village, left bank of Yarjep) 950m						
Species						
Begonia nepalensis	8000	110.694	4000	31.225	5000	60.331
Hedychium spicatum	1000	19.188	2000	18.156	-	-
Amomum subulatum	1000	18.680	1000	13.346	-	-
Molineria capitulata	1000	23.418	-	-	-	
Musa bulbisiana	4000	128.021	2000	83.436	1000	35.352
Impatiens cathcartii	-	-	12000	36.964	22000	38.008
Elatine ambigua	-	-	64000	83.354	92000	42.533
Hydrocotyle nepalensis	-	-	15000	33.521	-	-
Muhlebergia viminium	-	-	-	-	138000	66.050

Crawfurdia speciosa	-	-	-	-	4000	5.203
Nepeta ciliaris	-	-	-	-	6000	5.924
Hydrocotyle nepalensis	-	-	-	-	12000	7.917
Polystichium sp.	-	-	-	-	1000	5.420
Carex rotundus	-	-	-	-	2000	4.556
Colysis pedunculata	-	-	-	-	3000	4.976
Elatostema platyphyllum	-	-	-	-	8000	10.706
Persicaria chinensis	-	-	-	-	8000	6.860
Pteris vittata	-	-	-	-	4000	6.164

Total tree density ranged from 360 trees/ha (at power house site) to 380 trees/ha (at intake site). The sapling density was more (800 plants/ha) in the powerhouse site as compared to the intake (600 plants/ha) site. The total density of shrubs varied from 2880 to 4320 individuals ha^{-1}. It was comparatively higher in the intake site (4320 individual ha^{-1}) as compared to powerhouse site. The maximum individual shrub density was recorded for *Strobilanthes extensa* (2800 individual ha^{-1}) in the intake site and minimum values were recorded for *Arenga saccharifera* and *Luculia pinceana* (40 individual ha^{-1}) at the same site (see Table 3.5.1.3).

The total basal cover ranged from 102.868 m^2/ha at power house site to 236.439 m^2/ha at intake site. The lowest mean basal area was recorded for *Acer thomsonii* and *Gamblia ciliata* (0.0778 m^2/tree) in the intake site, whereas the highest was recorded for *Altingia excelsa* (0.669 m^2/ tree) at the same site. *Altingia excelsa* was the single dominant tree species in the intake site with an IVI of 67.35. Similarily, *Alnus nepalensis* was the dominant species at the power house site with an IVI of 61.20 (Table 3.5.1.3).

Among herbs, on the proposed intake site, *Hedychium spicatum* was the dominant species having maximum density (11000 plants/ha) during winter. *Elatine ambigua* recorded high density during premonsoon (90000 plants/ha) and monsoon season (190000 plants/ha) (Table 3.5.1.4). As per the IVI values, *Hedychium spicatum* was the dominant species during winter (117.909) and monsoon season (94.958), while *Elatine ambigua* was the dominant species with highest IVI (94.958) during premonsoon. The lowest IVI of 4.941 was noted in *Carex cruciata* during monsoon.

At the proposed power house site, *Begonia nepalensis* was the most dominant species during winter (8000 plants/ha). It was followed by *Musa bulbisiana* (4000 plants/ha). *Elatine ambigua* was the most dominant species during premonsoon season (64000 plants/ha), while *Muhlenbergia viminum* was dominat during monsoon (138000 plants/ha). Maximum value of IVI was observed in *Musa bulbisiana* during winter (128.021) and premonsoon (83.346). It was followed by *Begonia nepalensis* (110.694) during winter. *Muhlenbergia viminum* was the dominant species with highest IVI (66.050) during monsoon. The minimum IVI of 4.556 was noted for *Carex rotundus* during monsoon.

ii) ***Species Diversity***

The species diversity (H) in the tree stratum ranged from 1.926 (power house site) to 2.807 (intake site). The species diversity for sapling and shrub strata ranged from 1.362 to 1.543 and 1.148 to 1.557, respectively (Table 3.5.1.6). The shrub diversity was higher on the power house site and decreased at intake site. The maximum individual shrub density was observed for *Strobilanthes extensa* (2800 individual ha^{-1}) at intake site and minimum for *Melocalamus compactiflorus* (40 individual ha^{-1}) at power house site. The herb species richness and diversity increased from powerhouse site to intake site (Table 3.5.1.6).

Table 3.5.1.5 Number of herb species encountered on project sites in different seasons

Seasons	No. of species	
	Site V1	Site V2
Winter	9	5
Premonsoon	8	7
Monsoon	13	14

Table 3.5.1.6 Species Diversity Indices (H) for different vegetation components at different sampling sites in Tato-I HE Project

Vegetation component	Shannon's Index (H)		
	Winter	Premonsoon	Monsoon
Intake site			
Trees	2.807	2.807	2.807
Saplings	1.362	1.362	1.362

Shrubs	1.148	1.148	1.148
Herbs	2.046	1.032	1.522
Power House site			
Trees	1.926	1.926	1.926
Saplings	1.543	1.543	1.543
Shrubs	1.557	1.557	1.557
Herbs	1.229	1.156	1.601

iii) *Plant Biodiversity*

A total of 70 species of plants were recorded under the ecological investigation during different sampling seasons. Out of which 26 were trees, 13 shrubs and 31 herbs. The ground vegetation comprised of ephemeral, annual and perennial species of grasses, sedges, legumes and non legume forbs and ferns.

iv) *Lower Plant Diversity (Cryptogams)*

Cryptogamic flora of the state is very rich with a diverse species composition. However, no studies on this component of the flora have been carried out in detail. As many as 54 species of algae belonging to 23 genera have been reported from the area. The lichen flora of Arunachal is also rich in species composition with nearly 331 species of lichens belonging to 72 genera and 41 families recorded from the state. Pteridophytes are important constituents of the floristics of Arunachal. The surveys of Botanical Survey of India have recorded about 452 species of fern and fern allies from Arunachal Himalaya (Table 3.5.1.7).

Table 3.5.1.7 Some common pteridophtes of the Tato-I HEP influence zone (based on available literature)

Sl.No.	Species	Family	Habit	Altitude (m)
1.	*Equisetum ramosissimum*	Equisetaceae	herb	Up to 3000
2.	*Selaginella indica*	Selaginellaceae	herb	Up to 2800
3.	*Marsilea minuta*	Marsileaceae	herb	Up to 1200
4.	*Alsophila spinulosa*	Cyatheaceae	herb	300-1500
5.	*Gymnosphaera gigantea*	-do-	tree	Up to 1200
6.	*Dicranopteris linearis*	Gleicheniaceae	herb	Up to 1500
7.	*Lygodium japonicum*	Lygodiaceae	creeping herb	200-2000

8.	*Adiantum edgeworthii*	Adiantaceae	herb	500-1000
9.	*A. lunulatum*	-do-	herb	Up to 1500
10.	*Vittaria sikkimensis*	Vittariaceae	epiphytic herb	600-2000
11.	*V. flexuosa*	-do-	epiphytic herb	300-4000
12.	*Pteris vittata*	Pteridaceae	terr. fern	Up to1500
13.	*Pteridium aquilinum*	Pteridiaceae	terr. fern	600-2700
14.	Coniogramme caudata	Hemionitidaceae	terr. Fern	1200-2100
15.	*Pyrrosia adnascens*	Polypodiaceae	epi. fern	Up to 1200
15.	*Colysis pedunculata*	-do-	epi. fern	up to 2000
16.	*Lepisorus nudus*	-do-	ep. fern	1000-3600

v) *Taxonomic Diversity*

The proposed Tato-I H. E. Project area extends from nearby Heyo to Meing along the left bank of the Yarjep River. Out of about 17,000 species of flowering plants in India and about 4,156 species of flowering plants reported from Arunachal Pradesh Himalaya (Mudgal & Hajra, 1999; BSI, 2006), there are nearly 356 species of angiosperms recorded in the free draining catchment of Tato-I H.E. project encompassing the valleys of Yarjep river and its major tributaries Sarak I, Sarak II and Sang Nalas (**Annexure-III**). About 93 families of angiosperms are represented in these areas of which 76 are dicots and 17 are monocots. The dicotyledons are represented by 254 plant species belonging to 198 genera and 76 families (out of 2,917 genera and 327 families in India), while the monocotyledons are represented by 17 families, 71 genera and 102 species. Gymnosperms are represented by a single family i.e 1 genera and 1 species. The ratio of monocot to dicot species is 1:2.49 (102 monocots and 254 dicots). For monocots, family to genera, family to species and genera to species ratios are 1: 4.17, 1: 6 and 1: 1.43, respectively. The genus to species ratio for this region is around 1: 1.43 which is nearly similar to that of Arunachal Pradesh (1: 3.17) (BSI, 2006). However, this ratio is much less in comparison to the corresponding ratio of 1:13 for the world and 1: 6 for India (Raizada and Saxena, 1978; Mudgal & Hajra, 1999). This result confirms the general view that within the same floral region flora of smaller areas has lower genus-species ratio.

Poaceae with 31 genera and 43 species and Asteraceae with 17 genera and 19 species are the largest families of monocots and dicots, respectively. Among gymnosperms, Pinaceae is the single family represented by 1 genera and 1 species. Among dominant genera represented by 5 or more species in the project area are *Carex* (6), *Cyperus* (6) and *Rubus* (5). A number of monotypic genera distributed over different habitats were observed in the project area. Some of these taxa are *Bischofia javanica* (Bischofiaceae), *Gynocardia odorata* (Flacourtiaceae) and *Houttuynia cordata* (Saururaceae).

vi) ***Rarity and Endemism***

The project area is largely degraded due to high human pressure, large scale lopping, tree felling, construction of roads, jhum, grazing, etc. Inspite of this, some of the forest areas harbour rare, endangered and endemic species of plants which are important for conservation purpose. Nayar and Sastry (1987-1990) have reported some rare and endemic species viz., *Cymbidium eburnum, Livistona jenkinsiana, Paphiopedilum fairrienum, Pschotriya aborensis, Xanthophyllum burkillii*, etc. from low hills in the altitudinal range of 300-1500 m elevation (Table 3.5.1.8). Since the project fall within this altitudinal range there is possibility that some of these species may be present in the project area though they were not encountered during field sampling and survey. Given the level of human activity around the Intake and PH sites, and taking into account that the project land is mostly degraded forest or scrubs, the probability to encounter rare species on the project land itself is low.

Table 3.5.1.8 Rare, vulnerable, endangered and endemic plants of low hills in the Tato-I HE project area (As per Red Data Book)

Species	Family	Altitude (m)	Habit	Status
Cymbidium eburnum	Orchidaceae	1000-1500	Herb	Vulnerable
Livistona jenkinsiana	Arecaceae	Up to 1000	Tree	Endangered
Paphiopedilum fairrienum	Orchidaceae	1400-2000	Herb	Endangered
Psychotria aborensis	Rubiaceae	300-1200	Shrub	Endangered/ Endemic
Xanthophyllum burkillii	Xanthophyllaceae	800-1400	Tree	Rare/ endemic

vii) ***Parasitic Flora***

During the field surveys in different areas of the proposed Tato-I HE project a few parasitic plant species were observed. These plant species belong to the families Cuscutaceae and Loranthaceae. *Cuscuta reflexa* (Cuscutaceaae) was found growing on *Altingia excelsa*. *Taxilus umbellifer* was found growing as long climbing parasite on wide range of hosts in the area, namely

Boehmeria macrophylla, Maesa chisia and *Mussaenda roxburghii,* while *Scurrulla elata* was seen on *Ficus semicordata* in the project area.

viii) *Epiphytes*

Epiphytes are often attached to the trunks and branches of forest trees. Angiospermic epiphytes mostly belong to family Orchidaceae and Araliaceae. There is also rich growth of epiphytic ferns. A number of epiphytic orchids belonging to the genera *Bulbophyllum*, *Coelogyne*, *Cymbidium*, *Dendrobium*, etc were observed in the area. The epiphytic ferns include *Colysis*, *Lepisorus*, *Polypodioides*, *Pyrrosia* and *Vittaria*. A large number of non vascular epiphytes such as mosses and lichens also covered space on the barks of the trees in the forest.

ix) *Physiognomic Diversity*

The diversity of vegetation in Tato HEP area and its adjacent areas was assessed in terms of physiognomy of its floral elements. Some of the families that showed diverse habit forms of trees, shrubs and climbers include Papilionaceae, Rosaceae and Euphorbiaceae. Rosaceae, for example, was represented by *Duschesnea indica* (herb), *Rubus ellipticus* (shrub), *Rubus niveus* (climber) and *Photinia cuspidata* (tree). On the contrary, some of the families such as Magnoliaceae, Meliaceae, Bignoniaceae, Lauraceae, Betulaceae, Fagaceae, etc. were represented by tree species only. Leeaceae, Melastomataceae, Caprifoliaceae, Myrsinaceae and Araliaceae are some of the families which were mostly comprised of shrubby species. Members of Menispermaceae, Cucurbitaceae, Vitaceae, Dioscoreaceae and Smilacaceae exclusively comprised climbers. Herbaceous species formed the bulk of flora (54.62%) followed by trees (21.00%), shrubs (16.52%), climbers (7.56%) and stem parasites (0.84%).

Predominance of herbaceous species even at the lower altitudes indicates that the biotic pressure has been responsible for arresting woodland formation. The ecosystems in the entire valley are highly disturbed due to anthropogenic activities like conversion of forests into agricultural fields (Jhuming), collection of fodder and firewood by local inhabitants and road building and hydro-power projects activities. These activities result in the formation of scrubs and secondary forests in the region.

x) *Phytogeography*

The floral elements in Tato-I project area were analysed for their floristic similarities with other regions of the world and to find out the nature and composition of the flora. Clarke (1889) suggested that Eastern Himalaya and Assam are distinct sub areas based on his studies on the distribution of the family Cyperaceae. Hooker (1906) in his botanical divisions of India treated Eastern Himalaya as a separate area and merged parts of Assam, Shillong plateu, Naga and Manipur hills with Myanmar. Rao (1974) described close affinities between the flora of Assam and Myanmar and treated them as a part of the Eastern border lands. Takhtajan (1986) placed Arunachal Pradesh in the Eastern Himalayan Province within Eastern Asiatic region of Boreal sub-kingdom along with parts of eastern Nepal in the west up to Kali river valley, Darjeeling, Sikkim, Bhutan, large parts of Assam Himalaya, certain south and southern parts of Tibet.

The flora of Arunachal Pradesh has close affinities with tropical South-East Asian-Malayan, temperate Himalayan-Chinese and Japanese floras and has some elements common with peninsular India, Sri Lanka, Tibet and Euro-Siberian region. Floral elements from South East Asian region, which include Myanmar, Thailand, Indo-China, Indonesia and Malaysia, were found in the tropical and subtropical forests of the proposed project area. These include many trees, shrubs and climbers such as *Bischofia javanica, Brassiopsis griffithii, Engelhardtia spicata, Oroxylum indicum,* etc. Himalayan - Chinese-Japanese elements such as *Lyonia ovalifolia, Litsea sericea, Michelia doltsopa, Quercus* spp. are quite common in this region. The European and Mediterranean elements are represented by the species of *Anemone, Artemisia, Ranunculus,* etc. The elements common with Peninsular India, Sri Lanka, Tibet, Europe and Siberia are *Capparis olacifolia, Casearia vareca, Thunbergia coccinea,* etc. The New World elements are represented by weeds of cultivated lands, open forest areas and waste places such as *Ageratum conyzoides, Bidens bipinnata* and *Chromolaena odoratum*.

xi) *Economically Important Plants*

The flora of Arunachal Pradesh has a rich diversity of plants of day-to-day importance which have been used by the local communities for centuries as the only means of sustenance. The different tribes living in this area frequently use the plant materials for their daily needs as food, medicine, fiber, fodder, fuel wood and timber and various minor forest products. The usage of various plant species by the local tribes varies with the altitude and availability of resources in the surrounding areas. A comprehensive account of these plant resources given below:

Medicinal Plants

This region harbours a wide range of medicinal plants used in Ayurvedic, Homoeopathic and Unani medicines or used by the local people. Some of the medicinal plants like *Achyranthes aspera, Acorus calamus, Artemisia nilagirica, Bergenia ciliata, Cyperus rotundus, Gynocardia odorata, Hedychium spicatum, Houttuynia cordata, Oroxylum indicum* and *Viola betonicifolia* are quite common in the tropical and sub-tropical parts of proposed project. *Berberis asiatica, Gaultheria numularoides, Lyonia ovalifolia, etc.* are common in the temperate part. These plants are used internally for treating stomachic diarrhea, dysentery, cough, cold, fever and asthma and externally for rheumatism, skin diseases, cuts, boils and injuries. The list of some medicinally important plant species found in the project area given in Table 3.5.1.9 (**Plate 3.5.1.2a**).

Table 3.5.1.9 Some common medicinal plants of project area

Sl. No.	Botanical Name	Family	Vern./ Local Name	Altitude (m)	Part/s used
1.	*Amomum subulatum*	Zingiberaceae	Eleichi	Up to 1200	Fruit
2.	*Abroma angusta*	Sterculiaceae	Yadukh	900-1050	Roots
3.	*Achyranthes aspera*	Amaranthaceae	Chir-chita	Up to 2400	whole plant
4.	*Acorus calamus*	Acoraceae	Kilatolyo	1000-2000	Rhizome
5.	*Ageratum conyzoides*	Asteraceae	Pasho	Up to 2600	Leaf
6.	*Arisaema tortuosum*	Araceae	Tongsa	Up to 2700	Tuber
7.	*Bischofia javanica*	Bischofiaceae	kainjal	Up to 1200	Fruit
8.	*Centella asiatica*	Apiaceae	Barong	900- 2300	Whole plant
9.	*Engelthardtia spicata*	Juglandaceae	Silapoma	800-1600	Bark
10.	*Gynocardia odorata*	Flacourticeae	Gante	Up to 1200	Fruit
11.	*Hedychium spicatum*	Zingiberaceae	Ruksana	Upto 1800	Root
12.	*Houttuynia cordata*	Saururaceae	Honya	1000-2400	Leaf
13.	*Lyonia ovalifolia*	Ericaceae	Sinka	1000-3000	Leaf
14.	*Oroxylum indicum*	Begnoniaceae	Paksam	250-900	Seed
15.	*Molinaria capitulata*	Hypoxidaceae	Kimu	800-1600	Fruit
16.	*Ostodes paniculata*	Euphorbiaceae	Byapari	Up to 1000	Leaves

17.	*Rhus chinensis*	Anacardiaceae	Bakimilio	Up to 1500	Fruits
18	*Viola betonicifolia*	vanfsa	Violaceae	Up to 1500	Whole plant
19.	*Zanthoxylum acanthopodium*	Rutaceae	Honyum	1000-2000	Whole plant

Food Plants

The natives of Arunachal collect a large number of wild edible plants in the form of tubers, rhizomes, shoots, flowers, fruits, berries, seeds, etc. from the natural forests to supplement their diet. These communities have evolved sound techniques for the safe consumption of these forest products through ages. The local people have definite knowledge of poisonous or toxic plants which can not be consumed raw and this information is passed on to the next generation. These wild edible species are very rich in carbohydrates, starch, protein, sugar and oil. Among the wild edible plants consumed are the leaves and young twigs of *Aconogonum molle, Amaranthus spinosus, Chenopodium album, Fagopyrum esculentum, Girardinia diversifolia, Rumex nepalensis*, etc. The rhizomes and tubers of *Colocasia esculenta, Dioscorea bulbifera* and *Zingiber officinale* are commonly consumed as vegetables. Young shoots of *Bambusa tulda* and *Dendrocalamus hamiltonii* are used as food ingredients. Flower buds of *Bauhinia purpurea* and *Oroxylum indicum* are used as vegetables. Fruits of *Garcinia cowa, Ficus* spp., *Musa balbisiana, Phyllanthus emblica, Spondias pinnata*, etc. are eaten as raw or cooked as vegetables.

Horticultural Fruits

C*itrus limon* (Nimbu), *C. reticulata* (Suntala), *Mangifera indica* (Aam), *Morus indica* (Mulberry), *Musa balbisiana* (Kaul), *Phyllanthus emblica* (Aonla), *Psidium guajava* (Guava), *Prunus persica* (Peach), *Pyrus communis* (Naspati), etc are some of the fruits yielding cultigens in the area (**Plate 3.5.1.2b**).

Fodder Plants

The human population of the catchment depends essentially on naturally growing trees, shrubs, herbs and grasses for the fodder requirements of their cattle and livestock. Some fodder trees like *Bauhinia purpurea, Ficus auriculata, F. semicordata* and *Morus laevigata* are grown as fodder plants at low altitudes in the proposed project area. In addition to these, there are many shrubs and herbs viz., *Bambusa tulda, Capillipedium assimile, Debregeasia longifolia, Dendrocalamus* *hamiltonii*, *Digitaria ciliaris, Eleusine coracana, Oryza sativa, Setaria* spp., etc are also used for this purpose.

Timber Trees and Fuelwood

Most important timber yielding species of the area include *Altingia excelsa* (Jutli), *Bischofia javanica* (Kainjal), *Castanopsis indica* (Hingori), *Kydia calycina* (Pichola), *Pinus wallichiana* (Blue pine), *Terminalia myriocarpa* (Hollock), etc. In addition to these trees, some woody bamboos like *Bambusa palllida*, *B. tulda* and *Dendrocalamus hamiltonii* are also used for this purpose.

Miscellaneous uses

Some of the plant species in the project area are used by the local inhabitants for various purposes. A list of some commonly occurring plant species and their miscellaneous uses are given in Table 3.5.1.10.

Table 3.5.1.10 List of some common useful plant species of the project area

Sl. No.	Plant Species	Miscellaneous uses
1.	*Artemisia nilagirica*	The extracted juice from the leaves is diluted when taken bath in it relives itching.
2.	*Colocasia esculenta*	Tubers of this plants are eaten as vegetables.
3.	*Eleusine coracana*	Cultivated for seeds in Jhum areas.
4.	*Fagopyrum esculentum*	Leaves cooked as vegetables.
5.	*Gynocardia odorata*	The fruit pounded and mixed with water and used as poison for catching fishes.
6.	*Hedychium spicatum*	Cultivated for ornamental purpose
7.	*Houttuynia cordata*	The whole plant is used as condiment.
8.	*Macaranga denticulata*	Berries are eaten fresh in case of fever.
9.	*Molinaria capitulata*	Fruits are eaten.
10.	*Oxyspora paniculata*	The stem is used as tooth brush.

Annexure-III List of gymnosperms and angiosperms in the study area of Tato-I HEP

Gymnosperms				
Genus	**Species**	**Family**	**Habit**	**Altitude(m)**
Pinus	*wallichiana*	Pinaceae	tree	1200-2400
Angiosperms				
Anemone	*vitifolia*	Ranunculaceae	herb	1200-2400
Clematis	*buchananiana*	Ranunculaceae	climber	800-1000
	gouriana	Ranunculaceae	climber	800-1200
Ranunculus	*cantoniensis*	Ranunculaceae	herb	950-2500
Thalictrum	*foliolosum*	Ranunculaceae	herb	to 1800
Magnolia	*hodgsonii*	Magnoliaceae	tree	Up to 1500
Michelia	*doltsopa*	Magnoliaceae	tree	1300-1700
	glabra	Magnoliaceae	tree	800-1200
	oblonga	Magnoliaceae	tree	1200-1800
	punduana	Magnoliaceae	tree	1000-1500
Stephania	*elegans*	Menispermaceae	climber	to 1800
	glandulifera	Menispermaceae	climber	450-1700
Tinospora	*crispa*	Menispermaceae	climber	800-1000
Brassica	*nigra*	Brassicaceae	herb	to 1500
	juncea	Brassicaceae	herb	1000-1200
Cardamine	*hirsuta*	Brassicaceae	herb	800-1000
Capparis	*assamica*	Capparaceae	herb	800-1200
Viola	*betonicifolia*	Violaceae	herb	800-1500
Casearia	*vareca*	Flacourtiaceae	tree	800-1200
Gynocardia	*odorata*	Flacourtiaceae	tree	800-1100
Arenaria	*neelgherrensis*	Caryophllaceae	herb	1000-2300
	orbiculata	Caryophllaceae	herb	15-2600
Brachystema	*calycinum*	Caryophllaceae	herb	1100-2500
Drymaria	*diandra*	Caryophllaceae	herb	1000-1300
Stellaria	*decumbens*	Caryophllaceae	herb	1000-1600
Hypericum	*elodeoides*	Hypericaceae	herb	1100-3000
	japonicum	Hypericaceae	herb	1700-1800
Garcinia	*cowa*	Cluciaceae	tree	800-1200
Camellia	*caudata*	Theacee	shrub	1000-1800

	kissi	Theaceae	shrub	1100-1800
Eurya	*siangensis*	theaceae	shrub	1150-1800
	acuminata	Theaceae	tree	900-1500
	cerasifolia	Theaceae	tree	1500-1800
	nitida	Theaceae	tree	1000-2000
Schima	*wallichii*	Theaceae	tree	1200-2000
Saurauia	*punduana*	Actinidiaceae	tree	900-1800
Abelmoschus	*manihot*	Malvaceae	herb	800-1200
Kydia	*calycina*	Malvaceae	tree	800-1400
Sida	*acuta*	Malvaceae	shrub	800-1200
	rhombifolia	Malvceae	herb	800-1500
Urena	*lobata*	Malvaceae	herb	to 1500
Abroma	*angusta*	Malvaceae	shrub	800-900
Endospermum	*chinense*	Sterculiaceae	tree	800-1000
Sloanea	*tomentosa*	Elaeocarpaceae	tree	1400-1600
Elaeocarpus	*varunua*	Elaeocarpacdeae	tree	1400-1600
Hiptage	*benghalensis*	Malpighiaceae	climber	to 1800
Impatiens	*angustiflora*	Balsaminaceae	herb	1000-1500
	arguta	Balsaminaceae	herb	900-2130
	drepanophora	Balsaminaceae	herb	800-1500
	laevigata	Balsaminaceae	herb	800-1000
	racemosa	Balsaminaceae	herb	1500-2000
	tripetala	Balsaminaceae	herb	to 1500
Oxalis	*corniculata*	Oxalidaceae	herb	to 2700
Clausena	*excavata*	Rutaceae	tree	to 1000
Tetradium	*rutaecarpa*	Rutaceae	tree	to 1000
Todalia	*asiatica*	Rutaceae	shrub	to 1600
Zanthoxylum	*acanthopodium*	Rutaceae	shrub	1000-2500
Aglaia	*edulis*	Meliaceae	tree	
Aphanomixis	*chittagona*	Meliaceae	tree	800-1200
Chukrasia	*tabularis*	Meliaceae	tree	800-1600
Dysoxylum	*gobara*	Meliaceae	tree	800-1100
Toona	*microcarpa*	Meliaceae	tree	to 1200
Ilex	*dipyrena*	Aquifoliaceae	tree	1000-1800

Celastrus	*championii*	Celastraceae	climber	1000-1800
Euonymus	*hamiltonianus*	Celastraceae	tree	Up to 1200
Cissus	*japonica*	Vitaceae	climber	to 1500
	heyneana	Vitaceae	climber	800- 1400
Cayratia	*japonica*	Vitaceae	climber	to 1500
Parthenocissus	*semicordata*	Vitaceae	climber	1200-1900
Leea	*asiatica*	Vitaceae	shrub	800-1200
	indica	Vitaceae	shrub	to 1000
Allophylus	*serratus*	Sapindaceae	shrub	800-1200
Lepisanthes	*senegalensis*	Sapindaceae	tree	Up to 1000
Acer	*thomsonii*	Aceraceae	tree	1200-2400
Spondias	*pinnata*	Anacardiaceae	tree	Up to 1000
Rhus	*succadanea*	Anacardiaceae	tree	to 1650
	chinensis	Anacardiaceae	tree	to 2000
Crotolaria	*cajan*	Papilionaceae	shrub	to1500
Desmodium	*microphyllum*	Papilionaceae	herb	to 1600
Erythrina	*stricta*	Papilionaceae	tree	to 1400
Bauhinia	*purpurea*	Caesalpiniaceae	tree	to 1500
	variegata	Caesalpiniaceae	tree	to 1750
Albizia	*lebbeck*	Mimosaceae	tree	to 1500
	odoratissima	Mimosaceae	tree	to1500
Photinia	*cuspidata*	Rosaceae	tree	1500-2200
Duschesnia	*indica*	Rosaceae	herb	1200-2400
Potentilla	*nepalensis*	Rosaceae	herb	1500-2500
	sundersiana	Rosaceae	herb	1800-3600
Prunus	*cerasoides*	Rosaceae	tree	1200-3000
	persica	Rosaceae	tree	800-1500
Rubus	*burkillii*	Rosaceae	shrub	900-1500
	hamiltonii	Rosaceae	shrub	900-1500
	ellipticus	Rosaceae	shrub	1500-1800
	lineatus	Rosaceae	shrub	to 2000
	rosifolius	Rosaceae	shrub	1000-1500
	niveus	Rosaceae	shrub	to 1100
Rosa	*brunonii*	Rosaceae	shrub	to 2599

Bergenia	*ciliata*	Saxifragaceae	herb	
Dichroa	*febrifuga*	Saxifragaceae	shrub	to 2500
Hydrangea	*robusta*	Hydrangeaceae	shrub	to 2500
Altingia	*excelsa*	Hamamelidaceae	tree	800-1600
Exbucklandia	*populnea*	Hamamelidaceae	tree	to 2000
Melastoma	*erythrophylla*	Melastomataceae	shrub	600-1500
	malabathricum	Melastomataceae	shrub	400-1400
Osbeckia	*normale*	Melastomataceae	shrub	to 2000
	chinensis	Melastomataceae	shrub	
Oxyspora	*paniculata*	Melastomataceae	shrub	1000-2000
Ludwigia	*octavalvis*	Onagraceae	herb	to 900
Benincasa	*hispida*	Cucurbitaceae	climber	500-1400
Cucumis	*melo*	Cucurbitaceae	climber	
Centella	*asiatica*		herb	to 1700
Hydrocotyle	*nepalensis*	Apiaceae	herb	to 1600
Oenanthe	*javanica*	Apiaceae	herb	1000-2000
Pimpinella	*diversifolia*	Apiaceae	herb	1500-2200
Brassiopsis	*aculeata*	Araliaceae	tree	1500-2000
	griffithii	Araliaceae	tree	800-1400
Hedera	*trifoliatus*	Araliaceae	shrub	1000-1200
	nepalensis	Araliaceae	climber	1500-2500
Pentapanax	*leschenaultii*	Araliaceae	shrub	to 1500
Schefflera	*bengalensis*	Araliaceae	shrub	800-1500
	impressa	Araliaceae	tree	
	wallichiana	Araliaceae	tree	1500-1800
Alangium	*chinense*	Alangiaceae	tree	1500-2000
Viburnum	*colebrookianum*	Caprifoliaceae	shrub	to 1000
Galium	*asperuloides*	Rubiaceae	herb	200-2000
Hedyotis	*scandens*	Rubiaceae	herb	1500-2400
Knoxia	*sumatrensis*	Rubiaceae	herb	
Luculia	*pinceana*	Rubiaceae	shrub	1100-1800
Mussaenda	*roxburghii*	Rubiaceae	shrub	to 1500
Ophiorrhiza	*glabra*	Rubiaceae	shrub	600-1500
Paederia	*foetida*	Rubiaceae	shrub	800-1200

Valeriana	*jatamansi*	Valerianaceae	herb	2000-3000
Artemisia	*nilagirica*	Asteraceae	herb	800- 2500
Aster	*molliusculus*	Asteraceae	herb	1200-1800
Conyza	*bonariensis*	Asteraceae	herb	to 2450
	japonica	Asteraceae	herb	900-2500
	candensis	Asteraceae	herb	1500-2500
Dichrocephala	*integrifolia*	Asteraceae	herb	to 1800
Circium	*wallichii*	Asteraceae	herb	1400-2400
Ageratum	*conyzoides*	Asteraceae	herb	to 2000
Ageratina	*adenophora*	Asteraceae	herb	to 1900
Chromolaena	*odoratum*	Asteraceae	shrub	to 2000
Bidens	*bipinnatus*	Asteraceae	herb	to 2000
Eclipta	*prostrata*	Asteraceae	herb	to 1500
Galinsoga	*parviflora*	Asteraceae	herb	to 2500
Tridex	*procumbens*	Asteraceae	herb	to1000
Inula	*cappa*	Asteraceae	herb	to 2400
Anaphalis	*busua*	Asteraceae	herb	600-3300
Gnaphalium	*affine*	Asteraceae	herb	1200-3000
	hypoleucum	Asteraceae	herb	1500-2400
Tagetes	*minuta*	Asteraceae	herb	to 2000
Vernonia	*cinerea*	Asteraceae	herb	to 1500
Campanula	*sylvatica*	Campanulaceae	herb	to 1800
	pallida	Campanulaceae	herb	1200-3000
Gaultheria	*nummularioides*	Ericaceae	shrub	1200-2400
Lyonia	*ovalifolia*	Ericaceae	tree	1400-2400
Maesa	*chisia*	Myrsinaceae	shrub	900-1800
Myrsine	*semiserrata*	Myrsinaceae	shrub	1000-2700
Symplocos	*ramosissima*	Symplocaceae	tree	1000-2000
Jasminum	*multiflorum*	Oleaceae	climber	to 1500
Cryptolepis	*buchanani*	Apocynaceae	climber	1000-1800
Trachelospermum	*fragrans*	Apocynaceae	climber	1000-2100
Marsdenia	*roylei*	Asclepiadaceae	climber	900-2400
Buddleja	*paniculata*	Loganiaceae	shrub	850-1700
	asiatica	Loganiaceae	shrub	850-1600

Cynoglossum	*glochdiatum*	Boraginaceae	herb	1200-2400
Ipomoea	*purpurea*	Convolvulaceae	climber	to 1600
	carnea	Convolvulaceae	shrub	to 1200
Cuscuta	*reflexa*	Cucutaceae	climber	800-2400
Solanum	*nigrum*	Solanaceae	herb	800-1800
	viarum	Solanaceae	shrub	to 1200
Physalis	*minima*	Solanaceae	herb	800-1200
Datura	*stramonium*	Solanaceae	shrub	to 1400
Mazus	*surculosus*	Scrophulariaceae	herb	1200-2400
	pumilus	Scrophulariaceae	herb	1000-1800
Lindera	*antipoda*	Scrophulariaceae	herb	Ca 1250
Mimulus	*nepalensis*	Scrophulariaceae	herb	1200-1800
Verbascum	*thapsus*	Scrophulariaceae	herb	to 900
Aeschynanthus	*gracilis*	Gesneraceae	shrub	to 1500
Chirita	*pumila*	Gesneraceae	herb	800-1700
Didymocarpus	*andersonii*	Gesneraceae	herb	800-1600
	pulcher	Gesneraceae	herb	900-2500
Oroxylum	*indicum*	Begnoniaceae	tree	to 1550
Thunbergia	*coccinea*	Acanthaceae	climber	800-1800
Strobilanthes	*extensa*	Acanthaceae	shrub	800-1900
	hamiltoniana	Acanthaceae	sh	to 1500
Dicliptera	*bupleuroides*	Acanthaceae	herb	to 1800
Plantago	*erosa*	Plantaginaceae	herb	800-1600
Ocimum	*gratissimum*	Lamiaceae	herb	to 2000
Plectranthus	*barbatus*	Lamiaceae	herb	1400-2200
Anisochilus	*pallidus*	Lamiaceae	herb	900-1600
Elsholtzia	*ciliata*	Lamiaceae	herb	1300-2600
	strobilifera	Lamiaceae	herb	1500-2700
Perilla	*frutescens*	Lamiaceae	herb	800-1500
Salvia	*plebeia*	Lamiaceae	herb	1525
Scutellaria	*plectranthoides*	Lamiaceae	herb	1200-2400
Anisomeles	*discolor*	Lamiaceae	herb	800-2400
Colquhounia	*indica*	Lamiaceae	herb	800-2300
Leucosceptrum	*canum*	Lamiaceae	shrub	1200-2500

Ajuga	*macrosperma*	Lamiaceae	herb	1200-3000
Amaranthus	*spinosus*	Amaranthaceae	herb	to 2000
Cyathula	*prostrata*	Amaranthaceae	herb	to 1800
Achyranthes	*aspera*	Amaranthaceae	herb	to 1800
Alternanthera	*sessilis*	Amaranthaceae	herb	to 1500
Gomphrena	*celosoides*	Amaranthaceae	herb	800-1700
Chenopodium	*album*	Chenopodiaceae	herb	800-2100
	aromaticum	Chenopodiaceae	herb	800-2400
Polygonum	*plebium*	Polygonaceae	herb	to 1500
Persicaria	*barbata*	Polygonaceae	herb	800-2000
	posumbu	Polygonaceae	herb	800-1500
	capitata	Polygonaceae	herb	800-2600
	chinense	Polygonaceae	herb	800-2600
Aconogonum	*molle*	Polygonaceae	shrub	1000-2000
Fagopyrum	*esculentum*	Polygonaceae	herb	1500-2800
Rumex	*nepalensis*	Polygonaceae	herb	1000-3000
Houttuynia	*cordata*	Saururaceae	herb	1000-1200
Pepromia	*heyneana*	Piperaceae	herb	to 1800
	reflexa	Piperaceae	herb	to 1890
Piper	*pedicillatum*	Piperaceae	shrub	to 1400
Phoebe	*hainesiana*	Lauraceae	tree	800-1600
Cinnamomum	*tamala*	Lauraceae	tree	1400-1700
	glauscescens	Lauraceae	tree	to 1200
Persea	*robusta*	Lauraceae	tree	to 1200
Litsea	*sericea*	Lauraceae	tree	1400-2500
Actinodaphne	*obovata*	Lauraceae	tree	to 1400
Taxilus	*umbeliflora*	Loranthaceae	shrub	to 1200
Scurrula	*umbeliflora*	Loranthaceae	shrub	to 2000
Euphorbia	*hirta*	Euphorbiaceae	herb	to 1200
	stracheyi	Euphorbiaceae	herb	1500-2500
Macaranga	*denticulata*	Euphorbiaceae	tree	to 1800
Sapium	*sebiferum*	Euphorbiaceae	tree	800-1500
Mallotus	*philippensis*	Euphorbiaceae	tree	800-1600
Baccaurea	*ramiflora*	Euphorbiaceae	tree	to 1000

Ostodes	*paniculata*	Euphorbiaceae	tree	800-1200
Ricinus	*communis*	Euphorbiaceae	shrub	to 1600
Phyllanthus	*emblica*	Euphorbiaceae	tree	to 1200
	urinus	Euphorbiaceae	herb	to 1000
Bischofia	*javanica*	Bischofiaceae	tree	to 1000
Morus	*laevigata*	Moraceae	tree	to 2000
Ficus	*semicordata*	Moraceae	tree	to 1500
	oligodon	Moraceae	tree	to 1400
	auriculata	Moraceae	tree	to 1500
Urtica	*parviflora*	Urticaceae	herb	to 1600
Gerardinia	*diversifolia*	Urticaceae	herb	to 2000
Pilea	*umbrosa*	Urticaceae	herb	to 1600
	scripta	Urticaceae	herb	to 1400
Lecanthus	*peduncularis*	Urticaceae	herb	to 1600
Elatostema	*sessile*	Urticaceae	herb	to 1500
	sesquifolium	Urticaceae	shrub	to 1600
Boehmeria	*rugulosa*	Urticaceae	shrub	to 1400
	macrophylla	urticaceae	shrub	to 1800
Debregeasia	*longifolia*	Urticaceae	shrub	800-1800
Engelhardtia	*spicata*	Juglandiaceae	tree	800- 2300
Carpinus	*viminea*	Betulaceae	tree	1200- 2600
Alnus	*nepalensis*	Betulaceae	tree	1000-2200
Quercus	*semiserrata*	Fagaceae	tree	1600- 2300
	glauca	Fagaceae	tree	1200-1800
	leucotrichophora	Fagaceae	tree	1200-2600
	lamellosa	Fagaceae	tree	1700-2700
Lithocarpus	*elegans*	Fagaceae	tree	900-2200
Castanopsis	*indica*	Fagaceae	tree	800-1500
	hystrix	Fagaceae	tree	2000-2300
Populus	*australis*	Salicaceae	tree	to 2000
Monocots				
Vallisneria	*spiralis*	Hydrocharataceae	herb	to 1200
Hydrilla	*verticillata*	Hydrocharataceae	herb	to 1200
Bulbophyllum	*affine*	Orchidaceae	ep. Herb	1200-2000

Dendrobium	*porphrochilum*	Orchidaceae	ep. Herb	1000-2000
	amoenum	Orchidaceae	ep. Herb	1000-1500
	longicornu	Orchidaceae	ep. Herb	1000-1500
Calanthe	*ovalis*	Orchidaceae	ep. Herb	800-1800
Eria	*elegans*	Orchidaceae	ep. Herb	1500-2500
Spiranthes	*sinensis*	Orchidaceae	terr. herb	1000-2500
Amomum	*subulatum*	Zingiberaceae	herb	Up to 1200
Curcuma	*aromaticum*	Zingiberaceae	herb	to1500
Hedychium	*spicatum*	Zingiberaceae	herb	to1800
	coccinneum	Zingiberaceae	herb	to1502
	thrysiforme	Zingiberaceae	herb	to1503
Zingiber	*offiinale*	Zingiberaceae	herb	cult.
Musa	*bulbisiana*	Musaceae	herb	to 1600
	paradisiaca	Musaceae	herb	to 1500
Dioscorea	*oppositifolia*	Dioscoreaceae	climber	to 2000
Smilax	*glabra*	Smilacaceae	climber	to 1500
	aspera	Smilacaceae	climber	to 1800
	aspericaulis	Smilacaceae	climber	to 1500
Polygonatum	*oppositifolium*	Liliaceae	herb	to 2000
Molineria	*capitulata*	Hypoxidaceae	herb	to 2300
Pothos	*cathcartii*	Araceae	climber	to 1500
Raphidophora	*decursiva*	Araceae	climber	to 1500
Colocasia	*esculenta*	Araceae	herb	to 1800
	affinis	Araceae	herb	to 1500
Arisaema	*tortuosum*	Araceae	herb	to 2400
Acorus	*calamus*	Acoraceae	herb	1000-2700
Commelina	*benghalensis*	Commelinaceae	herb	Up to 1800
Murdania	*nudiflorum*	Commelinaceae	herb	Up to 1600
Cyanotis	*cristata*	Commelinaceae	herb	Up to 1500
Floscopa	*scandens*	Commelinaceae	herb	Up to 1800
Pollia	*hasskarlii*	Commelinaceae	herb	Up to 1500
Juncus	*inflexus*	Juncaceae	herb	Up to 1500
Calamus	*erectus*	Arecaceae	shrub	Up to 1200
Arenga	*saccharifera*	Arecaceae	shrub	Upto 1400

Pandanus	*nepalensis*	Pandanaceae	tree	Up to 1400
Eriocaulon	*viride*	Eriocaulaceae	herb	to 1500
Kyllinga	*brevifolia*	Cyperaceae	herb	to 2000
Bulbostylis	*densa*	Cyperaceae	herb	1500-2700
Cyperus	*niveus*	Cyperaceae	herb	throughout
	squarosus	Cyperaceae	herb	throughout
	compressus	Cyperaceae	herb	throughout
	cyperoides	Cyperaceae	herb	to 1500
	densa	Cyperaceae	herb	to 1500
	irria	Cyperaceae	herb	to 1800
Fimbristylis	*dichotoma*	Cyperaceae	herb	to 2300
	junciformis	Cyperaceae	herb	300-2400
Scirpus	*teratanus*	Cyperaceae	herb	to 1700
Schoenoplectus	*mucronatus*	Cyperaceae	herb	to 1800
	triqueter	Cyperaceae	herb	to 1800
Eriophorum	*comosum*	Cyperaceae	herb	300-3000
Carex	*nubigena*	Cyperaceae	herb	1500-4000
	longipes	Cyperaceae	herb	1000-3000
	myosurus	Cyperaceae	herb	1200-2000
	cruciata	Cyperaceae	herb	to1500
	filicina	Cyperaceae	herb	1000-1800
	decora	Cyperaceae	herb	1200-2400
Saccharum	*spontaneum*	Poaceae	herb	to 1500
	longisetosus	Poaceae	herb	to 1600
	rufipilus	Poaceae	herb	1800-2200
Paspalum	*scrobiculatum*	Poaceae	herb	to 2000
	paspalodes	Poaceae	herb	to 2300
Isachne	*logiflora*	Poaceae	herb	to 1700
	albens	Poaceae	herb	to 2300
Panicum	*antidotale*	Poaceae	herb	to 1400
	sumatrense	Poaceae	herb	to 1500
Thysanolaena	*latifolia*	Poaceae	herb	to 1500
Oplismenus	*compositus*	Poaceae	herb	to2300
Arundinella	*nepalensis*	Poaceae	herb	to 1500

Setaria	*glauca*	Poaceae	herb	to 2000
	verticillata	Poaceae	herb	to 1500
	palmifolia	Poaceae	herb	to 1600
Zea	*mays*	Poaceae	herb	to 2300
Imperata	*cylindrica*	Poaceae	herb	to 2000
Digitaria	*ciliaris*	Poaceae	herb	to 1700
Pogonatherum	*paniceum*	Poaceae	herb	to 1500
Arthraxon	*hispidus*	Poaceae	herb	to 1700
Apluda	*mutica*	Poaceae	herb	1400-1600
Capillipedium	*assimile*	Poaceae	herb	800-1200
Chrysopogon	*gryllus*	Poaceae	herb	to 2000
	acicularis	Poaceae	herb	to 1500
Themeda	*arundinacea*	Poaceae	herb	to 1500
	anathera	Poaceae	herb	to 1800
Sporobolus	*diander*	Poaceae	herb	to 1800
Agrostis	*micrantha*	Poaceae	herb	1200-1800
	vinealis	Poaceae	herb	to 1800
Calamagrostis	*emodensis*	Poaceae	herb	to 2100
Cynodon	*dactylon*	Poaceae	herb	to 2400
Eleusine	*indica*	poaceae	herb	to 1500
	coracana	Poaceae	herb	to 2300
Brachiaria	*ramosa*	Poaceae	herb	to 1500
Helictotrichon	*parviflorum*	Poaceae	herb	1200-1900
Arundo	*donax*	Poaceae	herb	to 1500
Eragrostis	*nigra*	Poaceae	herb	to 2400
	pilosa	Poaceae	herb	to 1500
	tenella	Poaceae	herb	to 1900
Poa	*annua*	Poaceae	herb	to 2800
	supina	Poaceae	herb	1800-2500
Brachypodium	*sylvaticum*	Poaceae	herb	1200-1800
Bambusa	*tulda*	Poaceae	shrub	to 1500
Melocalamus	*compactiflora*	Poaceae	shrub	to 1400
Dendrocalamus	*hamiltonii*	Poaceae	shrub	to 1400

Plate 3.5.1.1a Epiphytic lichen (Foliose lichen)

Plate 3.5.1.1b *Rhaphidophora decursiva* (climber in flowering)

Plate 3.5.1.1c ***Pteris*** **sp. with** ***Saccharum longisetosum***

Plate 3.5.1.2a *Cynoglosum zeylanicum*

Plate 3.5.1.2b *Pyrus communis* (cultivated fruit)

3.5.2 FAUNAL ELEMENTS

Arunachal Pradesh has been recognized as the 25th biodiversity hotspot in the world (Chowdhery, 1999). It is also among the 200 globally important eco-regions (Olson and Dinerstein, 1998). The entire area is covered under the 2D Eastern Himalaya biotic province. The region is located at the boundary of Indo-china and Indo-Malayan bio-geographic region, therefore, the fauna and flora of the region show close affinities with the Indo-china and Indo-Malayan biogeographic regions. Out of the total geographical area of 83,743 Sq. km, the forest cover accounts for 68847 Sq. Km. Thus, 82.21% of the State is under the forest cover. It is situated in the extreme North East corner of India. Arunachal Pradesh houses 40% of the floral and faunal species of India, many of which are endemic to the region. Although the floral and faunal diversity is rich and enormous in Arunachal Pradesh, the stresses on the biodiversity due to habitat loss and degradation can not be denied. The faunal elements especially mammals and birds are already under threat due to illegal poaching and hunting.

In addition to luxuriant forest growth and high faunal diversity, Arunachal Pradesh is richest in water resources and becomes a main target of development of hydro-power. The schemes thus identified in this State alone, is more than 50% of the PM's 50,000 MW hydro-power. These projects are supposed to lead to enormous impacts on the biodiversity.

The present contribution addresses the baseline information on fauna of the catchment and surrounding area of proposed Tato I project on Yarjep river in West Siang district of Arunachal Pradesh. The district also has wide altitudinal variation ranges nearly from 500 m to more than 6000 m. and harbours a large number of floral and faunal species. Siang basin (including Siyom and Yarjep sub basins) has also been planned for the exploitation of hydro-power under the cascade development. Thus, the identification and prediction of impacts of Tato-I H.E. project on the faunal elements would not be limited to the surrounding area, therefore, an approach of cumulative impacts is required.

Notably, surroundings and catchment of the Tato-I H.E. Project is an abode of various sub tribes which are unique in culture and customs and follow customary hunting. They have close association with forest, therefore, in order to conserve the biodiversity, the issues of these tribes are required to address imperatively. Tato-I H.E. Project is located between Tato II H.E. Project and Heo H.E. Project, thus, having a small free draining area. In this section we described the fauna of catchment, influence (800 m to 3600 m) and project area. The primary surveys were carried out in the project components area and free draining catchment.

3.5.2.1 Zoogeographical Distribution

3.5.2.1.1 *Catchment Area & Influence Area*

i) Mammals

Mammalian fauna of the catchment area is comprised of more than 36 species, grouped under 15 families (Table 3.5.2.1). All species of the catchment except Snow leopard, Takin, Musk deer, Serow and Himalayan marmot share the influence area (10 km radius) of the proposed project.

Primates comprises of four species, all are common in and around the influence area. Capped langur, Assamese macaque and Rhesus macaque are common in the region (up to 1600) and generally hunted upon by tribal people. Slow loris inhabits dense forest and rarely sighted. Carnivora is comprised of 12 species, except snow leopard all are distributed in the catchment and influence areas. Snow leopard is restricted in the upper catchment (above 4000 m). Though, its presence in the catchment is not confirmed. The presence of hides and jaws of Common leopard, Small Indian Civet, Small Indian mongoose and Black bear in the households of tribal villages as trophies indicate their common presence in the region (**Plate 3.5.2.1a**). Clouded leopard, Wild dog, Indian fox, and Small Indian Civet inhabit inner part of forest, therefore, rarely sighted in the influence area.

Artiodactyla is represented by 8 species and except *Budorcas taxicolor* (Takin) and *Muschus chrysogaster* (Musk deer) all are commonly present in the catchment and influence areas. Takin and Musk deer are distributed above 3000 m. in the catchment. Wild boar, Barking dear, Sambar, Goral and Mainland Serow are relatively common in the study area. They are hunted upon for food, their hides and horns and skulls. *Bos frontalis* (Mithun) is a semi domesticated animal and a large number of mithuns are slaughtered at the occasion of festivals and ceremonies.

Group Chiroptera is not well studied in the catchment. Interviewing the local residents, the presence of three species could be confirmed in the influence area of the proposed project. Rodentia is comprised of 4 species of squirrels and 3 species of rats. Squirrels are distributed in the inner forests while rats are common in and around the settlements. *Hylopetes alboniger* (Particolored flying squirrel) is confined to the lower reaches (below 900 m) of the proposed project while *Marmota himalayana* (Himalayan marmot) is confined to upper catchment (above 3500 m).

Conservation Status

Based on the WPA (1972) criterion a total of 12 species (Capped Langur, Slow loris, Common leopard, Clouded leopard, Leopard cat, etc.) inhabiting catchment area are categorized as Schedule I species, while 7 animals (Assamese macaque, Rhesus macaque, Wild dog, Indian fox, etc.) are classified as Schedule II species). Out of 12 Schedule I species 9 share the influence area of the project. None of the species belonging to order Chiroptera and Rodentia is Schedule I while 3 species have been considered as 'Vermin' under Schedule V (Table 5.3.2.1). Based on the criterion of ZSI (1994) a total of 10 species inhabiting catchment as well as influence areas are assessed for their conservation, out of which 6 are 'vulnerable', one is 'endangered' and three are 'insufficient known'. As per criterion of BCPP – CAMP, two species namely Common leopard and Musk deer are categorized as 'vulnerable' species while Snow leopard is considered as 'endangered' species. The remaining species are either 'low risk – least concerned' or 'low risk-near threatened'. In the IUCN red list all species of the catchment have been categorized for their conservation status. A total 5 species are placed under 'vulnerable' category while 3 are 'endangered'. Other species are considered as 'least concerned' or 'near threatened' (Table 3.5.2.1).

Table 3.5.2.1 Mammalian composition and their conservation status in the catchment and influence area of the proposed Tato-I H.E. Project

Scientific name	English name	WPA (1972)	ZSI (1994)	CAMP (1998)	IUCN (2010)	Distribution CA	IA
Cercopithecidae							
Semnopithecus pleateus	Capped Langur	I	VU	LRnt	LC	+	+
Macaca assamensis	Assames macaque	II	-	LRnt	NT	+	+
M. mulatta	Rhesus macaque	II	-	LRIc	LC	+	+
Loridae							
Nycticebus coucang	Slow loris	I	IK	LRnt	VU	+	+

Felidae							
Panthera pardus	Common leopard	I	VU	VU	NT	+	+
Panthera uncia	Snow leopard	I	VU	EN	EN	+	-
Neofelis nebulosa	Clouded leopard	I	EN	LRnt	VU	+	+
Prionailurus bengalensis	Leopard cat	I	VU	LRnt	LC	+	+
Felis chaus	Jungle cat	II	-	LRnt	LC	+	+
Canidae							
Cuon alpinus	Wild dog	II	-	LRnt	EN	+	+
Canis aureus	Jackal	II	-	LRlc	LC	+	+
Vulpes bengalensis	Indian fox	II	-	LRnt	LC	+	+
Viverridae							
Viverricula indica	Small Indian Civet	II	-	LRnt	LC	+	+
Herpestidae							
Herpestes javanicus	Small Indian mongoose	IV	-	LRlc	LC	+	+
Martes flavigula	Himalayan Marten	-	-	-	-	+	+
Mustelidae							
Lutra lutra	Common otter	I	-	NE	NT	+	+
Ursidae							
Ursus thibetanus	Black bear	I	-	LRlc	VU	+	+
Suidae							
Sus scrofa cristatus	Wild boar	III	IK	LRlc	LC	+	+
Cervidae							
Muntiacus muntjak	Barking dear	III	-	LRlc	LC	+	+
Cervus unicolor	Sambar	III	-	LRlc	NT	+	+
Muschus chrysogaster	Musk deer	I	-	VU	EN	+	-
Bovidae							
Bos frontalis	Gaur	I	VU	-	-	+	+
Nemorhaedus goral	Goral	III	-	-	NT	+	+
Capricornis sumatraensis	Mainland Serow	I	VU	-	VU	+	-
Budorcas taxicolor	Takin	I	IK	-	VU	+	-
Pteropodidae							
Cynopterus brachyotis		V	-	LRlc	LC	+	+
Rousettus leschenaultia	Fulvous fruit bat	-	-	LRlc	LC	+	+
Rhinolophidae							
Rhinolophus ferrum-equinum	Horseshoe bat	-	-	-	LC	+	+

Sciuridae							
Tamiops macclellandi	Himalayan stripped squi.		-	-	LC	+	+
Petaurista magnificus	Hodgson's flying squir.	-	-	-	LC	+	
Hylopetes alboniger	Particolored flying squir.		-	-	LC	-	+
Dremomys lokriah	Orange-bellied Himalayan squir			-	LC	+	+
Marmota himalayana	Himalayan marmot	-	-	-	LC	+	-
Muridae							
Mus booduga	Indian field mouse	V	-	LRlc	LC	+	+
Mus musculus	House mouse	V	-	LRlc	LC	+	+
Rattus rattus	House rat	V	-	LRlc	LC	+	+

LC = least concerned, NT = near threatened, VU = vulnerable, EN = endangered, IK = insufficient known, LRnt = Low risk near threatened, LRlc = low risk least concerned, CA = catchment area, IA = Influence area

ii) Avifauna

Avifauna of catchment and influence area comprises of pheasants, partridge, hawk, eagle, hornbill, barbets, Cuckoo, woodpeckers, Hoopoe, owl, crow, magpie, tree pie, drongo, swallows, Myna, pitta, shrike, sparrow, tits, bulbuls, flycatcher, thrushes, laughing thrushes, warblers, babblers, redstarts, sun birds, flower peckers, rose finches, pipits, scarlet etc. Catchment and influence areas are represented nearly by 75 species belonging to more than 25 families. Above 90% of the species are common in the catchment and influence areas (Table 5.3.2.2). Only *Lophophorus sclateri*, *Tragopan temminckii* and *Lerwa lerwa* are confined in the catchment area above 3000 m. while species like *Gracula religiosa* and *Picus chlorolophus* are found in the lower part of the influence area.

Sylviidae and Timalidae are largest families represented by 14% and 11% of the total species. About 44.8% of the total species are sparse resident while 37.7% are widespread resident. A single species - *Zoothera wardii* (Pied Ground Thrush) is sparse summer visitor in the catchment area. The hunting of the birds in the area is a common phenomenon, however, it can not be attributed to the livelihood. Only children of ‘Adi’ tribe are engaged in bird hunting. *Anthracoceros albirostris* (Great Indian Pied Hornbill) is most hunted bird species in the catchment, hunted for its beak.

Conservation Status

A few species of birds inhabiting the study area have been assessed for their conservation status by WPA (1972), IUCN (2010) and Bird International (2000). Only 5 species namely

Lophophorus sclateri (Scalater's monal), *Tragopan temminckii* (Temminck's tragopan), *Lerwa lerwa* (Snow partridge), *Accipiter nisus* (Northern Sparrow Hawk) and *Anthracoceros albirostris* (Great Indian Pied Hornbill) fall under the Schedule I while majority of the species have been categorized as Schedule IV species (Table 3.5.2.2). None of the species is 'endangered' and 'vulnerable' as per the criterion of IUCN. A total of 27 species have been considered as 'least concerned' by IUCN (2010). Beautiful Nuthatch (*Sitta formosaesi*) and *Parus nuchalis* (White-napped Tit) have been placed under the 'vulnerable' category by Birdlife International (2000).

Table 3.5.2.2 Avifaunal composition and their conservation status in the catchment and influence area of the proposed Tato I H.E. Project

Scientific name	Common Name	Status				
		Distribution			Conservation	
		Habit	CA	IA	WPA	IUCN
Phasianidae						
Lophophorus sclateri	Scalater's monal	R	+	-	I	-
Lophura leucomelana	Kaleej pheasant	R	+	+		LC
Tragopan temminckii	Temminck's Tragopan	R	+	-	I	LC
Lerwa lerwa	Snow partridge	r	+	-	I	LC
Accipitridae						
Accipiter nisus	Northern Sparrow Hawk	rw	+	+	I	LC
Ictinaetus malayensis	Black Eagle	R				
Columbidae						
Columba hodgsoni	Speckled Wood Pigeon	r	+	+	IV	LC
Streptopelia chinensis	Spotted Dove	R	+	+	IV	-
Cuculidae						
Cuculus micropterus	Indian Cuckoo	R	+	+	IV	-
Eudynamys scolopacea	Indian Koel	R	+	+	IV	-
Bucerotidae						
Anthracoceros albirostris	Great Indian Pied Hornbill	r	+	+	I	LC
Picidae						
Picoides macei	Indian Fulvousbreasted	R	+	+	IV	-
Picus chlorolophus	Lesser Yellownape	R	-	+	IV	LC
Megalaimidae						
Megalaima virens	Great barbet	R	+	+	IV	LC

M. asiatica	Blue-throated Barbet	R	+	+	IV	LC
Upupidae						
Upupa epops	Hoopoe	R	+	+	IV	-
Meropidae						
Nyctionornis athertoni	Blue-bearded bee eater	R	-	+	IV	LC
Strigidae						
Glaucidium cuculoides	Barred Owlet	r	+	+	IV	-
Pittidae						
Pitta nipalensis	Bluenaped Pitta	r	+	+	IV	
Hirundinidae						
Hirundo rustica	Eastern Swallow	RW	+	+	IV	LC
Delichon nipalensis	Nepal House martin	r	+	+	IV	-
Corvidae						
Corvus macrorhynchos	Jungle Crow	R	+	+	IV	-
Dicrurus aeneus	Bronzed Drongo	r	+	+	IV	LC
Cissa chinensis	Green Magpie	r	+	+	IV	LC
Dendrocitta formosae	Himalayan Treepie	R	+	+	IV	LC
Sturnidae						
Gracula religiosa	Hill Myna	r	-	+	IV	LC
Pycnonotidae						
Pycnonotus jacosus	Redwhiskered Bulbul	R	+	+	IV	LC
P. leucogenys	Whitecheeked Bulbul	R	+	+	IV	-
Laniidae						
Lanius schach	Long-tailed Shrike	R	+	+	IV	-
L. tephronotus	Grey-backed Shrike	rW	+	+	IV	-
Sylviidae						
Phylloscopus proregulus	Pallas Leaf Warbler	rW	+	+	IV	LC
P. trochiloides	Greenish Leaf Warbler	rW	+	+	IV	-
P. chloronotus	Lemon-rumped Warbler	rW	+	+	IV	LC
Seicercus castaniceps	Chestnut-headed Flycatcher	r	+	+	IV	-
S. burki	Spectacled Warbler	rW	+	+	IV	-
S. xanthoschistos	Grey-hooded Warbler	rW	+	+	IV	-
Yuhinia nigrimenta	Black-chinned Yuhina	R	+	+	IV	-
Y. gularis	Striped-throated Yuhina	R	+	+	IV	-
Y. occipitalis	Rufous-vented Yuhina	r	+	+	IV	-

Heterophasia picaoides	Long-tailed Sibia	r	+	+	IV	-
Actinodura egertoni	Rusty-fronted Barwing	r	+	+	IV	-
Timaliade						
Garrulax striated	Striatus Laughing Thrush	r	+	+	IV	-
Garrulax albogularis	White-throated Laughing Thrush	R	+	+	IV	-
Alcippe castaneceps	Chestnut-headed Tit-babbler	r	+	+	IV	-
Alcippe nipalensis	Nepal Quaker Babbler	r	+	+	IV	LC
Pteruthius melanotis	Black-eared Shrike Babbler	r	+	+	IV	-
Pellorneum ruficeps	Puff-throated Babbler	r	+	+	IV	
Stachyris ruficeps	Pygmy Wren Babbler	r	+	+	IV	
S. nicriceps	Grey-throated Babbler	r	+	+	IV	
Cisticolidae						
Prinia hodsonii	Ashy Grey Wren Warbler	R	+	+	IV	-
P. criniger	Himalayan Brown Hill Warbler	R	+	+	IV	-
Turdidae						
Myophonus caeruleus	Blue Whistling Thrush	R	+	+	IV	-
Zoothera wardii	Pied Ground Thrush	s	+	+	IV	LC
Turdus albocinctus	Whitecollared Blackbird	r	+	+	IV	LC
T. boulboul	Greywinged Black Bird	r	+	+	IV	LC
Muscicapidae						
Muscicapa rubecoloides	Bluethroated Flycatcher	R	+	+	IV	-
Eumyias thalassina	Verditer Flycatcher	R	+	+	IV	-
Rhyacornis fuliginosus	Plubeous Redstart	r	+	+	IV	-
Chaimarrornis leucocephalus	White Capped Redstart	r	+	+	IV	-
Cinculus pallasii	Himalayan Brown-dipper	r	+	+	IV	-
Enicurus scouleri	Little Forktail	r	+	+	IV	-
Paridae						
Parus monticolus	Greenbacked Tit	r	+	+	IV	-
*P. nuchalis**	White napped Tit	r	+	+	IV	LC
Sittidae						
Sitta himalayensis	Himalayan Whitetailed Nuthatch	r	+	+	IV	-
*Sitta formosaes**	Beautiful Nuthatch	r	+	+	IV	-
Certhiidae						
Tichodroma muraria	Wall Creeper	rw	+	+	IV	LC
Nectariniidae						

Dicaeum ignipectus	Firebreasted Flowerpecker	r	+	+	IV	LC
Aethopyga saturate	Black-throated Sunbird	r	+	+	IV	-
Passeridae						
Passer montanus	Tree sparrow	R	+	+	IV	LC
Anthus hodgsoni	Olive-backed pipit	W	+	+	IV	-
A. godlewiskii	Blyth's Pipit	w	+	+	IV	-
Fringillidae						
Carduelis spinoides	Himalayan Greenfinch	R	+	+	IV	LC
Carpodacus rubescens	Blanford's Rosefinch	r	+	-	IV	-
C. thura femininus	Yunan Whitebrowed Rosefinch	r	+	-	IV	LC
Pyrrhoplectus epaulette	Goldheaded Black Finch	r	+	+	IV	-
Haematospiza sipahi	Scarlet Finch	r	+	-	IV	LC

R = Resident, r = Local resident, W = Widespread winter visitor, w = Sparse winter visitors, s = sparse summer visitors, CA = catchment area, IA = Influence area

iii) Herpetofauna: Distribution & Conservation Status

Herpetofauna in Arunachal Pradesh is comprised of 78 species (12 families) of reptiles (Sanyal and Gayen, 2006) and 39 species (6 families) of amphibians (Sarkar and Ray, 2006). Of the 78 species of reptiles, 6 are common in West Siang district while out of 39 species of Amphibia only three occur in the district (Table 3.5.2.3). There is no earlier record of herpetofauna from Siyom and Yarjep valleys. Primary surveys for three seasons also indicate poor diversity of herpetofauna in the catchment and influence areas of proposed project. Herpetofaunal species listed in Table 3.5.2.3 are expected to inhabit the proposed project areas and its catchment. Among these species *Xenochrophis piscatori* (Checkered Keelback) is placed under the Schedule II, while *Rana* spp. are categorized as Schedule IV. None of the species inhabiting the catchment is threatened as per criterion of ZSI.

Table 3.5.2.3 Herpetofaunal elements occurring in the catchment area of Tato I H.E. Project

Reptile	Amphibia
Hemidactylus brookii	*Bufo himalayana*
Ahaetulla prasinus	*Rana cyanophlyctis*
Xenochrophis piscator	*Rana limnocharis*
Amphiesma stolata	
Psammodynastes pulverulentus	
Bungarus nigers	

iv) Invertebrates

This section highlights a brief account on the invertebrates of influence and catchment areas of Tato I H.E. project. It includes predominant species of protozoan, crustacean, insects, leeches, etc. Out of 23 protozoan reported from West Siang district (ZSI, 2006) *Giardia lamblia*, *Plasmodium vivax*, *P. falciparum Assulina muscorum* and *Eimeria* are most common species in study area. Crustacean fauna in the region comprises of Palaemonidae and Potamonids (crabs) only. They are represented by *Macrobrachium* sp. (?), *Carcinus* sp., *Portunus* sp. etc (**Plate 3.5.2.1b**). Crabs are widely distributed, found in larger part of surroundings while *Macrobrachium* sp. is limited in the lower fringe of the influence area. Annelids in the region comprise of leeches and earthworms. The common leech species of project and catchment areas are *Haemadipsa montana*, *H. sylvestris* and *H. montivindicus* (Mandal, 2006). They are found up to 3000 m. In addition, there are many species of earthworms having ethno-zoological importance. Insecta is the largest group, comprises of more than 1000 species in Arunachal Pradesh. The important groups in the study area are Diptera, Coleoptera, Hymenoptera, Lepidoptera, Hemiptera, Odonata, Ephemeroptera, Plecoptera, Trichoptera etc. Lepidoptera is largest group followed by Diptera. The project and catchment areas have a good share of insect diversity. Lepidoptera (butterflies) in the surrounding is comprised nearly of 30 species, *Pieris canidia*, *Eurema hecabe* and *Gandaca harina assamica* are most common in the study area. Among the Diptera *Chironumus* sp., *Simulium* spp. *Limonia* spp. *Chironomus* spp. and *Conosia irrorata* are predominant species in the catchment. Ephemeroptera is represented abundantly by *Cynigmula* sp., *Heptagenia* spp., *Baetis* spp. etc. Plecoptera and Trichoptera are dominated by *Perla* spp. and *Hydropsychae* spp., respectively. Hymenoptera in the catchment comprises of bees, wasps, ants and spiders. *Apis* spp., *Pachycondyla* spp. *Tiphia* spp., *Camponotus* spp. *Solenopsis geminate*, *Ampules* spp. are common Hymenopterans of the region. Coleoptera are mainly represented by *Epilachna bipunctata* and *Psephanus* spp.

3.5.2.1.2 Project Areas

i) Mammals

In the surrounding of the project components only Leopard cat was spotted near proposed power house in winter season. However, presence of trophies in the households indicates that Common Leopard (*Panthera pardus*), Barking Deer (*Muntiachus muntjak*), Wild Boar (*Sus scrofa*), Assamese Macaque (*Macaca assamensis*) and Himalayan Marten (*Martes flavigula*) are common in the project component areas. We observed the hides of Common Leopard, Barking Deer, Assames

Macaque and Himalayan Marten in the house holds of natives while skull of wild boar is preserved as trophies. Among these common species *Panthera pardus* is a Scheduled I and threatened species.

ii) Avifauna

Avifauna of the project areas of Tato I H.E. project comprises of 40 species, grouped under 21 families. Out of 40 species 38 could be located directly while 2 (Black Eagle and Great Indian Pied Hornbill) were confirmed with the help of indirect evidences (Table 3.5.2.4). Nearly 52% of the total species were sparse resident while 35% were widespread resident. Spotted Dove, Eastern Swallow, Bronzed Drongo, Redwhiskered Bulbul, White-cheeked Bulbul, Long-tailed Shrike, White-throated Laughing Thrush, White Capped Redstart, Himalayan Brown-dipper and House Sparrow were most common and abundant species, recorded during all seasons and almost at all sites. Maximum abundance - 7.3%, 6.4% and 7.8% were computed for House sparrow for winter, pre-monsoon and monsoon seasons, respectively. Among the observed species only Great Indian Pied Hornbill is placed under the Schedule I.

Table 3.5.14. Avifaunal composition in the project area of Tato I H.E. Project

Scientific name	Common Name	Distribution	Seasons		
			W	PrM	M
Accipitridae					
Ictinaetus malayensis	Black Eagle*	R			
Columbidae					
Columba hodgsoni	Speckled Wood Pigeon	r	+	+	+
Streptopelia chinensis	Spotted Dove	R	+	+	+
Cuculidae					
Cuculus micropterus	Indian Cuckoo	R	+	-	-
Bucerotidae					
Anthracoceros albirostris	Great Indian Pied Hornbill*	r			
Megalaimidae					
Megalaima virens	Great Barbet	R	+	+	+
Picidae					
Picoides macei	Indian Fulvousbreasted Pied Woodpecker	R	+	+	-
Strigidae					
Glaucidium cuculoides	Barred Owlet	r	+	-	-

Pittidae					
Pitta nipalensis	Blue-naped Pitta	r	-	-	+
Hirundinidae					
Hirundo rustica	Eastern Swallow	RW	+	+	+
Delichon nipalensis	Nepal House Martin	r	+	+	+
Corvidae					
Corvus macrorhynchos	Jungle Crow	R	+	+	+
Dicrurus aeneus	Bronzed Drongo	r	+	+	+
Cissa chinensis	Green Magpie	r	+	-	-
Sturnidae					
Gracula religiosa	Hill Myna	r	+	+	-
Pycnonotidae					
Pycnonotus jacosus	Redwhiskered Bulbul	R	+	+	+
P. leucogenys	Whitecheeked Bulbul	R	+	+	+
Laniidae					
Lanius schach	Long-tailed Shrike	R	+	+	+
Sylviidae					
Phylloscopus proregulus	Pallas Leaf Warbler	rW	+	+	+
P. trochiloides	Greenish Leaf Warbler	rW	+	-	+
Prinia hodsonii	Ashy Grey Wren Warbler	R	+	-	-
P. trochiloides	Greenish Leaf Warbler	rW	+	+	-
Timalidae					
Garrulax striated	Striatus Laughing Thrush	r	+	+	+
Garrulax albogularis	White-throated Laughing Thrush	R	+	+	+
Alcippe castaneceps	Chestnut-headed Tit-babbler	r	-	-	+
Muscicapidae					
Myophonus caeruleus	Blue Whistling Thrush	R	+	+	+
Turdus albocinctus	Whitecollared Blackbird	r	+	+	-
T. boulboul	Greywinged Black Bird	r	-	-	+
Rhyacornis fuliginosus	Plubeous Redstart	r	+	+	+
Chaimarrornis leucocephalus	White Capped Redstart	r	+	+	+
Cinculus pallasii	Himalayan Brown-dipper	r	+	+	+
Enicurus scouleri	Little Forktail	r			
Paridae					
Parus monticolus	Greenbacked Tit	r	+	+	+

P. nuchalis	White napped Tit	r	-	-	+
Certhiidae					
Tichodroma muraria	Wall Creeper	rw	+	-	-
Nectariniidae					
Dicaeum ignipectus	Firebreasted Flowerpecker	r	+	+	-
Passeridae					
Passer domestica	House Sparrow	R	+	+	+
Fringillidae					
Carduelis spinoides	Himalayan Greenfinch	R	-	-	+
Carpodacus rubescens	Blanford's Rosefinch	r	-	-	+
Haematospiza sipahi	Scarlet Finch	r	+	-	+

R = Widespread resident, r = sparse resident, W = Widespread winter visitor, w = sparse winter visitor

*Trophy was recorded

iii) Herpetofauna

Hemidactylus brookii is most common reptilian of the project component area, it was observed during all seasons. During the surveys two species of snakes (*Xenochrophis piscator* and *Amphiesma stolata*) were recorded in pre-monsoon season, however, they could not be identified precisely. In amphibia *Bufo himalayana* and *Rana cyanophlyctis* were common species of the project areas.

iv) Butterflies

The studies on the butterflies are very rare from the area under discussion. An inventory on the butterflies was made by CISMHE (2010) for EIA study of Tato-II H.E. Project. Because the influence area for both projects overlap so that same data have been used for Tato-I H.E. Project.

The density and diversity of butterflies were comparatively low as compared to lower Siang area. A total of 30 species of butterflies were recorded from the area where different project activities (intake, powerhouse, roads, colony, quarries, settlement, etc) are proposed (Table 3.5.2.5). These species belong to four families – Papilionidae, Pieridae, Lycaenida and Nymphalidae. Nymphalidae was most dominant family represented by 16 species. About 8 species, viz. Common rose (*P. aristolochia*), Common sailer (*Neptis hylas varmona*), Bicolor Commodore (*Limenitis zayla*) (**Plate 3.5.2.1c,d**), Common grass yellow (*Eurema hecabe*), Indian cabbage white (*Pieris* *canidia*), etc. had their abundant occurrence. The maximum abundance was recorded for Indian cabbage white in winter (19.3%) and pre-monsoon season (9.2%). In monsoon season tree yellow was most abundant species (11.76%). Tree yellow, Indian cabbage white, Himalayan fivering, Common fourring and Stripped blue crow were most common species found in all seasons. Maximum diversity was recorded from settlement area at Tato Gito villages. Variegated sailor and Crimson rose are categorized as Schedule 1 species (WPA 1972).

Table 3.5.15. Butterfly species at various sites of influence area of Tato I H.E. Project

Families/Comon name	Scientific name	Conservation Status (WPA, 1972)	Seasons		
			W	PrM	M
Papilionidae					
Crimson rose	*Pachliopta hector*	I	-	+	-
Common rose	*P. aristolochiae*	-	-	+	+
Red helen	*P. helenus helenus*	-	-	+	-
Common raven	*P. castor*	-	-	-	+
Pieridae					
Yellow orange tip	*Ixias pyrene familiaris*	-	-	-	+
Great orange tip	*Hebomoia glaucippe*	-	-	+	+
Tree yellow	*Gandaca harina assamica*	-	+	+	+
Common grass yellow	*Eurema hecabe*	-	+	-	+
Indian cabbage white	*Pieris canidia*	-	+	+	+
Redbase jezebel	*Delias aglaias*	-	-	+	-
Lycaenidae					
Indian oakblue	*Narathura bazalus*	-	-	+	+
Purple sapphire	*Heliophorus epicles indicus*	-	-	+	-
Metallic cerulean	*Jamides alecto eurysaces*	II	-	+	+
Dark cerulean	*J. bochus*	-	-	-	+
Punchinello	*Zemeros flegyas indicus*	-	+	+	-
Nymphalidae					
Bicolor Commodore	Limenitis zayla	-	+	+	+
Common earl	*Tanaecia julii appiades*	-	-	-	+
Grey count	*T. lepidea lepidea*	-	-	+	+
Himalayan fivering	*Ypthima sacra sacra*	-	+	+	+
Common fourring	*Y. hubenri hubenri*	-	+	+	+
Common maplet	*Chersonesia risa*	-	-	+	-

Blue duchess	*Euthalia duda*	-	-	+	+
Indian red admiral	*Vanessa indica indica*	-	+	+	+
Orange oakleaf	*Kallima horsfieldi*	-	-	+	-
Common sailor	*Neptis hylas varmona*	-	+	+	+
Variegated sailor	*Neptis antilope*	I	-	+	-
Common earl	*Tanaecia julii appiades*	-	-	+	-
Blackvein sergeant	*Parathyma ranga ranga*	-	+	-	+
Stripped blue crow	*Euoloea mulciber mulciber*	-	+	+	+
Grassy tiger	*Parantica aglea melanoides*	-	+	+	-

Source: Tato-II H.E. Project

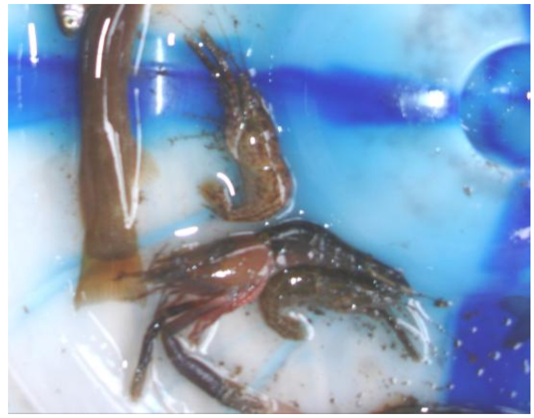
3.5.2.2 Customary Hunting

Animal hunting and slash and burn in Arunachal Pradesh are considered as one of the major threats for biodiversity. These phenomena are also in practice in the influence area of the Tato I H.E. project. Tribal population in influence area comprises of many sub tribes of Adi. They are non vegetarian in food habit and involved in customary hunting. In general, hunting is executed in all seasons but it increases during the occasions of tribal's function, festivals and marriage ceremonies. Most people use licensed air gun for hunting, however, traps in the forest are also used. The important species which are hunted for are Leopard, Barking deer, Black bear, Wild boar, Serow and Hornbills. Bird hunting by children can be attributed to their learning behaviour, for which they were found to use *Gulel*.

3.5.2.3 Conclusion

Catchment and influence area of Tato-I H.E. Project is covered with dense sub tropical wet hill forest housing a rich faunal diversity. The region is sparsely populated with tribal groups. Like other areas of Arunachal Pradesh animal hunting and jhum cultivation are one of the main stresses on the biodiversity. The enforcement of forest rules are not strict in these areas because of the customary rights of the people on the forest and forest products. Indeed, the enforcement of strict rules is not a sound alternative for the biodiversity conservation. It needs comprehensive awareness programmes and some alternatives, which could fulfill the fondness of tribes towards the ornaments and trophies. The artificial trophies made up of fiber glass may be one of the alternatives. Also, the traditional knowledge of tribes on forest and forest products can be used as a tool of biodiversity conservation.

a) Upper jaw of *Panthera pardus*



b) *Macrobrachium* sp.

(c) Common Sailer (*Neptis hylas varmona*)

(d) Bicolor Commodore (*Limenitis zayla*)

Plate 3.5.2.1 Different species of animals in the catchment and project areas can be confirmed by direct and indirect evidences

3.6 SOCIAL ENVIRONMENT

3.6.1 INTRODUCTION

A developmental project may affect the socio-economic and cultural profile in the surrounding positively or/and negatively and directly and indirectly. Land acquisition for project components, demographic changes, if any, due to project staff, workers, employment opportunities, etc lead to direct impacts on the socio-cultural and economic environment while use of water and forest resources have indirect impacts. In Environmental Impact Assessment study these issues are addressed imperatively to formulate an appropriate mitigation plan to avoid or minimize the adverse impacts on the surroundings of inhabitants.

Tato-I H.E. Project is a part of cascade development scheme, located partially in Tato circle and partially in Mechuka circle of West Siang district of Arunachal Pradesh. In this chapter a brief account on socio-economic profile of West Siang district and concerned circles is given. The detailed socio-economic, cultural profile and ethnography is described for influence area, affected villages and affected families in following headings. Catchment and influence areas of Tato I fall under Tato, Pidi and Mechuka circles of West Siang district. The brief discussion of these administrative units is described in following headings.

3.6.1.1 Arunachal Pradesh

Arunachal Pradesh covers an area of 83,743 sq. km and lies between latitudes 26^0 28’ to 29^0 30’ N and longitudes 91^0 30’ to 97^0 30’ E. Arunachal Pradesh is bordered by Bhutan in the west, Myanmar in the south and southeast, Tibet in the north and the Indian State of Assam in the south. The total population of Arunachal Pradesh is 13,82,611 with a sex ratio of 920 (females to 1000 males) (Census, 2011). The average population density is 16.5 persons per sq km. Average literacy in Arunachal Pradesh is 57.09% with maximum in males (69%). Administratively, Arunachal Pradesh is divided into 16 districts, namely Tawang, West Kameng, East Kameng, Papum Pare, Lower Subansiri, Upper Subansiri, West Siang, East Siang, Upper Siang, Dibang valley, Lohit, Changlang, Tirap, Lower Dibang Valley, Anjaw and Kurung-Kumey. Itanagar is the State capital of Arunachal Pradesh, which is located in Papum Pare district.

3.6.1.2 West Siang District

The proposed Tato-I H.E. Project is located in West Siang district of Arunachal Pradesh. Prior to 1970 West Siang was a part of Siang Frontier Division and was recognized as Siang district after 1971. Later on Siang district was divided into West Siang and East Siang districts. District West Siang is divided into 6 sub-divisions, 10 blocks, 20 administrative circles and 397 villages. The district headquarter of West Siang is located at Aalo. As per Census (2011) the total population of West Siang district is 1,12,272 with sex ratio of 916 (females to 1,000 males), which is marginally lower than the State average of 920. The population density of the district is 12 individuals per sq. km, nearly same as that of the State (14 person/sq km). West Siang district is one of the districts which recorded lowest decadal growth of 8%. The scheduled tribe (ST) population accounts for 81.7% of the total population in the district. The district recorded a total literacy rate of 59.47%, which is slightly higher than the state average.

3.6.1.3 Mechuka Circle

Mechuka sub-division of the West Siang district is comprised of four circles including Tato circle, Pidi Circle, Mechuka circle and Monigong Circle. The proposed project is situated across Tato and Mechuka circles. Total population of Mechuka sub-division is 9,973 with a significantly better sex ratio of 995 compared to the district and the State (Census, 2001). Considering the 8% decadal growth of West Siang district, the total population of Mechka as per Census 2011 is 10770. The average literacy rate in Mechuka circle is 35.8% with considerably higher rates in males (45.4%), but overall literacy in the Circle is rather significantly lower compared to the state average of 54%. The age group of 0-6 year accounts for 19.3% of total population. About 42% of the total population is of worker category in which 24% are males and 18% are females. Of the total workforce, main workers are about 91%. Most of the workers are cultivators.

3.6.1.4 Pidi Circle

A part of the influence area of Tato-I H.E. Project falls in the Pidi circle of West Siang district of Arunachal Pradesh while the catchment area is covered under the Mechuka circle. Total population of Pidi circle is 666 come from 131 households (Census, 2001) (Considering the average decadal growth of West Siang district, the expected population is nearly 719). Sex ratio of the circle 1012 which is better than state and district averages. Pidi circle is inhabited by 100% of tribal population. Literacy rate of Pidi circle is 27.6% with slightly highest in males (33.8%). Low literacy rate can be attributed to the low infrastructure due to inaccessibility of the region. Age group 0-6 accounts for 15.3% of the total population.

3.6.1.5 Tato Circle

The total population of Tato Circle is 2132 with a sex ratio of 925. The sex ratio is marginally lower than the figures of Mechuka, but better than the State average. The average literacy rate of Tato circle is 33.1% with maximum in males (40.6%). These figures are significantly lower than the literacy rates of the State. Age group of 0-6 year constitutes 23% of total population. Total workers account for 47.6% of the population of which 26.6% are males and 21% are females. Out of the total workforce, main workers are about 82%.

Tato Circle is catered to by one middle and five primary schools. The Circle lacks educational institution of secondary or college level. The health facilities comprise of one primary health centre and a pharmacy, located in Tato village.

3.6.2 INFLUENCE AREA

A total of 20 villages under the jurisdiction of 3 administrative circles are located in the influence area (10 km radius) of Tato-I H.E. Project. Detailed socio-economic profile of these villages is given below.

3.6.2.1 Demography

Total population of the villages of influence area is 2168 belonging to 390 households (Census, 2001) (Table 3.6.1.1). Average sex ratio in these villages is 974, which is better than state average. Age group 0-6 accounts for 23% of total population. Except Tagurshit, Tadogito villages and Tato Head Quarters all villages are inhabited by Scheduled tribe population (ST). ST population accounts for 97.6% of the total population of influence area.

Table 3.6.1.1 Demographic profile of the villages located in the influence area of Tato-I H. E. Project as per Census 2001

		Population Structure								
Village	**HH**	**Total**	**Male**	**Female**	**T 0-6**	**M 0-6**	**F 0-6**	**Sex Ratio**	**SC**	**ST**
Mechuka Circle										
Rego	18	97	48	49	30	14	16	1021	0	97

Rapum	16	100	51	49	13	5	8	961	0	100
Hiri	7	27	14	13	3	1	2	929	0	27
Purying	10	65	31	34	10	5	5	1097	0	65
Lipusi	3	17	6	11	2	1	1	1833	0	17
Padusa	10	51	26	25	12	6	6	962	0	51
Gapo	25	127	64	63	32	19	13	984	0	127
Meying*	4	21	11	10	6	1	5	909	0	21
Chengrung	10	58	32	26	16	10	6	813	0	58
Pauk	5	30	14	16	2	2	0	1143	0	30
Pidi Circle										
Hirong	12	68	38	30	15	8	7	789	0	68
Barbo	11	65	36	29	8	2	6	806	0	65
Lungte	18	111	56	55	16	8	8	982	0	111
Pabungying	12	43	22	21	8	4	4	955	0	43
Tato Circle										
Tato Village	50	287	132	155	83	34	49	1174	0	287
Heyo	12	58	35	23	9	4	5	657	0	58
Tagur	12	56	25	31	11	7	4	1240	0	45
Tadogitu	20	101	56	45	27	14	13	804	0	83
Quying	16	115	54	61	17	7	10	1130	0	115
Tato H.Q.	119	671	347	324	179	95	84	934	0	648
Total	**390**	**2168**	**1098**	**1070**	**499**	**247**	**252**	**974**	**0**	**2116**

SC=Scheduled Castes, ST=Scheduled Tribes (Source: Census of India 2001)

* In Census 2001, Meying was not considered as a revenue village and its figures were included in Gapo's figures. For the purpose of clarity, Gapo's and Meying's population were split in the above table, keeping in mind the same final figures.

3.6.2.2 Education Profile

Educational infrastructures are poorly developed in the villages of influence area. Nearest centres for secondary education are located at Tato and Mechuka. Average literacy rate in these villages is 45.5%, considerably higher in male population (Table 3.6.1.2).

Table 3.6.1.2 Educational profile of the village located in the vicinity of Tato I H. E. Project as per Census 2001

Village	Literates			Literacy Rate %		
	T	M	F	T	M	F
Mechuka Circle						
Rego	39	20	19	58.2	58.8	57.6
Rapum	51	29	22	58.6	63.0	53.7
Hiri	9	5	4	37.5	38.5	36.4
Puring	24	17	7	43.6	65.4	24.1
Lipusi	4	2	2	26.7	40.0	20.0
Padusa	10	9	1	25.6	45.0	5.3
Gapo	41	21	20	43.2	46.7	40.0
Meying	2	2	0	13.3	20.0	0.0
Chengrung	30	19	11	71.4	86.4	55.0
Pak	14	8	6	50.0	66.7	37.5
Pidi Circle						
Hirong	13	9	4	24.5	30.0	17.4
Barbo	23	18	5	40.4	52.9	21.7
Lungte	45	26	19	47.4	54.2	40.4
Pabungying	18	11	7	51.4	61.1	41.2
Tato Circle						
Tato Village	80	53	27	39.2	54.1	25.5
Heyo	25	16	9	51.0	51.6	50.0
Tagur	8	5	3	17.8	27.8	11.1
Tadogitu	5	5	0	6.8	11.9	0.0
Quying	23	12	11	23.5	25.5	21.6
Tato H.Q.	296	183	113	60.2	72.6	47.1
Total	**760**	**470**	**290**	**45.5**	**55.2**	**35.5**

(Source: Census of India 2001)

3.6.2.3 Occupation and Cropping Pattern

About 44.5% of the total population is employed in various works, of which 39% are main workers and remaining are marginal workers (Table 3.6.1.3). The majority of the main workers are involved in cultivation including jhum. Maize, Millets and rice are main crops in these villages. Both main and marginal workers are dominated by male workers. About 55.5% non workers includes 23% 0-6 year age class.

3.6.2.4 Other Amenities

The villages of influence zone under Mechuka and Tato circles like Rego, Hiri, Gapo, Padusa, Tato, Tadogito and Tato head quarters etc. are connected to the national highway while the villages of Pidi circle like Hirong and Lungte are connected with link road. Most of the villages have facilities of tap water, supplied from springs, though, it is not treated. To avail the facilities of bank, post office and secondary school and primary health facilities Mechuka and Tato are main centers in the area.

3.6.3 AFFECTED VILLAGES

The lands near four villages namely, Meying, Gapo, Heyo and Tato villages are affected due the various components of the project. Only Gapo, Heyo and Tato are revenue villages. Intake site would be located near Gapo and Meying villages. The proposed power house site is located in community lands not far from the Heyo and Tato villages. The detailed socio-economic profile of these villages is given below. Gapo and Meying villages' areas are also impacted by Heo HEP components and structures. In order to avoid any double counting in the EMP plans of Heo and Tato-I HE Projects, Gapo and Meying villages will be considered as affected villages exclusively for the Tato-I H.E. Project, for the purpose of Rehabilitation and Resettlement plan.

3.6.3.1 Demography

Total population of affected villages is 493 comes from 91 households (Census, 2001). Average sex ratio in these villages is 1037. Age group 0-6 accounts for 26.4% of the total population. All inhabitants of the affected villages belong to Scheduled tribe (Table 3.6.1.4).

Table 3.6.1.3 Occupation pattern in the villages located in the influence area of Tato-I H. E. Project as per Census 2001

Village	Work Force											
	Total Workers			Main Workers			Marginal Workers			Non Workers		
	T	M	F	T	M	F	T	M	F	T	M	F
Mechuka Circle												
Rego	39	19	20	39	19	20	0	0	0	58	29	29
Rapum	45	22	23	45	22	23	0	0	0	55	29	26
Hiri	18	10	8	18	10	8	0	0	0	9	4	5
Puring	39	21	18	39	21	18	0	0	0	26	10	16
Lipusi	8	2	6	8	2	6	0	0	0	9	4	5
Padusa	26	10	16	26	10	16	0	0	0	25	16	9
Gapo	69	32	37	69	32	37	0	0	0	58	32	26
Meying	11	7	4	11	7	4	0	0	0	10	4	6
Chengrung	23	11	12	23	11	12	0	0	0	35	21	14
Pauk	16	7	9	16	7	9	0	0	0	14	7	7
Pidi Circle												
Hirong	28	13	15	28	13	15	0	0	0	40	25	15
Barbo	30	15	15	26	14	12	4	1	3	35	21	14
Lungte	51	24	27	45	23	22	6	1	5	60	32	28
Pabungying	25	13	12	18	6	12	7	7	0	18	9	9

Tato Circle												
Tato Village	132	70	62	121	69	52	11	1	10	155	62	93
Heyo	22	14	8	19	13	6	3	1	2	36	21	15
Tagur	28	12	16	26	10	16	2	2	0	28	13	15
Tadogitu	55	30	25	52	27	25	3	3	0	46	26	20
Quying	54	25	29	53	25	28	1	0	1	61	29	32
Tato H.Q.	246	142	104	166	117	49	80	25	55	425	205	220
Total	**965**	**499**	**466**	**848**	**458**	**390**	**117**	**41**	**76**	**1203**	**599**	**604**

T=Total, M=Male, F=Female.

Table 3.6.1.4 Demographic profile of the affected villages of Tato-I H. E. Project as per Census 2001

		Population Structure								
Village	**HH**	**Total**	**Male**	**Female**	**T 0-6**	**M 0-6**	**F 0-6**	**Sex Ratio**	**SC**	**ST**
Gapo	25	127	64	63	32	19	13	984	0	127
Meying	4	21	11	10	6	1	5	909	0	21
Tato Village	50	287	132	155	83	34	49	1174	0	287
Heyo	12	58	35	23	9	4	5	657	0	58
Total	**91**	**493**	**242**	**251**	**130**	**58**	**72**	**1037**	**0**	**493**

3.6.3.2 Education profile

Average literacy rate in the affected villages is 40.8%, being significantly higher in male population. Tato stands for the relatively high literacy. High literacy rate in Tato villages can be correlated with availability of infrastructure at Tato head quarters (Table 3.6.1.5).

Table 3.6.1.5 Educational profile of the affected villages of Tato-I H. E. Project

	Literates			Literacy Rate %		
Village	**T**	**M**	**F**	**T**	**M**	**F**
Gapo	41	21	20	43.2	46.7	40.0
Meying	2	2	0	13.3	20.0	0.0
Tato Village	80	53	27	39.2	54.1	25.5
Heyo	25	16	9	51.0	51.6	50.0
Total	**148**	**92**	**56**	**40.80**	**50.0**	**31.3**

3.6.3.3 Occupation and Crop Pattern

Nearly 47.4% of the total population is employed in various works, in which main workers account for 44.6%. The main workers category is dominated with male population. Marginal workers account for only 2.8% of total population, in which females are predominant (2.4%) (Table 3.6.1.6). Non workers include age group 0-6 year also. Most of the population is engaged in cultivation including *jhum*. Maiz, millets, rice and pulses are main crops in these villages.

Table 3.6.1.6. Various workers' categories in the affected villages

	Total			Main			Marginal			Non-Worker		
Villages	**T**	**M**	**F**	**T**	**M**	**F**	**T**	**M**	**F**	**T**	**M**	**F**
Gapo	69	32	37	69	32	37	0	0	0	58	32	26
Meying	11	7	4	11	7	4	0	0	0	10	4	6
Tato Village	132	70	62	121	69	52	11	1	10	155	62	93
Heyo	22	14	8	19	13	6	3	1	2	36	21	15
Total	**234**	**123**	**111**	**220**	**121**	**99**	**14**	**2**	**12**	**259**	**119**	**140**

3.6.3.4 Other Amenities

Tato and Gapo villages are located on the right bank of the river, alongside the National highway connecting Aalo and Mechuka. These villages have the facilities of primary education while infrastructure for the secondary education is available at Tato headquarters. The Tato head quarters caters to primary health, telecommunication and market facilities to affected villages. The village areas are not electrified. Inhabitants use tapped untreated spring water. Transportation is very poor in these villages. The villages have lack of proper sanitation. The villagers located alongside the roads use LPG while others use fuel wood. Majority of the houses are kachha, made up of bamboo, wooden poles and thatching grasses.

3.6.4 AFFECTED FAMILIES

The ultimate purpose of identifying Affected Families is to properly implement a well targeted Rehabilitation plan. The land required falls under two Communities on both banks of the Power House site and also under the two directly affected villages on both banks of the intake site, i.e Gapo and Meying villages.

Land of Gapo and Meying villages' areas are also impacted by Heo HEP components and structures but they are considered only under the Tato-I HEP for the purpose of Rehabilitation and Resettlement plan of the EMP.

Therefore, the families belonging to the Communities of Gapo and Meying villages and to the Communities holding the land of the power house site (or from whom individual land is to be acquired under the project land requirement, if any) will be considered affected families of the Tato-I

H.E. Project. A detailed socio-economic profile of the affected families of these Communities is given below.

A detailed social survey will be performed again during the procedure for land acquisition, and before the time of implementation of the plan in order to have the most up to date information and in order to implement the most targeted and efficient R & R plan.

3.6.4.1 Demographic Profile

A total of 77 households (88 families) are directly affected due to the acquisition of community or private land. Total population of these households is 301 persons with a sex ratio of 846. Age group 0-6 year accounts for 20.9% of the total population (Table 3.6.1.7). All households belong to Schedule Tribe category.

Table 3.6.1.7 Population structure of project affected households/families of Tato-I H.E. Project

Village /Community	Population Structure							
	HH	Total	Male	Female	0-6 yr	ST	SC	SR
Gapo	24	123	60	63	24	123	0	1049
Meying	6	22	9	13	5	22	0	1444
Rinya Community	18	50	31	19	11	50	0	612
Heyo Community	29	106	63	43	23	106	0	682
Total	**77**	**301**	**163**	**138**	**63**	**847**	**0**	**846**

HH: Households; ST: Scheduled Tribe; SC: Schedule Cast; SR: Sex Ratio

3.6.4.2 Education Profile

Average literacy rate in affected households is about 51% with maximum of 59% in one of the communities. The trend shows an increasing literacy pattern as compared to that of Census 2001. The education percentage decreases gradually towards higher classes (**Table 3.6.1.8**).

Table 3.6.1.8 Education profile and literacy rate in the affected households of Tato-I H.E. Project

Village / community	P	M	HS	SS	Gr	PG	Total	Literacy (%)
Rinya Community	6	4	3	5	4	0	23	58.97

Heyo Community	18	16	5	4	1	0	43	51.81
Gapo	29	8	6	3	4	1	51	51.00
Meying	2	2	1	1	2	0	8	47.06
Total	**55**	**30**	**15**	**13**	**11**	**1**	**125**	**51.02**

P= Primary class, M= middle class, HS = Higher secondary, SS – Senior secondary, Gr = graduation, PG = Post Graduate

3.6.4.3 Occupation Pattern & Crops

The members of project affected families are employed in various works like government services, cultivation, small scale business, and labour work. Around a third of the total population comes under the worker's category. The majority of the inhabitants are engaged in cultivation including Jhum. About 8.8% of the total population is employed in government and private services (Table 3.6.1.9). Millets, rice ginger etc are main crops of project affected families.

Table 3.6.1.9 Occupation pattern in the project affected families of Tato-I H.E. Project

Village/community	Govt/Pvt.	Pens.	Culti	Busi.	Labo.	Total	%age
Rinya	4	0	7	0	6	17	34.00
Heyo Community	3	0	42	0	0	45	42.45
Gapo	0	0	3	0	2	5	22.73
Meying	2	0	47	0	6	55	44.72
Total	**9**	**0**	**99**	**0**	**14**	**122**	**45.02**

3.6.4.4 Livestock Population

Livestock population comprises of cows, mithuns, goats, horses, pigs, chicken etc. Mithun, goats, pigs and chicken are main source of protein in the area while cows are main source of milk. Mithun is a semi domesticated animal. High number of mithuns reared in the household is a status symbol in the area Table 3.6.1.10.

Table 3.6.10. Livestock population of project affected families of Tato-I H.E. Project

Villages/community	Cow	Mithun	Ox	Goat	Sheep	Horse	Mule	Chicken	Pig
Rinya Comty	32	51	0	68	0	3	0	70	42
Heyo Comty	67	51	0	107	0	0	0	192	47

Meying		3	13	0	5	0	0	0	9	2
Gapo	15	5	0	29	0	0	0	53	12	114
Total	**117**	**120**	**0**	**209**	**0**	**3**	**0**	**324**	**103**	**876**

3.6.4.5 Vulnerable Person

BPL (Below Poverty Level) family members, Scheduled Tribe family members, widows, destitute, and handicapped persons are considered as vulnerable persons. All affected persons belong to Scheduled Tribe while 30 families come under the BPL category (Table 3.6.1.11). A total of 6 persons were widows in the affected families while the handicapped category includes 1 person.

Table 3.6.1.11Status of vulnerable persons in the project affected families of Tato-I H.E. Project.

Village/Cty	BPL family	Widow	Destitute	Handicapped
Rinya Cty	7	2	0	0
Heyo Cty	20	0	0	1
Gapo	2	0	0	0
Meying	1	4	0	0
Total	**30**	**6**	**0**	**1**

3.6.4.6 Fuel Use Pattern

All project affected families are users of fuel wood, supplemented by LPG and kerosene. Nearly 66% and 80% of project affected families of Rinya community and Gapo villages have access to LPG while only 6% families of Heyo village have LPG. Similarly all project affected families are not users of Kerosene (Table 3.6.1.12). The more number of LPG users in Gapo and Tato villages can be attributed to the location of these villages on the highway.

Table 3.6.1.12 Fuel used profile of the project affected families of Tato-I H.E. Project

Villages	Gas	Kerosene	Wood
Rinya Cty	10	5	15
Heyo Cty	6	12	30
Gapo (& Meying)	4	2	5
Total	**20**	**19**	**50**

3.6.5 LIVING STANDARD

Heyo and Meying villages are located in the forest area, where transport facilities are not available. Among the project affected villages Tato Village and Gapo villages are connected to the highway, however, transport facilities are very poor in the region. The State Transport buses and private light vehicles are main means of transport. The majority of the families in the area owns *kaccha* houses, consisting of bamboo poles thatched grasses. Some inhabitants located along the road sides own *pucca* houses. Aalo, district head quarters, is the main market, located about 150 km away. Majority of the households are not electrified. Villages are connected to the tap water facilities with few common points. The water is tapped from nearby springs which are untreated. Regarding the education, health, telecommunication, and transportation, the infrastructure facilities are very poor in the influence zone. Living standard of inhabitants is not satisfactory and entire area needs strengthening in infrastructure facilities and empowerment.

3.6.6 CULTURAL ENVIRONMENT

3.6.6.1 Brief History

Well documented history of Arunachal Pradesh starts with 16th century, when Ahom kings ruled the region. The population comprised mostly of Tibeto – Burmese linguistic origin. In 1826 British took over Assam after Yanlaboo treaty. Before 1962, as a part of Union of India, Arunachal Pradesh was known as North Eastern Frontier Agency (NEFA) and was constitutionally a part of Assam State. It was administered by the Indian Ministry of External Affairs till 1965 and subsequently by the Ministry of Home Affairs through Governor of Assam. On 20th January 1972 it was declared as Union Territory and renamed as Arunachal Pradesh. On 20th February 1987, it became 24th State of the Indian Union.

West Siang was a part of Siang Frontier Division before 1971 and was recognized as Siang district after census 1971. Later on Siang district was divided into West Siang and East Siang districts. On the 23rd November, 1994 Upper Siang district was formed by carving out a few administrative circles from East Siang district. The head quarter of West Siang district is located at Aalo.

3.6.6.2 Ethnography

The ‘Galo’ and ‘Adi’ are the major tribal groups constitutionally reorganized in West Siang District of which former is the dominant group in the district. They both have their respective dialects also called Galo and Adi, respectively. However they both belong to a common origin and ancestor known as Abo/ Abu Tani. Mopin and Solung, respectively are their main festivals. The traditional village panchayat of ‘Galo’ and ‘Adi’ locally called Keba and Kebang respectively is a Judico-administrative body consisting of mature and influential elders, generally presided over by “Gaon Budha”. They look after the administration of justice by settling all matters of dispute. They are very fond of handicrafts, which can be seen in their cane and bamboo works like basket, trays, mats headgears etc.

The surrounding areas of the Heo HE project are inhabited by the Bokar, Pailibo Ramo, Memba and Khamba subgroups. These people worship “Donyipoolo” barring the Memba and Khamba who are Mahayana Buddhists by faith. Fairs and festivals like ‘Podi Barbi’, Losar, etc reflect their rich cultural heritage. In general the dances are performed in groups.

The arranged marriages with mutual consent are prevalent among the tribes. The offer for alliance is made would be from groom side. Gifts are exchanged between both the sides during the marriage. After marriage, the elder sibling separate in appropriate time and establish a new family while the younger stays with parents to look after.

Last rite is completed in the graveyards where all required personal belongings of the deceased are also buried with Ceremonial programme. The ceremonial programme, if required is organized by the family members of the deceased after one year or so. The Buddhist sub group however follows their universally well-known customs.

Chapter 4

ENVIRONMENTAL IMPACT

4
ASSESSMENT OF IMPACTS

4.1 INTRODUCTION

The ultimate aim of collection of baseline data in EIA is to assess the likely impacts of the human actions on the surrounding environment and to formulate suitable mitigation measures. It can play an important role in the decision making. The identification and assessing of impacts are complex process because of the nature, longevity, significance and magnitude of impacts on environmental and social systems. A particular action may have negative as well as positive impacts at the same time. The important activities in impacts assessment are impact identification, impact prediction and measurement, impact evaluation, identification of monitoring requirement and mitigation measurement and communication of impact information.

Identification of impact is the first step in impact assessment, which needs a detailed investigation. The impact prediction involves the nature and significance of impact in quantitative or qualitative terms. An impact may be positive or negative, reversible or irreversible, direct or indirect, short term and long term and temporary or permanent. Some of the impacts can be expressed in units while others are compared relatively, this phenomenon is called evaluation of impacts. After the identification, prediction and evaluation of impacts, a mechanism of mitigation of harmful impacts is followed. Finally quantitative data and qualitative information on impacts are presented, which enables non expert to comprehend them. There are a large numbers of methods of impact information.

The entire process of assessment of impacts outlined above has been followed for the Tato-I H.E. Project. The details are given below:

4.2 IMPACT IDENTIFICATION

In hydro-electric project, various actions like excavation, damming, quarrying, road construction, tunneling, blasting etc lead to impacts on the various ecosystems. The impacts are identified for the following environment.

4.2.1 Land Environment

Major actions, which directly and indirectly affect the land environment are land acquisition, tunneling and blasting, human influx for construction work, vehicular movement etc. These actions lead to deforestation and submergence, affect wildlife and plant species etc. The total land involved in the construction of the project is about 52.8 ha out of which 2.8 ha of land is underground and 47.7 ha land would be required for the surface work. The submerged and river bed area is about 3 ha. A total of nearly 1160 migrant population is likely to come in the area while vehicular movement would increase many times in the area.

4.2.2 Geophysical Environment

A head race tunnel of 3.9 km would pass through a few nalahs. In addition, blasting, quarrying and road construction activities may give rise to land slides and slips in the area.

4.2.3 Aquatic Environment

The actions in Tato-I H.E. Project, which would disturb the aquatic environment, are diversion of water from main channel, leaching out of loose soils in river water, and sewage outfall from the laborers colony and camp and effluents from workshop. They would lead to the adverse impacts on the physical, chemical, biological characteristics of the river water and fish species. The adverse impacts on the water quality would reduce the potability of water and would not facilitate a conducive environment for aquatic life fish species.

4.2.4 Air Environment

A sharp increase in the level of petroleum and chemical emission due to the deployment of heavy machines and a large number of vehicles and level of suspended particulate matter due to the excavation, dumping and transportation of muck are anticipated to affect the ambient air quality in the region. A large number of construction machines like cranes, loaders, compressors, robojet shotcrete machine, diesel sets will be installed at the construction sites. Also, number of light and heavy vehicles would increase manu times. These equipments and vehicles would trigger the high concentration of SPM, SOx, NOx and CO and would increase the noise level in the region.

4.2.5 Social Environment

The temporary demographic changes, employment opportunities to locals, peripheral development etc are anticipated to exert the pressure on the natural resources, demography of the area, local economy and to change the living standard and lifestyle of the inhabitants. Some of the impacts are beneficial while others are harmful. In addition, migrant population may have many social consequences like increase in social evils, cultural confliction, etc.

4.2.6 Downstream Impacts

The main action of the downstream impact is diversion of the river. The activity affects not only the aquatic life but fisheries, agriculture, livelihood of people and riparian vegetation in the downstream.

4.3 IMPACT PREDICTION AND MEASUREMENT

4.3.1 Land Environment

4.3.1.1 *Land use/ Land cover changes*

About 47.7 ha of surface land, mainly covered with dense or opened forest would be changed into the degraded areas due to quarrying, excavation, dumping of muck, road construction, colony area etc. It is a long term and permanent negative impact on the land environment. After the construction, temporary construction sites would require adequate restoration to minimize the adverse impacts.

4.3.1.2 *Submergence*

Tato-I H.E. Project envisages a weir, therefore, the total submergence is only 3 ha, including its 1.8 ha riverbed area. Thus, no major impact on the land use/land cover is anticipated.

4.3.1.3 *Wildlife*

The tunneling, turmoil of heavy equipment, vehicular movement and additional human pressure would not only keep away the animals but would affect their behaviour adversely. The project activity would lead to the shrinkage of the habitat of wild animals. The most affected animal species in the surroundings are Common leopard, Leopard cat, Jungle cat, Barking deer, Wild boar, etc. Some of the dimensions of the impacts are temporary and short term while others are long term and permanent. The project authority is suggested to control and schedule the blasting taking the animal behavior like breeding, feeding etc. into account. The close vicinity of Pirpir Korang Nalah was observed as a corridor of wildlife, therefore, project activities must be restricted and controlled in that area.

4.3.1.4 *Habitat/Species loss*

The various activities like quarry, road construction, colony, etc. would have direct impacts on the habitat and plant species. The important tree species in and around the construction sites are *Albizia odoratissima, Alnus nepalensis, Altingia excelsa, Castanopsis indica, Lithocapus elegans, Macaranga denticulata*, etc. Other trees observed in this area are *Brassiopsis aculeata, Carpinus viminea, Casearia glomerata, Eurya acuminata, Garcinia cowa, Lyonia ovalifolia, Rhus chinensis*, etc. Shrub elements are composed of *Boehmeria macrophylla, Debregeasia longifolia, Elaeagnus parviflora, Maesa chisia, Rubus ellipticus* and *Schefflera bengalensis*. In order to clear the construction sites, a number of trees shall be removed from the area. In addition to direct acquisition and tree felling, there is possibility of species loss due to over exploitation of trees by migrant population. The loss of species and habitat would adversely affect the animal species like birds, butterfly etc.

4.3.1.5 *Phyto-retardation*

High concentration of suspended particulate matter (SPM) would lead to the phytoretardation in and around the activity area, which will reduce the physiological process in the plant species. Many plant species are intolerant of the phytoretardation and become wiped out from the area. Such impacts are short term (construction phase) and reversible in the nature.

4.3.1.6 *Introduction of Invasive Species*

Migrant population is anticipated to be cause of introduction of alien species in the area. There are some invasive species like *Ageratina adenophora, Ageratum conyzoides, Chromolaena odoratum,* which already grow in the area. These species are highly tolerant and grow well in degraded sites and spread rapidly. They may trigger the loss of biodiversity.

4.3.1.7 *Pressure on Natural Resources*

Due to the influx of migrant workers, there may be sharp increase in the human population, which may affect the natural resources adversely. There are fair possibilities of overexploitation of fuel wood, poaching and animal hunting because a part of the migrant population will be from other parts of Arunachal Pradesh. The tribes of Arunachal Pradesh are fond of animal hunting.

4.3.1.8 *Generation of Solid Wastes*

A total population of nearly 1160 persons is anticipated to come for the construction work of the Tato-I H.E. Project. Calculation of the average annual generation of solid waste results in around 200 tons of solid waste in the areas. The solid waste would comprise of plastic, metals, papers, glass and biodegradable wastes. The wastes would lead to the adverse impacts on the landscape, and would be obnoxious, if not managed properly.

4.3.1.9 *Visual Effect*

The quarrying sites, roads, and other construction sites would decrease the scenic beauty of the area. The construction sites would be obnoxious till the restoration.

4.3.2 Geophysical Environment

The project area falls in Dirang formation resting over the Sela group of rocks. The formation comprises a thick sequence of low grade metasedimentaries comprising garnet-muscovite schist, phyllite, sericite- quartzite, calc silicate and tremolite-actinolite marble, truncated in the north by MCT.

The rocks exposed at the Weir site are predominantly quartzite with sub-ordinate quartzo-feldspathic gneiss ± some schist bands. The head race channel or the power channel is primarily located in reaches covered by riverine deposits and zone of accumulation of palaeo-slide debris. Formation of channel will be essentially in cut reaches. The proposed Head Race Tunnel (HRT) alignment passes through a rough and rugged terrain with very difficult access on the left bank of Yarjep (Shi) River. The Head Race Tunnel crosses a number of cross drainage systems and one of them is Pirpit Korang nalah falling on the alignment just before the second bend and first major bend where low cover is expected. The Powerhouse is located on the left bank and a small nalah is joining the main river on this bank. A suitable crossing arrangement has been made at appropriate levels so that the nalah does not foul the construction activity. The location of the powerhouse is considered favorable taking advantage of the flat surface available on the left abutment. The predominant rock type at the powerhouse site is banded gneisses which are exposed on both the banks of the Yarjep (Shi) River.

4.3.3 Aquatic Environment

4.3.3.1 *Deterioration of Water Quality*

A large number of workers would camp along side the river. Also, many equipment and machineries would be stationed at working area. There are fair possibilities of sewage outfall, discharge of effluents and open defecation, bathing along side the river, which would adversely affect the water quality in upstream and downstream. Moreover, dearth of water in downstream would decrease the dilution of pollutants. These activities would exert the pressure in water quality, lessen the dissolved oxygen, pH, and increase the BOD, coliform concentrations. The deteriorated water would decrease the potability of water. In addition, leaching out of loose soil from the dumping areas and its dispose off would increase the turbidity of water.

4.3.3.2 *Generation of Waste Water*

The 1,160 people expected to come for construction will release nearly 1,16,000 liters of waste water per day is foreseen for the Tato I H.E. Project. Waste water drained into the river would deteriorate the overall quality of water.

4.3.3.3 *Species and Habitat Loss*

During the construction phase, no significant changes in the species composition and habitat changes are anticipated. But in operation phase it would occur considerably due to the diversion of water from main river channel. A dearth of water in the main channel is not expected to have rich diversity and to sustain column feeder fish species like *Garra* sp., and *Schizothorax* sp. Too low water discharge in downstream would destroy the breeding grounds of fish species.

4.3.3.4 *Fish Movement*

An intake channel would affect the movement of fish like *Schizothorax richardsonii*, *Garra* sp. etc adversely.

4.3.3.5 *Fisheries*

Because of the migrant population fishing activities may increase during the construction phase in the project area. After the construction and diversion, fisheries would be affected adversely. It would affect the local fishermen. In the absence of large size species in the downstream section fishermen may land small sized species. Notably, a very few fishermen are engaged in the fishing activities, therefore, major livelihood loss of natives is not foreseen.

4.3.4 Air & Noise Environment

4.3.4.1 *NO_2 and SO_2 Level*

The level of NO_2 and SO_2 in the surrounding of Tato I H.E. Project is far below the National Ambient Air Quality Standard due to very sparse population and pristine ecosystem. During the construction phase, a large number of equipment, vehicles, etc, viz. DG sets, cranes, rollers, dumpers, trucks, would be deployed, thus, emission of pollutants would increase many fold in the area. These pollutants have adverse effects on human health. At the point source, annual average level of NO2 and SO2 may reach above the permissible limits (20 μg m^{-3} and 20 μg $m^{-3)}$ but concentration would decrease gradually along peripheral gradient.

4.3.4.2 *Suspended Particulate Matter (SPM)*

The actions like excavation, tunneling, quarrying, dumping and vehicular movement would lead to the high concentration of SPM in air quality. The high concentration of SPM would have adverse effects on the human as well as plan health. Likewise the concentrations of NO2 and SO2, the annual average level SPM may reach above the permissible limits (500 μg m^{-3}) but concentration would decrease gradually along peripheral gradient.

4.3.4.3 *Noise Level*

The region is composed, no disturbing noise occurs in the entire Yarjep (Shi) valley. During the construction phase operation of machines like compressor, loader, roller, bulldozer, vehicles, blasting would increase the sound level significantly. These activities would disturb the human population (loss of hearing) as well as wildlife. All equipment deployed at the working sites are not supposed to run at same time so that it would be difficult to assess the over all level of sound, however, Table 4.1.1.1 gives the sound generating capacity of different equipment at the source. The safe minimum standards in this region would need that the sound level of the instruments should not be more than 60dBA beyond 1000m. During night time strict silence needs to be observed and there should be minimum use of light. Such negative impacts would remain for short time during construction phase only. The impacts are temporary and reversible in nature.

Table 4.1.1.1 Sound level produced by different instruments while in operation

Sl. No.	Equipments	Sound Level (dBA)
1.	Truck Mounted Crane	76-83
2.	Un-silenced scraper/grader	82
3.	Generator	82
4.	Un-silenced pile diver	110
5.	Un-silenced compressor	80
6.	Un-silenced pneumatic drill	90
7.	Heavy duty bulldozer	91-107
8.	Light duty bulldozer	93-101

Source: Kerr *et al.*, 2002

4.3.4.4 *Visual Impact*

During the construction phase SPM are clearly visual in the air. It becomes irritating and obnoxious in a wider range. It affects the human health adversely.

4.3.5 Human Environment

For the purpose of construction work, a considerable number of outsider labourers and project staff would enter the area. The outsider workers would have various effects, described below.

4.3.5.1 *Demographic Changes*

Around 1160 persons including family members of workers are expected to come in the area. The human population density in the surrounding areas is very low, therefore, prominent increase in the human population would be seen. During the construction phase the outsiders would account for about 50% of the total population of influence area. The demographic changes have many beneficial and harmful impacts. Though, it is a temporary phenomenon and after construction period, about all of the migrants would be homed.

4.3.5.2 ***Cultural Confliction***

Change in the demography may trigger the cultural confliction between natives and outsiders because the area is dominated by tribal population. These tribes are unique in their culture, customs and their traditions. The high number of migrant population may bring the anxiety among the tribe, which may result in the confliction.

4.3.5.3 ***Social Evils and threats to new disease***

Sometimes outsider population is associated with crimes and other social evils. The natives may be affected adversely. In addition, the migrant population is expected to be carrier of new diseases.

4.3.5.4 ***Interaction***

An interaction between natives and migrant population is anticipated to facilitate an exposure to natives. Such types of exposure would have positive impacts on the local population.

4.3.5.5 ***Small Scale Business***

The migrant population would provide a fair possibility of a surplus income for natives. The local people could start small scale business for daily needs in the area.

4.3.6 Downstream Impacts

4.3.6.1 ***Habitat/species loss, Deterioration of Water quality, Fish***

The diversion of river water from main channel is foreseen to trigger the habitat loss, changes in species composition, water quality, fish and fisheries. All these impacts are described under the heading 4.3.3.

4.3.6.2 ***Change in Flow Regime***

Change in the flow regime may have many environmental consequences, which are described above. In addition, there are many unseen impacts of changed environmental flow. About 6.0 km river stretch would undergo through scarcity of water. Though, a few tributaries like Pirbi Korong, an unnamed nallah and Shea Nallah join Yarjep (Shi) at 0.3 km, 0.9 km and 2.8 km downstream of the intake on left bank while a small tributary confluences at 1.1 km on the right bank downstream of the intake. The water discharge of Pirbi Korong and Shea nallah rangers from 0.41 to 5.5 cumec and 0.76 to 10.23 cumec, respectively. These tributaries contribute to Yarjep (Shi) river, with a certain quantity of water but adverse impact cannot be denied. The major impacts in the downstream stretch anticipated are increase in the water temperature, decrease in dissolved oxygen, increase in the density of pollution tolerant species, decrease in the density of pollution intolerant species, isolation of breeding pools of fish and deposition of sand bars at the mouth of tributaries. These impacts are generally negative and long lasting. A minimum environment flow will be left in the river in order to mitigate such adverse impact.

4.3.6.3 *Livelihood*

The livelihood of people largely depends on the river water, if irrigation and fisheries depend on the river water. In the downstream stretch no irrigation land falls while fishing activities are very low. Thus, no adverse impacts on the livelihood are anticipated.

4.3.6.4 *Drinking Water*

Villagers do not depend on the river for drinking water. They exploit drinking water from springs, therefore, no negative impacts are foreseen on drinking water after diversion of water.

4.3.6.5 *Bank Erosion*

After the diversion of water, the possibility of bank erosion increases because downstream channel would receive turbid free water from weir and tail race channel. The turbid free water has more eroding capacity.

4.3.6.6 Riparian Vegetation

Low water flow in the downstream channel is anticipated to affect the riparian vegetation adversely.

4.3.7 Economic Upliftment

In order to mitigate or to avoid adverse impacts predicted, project authorities would implement many mitigation measures related to environment and societies. There would be good share of employment for local people. In addition to direct employment in the project activities, the inhabitants would be benefited indirectly like small contract, etc. There will be significant changes in the infrastructure facilities like transportation, education, health, etc. The Rehabilitation and Resettlement Plan in EMP report is directly related to the local people and their upliftment. In addition to the relief package, project authorities would implement a peripheral or social development plan. The provisions would have been made towards local participation in the project activities, infrastructure development like school, health centre, adoption of village, scholarship scheme, play ground, etc. development of small scale business, etc. The social development plan would play an important role in empowering the vulnerable groups of the region. It would put in positive impacts on the tribal community for long time and would be strategic in the nature.

4.3.8 Impact Information

After a detailed analysis, the predicted impacts were divided on the basis of their nature, magnitude, longevity and significance. Each impact was analyzed under the categories mentioned above and quantified using modified Leopold matrix-. Each impact was assigned with a score using a scale of 1-5, depending on the magnitude and potential. A positive and negative sign was provided for beneficial and harmful nature of the impacts. The rows' totals of matrix- reflect the total impacts of an action on the various environment component while the columns' totals reflect the impact of all actions on one environmental variable.

Table 4.1.1.2 indicates relative comparison of impacts of various actions on the different environmental components during the construction as well as operation phases. Details are provided in the Matrix 4.1 and 4.2. Majority of the impacts is negative but minor in their potential. Notably, the magnitude of negative impacts decreases considerably in the operation phase. In the construction phase, total score is -89, of which 110 stands for negative impacts and 21 for positive impacts. During the operation phase total score decrease to – 46 of which negative impacts score for 63 and positive for 17. In the construction phase migrant population and excavation/tunneling are major activities which pose major impacts on the environmental and social components while community development is most positive impact. In operation phase diversion of water leads to maxima negative impacts. The downstream impacts are long lasting and permanent in the nature.

Table 4.1.1.2 Summary of impacts of various actions in construction and operation phases

Actions	Construction Phase		Operation Phase	
	Positive	Negative	Positive	Negative
Intake	0	0	0	3
Road construction	1	13	1	5
Submergence	0	2	0	2

Power house	0	14	0	5
Adits	0	2	0	2
Dumping	0	11	0	5
Excavation/Tunnel.	0	17	0	3
Quarrying	0	11	0	4
Colony	0	2	1	3
Diversion	0	0	1	18
Migrant population	4	23	1	10
Construction method/	2	12	1	1
Vehicular Movement	3	3	3	2
Community Development	11	0	9	0
Total	**21**	**110**	**17**	**63**

Table 4.1.1.3 shows relative impacts on the various environmental and social components. In the construction phase wildlife and ambient air quality are most adversely impacted components while employment opportunities and infrastructure development are the benefited social components. In operation phase land use and land cover would be changed permanently causing negative visual effect.

Table 4.1.1.3 Summary of impacts on various environmental variables in construction and operation phases

Environmental/	Construction Phase		Operation Phase	
Social variables	Positive	Negative	Positive	Negative
Land use /land cover	0	8	0	9
Habitat loss/ Degradation	0	1	0	1
Wild life	0	12	1	5
Phytoretardation	0	6	0	0
Exploitation of resource	0	2	0	2
Visual Effect	0	6	0	8
Ground Water Level	0	3	0	2
Weathering	0	3	0	0
Landslides/slip	0	2	0	1
Stability	0	4	0	0
Deterioration of water	0	9	0	4

Species/ Habitat loss	0	3	0	5
Fish Movement	0	0	0	5
Fisheries	0	2	0	5
NO_2, SO_2 Level	0	7	0	2
SPM	0	13	0	1
Noise Level	0	11	0	2
Visual Impact	0	10	1	6
Demographic changes	0	4	0	1
Cultural confliction	0	2	0	1
Social evils	0	2	0	1
Interaction	2	0	1	0
Small scale business	2	0	1	0
Downstream Impact*				
Habitat /species loss/	-	-	-	-
Flow regime	0	0	0	1
Livelihood	0	0	0	0
Drinking water	0	0	0	0
Bank erosion	0	0	0	1
Riparian vegetation	0	0	0	1
Employment	5	0	2	0
Social values	4	0	4	0
Basic amenities	7	0	7	0
Marketing	1	0	1	0
Total	**21**	**110**	**18**	**64**

*some of the downstream impacts are mentioned in aquatic environment

4.4 IDENTIFICATION OF MITIGATION MEASURES

After the identification and prediction of impacts some mitigation measures are identified to ameliorate the negative impacts. Some of the important mitigation measures which are warranted to conserve the environment are listed below

i). Adequate safeguard measures for wildlife conservation and preservation of biodiversity

ii). The activity like blasting must be scheduled and controlled taking the animal behaviour like movement time, breeding, corridor, etc. into account iii). Afforestation in degraded land and catchment area

iv). Adequate engineering measures at construction sites, catchment area, dumping areas, land slides to arrest the soils

v). Restoration of quarry sites, colony area, road sites and other construction sites

vi). Maintenance of water quality, air quality and noise level

vii). Fish and Fishery development

viii). Regular monitoring of migrant population to prevent the overexploitation of forest resources, poaching, crime, social evils, and cultural confliction.

ix). Development of infrastructure in the surrounding area towards education, health, transportation, etc.

x). Adequate measures for disposal of waste

xi). Suitable mitigation measures for downstream impacts

All mitigation measures are taken into account in the Environment Management plan of Tato-I H.E. Project.

4.5 CUMULATIVE IMPACT ASSESSMENT

Generally assessment of the impacts is addressed in isolation considering a particular project. Sometimes it becomes insignificant when there are other existing or/and proposed projects in the close vicinity. Therefore, in order to achieve the aim, evaluation of impacts is carried out in context of combined effects of all past, present and reasonably foreseeable future activities. Cumulative impact assessment also provides valuable and important inputs particularly in monitoring of environmental sustainability impacts. Thus, the process of analyzing cumulative effects is an enhancement of the traditional environmental assessment components: (i) scoping, (ii) describing the affected environment, and (iii) determining the environmental consequences.

The cumulative impacts are broadly divided into two categories namely additive cumulative impacts and synergistic cumulative impacts. In this contribution, synergistic cumulative impacts are described because the combined effects of the projects are considerably larger than the impact of an individual project. The present contribution deals with the impact assessment of cascade development on the Yarjep (Shi) river in West Siang district of Arunachal Pradesh.

Though, there are many projects like Tato-II, Tato-I. Heo, Pauk, Rego, Tagurshit projects are proposed in the basin but hence, a cumulative impact assessment for three projects, namely Tato-I, Heo, and Pauk H.E. Projects is formulated. These projects are owned by a same agency so that the main purpose of cumulative impact assessment is to mitigate the adverse impacts of the projects under the comprehensive and coordinated system. The mitigation measures for these projects are given separately, however, an approach of coordination for the implementation of the various management plan has been followed.

4.5.1 Brief Description of the Projects

The cumulative impacts of three projects on the surrounding environment are addressed in this contribution. Prior to highlight the identification and prediction of impacts, an account of comparative salient features of these projects is given in Table 4.4.

Table 4.1.1.4 Salient features of the projects proposed on Yarjep (Shi) river in casecade

		Tato I HEP	Heo HEP	Pauk HEP
Location of Intake/dam/barrage				
Latitude	:	28˚ 32’ 32”	28°32’20’’N	28˚ 32’ 46”N
Longitude	:	94˚ 18’ 43”	94°16’31’’E	94˚ 14’ 43”E
Location of Power House				
Latitude	:	28˚ 31’ 53”	28°32’32’’N	28˚ 32’19”N
Longitude	:	94˚ 21’ 31”	94°18’43’’E	94˚ 16’ 01”E
Catchment area at dam site	:	1154 sq km	1065 sq. km	985 sq km
Design Flood	:	3400 cumecs	3200 cumecs	3700 cumecs
Weir/dam top	:	1195.5 m	1400 m	1550 m
River Bed Level at Intake site	:	1188 m	1385 m	1445 m
Height of weir/dam (above river bed level)	:	7.5 m	15 m	105 m
Design discharge	:	133 cumecs	130.2 cumecs	118 cumecs
Submergence	:	3 ha	8.4 ha	34.1 ha
Length of HRT	:	3.9 km	3.55 km	2.8 km
PH Type	:	Surface	Surface	Surface
Installed capacity	:	186 MW	240 MW	145 MW
Construction period	:	4 years	4 years	4 years
Total land to be acquired	:	52.8 ha	55.7 ha	91.7 ha

4.5.2 Identification & Prediction of Cumulative Impacts

Cumulative impact assessment is a part of strategic environmental assessment, provides better scope than project level impact assessment. Such types of studies address the impacts of development on environment and helpful in assessing the effect of policy, plan and programme on the environment. This section deals with the identification of impacts of Pauk, Heo and Tato I H.E. projects on the surroundings. Table 4.1.1.5 summarizes the various actions of three projects cumulatively during construction phase and operational phase.

4.5.3 Construction Phase

Various activities mentioned in the Table 4.5 would lead to cumulative impacts on the various environments like biological, social, human, air, human environments with different magnitudes in construction and operational phases. Nature of all impacts are same for all projects, however, magnitude of impacts would increase while considering cumulatively. Major adverse impacts on the flora and fauna are anticipated in the construction phase. Apart from the ecosystem services provided by plant species, many species of economic importance like *Actinodaphne obovata*, *Albizia odoratissima, Alnus nepalensis, Altingia excelsa, Brassiopsis aculeate*, *Cinnamomum glaucscens, Castanopsis tribuloides, Casearia glomerata, Engelhardtia spicata, Eurya acuminata*, *Ficus semicordata, F. Oligodon, Garcinia cow*, *Lyonia ovalifolia*, *Macaranga denticulata*, *Saurauia Schefflera bengalensis Schima wallichi*, *Xylosma longifoli*, , *Carpinus viminea*, *Quercus glauc,* etc. will be under the direct influence of the project.

Project activities have direct as well as indirect impacts on the wild animals. Generally activities of river valley project are concentrated in the lower reaches of valley but cascade development covers a larger area thus, leads to adverse impacts on the faunal species in large area. The important animal species like Panthera pardus, *Prionailurus bengalensisCanis aureus*¸ *Neofelis nebulosa*, *Macaca assamensis, Felis chaus, Lutra lutra, Sus scrofa cristatus Muntiacus muntjak, Lophura leucomelana* will be directly affected due to activities of all three projects. In addition, project activities during construction and operational phases are described below.

Table 4.1.1.5 Combined actions of three projects in Yarjep (Shi) valley of Arunachal Pradesh

Parameters	Construction Phase	Operation Phase	Nature of Impact
Land Environment			
Influence Area	581 sq. km	581. sq. km	-
Land use Changes	156.1 ha	44.1 ha	Negative, Permanent, Irreversible
Submergence	-	44.1 ha	Negative, Permanent
Generation of Solid Waste	1868 kg/ day	373 kg/ day	Negative, Temporary, Reversible
Quantity of Muck to be generated	28,27,293 m^3	-	Negative, Permanent, Reversible
Water Environment			
Hydraulic Changes	-	14 km d/s	Negative, Permanent, Irreversible
Generation of Waste Water	4,00,000 L/day	80,000 L/day	Negative, Temporary, Reversible
No. of Intermediate Tributaries	08	08	Positive, Permanent
Anthropogenic Pressure			
Total Migrant Population	4000	/	Negative, Temporary, Reversible
Biological Environment			
No of Trees Affected (approx.)	50,000	-	Negative, Temporary, Reversible
Social Environment			
Villages in Influence Area (Census, 2001)	29	29	-
Total Population of Influence Area (Census, 2001)	2899	2899	-
No of Affected Villages (Census, 2001)	10	-	Negative, Temporary, Reversible
No. of Affected Families/ HH (Social Survey)	209/144	-	Negative, Temporary, Reversible
Population of Affected Families (Social Survey)	733	-	-
Geophysical Environment			

Total Length of HRT	6.8 km	6.8 km	Negative, Permanent, Irreversible
Total Land required for Road	45.3 ha	-	Negative/Positive, Permanent, Irreversible
Total Area required for Quarry Sites	2.6 ha	-	Negative, Permanent, Irreversible
Total No of Nalahs Crossed By HRT	-	4	Negative, Temporary, Reversible

Total expected population of migrant workers would be higher that the existing population of influence area. The various professional and social activities of migrant workers are anticipated to lead the negative as well as positive impacts on the local population. These impacts in construction phase can be identified and predicted as demographic changes, cultural confliction, extraction of natural resources, social evils, threats to heath etc. The generation of solid waste and waste water is secondary impact of migrant population. On the other hand high population and ancillary activities would provide fair possibilities of development of small scale business. The additional requirement of food grains, milk, white goods, and other daily needs can provide a source of surplus income for locals.

Air quality is anticipated to be affected most adversely as compared to other parameters of environment. The ambient air pollutants are more concentrated at the source and their concentration decreases along the peripheral gradient. In case of cascade development, there would be many source of these pollutants, therefore, Yarjep (Shi) valley up to Mechukha would be affected. The obnoxious clouds of dust are foreseen to be visible in the valley. The air pollutants have impacts on human health and plant species, described earlier. Table 4.1.1.6 gives a summary of activities, their impacts and nature of impacts in the construction phase.

Table 4.1.1.6 Construction activities and their impacts

Construction Phase	Activity	Potential Environmental Impact
a) Site work / other facilities.	i) Cleaning and grading	Deforestation
	ii) Temporary facilities, such as sheds, approach roads, sanitary facilities	Dust emission and change in traffic intensity
	iii) Earth work comprising of excavation and trenches	Soil erosion, run off, increase in traffic, dust emission
	iv) Foundation work, piling and construction of check dams	Dust, visual and noise pollution
	v) Construction of permanent structures like roads, colony, etc.	Dust and noise pollution Deforestation
	vi) Mechanical erection and utility systems	Dust, noise and visual impact
	i) Excavation	Dust, soil erosion, wastewater generation and noise

b) Construction of approach roads tunneling works and foundations	ii) Drilling & Blasting	Dust, noise and health hazards, change in the course of course of water source, Wildlife disturbances
c) Disposal of muck	i) Dumping	Dust, noise and visual
	ii) Transportation	Dust, noise and visual
	iii) Excavation iv) Road Construction	Dust, SPM level Dust, SPM level, Noise
d) Socio-economic disturbances	i). Due to rehabilitation and resettlement aspects ii) Due to labour influx	Impact on human health, cultural, aesthetics, etc. Various social, cultural changes
e) Installation of Equipment like loader, cranes, crushers, compressors, heavy vehicle, DG sets	i) Operation ii) Running	Increase in NOx, SOx and CO_2 Disturbance to wildlife Add to social services
f) Other works	i) Lighting iii) Landscaping iv) Solid waste disposal v) Finishing activities like removal of temporary works	Adverse impacts on flora, entomo-fauna Visual impact, beautification Soil pollution, visual impact Generation of solid waste, visual impact

4.5.4 Operational Phase

Permanent acquisition of land, downstream and upstream activities are major impacts which would remain during the operational phase. After the construction phase, most of the project activities would cease, thus, magnitude of associated impacts would decrease significantly. There would be no more removal of plant species. In case of wild animal species permanent impacts like habitat fragmentation and habitat shrinkage due to structural units, vehicular movement would occur but the source of high noise (blasting, tunneling) would come to end. Major part of the vehicles and machines running in the area will be removed. Similarly, most of the migrant workers (about 90%) will be homed. All the labour camps and temporary colonies will be dismantled and the project authorities would carry out the phytoremediation of those sites. The degraded habitats will be stabilized during the operational phase. The pressure on the aquatic ecosystem will reduce due to the decreasing anthropogenic pressure. Air pollutants will decrease due to closing of construction activities.

The diversion of water is major impact during the operational phase, which would result into the scarcity of water from nearly 14 km river stretch. Paucity of water in downstream stretch would have adverse impacts on ichthyofauna, and other biotic communities. Diurnal variation in the flow would destabilize biotic communities of the river.

The implementation of local area development and community development plans is expected to be most beneficial activity of the project. Such types of plans work in the construction as well as operational phases. Joint efforts of all projects are expected to help a large area in West Siang district. The provisions of schools, health centres, footpaths, roads, income generation schemes, training programme etc. would put in to empowerment of society and development of infrastructure.

Most of the management plans suggested to restore the environment are implemented in the operational phase of the project. Table 4.1.1.7 gives a summary of activities, their impacts and nature of impacts in the operation phase.

Table 4.1.1.7 The major impacts identified during the operational phase

Operational Phase	**Activity**	**Potential Environmental Impact**
a) Site work / other facilities.	i) Creation of reservoir	i) Leads to submergence of a large number of plant, causes habitat shrinkage and fragmentation, helpful in fishery development
	ii) Construction of permanent structures like roads, colony, etc.	ii) Sewage outfall, vehicular movement, which would disturb wild animals.
	iii) Dam structure	iii) Hampers fish migration
b) Construction of footpath	i) in affected villages	i) It will help the local people in the transportation
c) Downstream impacts	i) There will be reduction in the water over a 14 km stretch	i) It would cause habitat fragmentation for fish and provide new corridors for wildlife ii) Low dilution of pollutants would lead to deterioration of water quality

d) Socio-economic impacts	i) Amenities	i) The establishment of new schools, health centres and market complex, provision of drinking water, electricity etc. would empower the tribal population, improve the quality of life in the region and provide fair job opportunities
e) Implementation of EMP	CAT, Biodiversity Management, Fisheries, Landscaping, etc	Reduce the negative impacts, restoration of environment, etc.

Matrix 4.1 Modified Leopold Matrix to study the environmental impacts in construction phase

Environmental effects / Developmental Activities	Land Environment						Geophysical Environment				Aquatic Environment				Air Environment & Noise				Human Environment					Downstream Environment						Economic Upliftment				**Total**
	Land use /land cover	Habitat loss/ Degradation	Wild life	Phytoretardation	Exploitation of resource	Visual Effect	Ground Water Level	Weathering	Landslides/slip	Stability	Deterioration of water	Species/Habitat loss	Fish Movement	Fisheries	NO_2, SO_2 Level	SPM	Noise Level	Visual Impact	Demographic changes	Cultural confliction	Social evils	Interaction	Small scale business	Habitat /species loss/	Flow regime	Livelihood	Drinking water	Bank Erosion	Riparian vegetation	Employment	Social value	Basic amenities	Marketing	
Intake	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	0	0	0	0	0	0	0	0	0	**00**
Road construction	-2	0	-1	-1	0	-1	0	-1	-2	0	-1	0	0	0	0	-2	-1	-1	0	0	0	0	0	-	0	0	0	0	0	0	0	1	0	**-12**
Submergence	-1	-1	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	0	0	0	0	0	0	0	0	0	**-2**
Power house	-2	0	-1	0	0	-1	-1	-1	0	-2	-2	0	0	0	-2	-2	0	0	0	0	0	0	0	-	0	0	0	0	0	0	0	0	0	**-14**
Adits	0	0	0	0	0		0	0	0	0	-1	0	0	0	0	0	0	-1	0	0	0	0	0	-	0	0	0	0	0	0	0	0	0	**-2**
Dumping	-1	0	0	-2	0	-1	0	0	0	0	-1	-1	0	0	-1	-2	0	-2	0	0	0	0	0	-	0	0	0	0	0	0	0	0	0	**-11**
Excavation/Tunnel.	0	0	-3	-2	0	-1	-2	0	0	-2	0	0	0	0	0	-2	-3	-2	0	0	0	0	0	-	0	0	0	0	0	0	0	0	0	**-17**
Quarrying	-1	0	-1	-1	0	-2	0	-1	0	0	0	0	0	0	0	-2	-1	-2	0	0	0	0	0	-	0	0	0	0	0	0	0	0	0	**-11**
Colony	-1	0	-1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**-2**
Diversion	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	**0**
Migrant population	0	0	-2	0	-2	0	0	0	0	0	-3	-1	0	-2	-1	-1	-2	-1	-4	-2	-2	2	2	-	0	0	0	0	0	0	0	0	0	**-19**
Construction method/	0	0	-2	0	0	0	0	0	0	0	-1	-1	0	0	-2	-2	-3	-1	0	0	0	0	0	-	0	0	0	0	0	2	0	0	0	**-10**
Vehicular Movement	0	0	-1	0	0	0	0	0	0	0	0	0	0	0	-1	0	-1	0	0	0	0	0	0	-	0	0	0	0	0	0	2	1	0	**0**
Community Development	0	0	-	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	0	0	0	0	0	3	2	5	1	**11**
Total	**-8**	**-1**	**-12**	**-6**	**-2**	**-6**	**-3**	**-3**	**-2**	**-4**	**-9**	**-3**	**0**	**-2**	**-7**	**-13**	**-11**	**-10**	**-4**	**-2**	**-2**	**2**	**2**	**-**	**0**	**0**	**0**	**0**	**0**	**5**	**4**	**7**	**1**	**-89**

Matrix 4.2 Modified Leopold Matrix to study the environmental impacts in operation phase

Environmental effects / Developmental Activities	Land Environment						Geophysical Environment				Aquatic Environment				Air Environment & Noise				Human Environment					Downstream Environment						Economic Upliftment				**Total**
	Land use /land cover	Habitat loss/ Degradation	Wild life	Phytoretardation	Exploitation of resource	Visual Effects	Ground Water	Weathering	Land Slide/slips	Stability	Deterioration of Water	Species/Habitat Loss	Fish Movement	Fisheries	NO_2, SO_2	SPM	Noise Level	Visual Impacts	Demographic change	Cultural confliction	Social evils	Interaction	Small Scale business	Habitat /species loss/	Flow regime	Livelihood	Drinking water	Bank Erosion	Riparian vegetation	Employment	Social value	Basic amenities	Marketing	
Intake	0	0	0	0	0	0	0	0	0	0	0	0	-3	0	0	0	0	0	0	0	0	0	0	-	0	0	0	0	0	0	0	0	0	**0**
Road construction	-2	0	-1	0	0	-1	0	0	-1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	0	0	0	0	0	0	0	1	0	**-3**
Submergence	-1	-1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	0	0	0	0	0	0	0	0	0	**-2**
Power house	-2	0	-1	0	0	-1	-1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	0	0	0	0	0	0	0	0	0	**-5**
Adits	0	0	0	0	0		0	0	0	0	-1	0	0	0	0	0	0	-1	0	0	0	0	0	-	0	0	0	0	0	0	0	0	0	**-2**
Dumping	-1	0	0	0	0	-1	0	0	0	0	-1	0	0	0	0	0	0	-2	0	0	0	0	0	-	0	0	0	0	0	0	0	0	0	**-5**
Excavation/Tunnel.	0	0	0	0	0	-1	-1	0	0	0	0	0	0	0	0	0	0	-1	0	0	0	0	0	-	0	0	0	0	0	0	0	0	0	**-3**
Quarrying	-1	0	0	0	0	-2	0	0	0	0	0	0	0	0	0	0	0	-1	0	0	0	0	0	-	0	0	0	0	0	0	0	0	0	**-4**
Colony	-1	0	-1	0	0	0	0	0	0	0	-1	0	0	0	0	0	0	1	0	0	0	0	0	-	0	0	0	0	0	0	0	0	0	**-2**
Diversion	-1	0	1	0	0	-2	0	0	0	0	0	-5	-2	-4	0	0	0	-1	0	0	0	0	0	-	-1	0	0	-1	-1	0	0	0	0	**-17**
Migrant population	0	0	-1	0	-2	0	0	0	0	0	-1	0	0	-1	-1	-1	-1	0	-1	-1	-1	1	1	-	0	0	0	0	0	0	0	0	0	**-11**
Construction method	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-1	0	0	0	0	0	0	0	0	-	0	0	0	0	0	1	0	0	0	**0**
Vehicular Movement	0	0	-1	0	0	0	0	0	0	0	0	0	0	0	0	0	-1	0	0	0	0	0	0	-	0	0	0	0	0	0	2	1	0	**1**
Community Development		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	0	0	0	0	0	1	2	5	1	**9**
Total	**-9**	**-1**	**-4**	**0**	**-2**	**-8**	**-2**	**0**	**-1**	**0**	**-4**	**-5**	**-5**	**-5**	**-2**	**-1**	**-2**	**-5**	**-1**	**-1**	**-1**	**1**	**1**	-	**-1**	**0**	**0**	**-1**	**-1**	**2**	**4**	**7**	**1**	**-46**

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ANNEXURES

Annexure I

QUESTIONNAIRE FOR SOCIO-ECONOMIC SURVEY OF AFFECTED VILLAGES DUE TO PROJECT RELATED ACTIVITIES OF PROPOSED TATO-I H.E. PROJECT, ARUNACHAL PRADESH

1. Village Name ____________________

   a) District __________ b) Development Block __________

   b) Tehsil __________ d) Panchayat __________

2. Area (ha) ____________________

3. Number of households ____________________

4. Population Profile:

   Total population:

   a) Male ____________________

   b) Female ____________________

   c) Scheduled Castes ____________________

   d) Scheduled Tribes ____________________

5. Workers:

   a) Main workers ____________________

   b) Farmers ____________________

   c) Marginal workers ____________________

   d) Others ____________________

6. Total Cultivable area (ha) ____________________

7. Net Sown area (ha) ____________________

8. Net Irrigated area (ha) ____________________

9. Cropping Pattern:

   Area (ha) under principal crops and yield (per ha) ____________________

Cereals

a) Wheat ______

b) Maize ______

c) Rice ______

d) Others ______

Pulses

Rajmah ______

Others ______

10. Horticulture:

Area (ha) under principal crops and annual production

a) ______

b) ______

c) ______

d) ______

11. Medical Facilities:

a)	Allopathic institutions	No.	No. of Beds	No. of Doctors	Other Staff
	1) Hospitals				
	2) Community Health Centres				
	3) Primary Health Centres				
	4) Dispensary				
	5) Health Sub-centre				

b) Ayurvedic Institutions: Nos. No. of Beds

1) Hospitals ____________________

2) Dispensary ____________________

c) Health & Hygiene:

Prevalent Diseases ____________________

Endemic Diseases ____________________

Epidemic Diseases ____________________

12. Educational Institutions:	Number	Student Strength	No. of Teachers
a) Primary schools			
b) Middle schools			
c) High / Higher Secondary schools			
d) Colleges			

If there is no school, then nearest school and distance from the village.

13. Veterinary Facilities:

a) Hospitals ____________________

b) Dispensary ____________________

c) Artificial Insemination Centres ____________________

14. Sewage & Sanitation Facilities, if any ____________________

____

15. Whether Electrified Yes / No

– Any electrical sub-station ____________________

– If not electrified, then the nearest electrified village ____________________

16. Roads Length (km)

a) Unmetalled ______

b) Metalled ______

c) Jeepable ______

d) If not connected by any road, then the nearest road head (distance)

______

17. Post Office Yes / No

If the answer is 'No', then the location and distance of nearest post office

______

18. Telegraph Office ______

19. Banks ______

20. Police Post ______

21. State Government Employees ______

22. Central Govt. Employees ______

23. Drinking water availability:

Source ______
(River, Well, Hand-pump, Tap, Public Standpost, springs and others)

Quality :	Satisfactory :	Yes/ No (Nature of problem, if No)
Quantity :	Adequate/ Inadequate	For drinking water (litres) For other use (litres)

Any other specific drinking water problem
If the water is not fit for drinking, how do you purify it.
(filtering through cloth, boiling, alum treatment, disinfectant, decantation) etc.

Water borne diseases, if any
(Dysentary, Diarrhoea, Jaundice, Gastroenteritis, others, etc.)

24. Livestock:

- Sheep ______________ Buffaloes ______________
- Goat ______________ Horses & Mules ______________
- Cows ______________

25. Co-operative Societies & NGOs______________

26. Village Panchayat ______________

27. Fair Price Shop ______________

28. Tourist/Recreational Spot ______________
(Religious place, historical monument, sanctuary, others, etc.)

29. Fertilisers used and consumption ______________

30. a) Forest Range/Division ______________

Forest Check Post/s ______________

b) Forests & Forest Produce:

Forests:

Reserve Forest ______________

Protected Areas ______________

Revenue Forest ______________

Forest produce:

Medicinal herbs ______________

Misc. ______________

31. Natural Water Sources:

a) Springs ______________

b) Brooks ______________

c) Water Quality ______________

32. Literacy ____________________

33. Income Pattern:

a) Farming ____________________

b) Salaried:

- Government ____________________

- Private ____________________

c) Businessman/Shops/Trading ____________________

34. Government Schemes (Both Central & State Govt.) like IRDP, etc.

____

____

35. Vocational Training Centres, if any ____________________

____

36. Meteorological Data:

a) Rainfall

i) Average Annual __________ ii) Daily (mm) __________

b) Temperature Mean: ______ Max. ______ ^{o}C Min. ______ ^{o}C

Daily record, if available ____________________

c) Snowfall ____________________

d) Hailstorms a) Intensity __________ b) Frequency __________

e) Flashfloods a) Historical __________ b) Frequency __________

37. Fishery Resources:

Type of Fish ____________________

Licenced Fisherman, if any ____________________

Fish catch ______

38. Small Scale Industries:

    a) Medicinal herbs collection ______

    b) Handicrafts ______

    c) Shawl making ______

    d) Carpet weaving ______

    e) Paper Machie ______

    f) Wooden carving ______

    g) Apiary ______

    h) Others ______

39. Mode of transport : ______

40. Vehicles:

    a) Bicycles ______

    b) Tractors ______

    c) Scooters/Bikes ______

41. Marketing Facilities:
    Local Trading Centre ______

42. Non-conventional Energy Sources:

    Solar lighting etc. ______

43. Recreational facilities ______
    (Library, Club, TV, Cinema, etc.)

44. Wastewater
    How do you dispose-off watewater ______
    (Drainage, Sewer, Soak pit, No organised system, etc.)

    Any specific problem related to waterwater ______

    Suggestions for improvement ______

45. Sanitation and Health

No. of families : Latrine proper sanitation facilities

Soakpit : ____________ Septic tank : ____________ Any other : ____________

(If No, where do you go for defecation)

Open space: Field: Road side: Public latrine:

46. Solid waste disposal:

(Unused land, road side, community dustbin, composting, any other)

Annexure II

QUESTIONNAIRE FOR SOCIO-ECONOMIC SURVEY OF AFFECTED FAMILIES DUE TO PROJECT RELATED ACTIVITIES OF PROPOSED TATO-I H.E. PROJECT, ARUNACHAL PRADESH

Village Name ______________________________

a) District ______________ b) Development Block ______________

b) Tehsil ______________ d) Panchayat ______________

1. Name of the head of the family ______________________________

2. Religion of the family ______________________________

3. Caste of the family: General ________ SC ________ ST ________ OBC ________

4. Number of Family Members ______________________________

5. Age group of the family members: Adults ______________________________

   Children (0-6) ______________________________

   Children (6-17) ______________________________

6. Number of earning members

7. Number of non-earning members Male [ ] Female [ ]

8. Number of dependants & relationship with head of the family Male ______________________________

   Female ______________________________

   Children: (Male : 0-6) ______________________________

   (Female : 0-6) ______________________________

9. Marital status of dependants : Married : Male [ ] Female [ ]

   Unmarried : Male [ ] Female [ ]

10. Occupation of family members:

   Father ______________________________

   Mother ______________________________

   Children : Daughter ______________________________

   Son ______________________________

   Others ______________________________

11. Occupation details:

Service Governmetn/ Non-government

Agriculture ______________________________

Business ______________________________

Any other ______________________________

12. Educational qualifications of family members:

Primary ______________________________

Higher Secondary ______________________________

Graduate ______________________________

Post-graduate ______________________________

and above ______________________________

13. Homestead Land:

	No. of house/houses	Area (Acres)
a) Owner	______________	______________
b) Tenant	______________	______________

14. No. of houses affected due to construction of project ______________________________

15. No. of houses left ______________________________

16. Land holding:

Total ______________Acres/ hectare/ any other ( )

Land under cultivation ______________ Acres

Location of land Same village ______________ (Area in acres/ha/any other)

Other village ______________ (Area in acres/ha/any other)

17. Land self tilled or by labourers ______________________________

18. Whether living in village or not, permanently/temporarily ______________________________

19. No. of shops/mills to be acquired/affected

20. No. of shops left

21. No. of animals :

Sheep	____________
Goat	____________
Cow	____________
Bull	____________
Horse	____________
Pig	____________
Others	____________

22. Income:
    a) Source/s ____________
    b) Total annual income including agriculture, self employment, salaries, casual wages, etc. ____________

22. Cropping Pattern ____________

23. Income /expenditure Pattern ____________

24. Details of government grants, if availed under Indian Rural Developmental Programme (IRDP) or other such schemes ____________

25. Health Status:
    - Name major diseases by which family members fell sick in last 3 years ____________
    - Type of treatment, family generally avails ____________ (allopathy, homoeopathy, ayurvedic, unani, etc.)
    - Does family knows preventive measures ____________ of the above diseases (Immunisation, water treatment, personal hygiene, do not know, etc.)
    - Where does family go for treatment ____________ (Household treatment, Pvt. medical practitioner, Govt. hospital, PHC, etc.)

- Have any member got vaccinated in the last one year ________________________
  (Cholera, Jaundice, any other)

26. Land aquisition

    a) Total land of the owner____

    b) Land to be acquired (ha) ____

    c) Land left (ha) ____

    d) Type of land acquired (ha)- Landuse ______________________________________

    e) Type of land left (ha) - Landuse ____

    f) Estimated loss due to loss of agricultural land, if any _________________________

    ____

27. Immovable Properties:

    a) Houses ____

    b) Wells ____

    c) Ponds ____

    d) Water- mills ____

    e) Others ____

28. Willingness to Accept:

    a) Willing to accept the loss of land (homestead/agricultural) Yes/No

    b) Is ready to accept the proper compensation offered for the loss as per the State policy Yes/No

    c) If answers to above questions are No, then give reasons _____________________

    ____

29. Would you welcome the project. Yes/ No
    (If No, give reasons)

Surveyor Name: _________________________ ________________________
Signature of the respondent

Date : _____________________

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DRAFT FINAL REPORT
June 2012

ENVIRONMENTAL IMPACT ASSESSMENT OF TATO-I HYDROELECTRIC PROJECT, Arunachal Pradesh

Volume-II
Management Plan

Prepared for:
Siyota Hydro Power Pvt. Ltd., New Delhi

CENTRE FOR INTER-DISCIPLINARY STUDIES OF MOUNTAIN & HILL ENVIRONMENT
University of Delhi, Delhi

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CATCHMENT AREA TREATMENT PLAN

5.1.1 INTRODUCTION

Generally speaking, for the optimal functionality and longevity of a dam or reservoir of hydropower projects, it is essential to limit and minimize the sediment intake to minimum level. It is a well established fact that reservoirs formed by dams on rivers are subjected to sedimentation. The process of sedimentation embodies the sequential processes of erosion, entrainment, transportation, deposition and compaction of sediment. The study of erosion and sediment yield from catchments is of utmost importance as the deposition of sediment in reservoir reduces its capacity and thus affecting the water availability for the designated use. The eroded sediment from catchment when deposited on streambeds and banks causes braiding of river reach. The removal of top fertile soil from catchment adversely affects the agricultural production. Thus, a well designed catchment area treatment plan is essential to ameliorate the above mentioned adverse processes of soil erosion. In hilly area, as in the present case, erosion due to water is a common phenomenon and the same has been studied as a part of the Catchment Area treatment (CAT) plan. Hence, it is necessary to adopt corrective measures in the catchment area so as to reduce the sediment load. Therefore, Catchment Area Treatment (CAT) plan is an integral part of most of the hydropower development project that pertains to preparation of a management plan for treatment of erosion prone area of the catchment through biological and engineering measures. The main impact of soil erosion and its consequences are:

- loss in the production potential
- reduction in water holding capacity
- loss of nutrients
- reduction in water supply
- increase in tillage operation costs
- reduction in infiltration rates

In the catchment area of the proposed Tato-1 HE Project, there is a very large plain in the upstream part of the river, known as Mechuka Plain where both slope of the river bed (average of 0.26% over 16 km long stretch) and velocity of the water in the river (0.5 m/s to 2 m/s) are very low. Most of the silts get deposited there. Downstream of this plain and upstream of Heo H.E. project, Pauk H.E. project is being developed by Velcan. The Arch Dam of Pauk H.E. Project creates a reservoir of 11.5 Mm^3 and 34 ha submergence area. The water velocity in the reservoir will fall down to less than 0.05 m/s, whereas the water velocity is never less than 0.2 m/s even in a desilting basin. Hence only desilted water is released by Heo H.E. Project tail race directly into Tato-I H. E. project intake. A very small part of the discharge comes from the catchment between Heo H.E. project dam and Tato-I intake. Hence the upstream Mechuka plain and Pauk Reservoir will be acting as a desilting basin for the Tato-1 H. E. project.

However, as a cautious practice, and even though Tato-I H.E. Proejct does not have a reservoir but only a very small pond (3 ha submergence including 1.8 ha river bed) CAT plan for the free-draining catchment area has been prepared with the main objective of arresting soil erosion. Based on the topographic factors, soil type, climate, land use and vegetation cover in the catchment area, various measures, both engineering / mechanical and biological are being proposed to be undertaken with the aim to check the soil erosion, prevent/check siltation of the pond and weir. The engineering measures will comprise construction of a number of check dams/walls, retaining walls, wire crates, etc. for gully control, stabilization of flood prone streams, landslides/slopes, river banks, roads, etc.

5.1.2 STUDY AREA AND STUDY APPROACH

The total area of free draining catchment of Tato-I HE Project from weir site upstream is around 7394.34 ha. The management plan is prepared for Yarjep catchment and its sub watersheds of Tato-I H. E. Project. Various spatial parameters like physiography, land use / land cover and soil class were studied before formulating a treatment plan for the catchment area of Tato-I HE Project. Various thematic maps have been used in preparation of the CAT plan. Geographic information system (GIS) was used as a common platform to analyze various spatial parameters, which is a computerized resource data base system. All the spatial data were Geo-referenced to geographic coordinate system of Yarjep catchment. GIS is a tool to store, analyze and display various spatial data. In addition, GIS has a capacity to perform numerous spatial functionalities with multi-thematic layers. It provides the capability to analyze large amount of data in relation to a set of established criteria. In order to ensure that latest and accurate data is used for the analysis. Besides remotely sensed satellite data has been used for deriving land use data complimented with ground truthing were also conducted.

The various steps covered in the study, are as follows:

1) Problem definition
2) Spatial database development and database acquisition
3) Erosion intensity assessment
4) Prioritization of sub watersheds for treatment
5) Activities to be undertaken (Biological measures and Engineering)
6) Period and Schedule of CAT plan implementation
7) Overall cost estimate of the CAT plan

The above mentioned steps are described in the following paragraphs.

5.1.3 PROBLEM DEFINITION

The requirements of the study were defined and the expected outputs were finalized, the various data layers of the catchment area to be used for the study are as follows:

- Drainage map
- Slope map
- Soil class and soil depth
- Land use classified map
- Soil erosion intensity mapping
- Area to be treated
- Treatment measures

5.1.4 SPATIAL DATABASE DEVELOPMENT AND DATA ACQUISITION

The data available from various sources has been collected. The contour maps, etc. were scanned, digitized and registered as per the requirement from the Survey of India (SOI) topographic sheets with a scale of 1:50,000. Data was prepared depending on the level of accuracy required. All the layers were geo-referenced and brought to common scale (real coordinates), so that overlay could be performed easily. A computer program using standard modeling techniques was used to estimate the soil loss. The formats of outputs from each layer were firmed up to match the formats of inputs in the program. The grid size to be used was also decided to match the level of accuracy required, the data availability and the software and time limitations. The format of output was finalized. Ground truthing and data collection was also included in the procedure. These data were collected, arranged and presented according to the standard methods used in the formulation of CAT plan. These data were organized and presented in the form of a general drainage map of the catchment and its sub-watersheds (see **Figs. 5.1.1 & 5.1.2**). A slope model for entire catchment area was digitized from the contours of Survey of India topographical, where available, following a 40 m contour interval (see **Fig. 5.1.3**).

For the present study, IRS P6 LISS-III digital satellite data was used for interpretation and image classification. The data has been procured in raw digital format and has been geo-referenced using Survey of India Topographical sheets with the help of standard data preparation techniques in standard image processing software. The interpretation of geo-referenced satellite data has been done using standard enhancement technique and ground truthing. A detailed ground truth verification has been undertaken as a part of ecological survey to enrich the image classification process.

Soil map for the entire project area was prepared from the basic data/map of soil classification prepared by National Bureau of Soil Survey and Land Use Planning (NBSS & LUP, NBSS Publ. No. 57b, 1997), Indian Council of Agricultural Research (IARI). Soil classes and soil depth were acquired. This basic information was transferred to a GIS based map and was later used to designate/ classify areas of varying soil erosion proneness in combination with information on slope and forest cover.

From the thematic maps of slope, drainage, soil and land use a composite erosion intensity unit (CEIU) map was prepared on 1:50,000 scale. We used hierarchical querying to extract the various erosion intensity units. The composite erosion intensity unit map was then superimposed on the drainage map with sub-watershed boundaries, so that treatable land units could be obtained sub-watershedwise.

The areas in the different sub-watersheds of the Tato-I H.E. Project requiring treatment were calculated from the composite erosion intensity unit map. For this a number of simple as well as complex spatial queries were run in a step-wise manner using GIS software (combination of ArcGIS 9.1 & GeoMedia Professional 5.2). These queries included different attributes of parameters viz. slope, soil depth, land use, etc. For executing these queries all the thematic maps of different attributes and parameters were geo-referenced to maintain the accuracy of the resultant outputs. In case of slope, the spatial queries were undertaken for different slope categories ranging from gently sloping category to very steep with different soil classes like shallow soils, deep soils, etc. The subsequent queries were executed with resultant outputs from the first level queries with different attributes of land use/ land cover. In all more than 150 such spatial queries were executed for the purpose for each and every sub-watershed separately. From these queries a thematic map of areas prone to erosion in the entire project area was prepared. From the thematic map of erosion intensity, areas that require treatment measures were extracted with the help of further spatial queries. Areas which were found inaccessible i.e. areas with more than 45^o (50%) slope and above 3200 m elevation with natural ecosystems with little human interference and tree line were excluded to arrive at those areas where appropriate treatment measures can be undertaken. Such areas were extracted for each individual sub-watershed.

The treatment measures for arresting soil erosion in the catchment were basically classified into biological measures and engineering measures. These measures have been suggested as favored methods of treatment at various places/sites, depending on its location and geographic/geological condition.

Based on drainage network and topographical features, the catchment was delineated into 7 sub watersheds (Sk1-Sk7) (see **Fig. 5.1.2**). Further, based on the above methods on the database generation various spatial factors such as drainage, slopes, land use/ land cover, soil classes and soil depth were generated. Subsequently, using the spatial functionalities in the GIS tools soil erosion susceptible map was also generated. Furthermore, these erosion maps were used to assess the areas to be treated during the subsequent years of the project tenure. In this section various spatial features will be discussed accordingly to the sub watershed wise.

5.1.4.1 Drainage

In the free draining area most of the tributaries are flowing from the right bank of river Yarjep. Tributaries along the left bank are smaller and seasonal. Along the right bank of the Yarjep River two large tributaries are both called Sarak Korong (see **Fig. 5.1.1**).

Sarak Korong-a

Sarak Korong flows from the southern part of the free draining area for 7.9 km towards north and joins with Yarjep Chu near Lipusi village. It is a springfed stream which flows on the northern slopes of 2625 m peak, drains through a narrow gorge and joins Yargyap Chhu at 1320 m in the downstream of Lipusi. The tributaries of Sarak Korong are spread in five sub-watersheds (Sk1-Sk5) (see **Fig. 5.1.1**).

Un-named nala

Further the main river channel is joined by another tributary along the right bank. It flows from the southern part for 5 km northward and join Yarjep Chu downstream of Padusa village (see **Fig. 5.1.1**).

Sarak Korong-b

The next river is also called as Sarak Korong and it is the last river along the right bank. The catchment of this tributary is predominantly covered with dense forest. The river flows for 5.7 km towards north and drains into Yarjep upstream of the intake site (see **Fig. 5.1.1**).

5.1.4.2 Slope

In the free draining area the moderately steep class is prevalently spread in the southern part. It covers 67% of the total free draining area. Steep slope is the second predominant slope class in the free draining area covering an area of 1466.87 ha which is 20% of the total free draining area. It is followed by strongly sloping class with area coverage of 10.7% of the total free draining area. The remaining slope classes i.e., Gently sloping class, Moderately sloping and Very steep covers mere areas of 0.07%, 2% and 0.5% of free draining area (see **Fig. 5.1.3**).

Moderately steep class is the predominant slope class in the free draining area of Tato-I HE Project. It is largely spread in the sub-watershed of Sk7 with area coverage of 1198.22 ha of land. The remaining sub-watersheds have area coverage of 450 ha to 900 ha of land (see Table 5.1.1). Steep slope is largely spread in the Sk5, Sk6 and Sk7 covering an area of 567.35 ha, 317.22 ha and 433.03 ha respectively. Moreover it is more predominant on the left bank side of Yarjep Chhu (see **Fig. 5.1.3**).

Table 5.1.1 Slope classes along the sub watersheds (in ha)

Sub watershed	Gently Sloping	Moderately Sloping	Strongly Sloping	Moderately Steep	Steep	Very Steep	Total
SK1	0	16.71	102.12	552.24	51.63	0	**722.70**
SK2	0	24.47	155.2	767.26	44.61	0	**991.54**
Sk3	0	8.81	96.25	509.09	19.58	0	**633.73**
SK4	0.99	12.66	58.41	580.55	33.45	0	**686.06**
SK5	0.99	18.43	101.55	866.45	567.35	17.95	**1572.72**
SK6	1.95	17.39	43.95	479.61	317.22	2.45	**862.57**
SK7	1.08	46.99	230.91	1198.22	433.03	14.79	**1925.02**
Total	**5.01**	**145.46**	**788.39**	**4953.42**	**1466.87**	**35.19**	**7394.34**

5.1.4.3 Soil Types

In the free draining the S1 soil association is predominantly spread with an area of 67% of the free draining area. It is followed by S6 soil group with area coverage of 32% of free draining area. Soil associations S4 and S2 are accounts for small area coverage of 0.4% and 1% of free draining area (**Fig.5.1.4**). The soil categories are explained in the Soil chapter (3.2.3) of the EIA report.

S1 association is prevalently spread in the sub-watersheds of Sk5 and Sk7 with area coverage of 1450.13 ha and 1632.64 ha respectively. In the sub watersheds of Sk3 and Sk6 it is spread on area of 633.73 ha and 682.06 ha respectively. S6 association is more characterized in the southern and head water region of Sarak Korong. It is more prominent in the sub-watersheds of Sk1, Sk2 and Sk4 with area coverage of 639.38 ha, 703.17 ha and 442.01 ha respectively (see Table 5.1.2).

5.1.4.4 Soil Depth

Shallow and moderately shallow are the two soil depth classes in the free draining area. Besides the unclassified soil depth class is mapped as rocky mountain in the free draining area. Shallow class is the most predominant soil class in the free draining area. Shallow class covers an area of 67% of the free draining area. It is largely spread in the sub-watersheds of Sk5 and Sk7 with area coverage of 1450.13 ha and 1664.44 ha respectively. Other sub-watersheds Sk3 and Sk6 have area in the range of ~650 ha (see Table 5.1.3 & **Fig.5.1.5**).

Table 5.1.2 Soil class and its area (ha) along the sub watersheds in the free draining area

Sub watershed	S1	S2	S4	S6	Total
SK1	29.46	53.87	0	639.38	**722.71**
SK2	252.39	35.97	0	703.17	**991.53**
Sk3	633.73	0	0	0	**633.73**
SK4	244.05	0	0	442.01	**686.06**
SK5	1450.13	0	0	122.59	**1572.72**
SK6	682.06	0	0	180.51	**862.57**
SK7	1632.64	0	31.81	260.58	**1925.03**
Total	**4924.46**	**89.84**	**31.81**	**2348.24**	**7394.35**

Moderately shallow is spread in a mere area of 1.2% of the free draining area and it is devoid in most of the sub-watersheds, except in Sk1 and Sk2 with small area coverage of 53.87 ha and 35.97 ha, respectively.

Table 5.1.3 Soil depth area coverage in the catchment

Sub watershed	Shallow	Moderately Shallow	Rocky Mountain	Total
Sk1	29.46	53.87	639.38	**722.71**
Sk2	252.39	35.97	703.17	**991.53**
Sk3	633.73	0	0	**633.73**
Sk4	244.05	0	442.01	**686.06**
Sk5	1450.13	0	122.59	**1572.72**
Sk6	682.06	0	180.51	**862.57**
Sk7	1664.44	0	260.58	**1925.02**
Total	**4956.26**	**89.84**	**2348.24**	**7394.34**

5.1.4.5 Land Use/ Land Cover

The project area designated for the catchment area treatment plan covers 7394.33 ha. The recent land use/ land cover of this area was interpreted from the satellite images and confirmed by the field surveys. A false color composite (FCC) was generated for the entire free draining area as well as for all the 7 sub-watersheds (**Fig. 5.1.6**). The land use /land cover of the free draining area of the HE project area as well as of all the 7 sub-watersheds was classified under Dense Forest, Open Forest, Scrub, Degraded Forest, Cultivation, Moraines, Barren, River and Snow.

Land use and land cover mapping was carried out by standard methods of analysis of remotely sensed data followed by ground truth collection and interpretation of satellite data. For this purpose digital data on CDROMs were procured from National Remote Sensing Agency, Hyderabad. Digital image processing of the satellite data and the analysis of interpreted maps were carried out at the Computer Centre at CISMHE using ERDAS Imagine 8.7. Several techniques and geo statistical approaches were used for the image processing of the Catchment. Such as supervised classification technique was used and later on a spatial statistic model (Maximum likelihood classifier) was applied for the sample set of the trained pixel were used to classify the satellite imagery. Unsupervised classification was also used in the procedure (Schowengerdt, 1997).

Digital data of IRS P6 LISS-3 and Landsat-7 full scene were used for image processing and thematic map preparation. For the secondary data, Survey of India toposheets on 1:50,000 and 1:25,000 were referred to for the preparation of base map and drainage map. With the objective of preparation of environment management plan and an action plan for watershed management and a catchment area treatment, the classification scheme adopted for the preparation of land use/ land cover maps and related thematic maps on 1:50,000 scale is as follows. Two forest density classes were interpreted for the forest cover mapping. The forests with >40% canopy cover were delineated as dense forests and between 10% and 40% crown density as open forest. Furthermore, degraded forests (with <10% canopy cover) and scrubs were also delineated for the purpose of erosion mapping. The cropland (agriculture) was also delineated for the calculation of erosion intensity classification. The non-forest land cover in the form of river, wetland and Jhum cultivation etc. was also delineated.

The base map, drainage map and land use/land cover map were prepared using the satellite data. Later it was digitized on computer for further processing and analysis using combination of ArcGIS 9.0 and GeoMedia Professional 5.2. The sub-watershed boundaries were then overlaid on the drainage map and land use map of free draining area in order to extract the drainage and land use of the sub-watersheds, which were further used for overlay analysis by Geographic Information System (GIS) techniques.

Table 5.1.4 Area (ha) under different land use/ land cover categories in different sub watersheds of Tato-I HE Project area

Sub watershed	Dense Forest	Open Forest	Scrub	Degraded Forest	Cultiva-tion	Moraines	Barren	River	Snow	Total
Sk1	239.13	1.37	258.34	0	0	38.95	99.59	0	85.32	**722.7**
Sk2	391.05	10.23	445.29	1.51	0	29.96	69.75	0	43.75	**991.54**
Sk3	338.23	156.06	122.69	16.74	0	0	0	0	0	**633.72**
Sk4	316.89	0.89	323.89	10.32	0	8.23	25.01	0	0.82	**686.05**
Sk5	616.27	433.75	251.68	255.23	5.13	0	0	10.67	0	**1572.73**
Sk6	432.9	94.52	258.33	70.89	0	0.8	5.12	0	0	**862.56**
Sk7	964.78	100.95	463.73	261.16	0.25	24.26	85.59	22.54	1.77	**1925.03**
Total	**3299.25**	**797.77**	**2123.95**	**615.85**	**5.38**	**102.2**	**285.06**	**33.21**	**131.66**	**7394.33**

Dense forest is prevalently spread in the free draining area of the Tato-I HE Project with area coverage of 44.6% of the total free draining area. It is followed by scrubs with area of 28.7% of the free draining area. Open forest is spread in an area of 10.8% and it is more prevalent in the northern part of the free draining area particularly along the right bank of Sarak Korong. Degraded forest is prevalent in the extreme north particularly on the left bank of the Yarjep Chhu. It has area coverage of 8.3% of the free draining area. Moraines and Barren land are more prevalent in the head water region of Sarak Korong, covering an area of 1.4% and 3.86% of the free draining area respectively. Snow accounts for 1.8% of the total free draining area (**Fig. 5.1.7**).

Dense forest is the most prevalent land cover in the free draining area. It is equally distributed in all the sub-watersheds. Sub-watershed Sk7 has area coverage of 964.78 ha of land under dense forest. The remaining sub-watersheds have area coverage in the range of ~230 ha to ~620 ha (see Table 5.1.4). Open forest is more prominent in the sub-watersheds along both the left banks of Sarak Korong. Therefore it is largely present in the sub-watershed of Sk5 with area under 433.75 ha of land. Sub-watersheds Sk3 and Sk7 have area coverage of 156.06 ha and 100.95 ha respectively. The remaining sub-watersheds have area less than 100 ha (see Table 5.1.4).

Scrub is the second predominant land cover in the free draining area. Scrub is largely spread in the sub-watershed of Sk2 & Sk7 with area coverage of 445.29 ha and 463.73 ha respectively.

Most of the sub-watersheds have area in the range of ~250 ha - ~450 ha. Except sub-watershed Sk3 has area of 122.69 ha of land under scrub (see Table 5.1.4).

Degraded forest is more prominent in the sub-watersheds of Sk5 and Sk7, covering an area of 255.23 ha and 261.16 ha, respectively.

5.1.4.6 Erosion Intensity Assessment

Soil erosion intensity mapping was carried out using the above thematic layer. Soil erosion is mainly caused due to moving water and the gravity. It varies from place to place. Furthermore, it is intensified by human induced developmental projects. Within the Himalayan river basins water is the main agent of erosion. Erosion by water is most complex process and takes place due to rain splash, sheet wash or rill wash, channel erosion in rivers or gullies. The catchment area of the proposed Tato-I HE project experiences silt loads in the major river and its tributaries. In the present context, one of the significant negative impacts of soil erosion is reduction of the life of weir of a hydroelectric project. The increased silt in the rivers has severe adverse impacts on the micro- and macro-organisms, above and below ground as well as for the aquatic biodiversity including fishes. There are a number of factors in the Yarjep river basin which are responsible for extensive soil erosion and heavy silt load in the river. In the following section we have described on how to use soil erosion process on Silt Yield Index (SYI).

5.1.4.6.1 *Estimation of Soil Erosion in Catchment*

The entire catchment area has been delineated into 7 sub-watersheds. Detailed drainage map for the entire free draining as well as for each sub-watershed was prepared at 1:50,000 scale. All the rivers and streams have been delineated in each sub-watershed. The areas under different erosion intensities were calculated using GIS software. For the estimation of erosion intensity three spatial factors, soil depth, slope and land use, each with five to seven parameters, were considered during hierarchical querying. For soil depth, deep (score 1), moderately deep (score 2) and moderately shallow (score 3), were used. In case of slope, five parameters, Gently Sloping (score1) to Steep (score 5) were considered and similarly seven categories of Dense forest (score 1), Open Forest (score 2), Scrub (score 3), Degraded Forest (score 4), Cultivation (score 5), Settlements (score 6), moraines and Barren (score 7), was taken into account for calculating erosion in the catchment. After running the queries, an area with the final score of 12 or above was designated as having very severe erosion, the score 10 to 12 was designated as severe, 7 to 9 was classified as moderate erosion and score up to 6 was classified as having slight erosion. Areas under different erosion intensities were estimated for each sub-watershed as well as for entire free draining area and the results are presented in Table 5.1.5. Around 66% of the total free draining area is found to be under moderate erosion class and nearly 24% area was classified under severe erosion (Table 5.1.5; **Fig. 5.1.8**). Severe erosion is spread in Sk2 and Sk5 with area coverage of 424.42 ha and 315.35 ha respectively. Very severe erosion accounts for 3% of the total free draining area and it is prevalently spread in the southern part i.e., sub-watersheds of Sk1, Sk2 and Sk7.

Table 5.1.5 Area under different intensity of erosion in the free draining of Tato-I H.E. project

Sub Water shed	Slight	Moderate	Severe	Very Severe	River	Snow	Total
SK1	1.67	225.35	304.59	105.78	85.32	0	**722.71**
SK2	12.06	454.47	424.42	56.84	0	43.75	**991.54**
SK3	60.67	567.15	5.9	0	0	0	**633.72**
SK4	9.96	406.92	251.58	16.77	0	0.82	**686.05**
SK5	69.29	1177.42	315.35	0	10.67	0	**1572.73**
SK6	18.58	640.42	200.55	3.02	0	0	**862.57**
Sk7	67.4	1467.42	313.53	52.37	22.55	1.77	**1925.04**
Total	**239.63**	**4939.15**	**1815.92**	**234.78**	**118.54**	**46.34**	**7394.36**

5.1.4.6.2 *Sediment Yield Index*

To calculate sediment yield index, methodology developed by All India Soil & Land Use Survey (Department of Agriculture, Government of India) was followed, where each erosion intensity unit is assigned a weightage value. When considered collectively, the weightage value represents approximately the relative comparative erosion intensity. A basic factor of K = 10 was used in determining the weightage values. The value of 10 indicates a static condition of equilibrium between erosion and deposition. Any addition to the factor K (10+X) is suggestive of erosion in ascending order whereas subtraction, i.e. (10-X) is indicative of deposition possibilities.

Delivery ratios were adjusted for each of the erosion intensity unit. The delivery ratio suggests the percentage of eroded material that finally finds entry into dam/reservoir or river/stream. Area of each composite unit in each sub-watershed was then measured.

Sediment yield index (SYI) was calculated using following empirical formula (for SYI of individual sub-watersheds see Annexure-I).

$$\text{SYI} = \frac{\sum (A_{ei} \times W_{ei} \times DR)}{AW} \times 100$$

where,

SYI = Sediment yield index

A_{ei} = Area of composite erosion intensity unit

W_{ei} = Weightage of composite erosion intensity unit

DR = Delivery ratio

AW = Total area of the sub-watershed

5.1.4.6.3 ***Erosion Intensity and Delivery Ratio***

Determination of erosion intensity unit is primarily based on the integrated information on soil characters, physiography, slope and land use/land cover. This is achieved through super-imposition of different thematic map overlays. Based on the ground-truth, carried out during the field work, weightage value and delivery ratio were assigned to each erosion intensity unit.

Delivery ratio, which depends on the type of material, soil erosion, relief length ratio, land cover conditions, etc. were assigned to all erosion intensity units depending on their distance from the nearest stream. The criteria adopted for assigning the delivery ratio are as follows:

Nearest Stream	Delivery ratio
0 - 0.9 km	1.00
1.0 - 2.0 km	0.95
2.1 - 5.0 km	0.90
5.1 - 15.0 km	0.80
15.1 - 30.0 km	0.70

5.1.5 PRIORITISATION OF SUB-WATERSHEDS FOR TREATMENT

Based on the Sediment Yield Index (SYI), sub-watersheds that require treatment measures were prioritized using the simple rule that the sub-watersheds with a higher SYI were ranked higher in priority for treatment (Table 5.1.6; see Annexure-I). The sub-watersheds would be treated on priority basis in the treatment scheme to be followed (Table 5.1.6). An index map showing treatment measures to be undertaken in different sub-watersheds was prepared according to their priority ranking for treatment and is given in **Fig. 5.1.9**.

Table 5.1.6 SYI for different sub-watersheds for Tato-I HE Project free draining catchment

Sub-watershed	Area (ha)	SYI	Treatment Area (ha)
Sk1	722.70	1379.19	20.49
Sk2	991.53	1422.71	26.48
Sk3	633.73	1246.43	5.90
Sk4	686.06	1290.80	9.99
Sk5	1572.72	1196.96	239.08
Sk6	862.57	1091.42	88.79
Sk7	1925.03	1163.30	188.18
Total	**7394.34**		**578.91**

The treatment area is the area subject to severe and very severe erosion that are accessible, i.e. less than 45° and below 3200 m elevation.

5.1.5.1 Year-wise Treatment of Watersheds

Silt yield index (SYI) has been calculated for all the 7 sub-watersheds, following the All India Soil and Land Use Survey (AISLUS) method and the sub-watersheds were accordingly prioritized for treatment (Table 5.1.7).

Table 5.1.7 Year-wise treatment of the sub-watersheds

Years	Sub-watershed Name	SYI	Priority Ranking	Treatment Area (ha)
Ist	Sk2	1422.71	1	26.48
	Sk1	1379.19	2	20.49
	Sk4	1290.80	3	9.99
	Sk3	1246.43	4	5.90
Total				**62.86**
IInd	Sk5	1196.96	5	**239.08**
IIIrd	Sk7	1163.30	6	**188.18**
IVth	Sk6	1091.42	7	**88.79**
Grand Total				**578.91**

5.1.6 ACTIVITIES TO BE UNDERTAKEN

For undertaking soil conservation measures in the Tato-I H.E. Project catchment area up to intake site various indirect or preventive measures like biological measures and direct or remedial measures like engineering measures have been discussed in the following paragraphs (see Table 5.1.8). Even though suggestions have been made regarding certain specific treatment measures to be undertaken in a particular sub-watershed, these measures, however, may require further micro-planning during the implementation stage.

5.1.6.1 Preventive Biological Measures

It is always better to undertake preventive measures than to mitigate the factors that ultimately leads to soil erosion. Such preventive measures will indirectly help to conserve soil in the long run, keeping in view the importance of integrating eco-restoration strategy with socio-economic needs of the local community wherein both ecology and economics are developed. The preventive measures that are suggested for the project area have been discussed below.

a) *Afforestation*

In the upland region like this project area, the trees and vegetation cover play an important role in the conservation of soil and ecology. Afforestation would be taken up in such forest areas that contain large patches of barren grassy slopes and are generally devoid of trees and are honey-combed by cultivation. In critically degraded areas, plantation of locally useful, diverse and indigenous plant species such as *Alnus nepalensis*, *Alangium chinense*, *Altingia excelsa*, *Bischofia javanica*, *Pterospermum acerifolium*, etc. would be undertaken. Afforestation measures would be taken up under catchment area treatment plan on 137.63 ha. An outlay of **Rs. 60.56 lakhs** has been provided to cover various areas under afforestation in different sub-watersheds.

Afforestation Programme

Different types of plantations would be undertaken under afforestation programme according to the methodology described below. The plantations that would be undertaken in the forest (scrub/degraded forest) would have a planting density of 1600 plants per ha and vegetative hedge in contour trenches. Contour planting conserves soil and enhances moisture regime and adverse effect of surface run off of rain water is reduced considerably. Trenches, pits and plants along the contour reduce velocity of water, increase soil moisture and facilitate seepage of water in soil and reduce soil loss resulting in better growth of plants. Hence, soil working and planting along contours would be strictly followed in the project.

In the afforestation areas, the digging of trenches and pits would be along the contour. About 20 to 30 m long contour trenches would be dug leaving a space of 50 cm (septa) between the two consecutive trenches. Soil would be dug on the lower side of the trench and after removing pebbles and weeds, the trench to be half refilled with soil and remaining soil would be collected to form berm on lower side of trench. On the berm, seeds of shrubs/hedges like *Arenga saccharifera*, Calamus erectus, Bambusa tulda, *Debregeasia longifolia*, *Mussaenda roxburghii*, etc. would be sown to raise vegetative barrier. The size of pits would be 45 cm^3. The contour trenches would be at an interval of 5 m.

For digging 1600 pits per ha, pits would be dug 15 cm uphill side from the contour trenches. The spacing of pits along contour trench will not be closer than 1.25 m. In afforestation areas soil working would be started in October-November and would be completed by March. It is important that filling of pits and half filling of trenches is completed before the onset of monsoon, otherwise dug soil will be washed away by rains leaving only stones and pebbles near the pit. Extreme care would be taken in transporting the plants from nurseries to the plantation site to avoid any damage. Planting would be completed before the monsoon period is over. With a view to conserve not only soil and water but also for fuelwood production, it is important to raise the vegetative barrier of hedge plants. The seeds of hedges like Bambusa, *Debregeasia*, *Melocalamus*, *Pinanga*, etc. will be sown in contour trenches before the onset of monsoon. When the water of surface run-off reaches the line of hedges its speed is checked and silt is stopped by the hedge plants and only percolated water passes down slowly. Hedges spread and grow well in the silt left behind and form a natural terrace. The plants planted in the pits near contour trenches get more moisture and grow fast.

Choice of Species

The species for plantations would be selected after considering altitude, aspect, biotic pressures, soil depth, moisture, etc. As there is pressure of cattle grazing, non-fodder/ fuelwood species would also be planted in suitable proportion in between the fodder species. The tree species that would be planted under this programme are : *Actinodaphne obovata*, *Altingia excelsa* (Jutli), *Castanopsis indica* (Hingori), *Cinnamomum tamala* (Tej Pata), *Ficus benjamina*, *Gynocardia odorata*, *Toona ciliata* (Poma), etc.

There are many shrubby plant species which are suitable for fodder/ fuelwood plantations, which are**:** *Bambusa tulda*, *B. pallida*, *Bauhinia variegata*, *Ficus auriculata* and *Morus alba.* The important legumes and grasses that would be planted are C*hrysopogon gryllus*, *Lolium perenne*, *Pennisetum purpureum*, *Thysanolaena latifolia* and *Themeda arundinacea* among grasses and White clover (*Trifolium repens*), Red clover (*Trifolium pratense*), Lucerene (*Medicago sativa*), Vetch (*Vicia villosa*), and Caucasian clover (*Trifolum ambiguum*) among legumes.

The plant species suitable for avenue and ornamental purposes are: *Altsonia scholaris, Bauhinia variegata*, *Cassia fistula*, *Delonix regia, Erythrina stricta*, *Exbuclandia poulnea*, *Hibisicus rosa-sinensis* and *Polyalthia longifolia*.

Fencing

Stone wall 120 cm high and 45 cm wide or 4 strand barbed wire fencing would be erected around the nursery and the plantation area during first year along with soil working. The cooperation of local villagers would be sought for the success of the plantation programmes.

Weeding and Mulching

Weeding, hoeing and mulching would be carried out during October-November. Weeding and loosening of soil by hoeing breaks the capillary action in soil and thus reduces the moisture loss. Mulching reduces evaporation and conserves soil moisture and adds humus to soil. Cut and uprooted weeds and grasses used as mulching material would be spread around the plant.

Watch and Ward and Fire Protection

Protection of plantation is the greatest challenge as some inhabitants and their livestock may damage the plantation before it is established. Hence the protection of plantation particularly in the juvenile stage is of paramount importance and watchmen/ chowkidars would be engaged from the nearby villages for the required job. Besides the above, other appropriate measures would be adopted to ward off these potential threats.

Table 5.1.8 Watershed-wise details of various activities

S.No.	Name of Sub-watershed	Component								
		Engineering Measures				Biological Measures				
		Gully Control			Bench Terracing	Afforestation	NTFP Regeneration/ Medicinal Plants Cultivation	Assisted Natural Regeneration	Pasture Improvement	Total
		Brushwood Check dams (Nos.)	DRSM checkdams (Nos.)	Contour Bunding (ha)	(ha)	(ha)	(ha)	(ha)	(ha)	
1.	Sk1	2	2	3.5	3.25	6.18	3.15	2.25	2.16	**20.49**
2.	Sk2	8	6	6.75	7.25	5.40	2.03	1.25	3.80	**26.48**
3.	Sk3	1	1	2	0	2.40	1	0	0.50	**5.90**
4.	Sk4	1	2	2	1.75	1.70	2	1	1.54	**9.99**
5.	Sk5	15	12	38	25.25	54.50	37.58	35.25	48.50	**239.08**
6.	Sk6	12	14	25.50	10.75	25.40	8.00	8.19	10.95	**88.79**
7.	Sk7	25	28	40	32	42.05	25.00	28.13	21.00	**188.18**
	Total	**64**	**65**	**117.75**	**80.25**	**137.63**	**78.76**	**76.07**	**88.45**	**578.91**

b) ***Assisted Natural regeneration in existing forest***

In some of the forest areas, conditions are conducive to natural regeneration provided that some sort of assistance is provided. Such areas shall be taken up under this component. The areas shall be closed to exclude biotic interference. Forest floor will be cleared of slash; debris and felling refuse to afford a clean seedbed to the falling seed. At certain places some soil raking may also have to be done to facilitate germination of seeds. Where natural regeneration is found deficient, it will be supplemented by artificial planting. Patch sowing in suitable areas may also be done. Bush cutting & cleaning operations are done depending on necessity. Up to 800 plants or patches per hectare will be planted /sown to hasten the process of regeneration in the area uniformly. An outlay of **Rs. 9.14 lakhs** @ Rs 11762 per ha for creation and Rs. 247 per ha for its maintenance has been made to cover 76.07 ha (see Annexure II).

c) ***NTFP Regeneration***

Arunachal Forest Division is rich in a variety of Non Timber Forest Produce (NTFP). However, because of over-exploitation of NTFP in the past there has been depletion of this valuable resource. Therefore, in order to augment natural stock of NTFP in the forests, it is proposed to take up planting of NTFP and establishing nurseries. An outlay of **Rs.34.23 lakhs** Rs @ Rs.36,563/- per ha has been suggested to cover about 78.76 ha for establishing (Rs.28.80 lakhs) and its maintenance (Rs.5.43 lakhs) of this facility for five years (see Annexure II).

d) ***Grazing Land/Pasture Improvement***

The livestock owned by the local communities exert significant pressure on the natural habitats. In order to improve the grazing areas/pastures and to make these sustainable, the degraded areas, particularly among community lands will be taken up for treatment under silvi-pastoral model. An outlay of **Rs. 18.17 lakhs** @ Rs.19,935/- per ha has been earmarked for this purpose and it will cover about 88.45 ha of land for development at a cost of Rs.17.63 lakhs and its maintenance will cost Rs.0.54 lakhs for five years (See Annexure II).

e) ***Forest infrastructure development***

For efficient management of forest resources, it is essential that field infrastructure of the State Forest Department of the area is adequately developed. Given the rugged mountainous terrain, there is a need to improve the existing forest roads and paths. Motor-able roads would be avoided in the forests of the catchment area as this would lead to habitat fragmentation, degradation and increased siltation. Only bridle paths, inspection paths and footbridges shall be constructed or improved for which an amount of **Rs.37.00 lakhs** has been earmarked (Table 5.1.10). Similarly, in remote localities of the Forest divisions there are no places for shelter for the staff, local people, tourists or trekkers. Therefore, following provisions will be made under the CAT Plan.

5.1.6.2 Treatment Measures: Engineering Measures

Gully erosion is one of the concerned soil erosion in the slope and hilly areas. The gullys would be treated with the help of engineering/ mechanical as well as vegetative methods. Check dams would be constructed in some of the areas to promote growth of vegetation that will consequently lead to the stabilization of the slopes/area and prevention of further deepening of gullies and erosion. For controlling the gullys, the erosive velocities are reduced by flattening out the steep gradient of the gully. This is achieved by constructing a series of checks which transform the longitudinal gradient into a series of steps with low risers and long flat treads. Different types of check dams would be required for different conditions comprising different materials depending upon the site conditions and the easy availability of material at local level.

In addition to the vegetative measures used for stabilization of gullys, temporary or permanent mechanical measures will be used as supplementary measures to prevent the washing away of young plantations by large volume of runoff. The gullys get stabilised over a period of time with the establishment and growth of vegetation cover. With the passage of time mechanical structures weaken and vegetative measures get strengthened.

For engineering measures following types of checkdams are suggested.

a) ***Brushwood checkdams***

The main advantage of brushwood checkdams is that they are quick and easy to construct and are inexpensive as they are constructed by using readily available materials at the site. In brushwood checkdams, small branches preferably of coppice species are fixed in two parallel rows across the gully or nala and packed with brushwood between the rows of these vertical stakes. The vertical stakes are tied down with wires or fastened with sticks across the top. The important consideration in erecting brushwood check dams is to pack the brushwood as tightly as possible and to secure it firmly. This type of check dam is generally constructed over small gullys or at the starting stretch of gullies (see **Plate 5.1.1**). In all, 64 brushwood checkdams/ vegetative spurs would be constructed to check gully erosion, stream bank protection and slope stabilization works.

b) ***Dry Rubble Stone Masonry (DRSM) checkdams***

The site where DRSM check dams are to be constructed is cleared and the sides are sloped 1:1. The bed of gully is excavated for foundation to a uniform depth of 0.45 m to 0.60 m and dry stones are packed from that level. Over the foundation, DRSM super structure of check dam is constructed. The stones are dressed and properly set in with wedges and chips. The width of checkdam at the base should be approximately equal to maximum height and successive courses are narrower so the section is roughly a trapezium. It is common to find upstream face of checkdams vertical with all slopes on the downstream face but while there is sound engineering reason for this in case of large checkdams, it is not of any use in small gullies control dams. In the centre of the dam portion sufficient waterway is allowed to discharge the maximum run off. The dry stone work should go up to 0.30m to 0.60m in the stable portion of the gully side to prevent end-cutting. Sufficient apron is provided to prevent scouring of the structure. The thickness of the apron packing would be about 0.45 m and gully sides above the apron have to be protected with packing to a height of at least 0.30 m above the anticipated maximum water level to prevent side scour being formed by the falling water. For gully control measures, 65 DRSM checkdams would be constructed (see **Plate 5.1.2**).

c) ***Slope modification by Stepping/Bench Terracing***

Bench terracing is one of the most popular mechanical soil conservation practices adopted by farmers in India and many other countries. It is constructed in the form of step like fields along contours by half cutting and half filling and would result in the conversion of the original slope into leveled fields. Thus, hazards of erosion are eliminated and manure and fertilisers applied are retained in the leveled fields. The sloping fields in the valley need to be bench terraced by cutting and filling with the latter supported by retaining stone wall. While making bench terraces, care will be taken not to disturb the top soil by spreading earth from the lower terraces to higher terraces. The vertical intervals between the terraces will not be more than 1.5 m and cutting depth would be kept at 50 cm. The minimum average width of the terrace would be 4 to 5 m to enable the usage of prolong hinge. The shoulder bunds of 30 x 15 cm would also be provided. The excess water from the terraces will be drained off by staggered channels. An area of 80.25 ha will be covered under this plan.

5.1.6.2.1 *Administrative Setup*

The catchment area treatment (CAT) project involves intensive and highly technical operations, which require the expertise of technical personnel. It is, therefore, recommended that the existing forest staff of Arunachal Pradesh Forest Division in the area look after all the works to be carried out under the CAT plan including plantation and maintenance as all the areas to be covered under CAT plan fall under these divisions. However, temporary staff may be engaged for the purpose during the project implementation period, i.e. for about four years.

Beside, several parallel activities should be undertaken to meet the various biological and engineering measure in process. These activities are Nursery development and forest infrastructure development. Other than that, some financial activities are also projected in the CAT plan. Activities such as Ecotourism can be promoted, Eco-restoration are formulated to meet the unemployment crisis at local level.

a) ***Nursery Development***

Proper development of nursery and allied services, like drip irrigation or micro-irrigation, will be crucial for successful execution of CAT plan. It will be important to prepare a stock of plant material for the supply of saplings for afforestation programme and various other activities. Main nursery may be developed near the intake site and the proposed colony areas, preferably along the road side for easy accessibility. This area possesses necessary infrastructure and various raw materials for nursery development can be easily made available. In addition, provision will also be made for two green-houses/chick houses for maintaining plant saplings. The estimated cost for the development of nursery and greenhouses will be around **Rs.15 lakh**. Development of nursery will start from the ignition year and will continue for 5 years (Table 5.1.9). During maintenance year (2 to 5 years) nursery will supply plants wherever required for the replacement.

Table 5.1.9 Cost for the Nursery Development

Amount (Rs. in lakhs)

Components	Development	Maintenance	Total
Shed House for raining saplings (one time grant)	0.50	0.50	1.00
Seeds collection procurement grant	1.00	-	1.00
Compost, soil, fertilizer and other materials	1.00	-	1.00

Shed House/ Chickhouse for maintaining and storing saplings (Nos 2)	1.00	0.5	1.50
Poly bags, pots, trays for raising saplings	1.00	-	1.00
Nursery Equipments	1.00	-	1.00
Glass wares and other laboratory wares	0.50	0.20	0.70
Chemicals, pesticides, and other plant growth regulators	0.50	0.20	0.70
Hand held trollies (Nos. 5) for transporting plant saplings	0.50	0.10	0.60
Mini-truck for transporting plants	1.00	1.00	2.00
Contingency grant for all recurring expenditure	1.00	-	1.00
Personnel/ staff	3.50	-	3.50
Total	**12.50**	**2.50**	**15.00**

b) ***Forest Infrastructure Development***

The works of the catchment area treatment plan will be executed by the Forest Department, Government of Arunachal Pradesh. These works will be an added responsibility for the Forest Department that may not have adequate facilities and infrastructure to execute the work as suggested in the plan. Provision has, therefore, been made in the CAT plan to develop the infrastructure of Forest Department in the region and accordingly a budget of **Rs. 37.00 lakhs** is proposed for this purpose (Table 5.1.10).

Table 5.1.10 Budget for development of State Forest Department infrastructure

Amount (Rs. in lakhs)

S.No.	Components	Qty./Unit	Total
1.	Forest Office Establishment (one office)	-	10.00
2.	Forest Fire Fighting System	-	2.00
3.	Office Vehicle	1 No.	5.00
4.	Road and Foot Path Development	-	3.00
4.	Machinery & Equipment*	-	5.00
4.	W & W	4 Nos.	2.00
5.	Monitoring & Evaluation	-	3.00
6.	Adm. Cost	-	4.00
7.	Contingency	-	3.00
	Total		**37.00**

* Machinery & Equipment : Computers, Laptop, Photocopier, Digital Camera, etc.

c) *Eco-Restoration*

There is urgent need to reduce the dependency of local population on the forest and other natural resources which are under severe pressure. The eco-restoration works and other activities related to area development and employment generation are suggested and should be carried out through community welfare committees (CWC) of local villages. These should include the following measures, which would help in rejuvenating the ecosystems and in reducing the soil erosion in the region.

1. Plantation in the degraded patches of community/civil/ forest land.
2. Water conservation and harvesting in the villages.
3. Soil conservation measures in village areas.
4. Improvement in agricultural and horticultural practices.
5. Technical and financial support for harnessing alternate energy sources such as micro-hydel and non-conventional energy (solar power and solar heating) to reduce pressure on the forest for fuel wood
6. Rural technology support programmes.
7. Awareness programmes for conservation of wildlife and natural resources.
8. Promotion of income generating schemes like ecotourism.

The total cost estimate for these activities is proposed as **Rs. 2.14 lakhs** (1% of total cost of treatment measures).

5.1.7 SCHEDULE OF TREATMENT PLAN

The total time scheduled for the execution of the planned CAT works has been kept at 4 years. Accordingly, areas from each sub-watershed have been prioritized for treatment and a year-wise plan has been assigned (**Fig.5.1.10**). Zero year has been kept for the development of nursery and raising sapling for plantation. Three to ten sub-watersheds have been suggested to be taken up for treatment in each year and accordingly area for treatment in each year is allotted. Maximum area for treatment will be taken up in the second year and minimum will be taken up in the first year. In the first and second years the area taken up for treatment is 62.86 ha and 239.08 ha, respectively and in the fourth year the area to be taken up for treatment is 88.79 ha. One year time is given for the maintenance of the executed work in the catchment. Accordingly, a separate budget for the maintenance is given in Table 5.1.11.

5.1.7.1 Monitoring and Evaluation

Monitoring and evaluation will be developed as in built part of the project management. Thus, a process of self-evaluation at specified intervals of time will ensure the field worthiness and efficacy of the CAT plan.

Annual work plan for each sub-watershed would be prepared well in advance specifying physical and financial targets, sites, locations and beneficiaries of each component of the project activity. Month-wise work scheme of various items of each component for the financial year would also be prepared in advance and its timely implementation would be ensured. Monthly progress report on all activities would be submitted by the Range Officers to Divisional Forest Officer for its subsequent submission to the project authorities and Ministry of Environment & Forests, Government of India. The monitoring committee appointed for this purpose would also monitor on a regular basis the quality and quantity of works carried out in the area.

For monitoring, reference points of silt load observation in the river are suggested to install silt recording station upstream of intake site in Yarjep River to evaluate the impact of the soil conservation measures. A sum of **Rs. 20.00 lakhs** has been provided for monitoring and evaluation.

5.1.8 PERIOD AND SCHEDULE OF IMPLEMENTATION

The execution of CAT plan in Tato-I -H.E Project area would require extensive efforts on the part of executing agencies. Keeping in view the local topography and climate, it is being estimated that the entire treatable area would require at least 4 years to be completed. However, the maintenance of plantations would continue for one year and accordingly CAT plan has been prepared for 5 years. All these works would have to start with the pre-construction activities especially the studies in respect of micro-planning for each sub-watershed, which would require further detailed investigations. Based on the silt yield index of the sub-watersheds, the conservation measures would be first taken up in sub-watershed Sk1, Sk2, Sk3, etc. (For details see Annexure-1). The year-wise index map of schedule of implementation of different conservation measures under CAT plan has been given in **Fig.5.1.10**. Table 5.1.12 gives the year-wise physical details of various engineering and biological treatment measures to be undertaken.

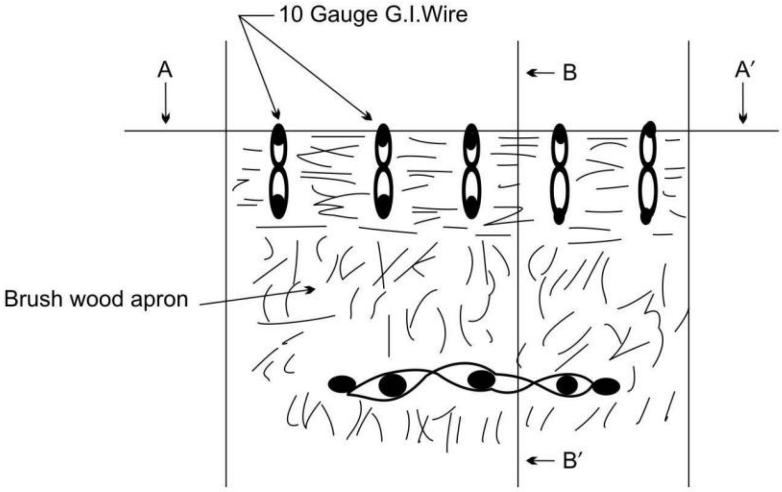
5.1.9 COST ESTIMATES

The total estimated cost of catchment area treatment plan to be spent over a period of seven years is **Rs. 305.85 lakhs**. All the costs towards the administration during the implementation work have been included in the cost estimates of CAT.

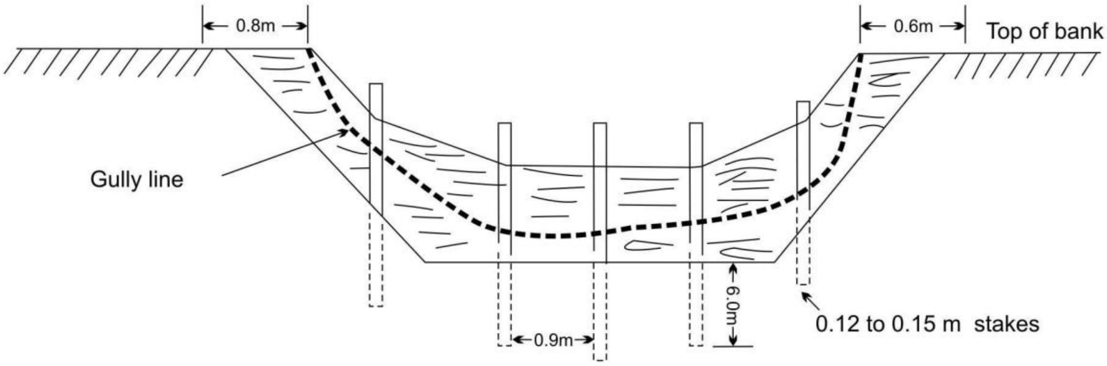
Table 5.1.11 Component-wise cost estimate for catchment area treatment works

S. No.	Item of Work		Unit	Qty.	Rate (Rs.)	Amount (Rs. in lakhs)
A.	**Engineering Measures**					
1.	Gully Control					
	a)	Brushwood checkdams	Nos.	64	26,000/-	16.64
	b)	DRSM checkdams	Nos.	65	33,281/-	21.63
	c)	Contour Bunding	ha	117.75	25,000/-	29.44
2.	Bench terracing		ha	80.25	7,500/-	6.02
	Total (1+2)					**73.73**
	Add 5% for maintenance of structures					3.69
	Sub-total (A)					**77.42**
B.	**Biological Measures**					
1.	Afforestation					
	i)	Creation	ha	137.63	39,000/-	53.68
	ii)	Maintenance			5,000/-	6.88
2.	Assisted natural regeneration in existing forests					
	i)	Creation	ha	76.07	11762/-	8.95
	ii)	Maintenance (see Table 2.14)			250/-	0.19
3.	NTFP Regeneration					
	i)	Creation	ha	78.76	36,563/-	28.80
	ii)	Maintenance (see Table 2.15)			6900/-	5.43
4.	Pasture development					
	i)	Creation	ha	88.45	19,935/-	17.63
	ii)	Maintenance			607/-	0.54
5.	Nurseries					15.00
	Sub-total (B)					**137.10**
	Sub-Total (A+B)					**214.52**

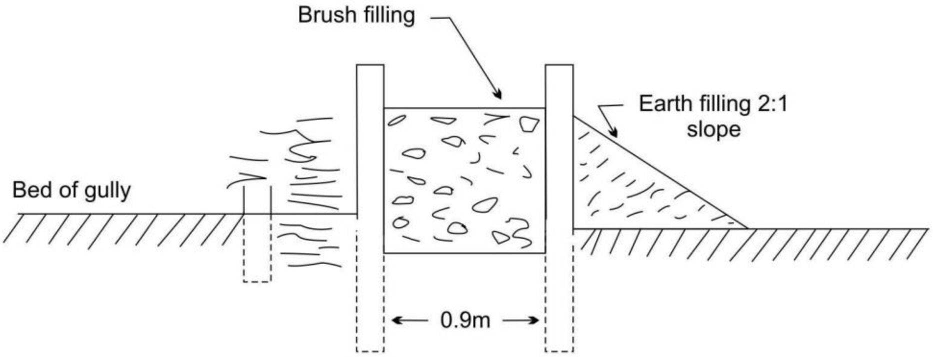
C.	**Micro-planning @ 3% of (A+B)**	**6.44**
D.	**Establishment Cost @ 7%**	**15.02**
E.	**Forest Infrastructure**	**37.00**
	Vehicles, machinery & equipment, paths, etc.	
F.	**Eco-restoration @ 1%**	**2.14**
G.	**Contingency @ 5%**	**10.73**
H.	**Monitoring and evaluation**	**20.00**
	Grand Total (A to H)	**305.85**



a) A double-row post brush dam



b) Section along A-A′



c) Section along BB′

Plate 5.1.1 A Schematic diagram of a double row brush wood check (a) and its cross section along the dam A-A′ (b) and across the dam (c).

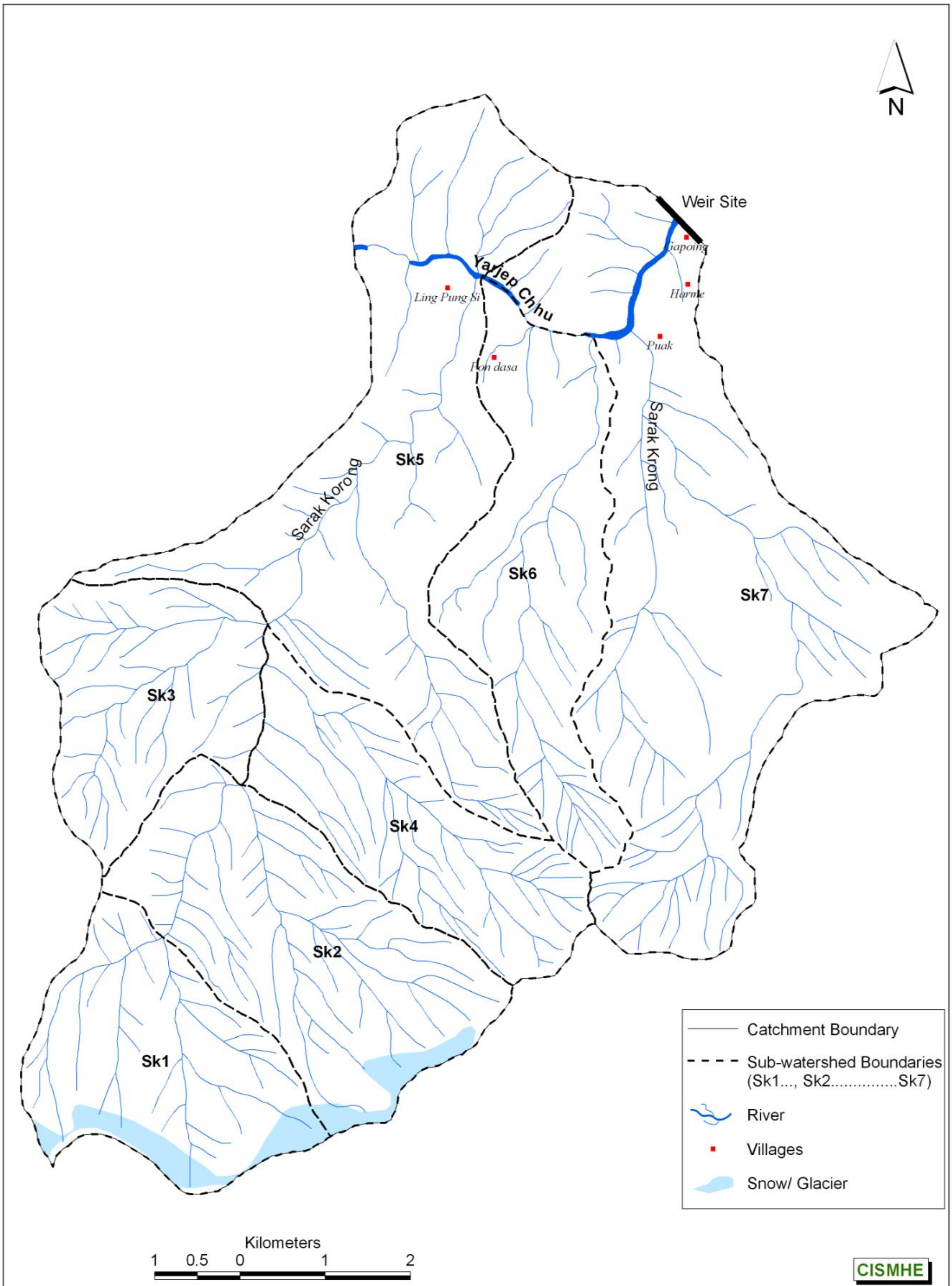
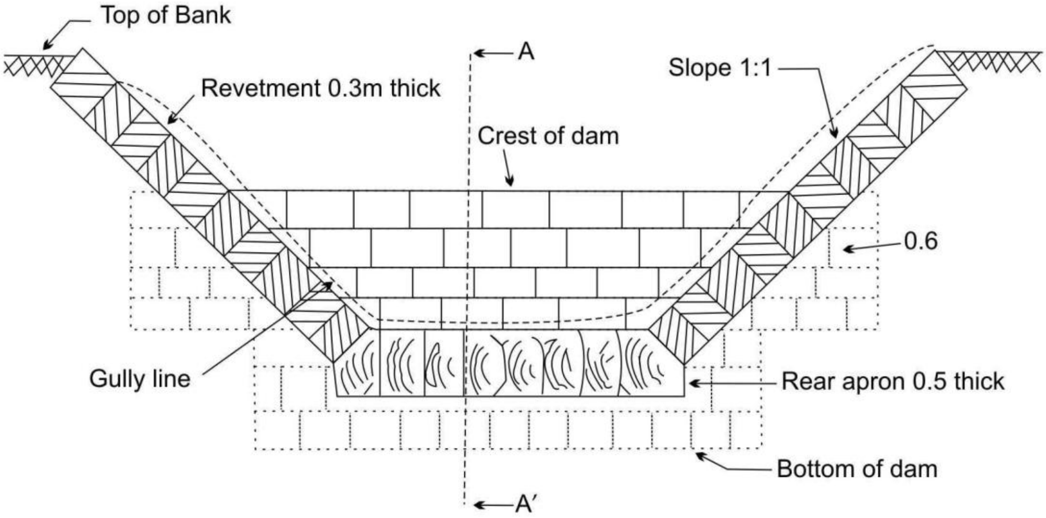
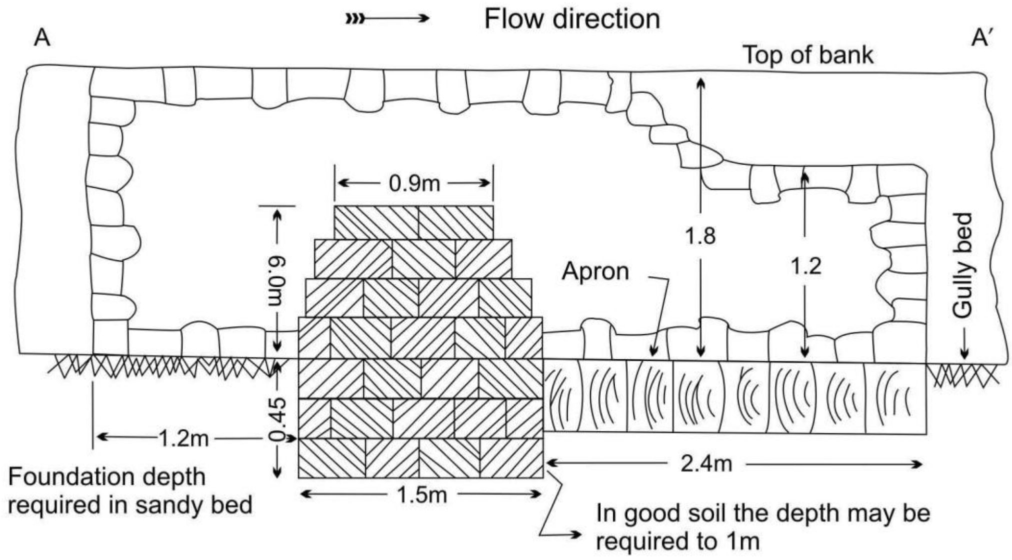


Fig.5.1.1 Index map showing drainage and subwatershed boundaries of Yarjep chhu in free-draining catchment of Tato-I H.E. project



a) Section of Dry rubble stone check dam along the structure



b) Section across the structure on A A′

Plate 5.1.2 A Schematic diagram of a Dry rubble stone check dam showing section along the dam looking up gully (a) and section along A-A′ on diagram(b) .

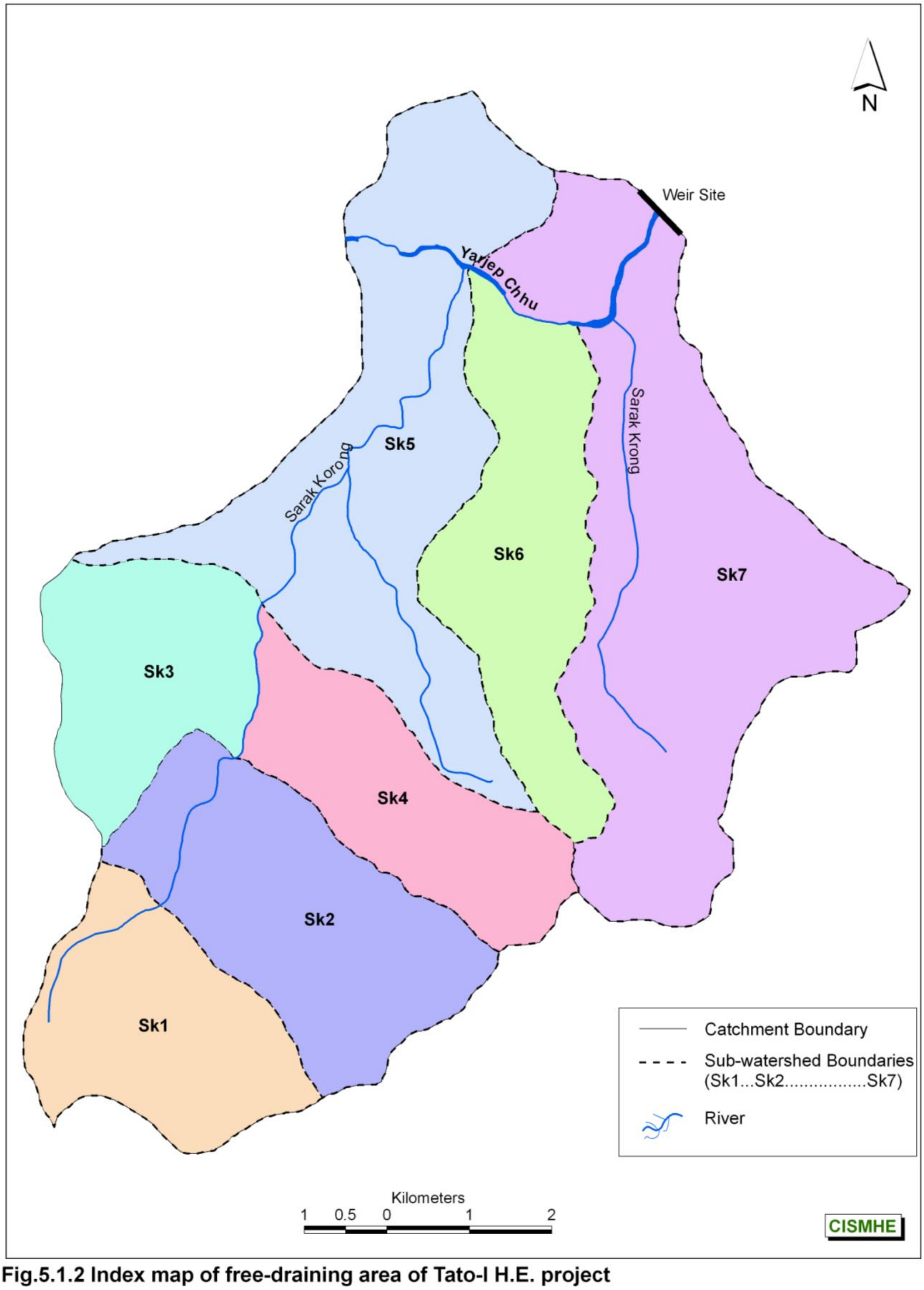


Fig.5.1.2 Index map of free-draining area of Tato-I H.E. project

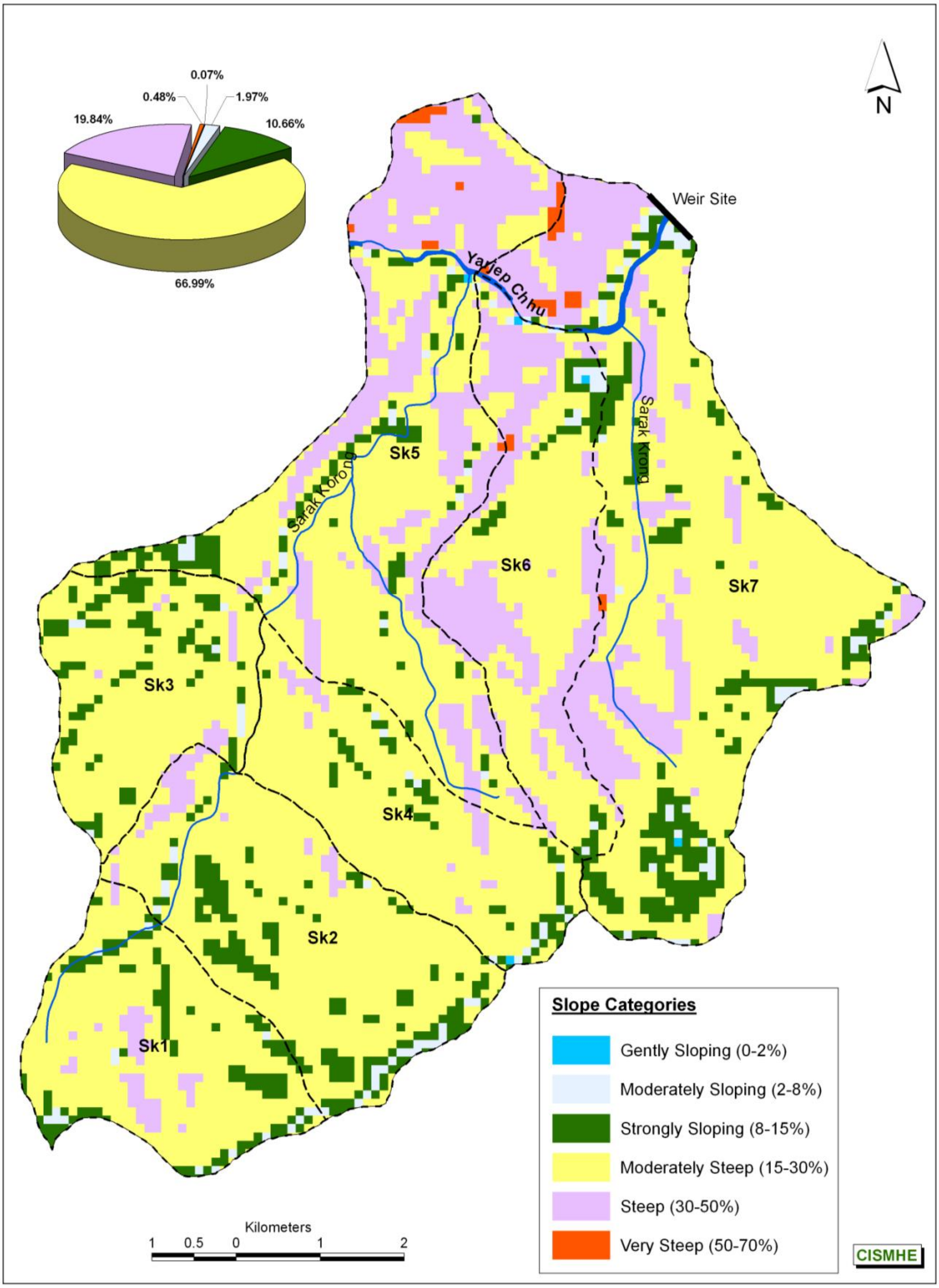


Fig.5.1.3 Slope map of the free-draining catchment area of Tato-I H.E. project

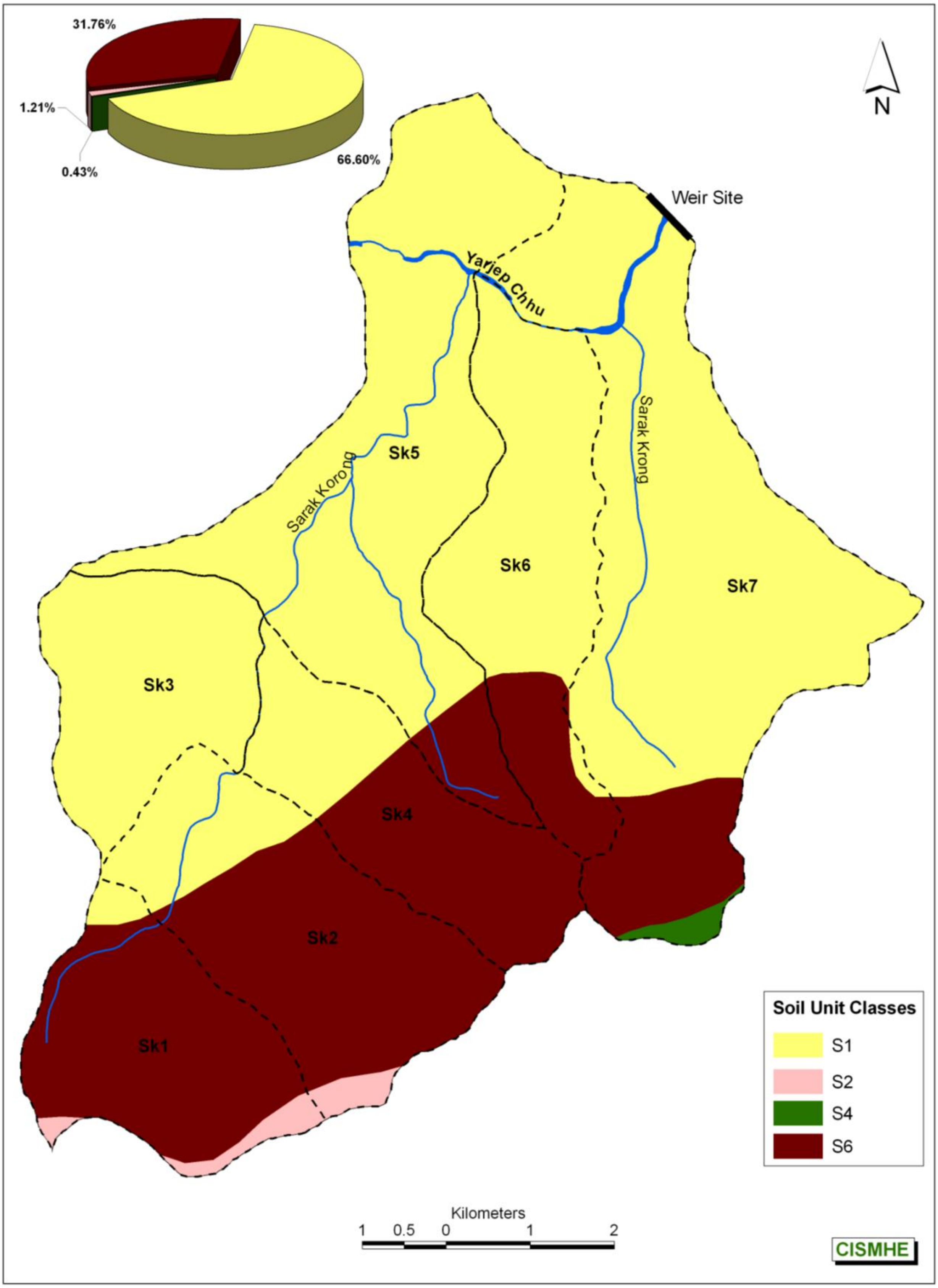


Fig.5.1.4 Soil map of the free-draining catchment of Tato- I H.E. project

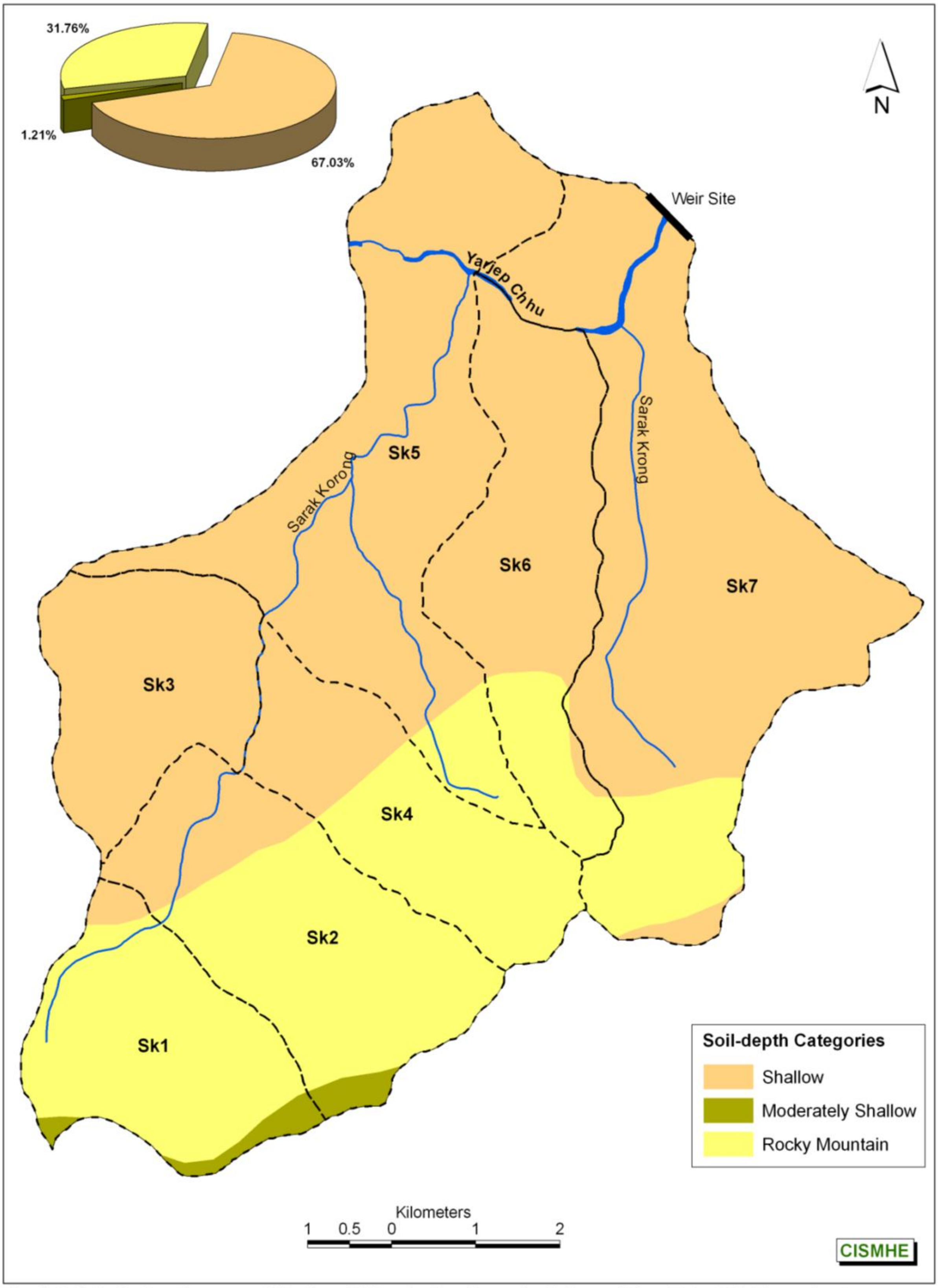


Fig.5.1.5 Soil-depth map of Yarjep Chhu in the free-draining of the Tato-I H.E. project up to the proposed dam site

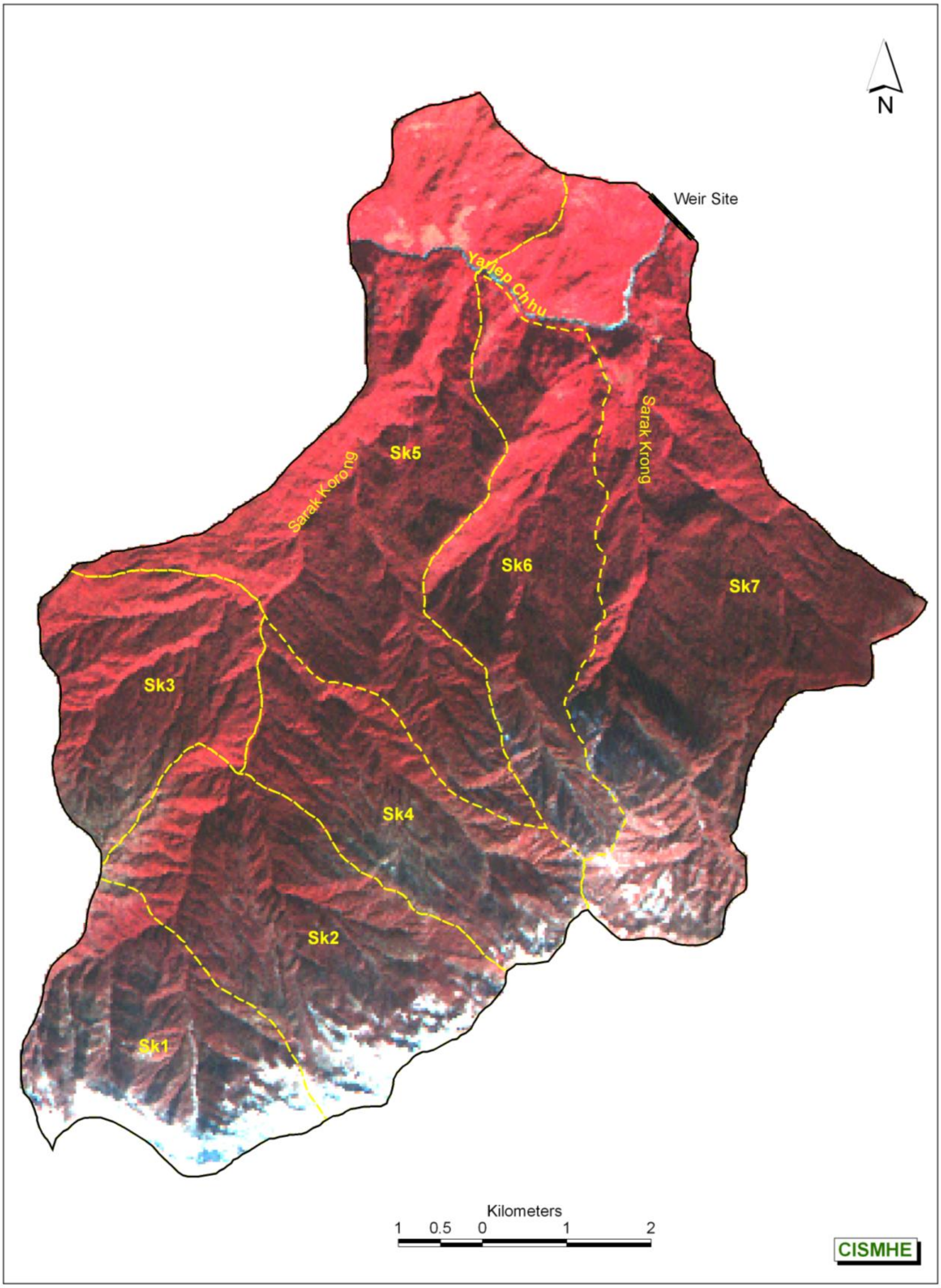


Fig.5.1.6 False Colour Composite (FCC) generated from IRS-P6 LISS-III, 2006 of the proposed Tato-I H.E. Project

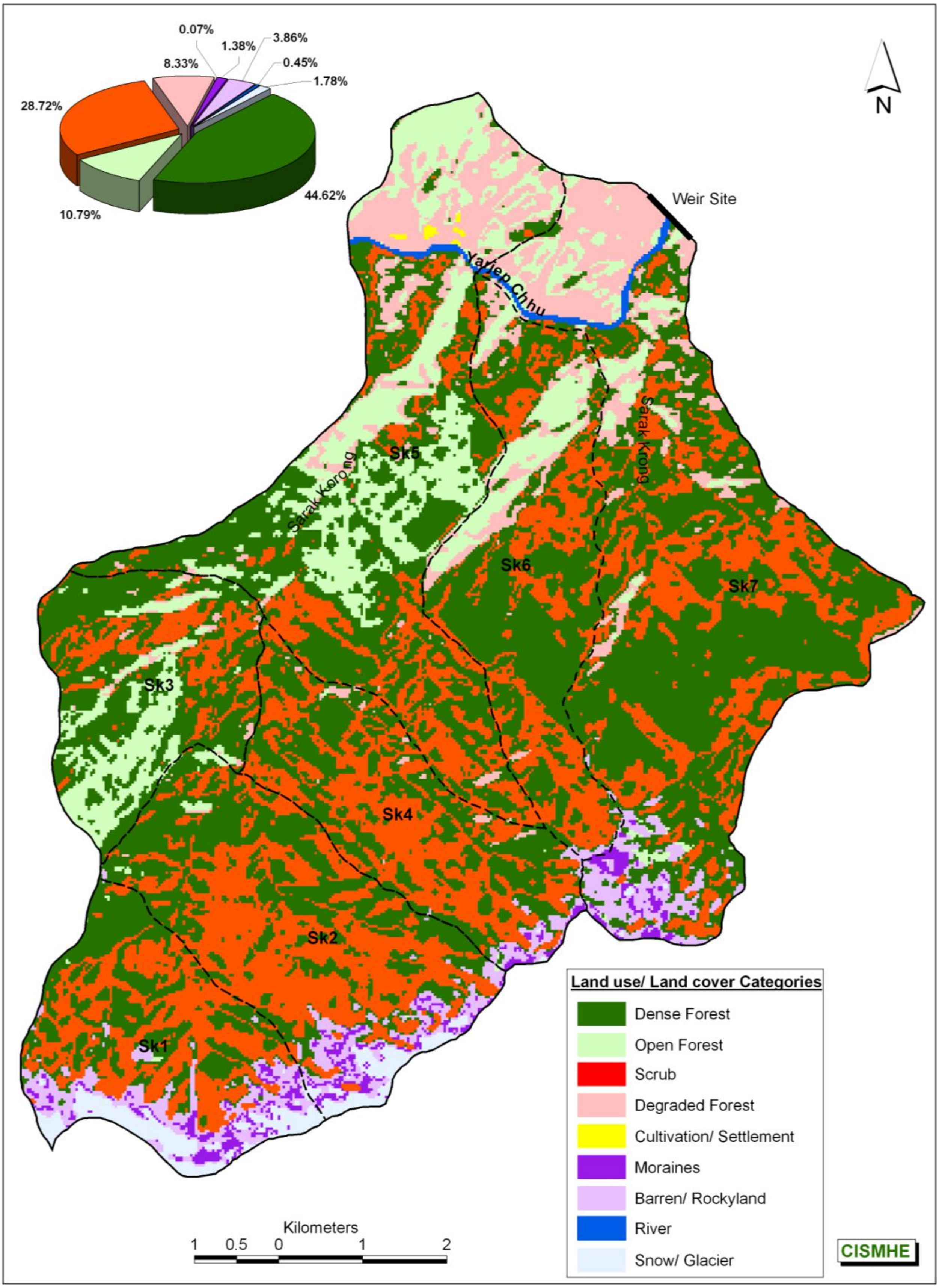


Fig.5.1.7 Land use/ land cover map of the free-draining catchmeht of Tato-I H.E. Project

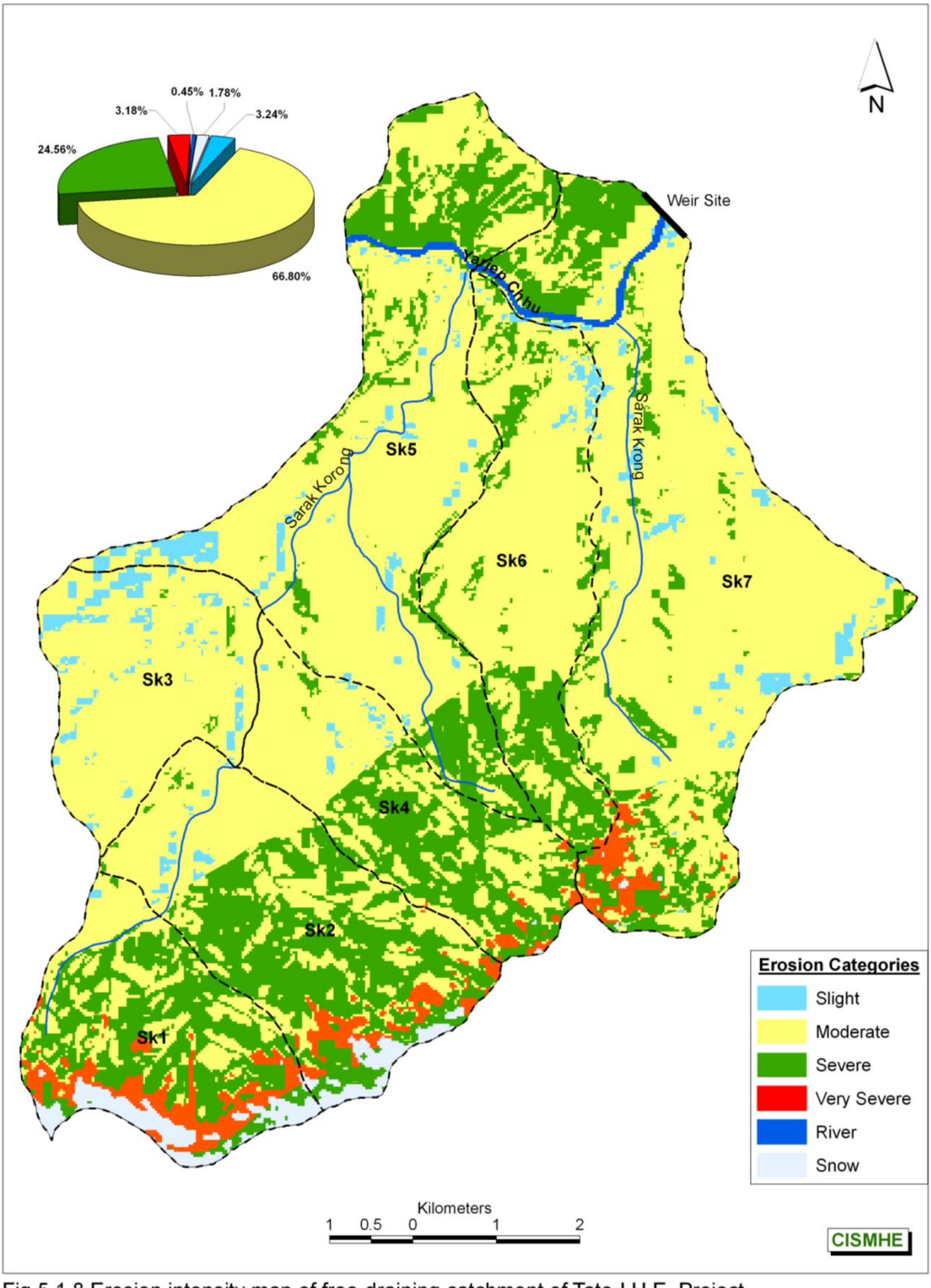


Fig.5.1.8 Erosion intensity map of free-draining catchment of Tato-I H.E. Project

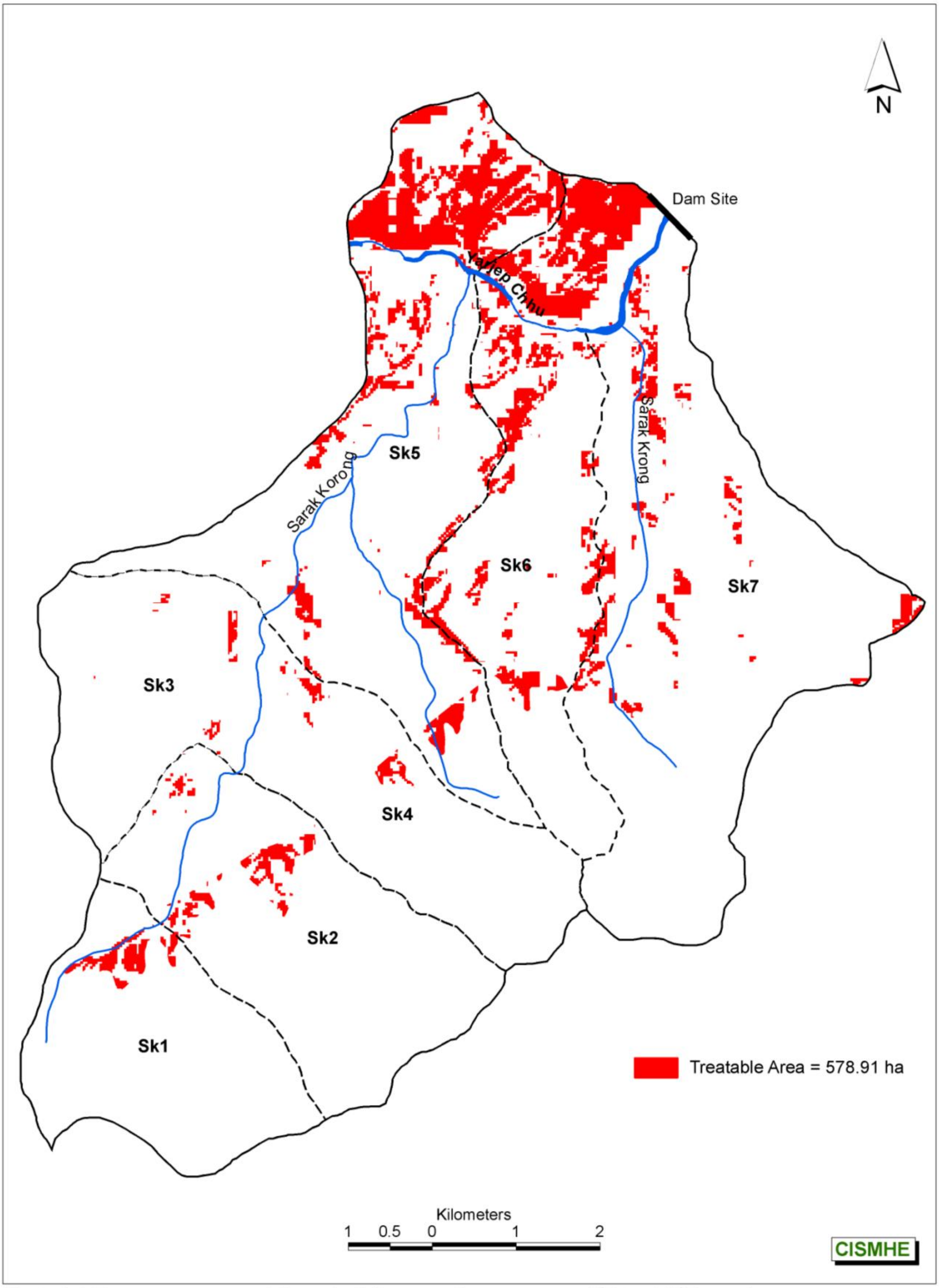


Fig.5.1.9 Treatment map of free-draining catchment area of Tato-I H.E. project

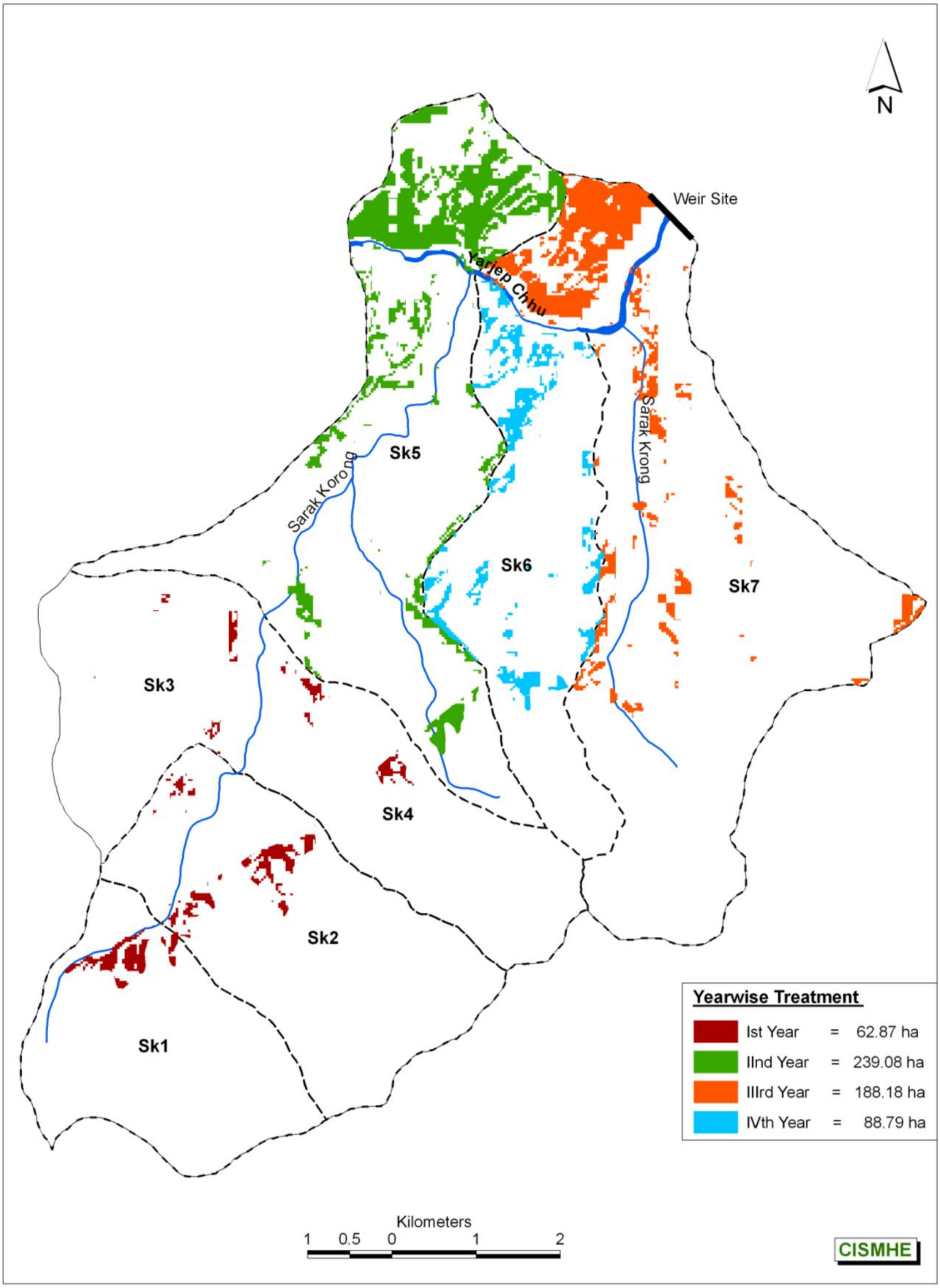
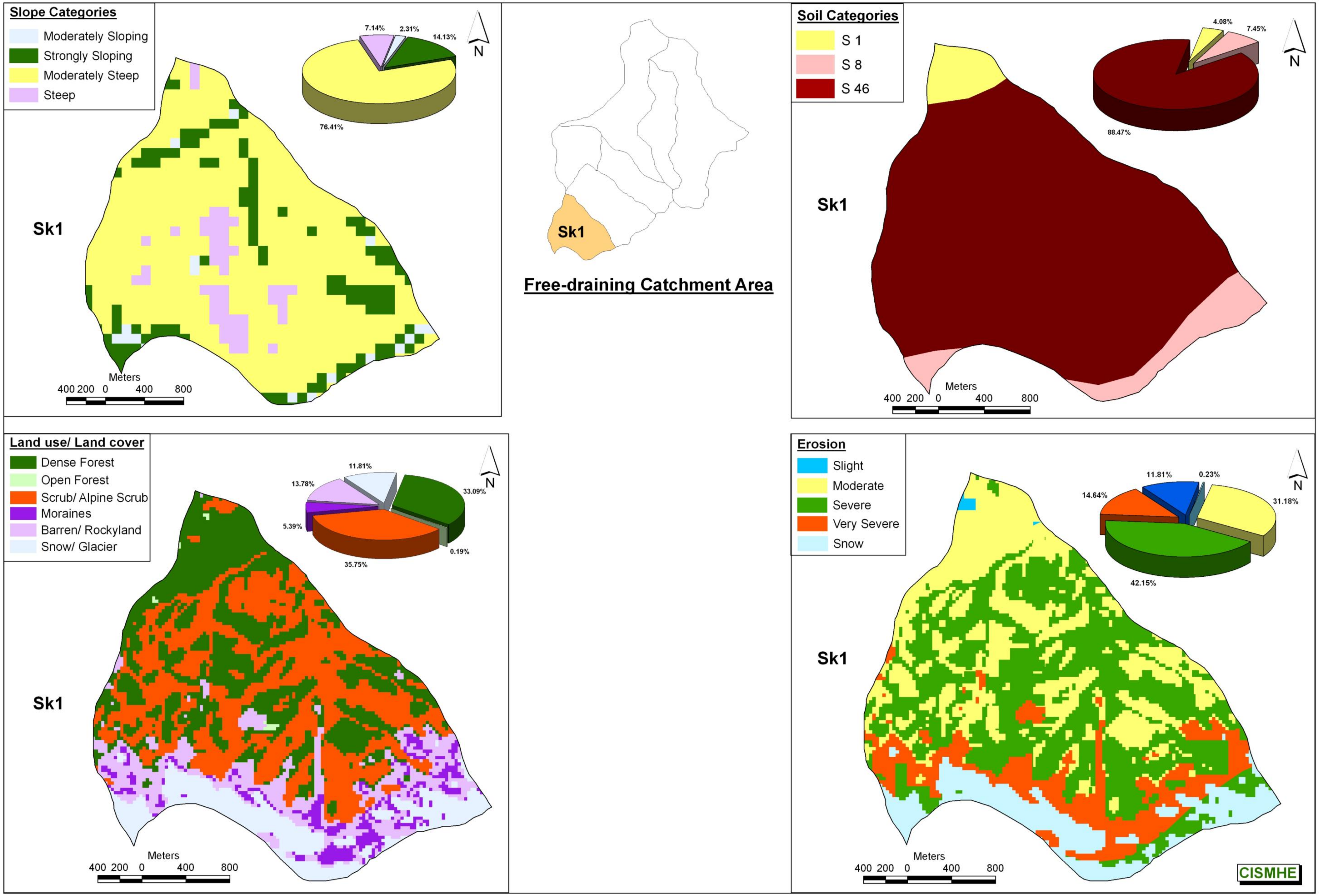
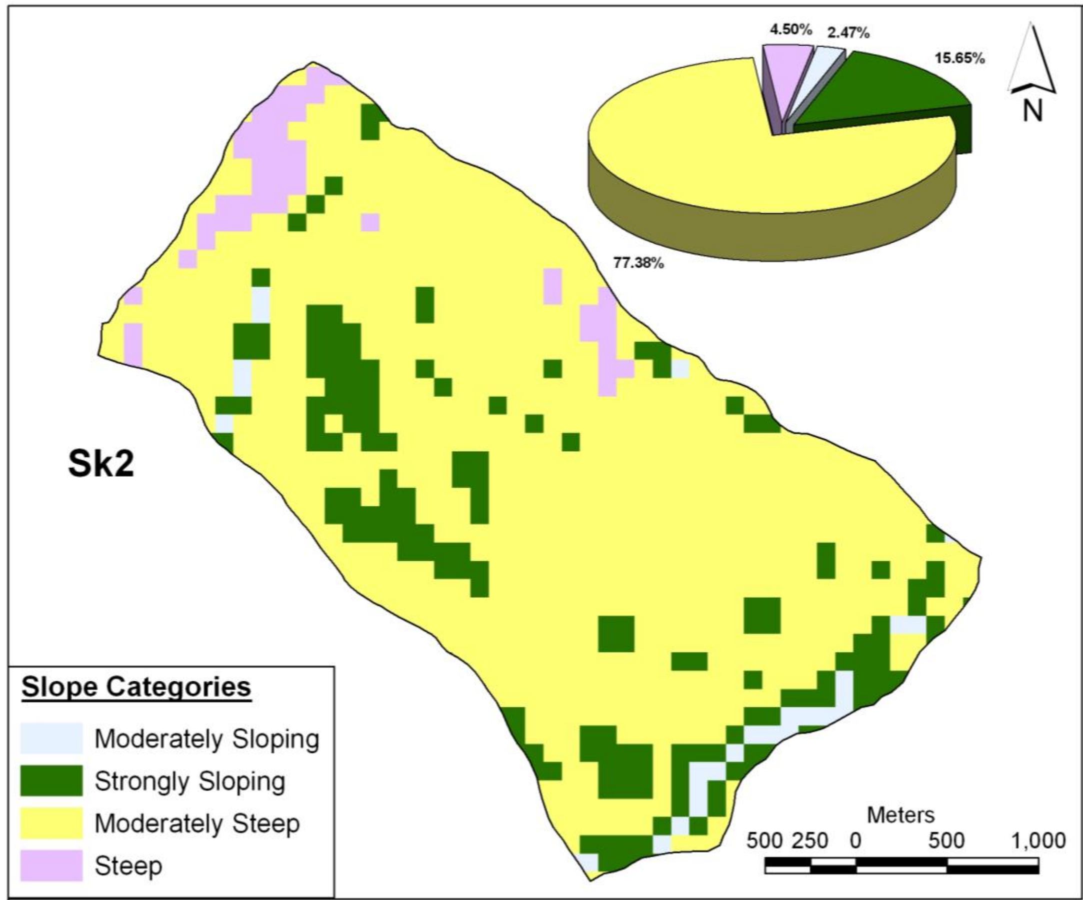
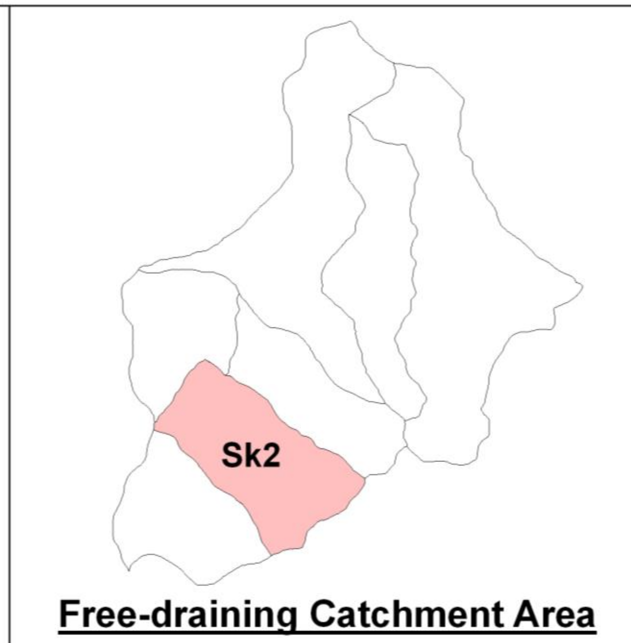
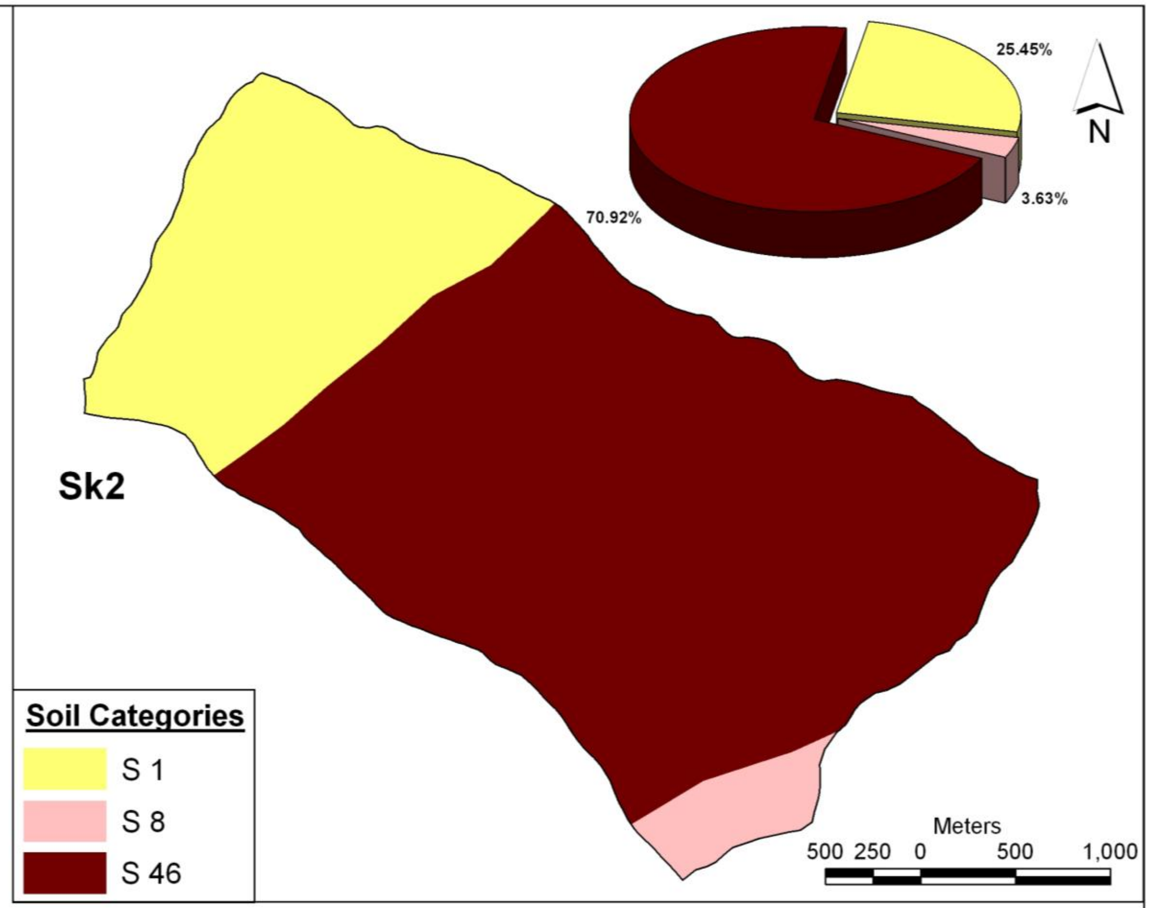


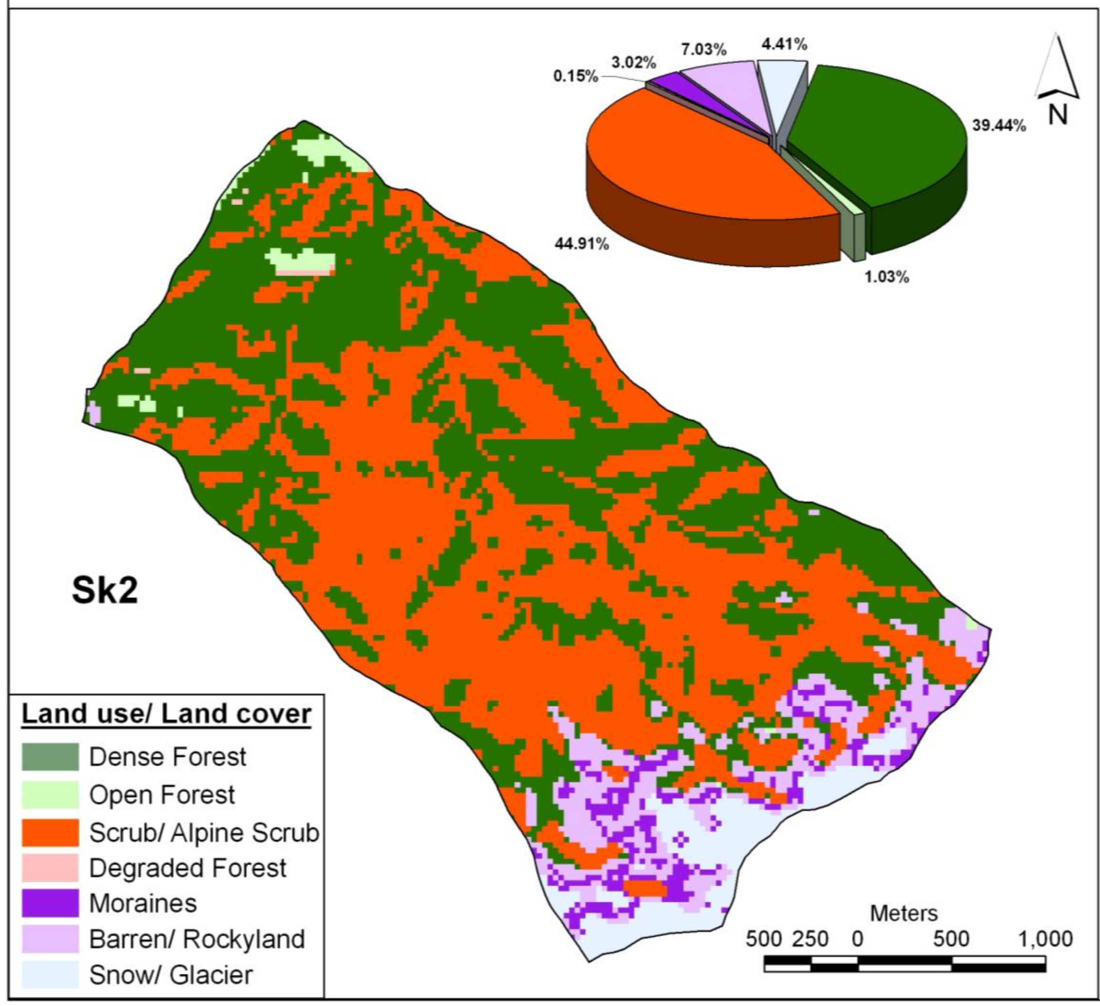
Fig.5.1.10 Yearwise treatment map of free-draining catchment area of Tato-I H.E. project

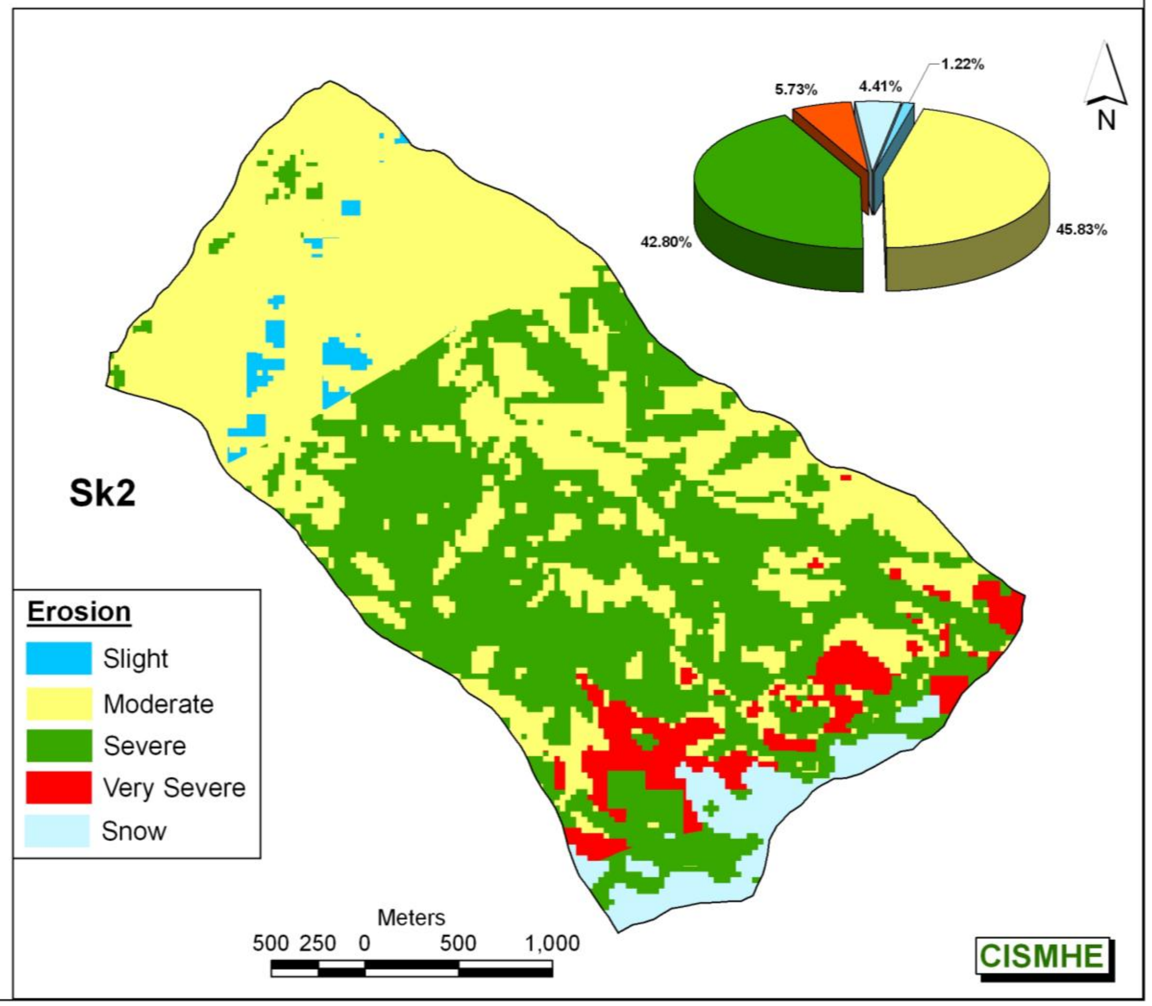

Slope Categories
Moderately Sloping
Strongly Sloping
Moderately Steep
Steep
7.14%
2.31%
14.13%
76.41%
N
Sk1
Meters
400 200 0 400 800
Sk1
Free-draining Catchment Area
Soil Categories
S 1
S 8
S 46
4.08%
7.45%
88.47%
N
Sk1
Meters
400 200 0 400 800
Land use/ Land cover
Dense Forest
Open Forest
Scrub/ Alpine Scrub
Moraines
Barren/ Rockyland
Snow/ Glacier
11.81%
13.78%
33.09%
5.39%
0.19%
35.75%
N
Sk1
Meters
400 200 0 400 800
Erosion
Slight
Moderate
Severe
Very Severe
Snow
11.81%
0.23%
14.64%
31.18%
42.15%
N
Sk1
Meters
400 200 0 400 800
CISMHE

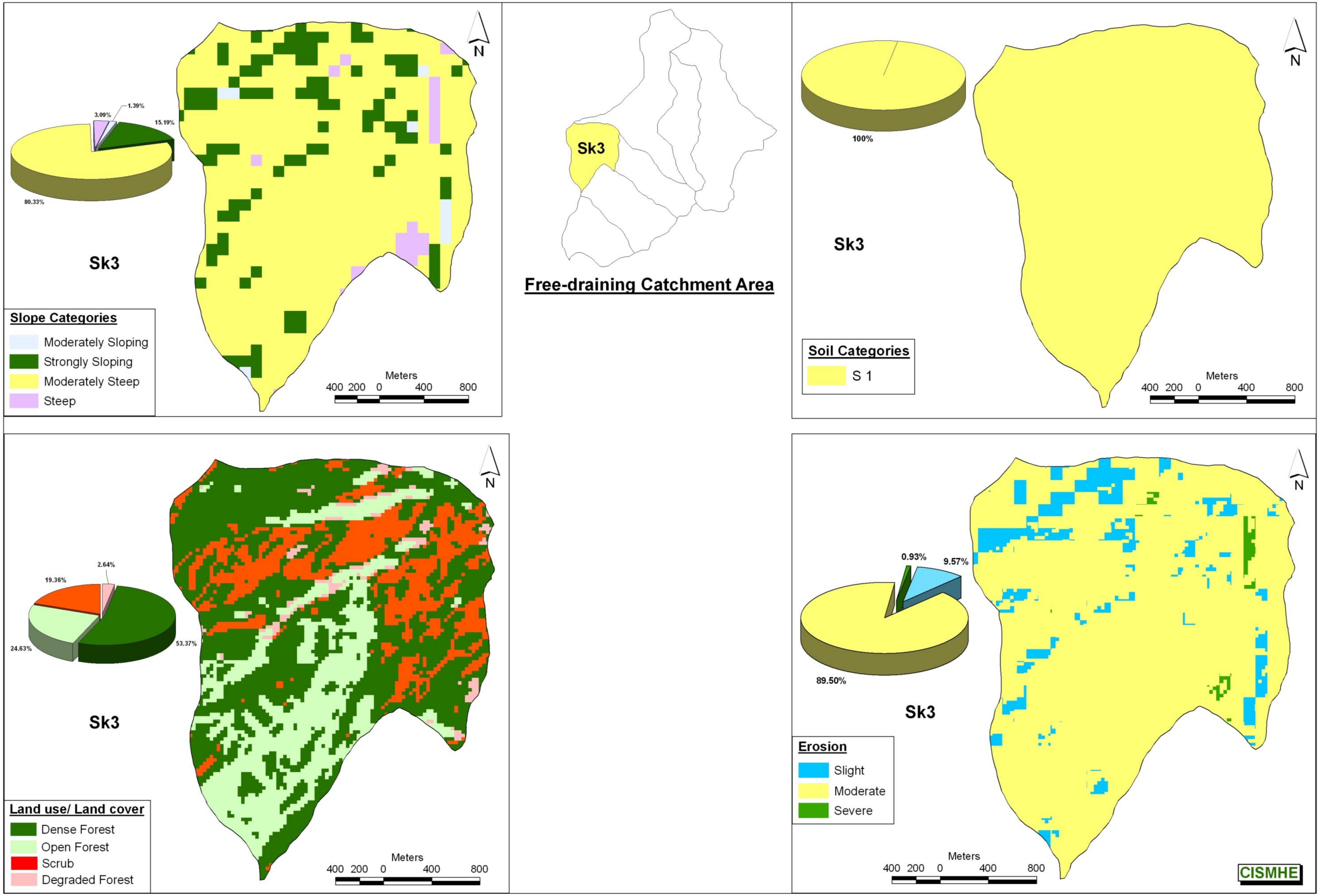

4.50%
2.47%
15.65%
77.38%
N
Sk2
Slope Categories
Moderately Sloping
Strongly Sloping
Moderately Steep
Steep
Meters
500 250 0 500 1,000


Sk2
Free-draining Catchment Area

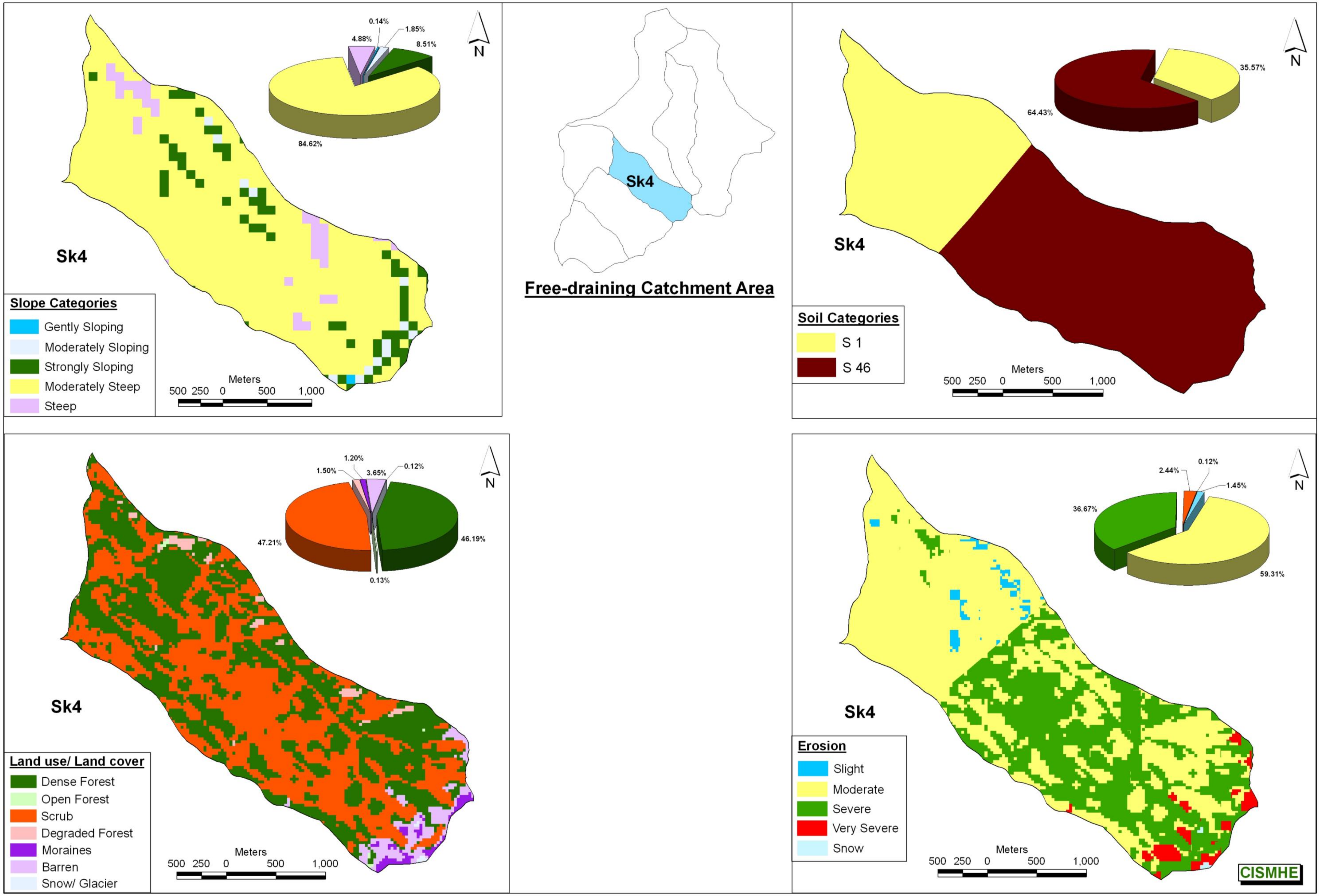

25.45%
70.92%
3.63%
N
Sk2
Soil Categories
S 1
S 8
S 46
Meters
500 250 0 500 1,000

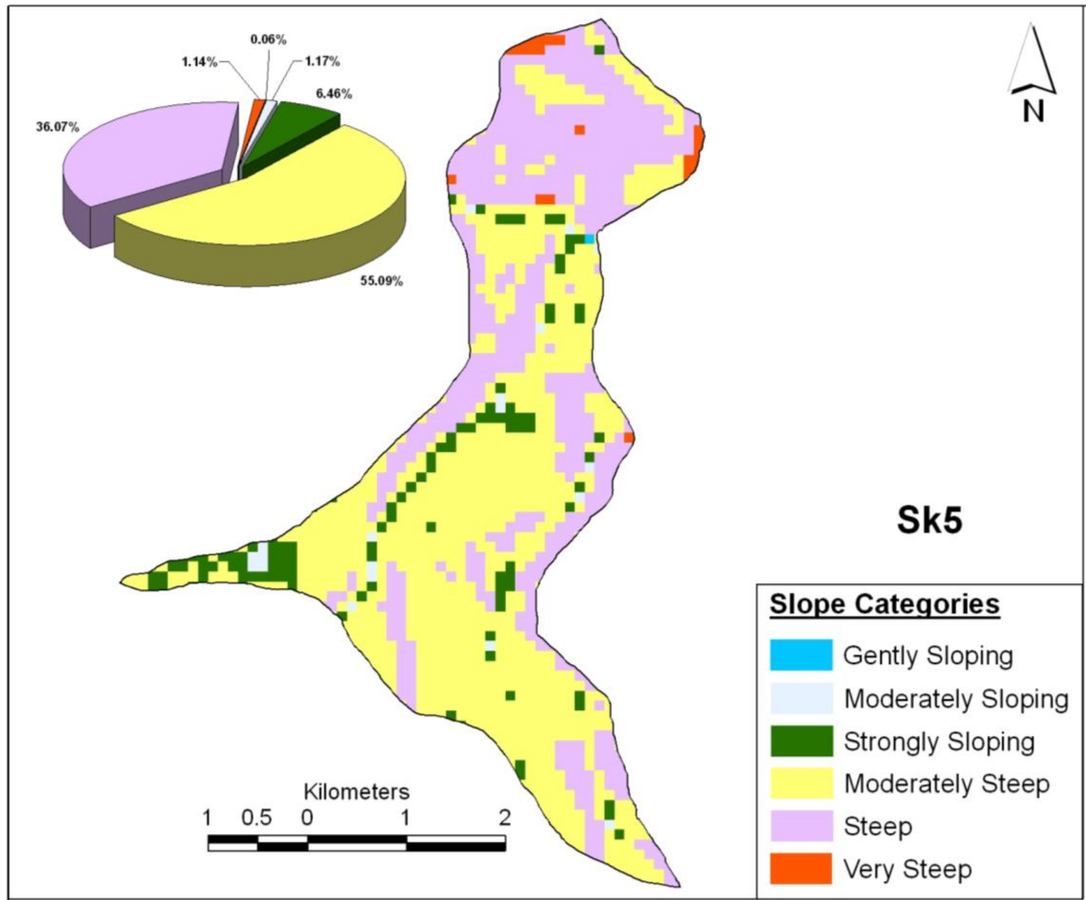

0.15%
3.02%
7.03%
4.41%
39.44%
44.91%
1.03%
N
Sk2
Land use/ Land cover
Dense Forest
Open Forest
Scrub/ Alpine Scrub
Degraded Forest
Moraines
Barren/ Rockyland
Snow/ Glacier
Meters
500 250 0 500 1,000


5.73%
4.41%
1.22%
42.80%
45.83%
N
Sk2
Erosion
Slight
Moderate
Severe
Very Severe
Snow
Meters
500 250 0 500 1,000
CISMHE

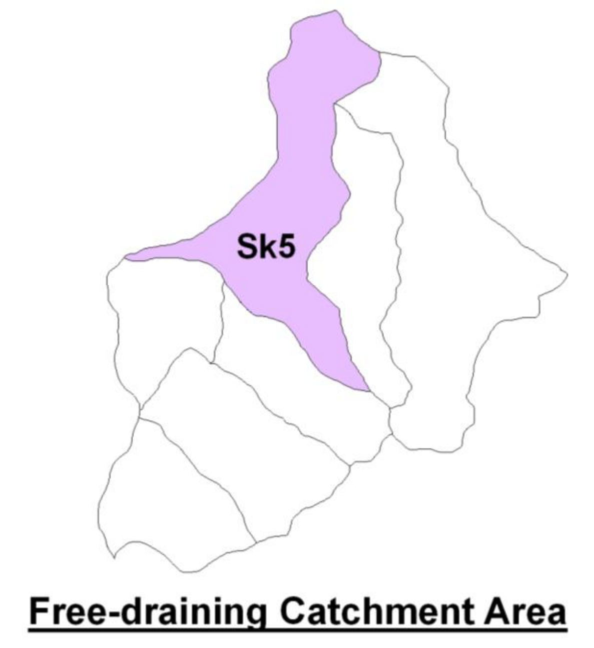


3.09%
1.39%
15.19%
80.33%
Sk3
Slope Categories
Moderately Sloping
Strongly Sloping
Moderately Steep
Steep
N
Meters
400 200 0 400 800
Sk3
Free-draining Catchment Area
100%
Sk3
Soil Categories
S 1
N
Meters
400 200 0 400 800
2.64%
19.36%
24.63%
53.37%
Sk3
Land use/ Land cover
Dense Forest
Open Forest
Scrub
Degraded Forest
N
Meters
400 200 0 400 800
0.93%
9.57%
89.50%
Sk3
Erosion
Slight
Moderate
Severe
N
Meters
400 200 0 400 800
CISMHE

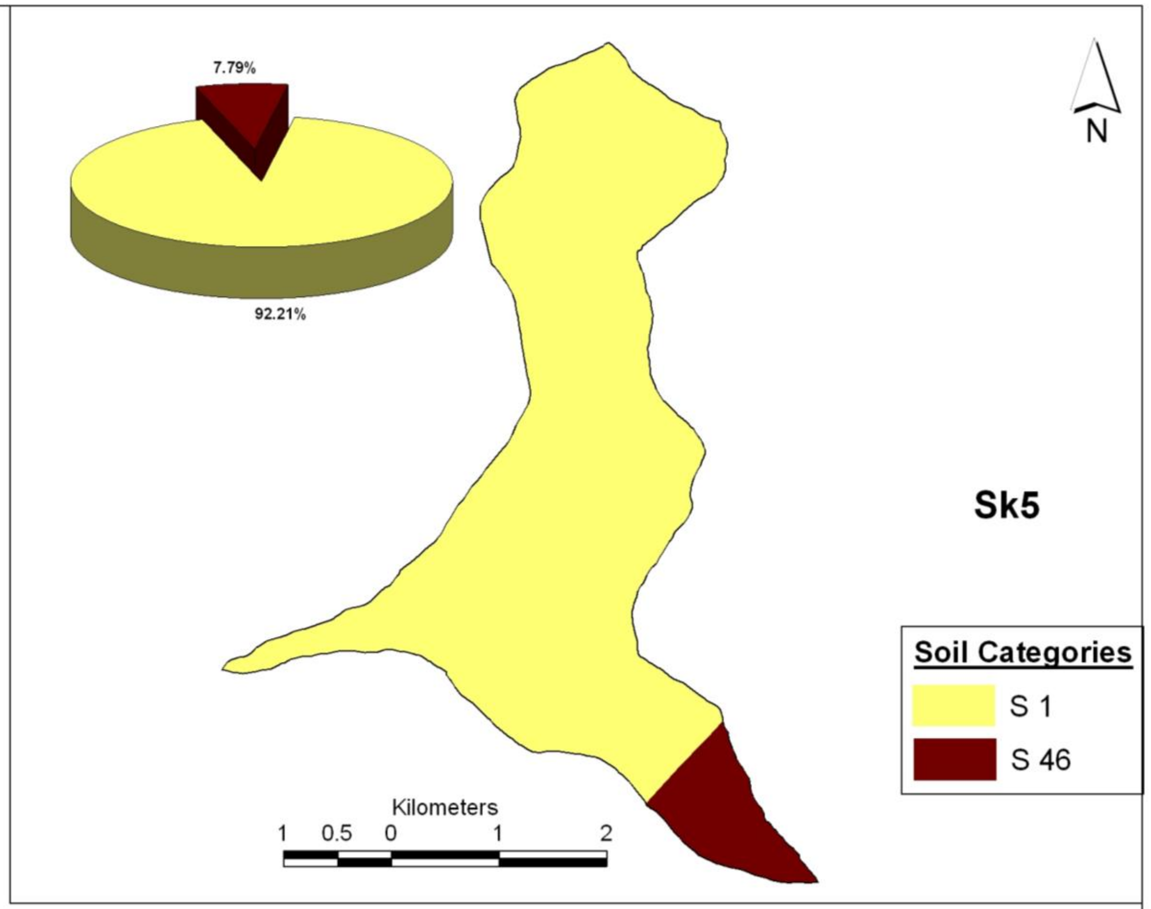

Sk4
Slope Categories
Gently Sloping
Moderately Sloping
Strongly Sloping
Moderately Steep
Steep
0.14%
1.85%
4.88%
8.51%
84.62%
N
Meters
500 250 0 500 1,000
Sk4
Free-draining Catchment Area
Sk4
Soil Categories
S 1
S 46
64.43%
35.57%
N
Meters
500 250 0 500 1,000
Sk4
Land use/ Land cover
Dense Forest
Open Forest
Scrub
Degraded Forest
Moraines
Barren
Snow/ Glacier
1.20%
1.50%
3.65%
0.12%
47.21%
46.19%
0.13%
N
Meters
500 250 0 500 1,000
Sk4
Erosion
Slight
Moderate
Severe
Very Severe
Snow
2.44%
0.12%
1.45%
36.67%
59.31%
N
Meters
500 250 0 500 1,000
CISMHE



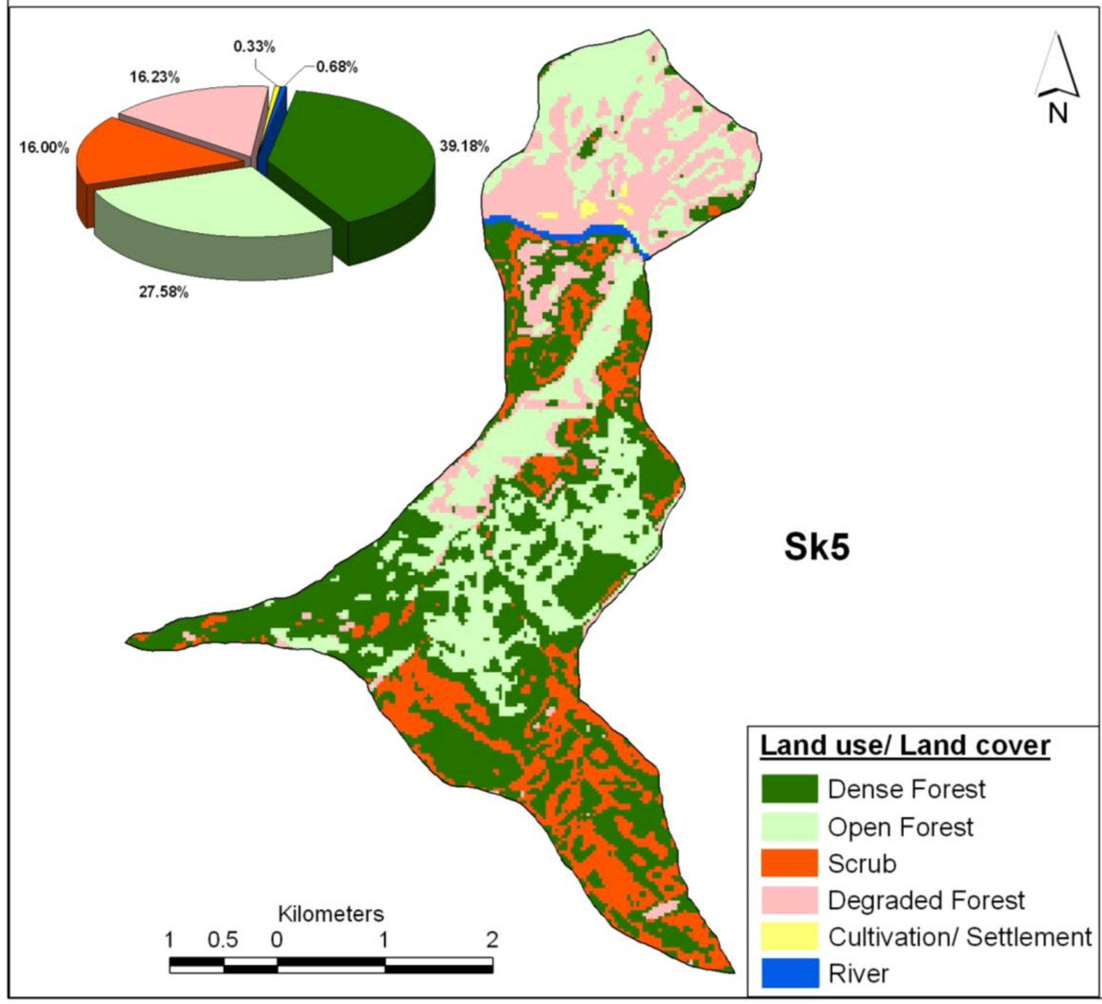
0.06%
1.14%
1.17%
6.46%
36.07%
55.09%
N
Sk5
Slope Categories
Gently Sloping
Moderately Sloping
Strongly Sloping
Moderately Steep
Steep
Very Steep
Kilometers
1 0.5 0 1 2



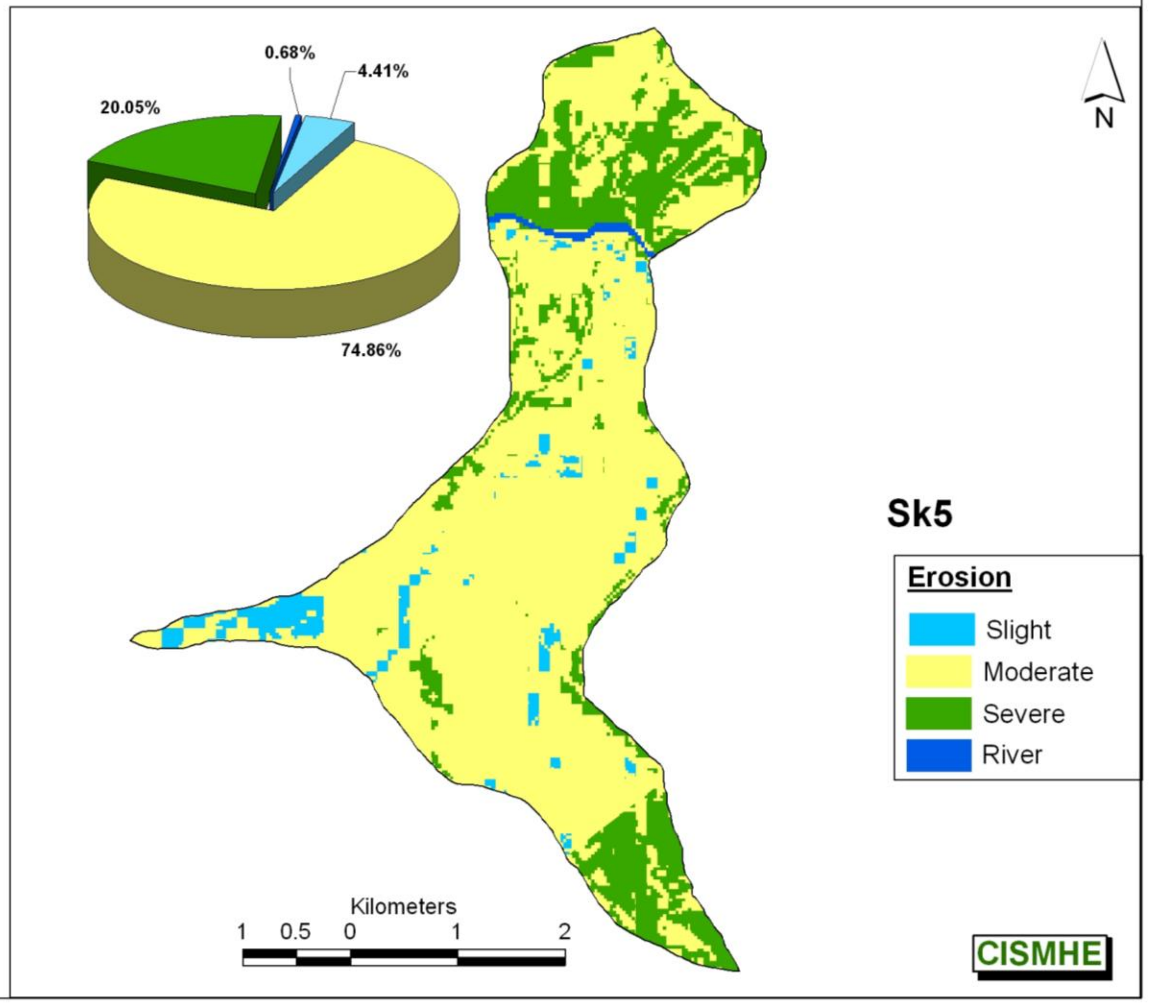
Sk5
Free-draining Catchment Area



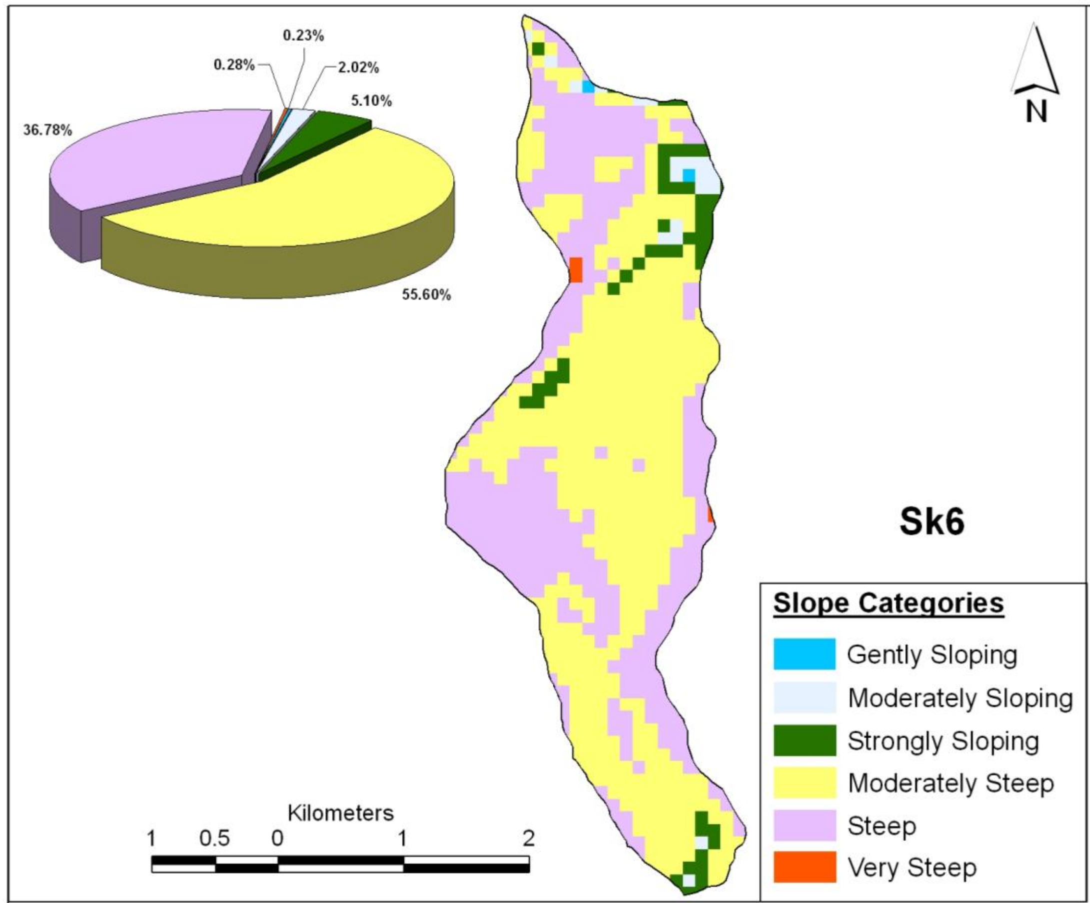
7.79%
92.21%
N
Sk5
Soil Categories
S 1
S 46
Kilometers
1 0.5 0 1 2



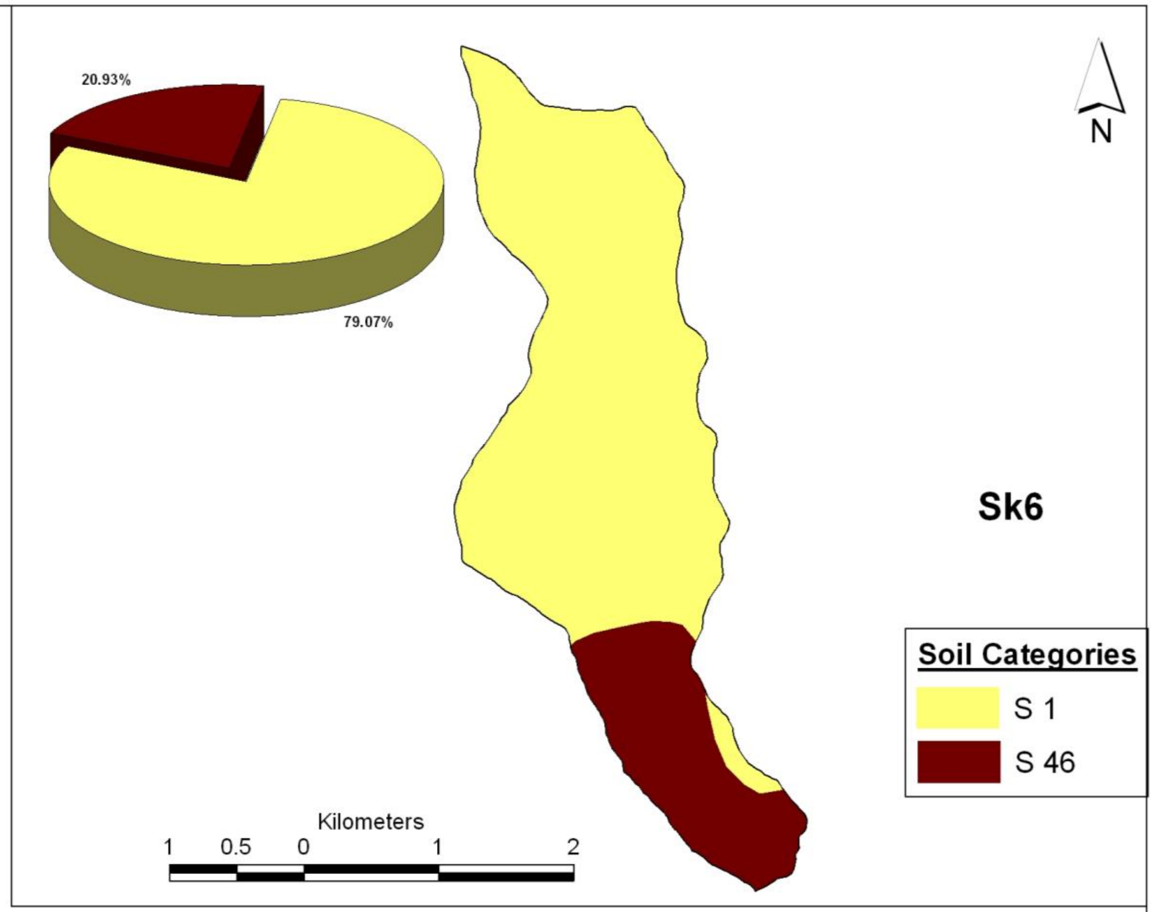
0.33%
16.23%
0.68%
16.00%
39.18%
27.58%
N
Sk5
Land use/ Land cover
Dense Forest
Open Forest
Scrub
Degraded Forest
Cultivation/ Settlement
River
Kilometers
1 0.5 0 1 2

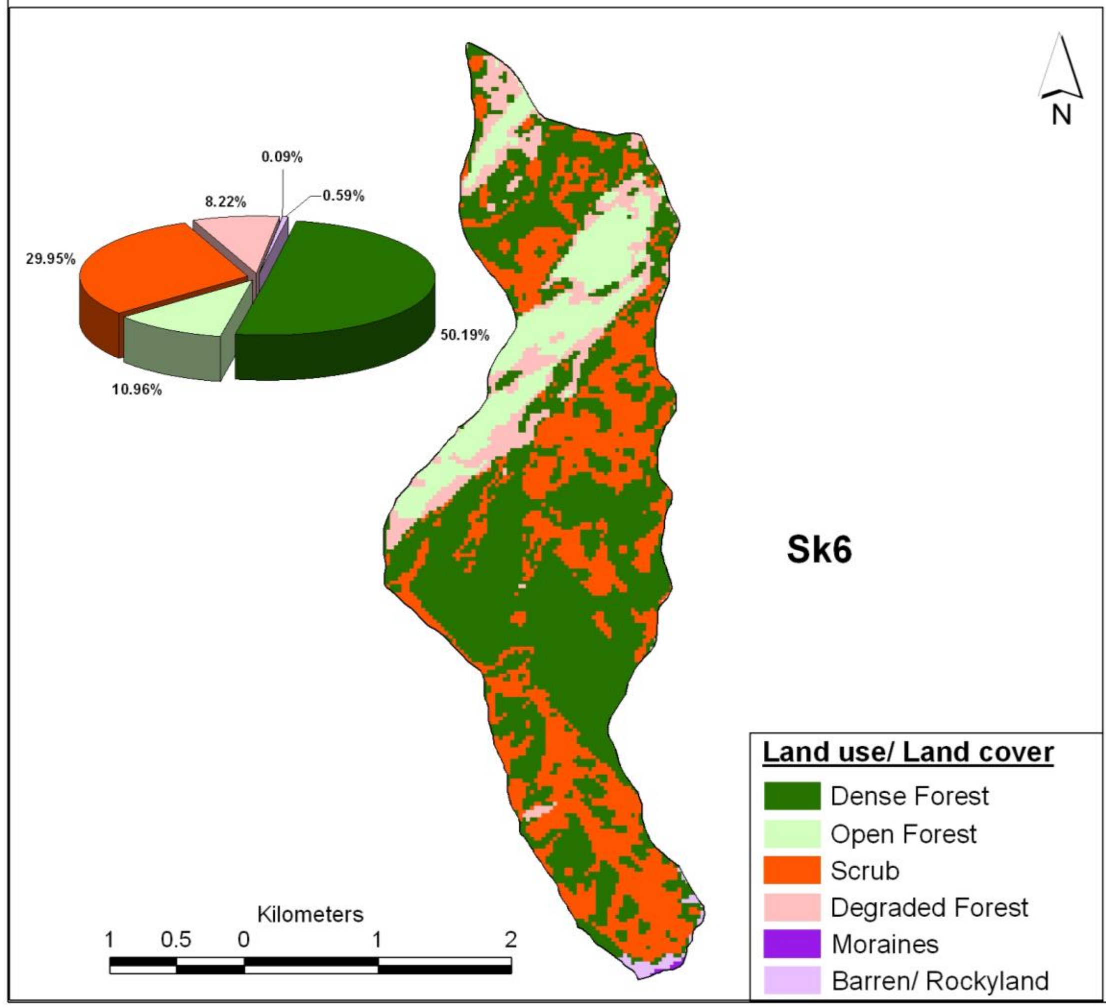


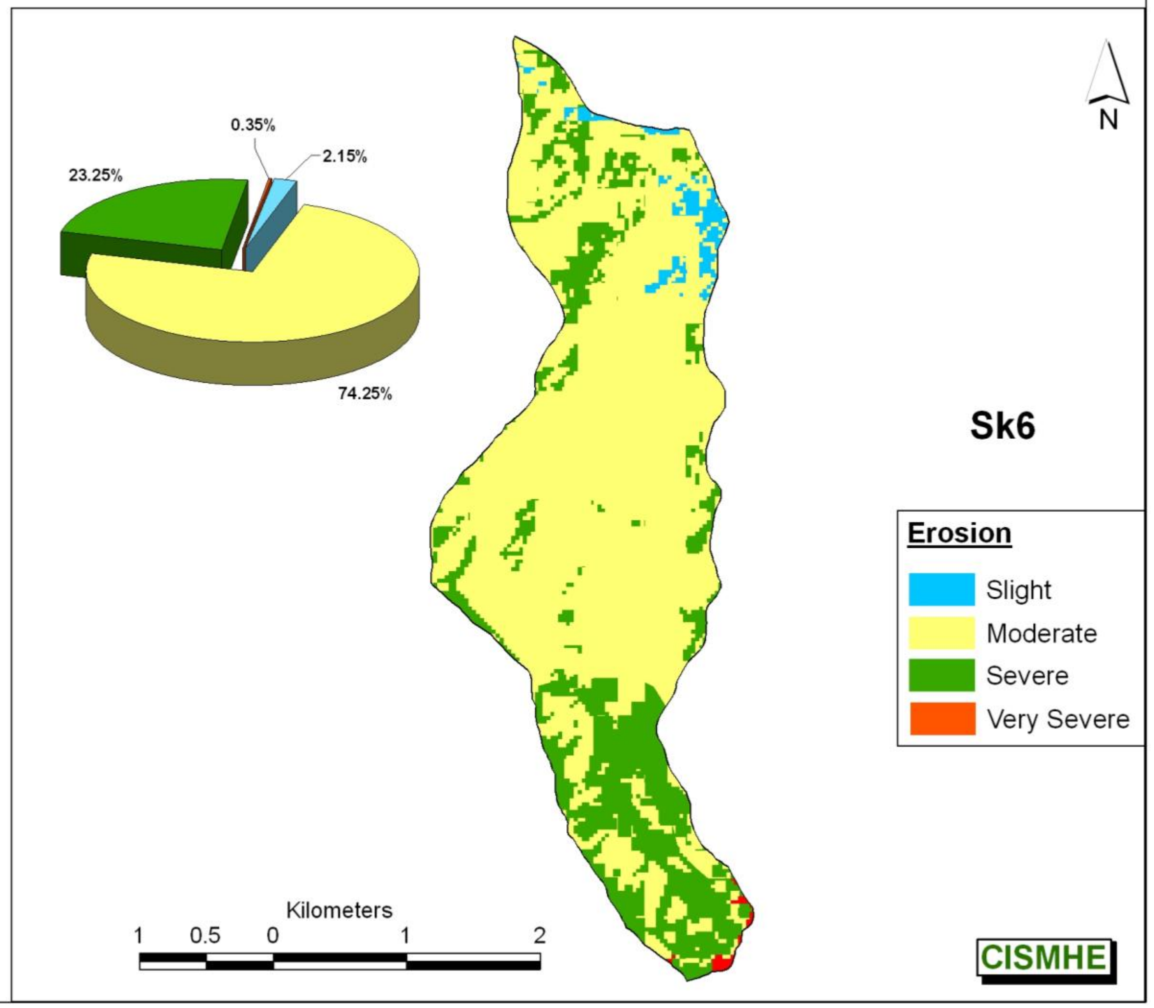
0.68%
4.41%
20.05%
74.86%
N
Sk5
Erosion
Slight
Moderate
Severe
River
Kilometers
1 0.5 0 1 2
CISMHE


0.23%
0.28%
2.02%
5.10%
36.78%
55.60%
N
Sk6
Slope Categories
Gently Sloping
Moderately Sloping
Strongly Sloping
Moderately Steep
Steep
Very Steep
Kilometers
1 0.5 0 1 2


Sk6
Free-draining Catchment Area


20.93%
79.07%
N
Sk6
Soil Categories
S 1
S 46
Kilometers
1 0.5 0 1 2


0.09%
8.22%
0.59%
29.95%
50.19%
10.96%
N
Sk6
Land use/ Land cover
Dense Forest
Open Forest
Scrub
Degraded Forest
Moraines
Barren/ Rockyland
Kilometers
1 0.5 0 1 2


0.35%
2.15%
23.25%
74.25%
N
Sk6
Erosion
Slight
Moderate
Severe
Very Severe
Kilometers
1 0.5 0 1 2
CISMHE

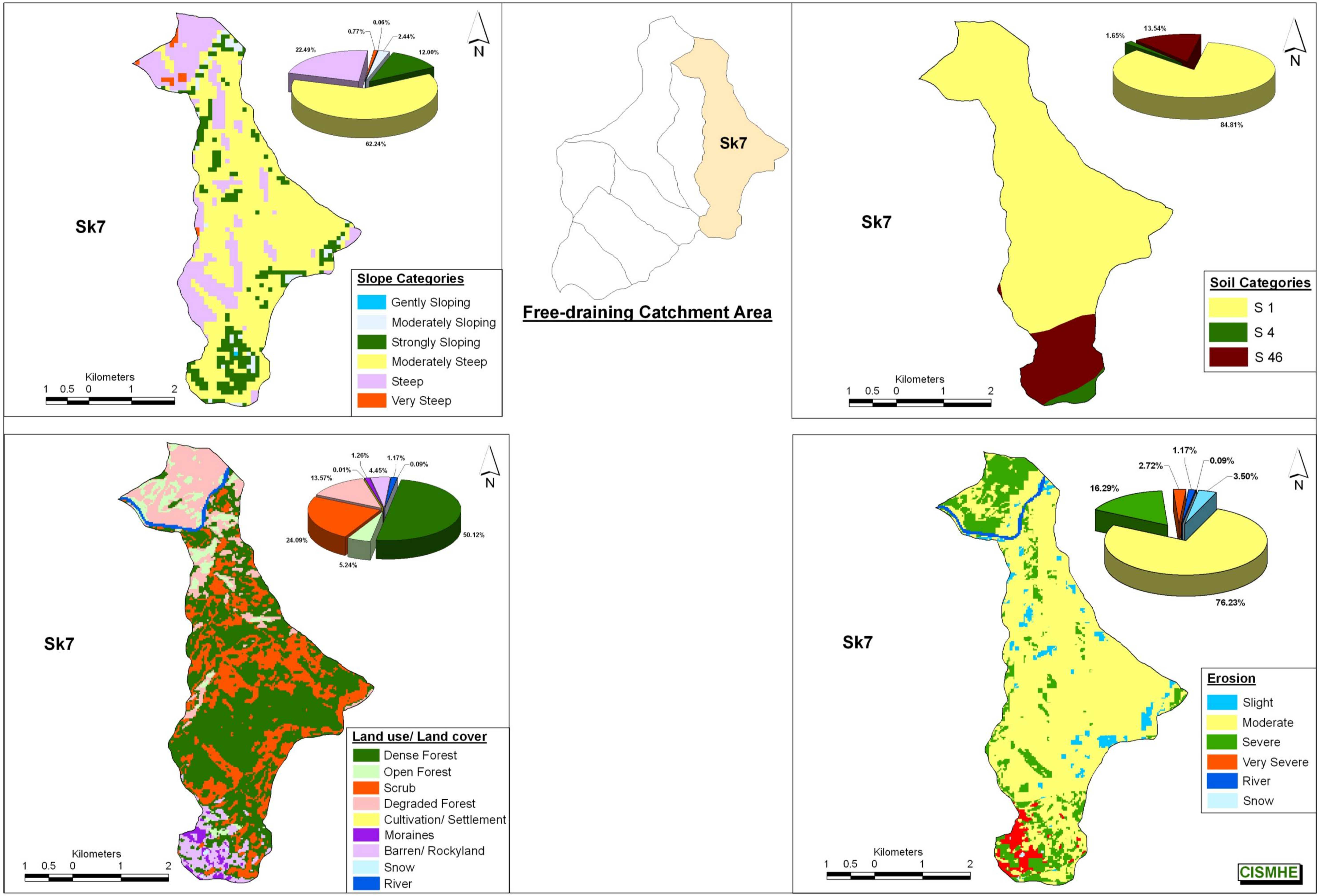

Free-draining Catchment Area
Sk7
Slope Categories
Gently Sloping
Moderately Sloping
Strongly Sloping
Moderately Steep
Steep
Very Steep
0.06%
0.77%
2.44%
22.49%
12.00%
62.24%
Kilometers
1 0.5 0 1 2
N
Soil Categories
S 1
S 4
S 46
1.65%
13.54%
84.81%
Land use/ Land cover
Dense Forest
Open Forest
Scrub
Degraded Forest
Cultivation/ Settlement
Moraines
Barren/ Rockyland
Snow
River
1.26%
1.17%
0.01%
4.45%
0.09%
13.57%
24.09%
5.24%
50.12%
Erosion
Slight
Moderate
Severe
Very Severe
River
Snow
1.17%
2.72%
0.09%
16.29%
3.50%
76.23%
CISMHE

Table 5.1.12 Physical and Financial layout plan of Catchment Area Treatment for Tato-I H.E. Project **(Amount in lakhs)**

S. No.	Item	Unit	0th Year		Ind Year		IIrd Year		IIIth Year		IVth Year		Vth Year		Total	
			Phy	Fin	Phy	Fin	Phy	Fin	Phy	Fin	Phy	Fin	Phy	Fin	Phy	Fin
A.	**ENGINEERING MEASURES**															
1.	**Gully Control**															
a)	Brushwood Check Dams	Nos.			7	1.82	26	6.76	21	5.46	10	2.60	-	-	**64**	**16.64**
b)	DRSM Check Dam	Nos.			7	2.33	27	8.99	21	6.99	10	3.32	-	-	**65**	**21.63**
c)	Contour Bunding	ha			12.79	3.20	48.63	12.16	38.27	9.57	18.06	4.51	-	-	**117.75**	**29.44**
2.	Bench Terracing/ Bally Benching	ha			8.72	0.65	33.14	2.49	26.08	1.96	12.31	0.92	-	-	**80.25**	**6.02**
Total (1+2)																**73.73**
Add 5% for maintenance of structures																**3.69**
Sub-total (A)																**77.42**
B.	**BIOLOGICAL MEASURES**															
1.	Afforestation															
i)	Creation	ha			14.95	5.83	56.84	22.17	44.73	17.44	21.11	8.24	-	-	**137.63**	**53.68**
ii)	Maintenance		-	-	-	-	-	0.75	-	2.84	-	2.23	-	1.06	-	**6.88**
2.	Assisted Natural Regeneration in existing forests															
i)	Creation	ha			8.26	0.97	31.42	3.70	24.72	2.91	11.67	1.37	-	-	**76.07**	**8.95**
ii)	Maintenance		-	-	-	-	-	0.02	-	0.08	-	0.06	-	0.03	-	**0.19**
3.	NTFP Regeneration															
i)	Creation	ha			8.55	3.13	32.53	11.89	25.60	9.36	12.08	4.42	-	-	**78.76**	**28.80**
ii)	Maintenance		-	-	-	-	-	0.59	-	2.24	-	1.77	-	0.83	-	**5.43**
4.	Pasture Development															
i)	Creation	ha			9.61	1.92	36.53	7.28	28.75	5.73	13.56	2.70	-	-	**88.45**	**17.63**
ii)	Maintenance		-	-	-	-	-	0.06	-	0.22	-	0.17	-	0.09	-	**0.54**
5.	Nursery (Creation & Maintenance)	ha	-	1.50	-	3.00	-	3.00	-	3.00	-	3.00	-	1.50	-	**15.00**
	Sub-total (B)															**137.10**
	Total (A+B)															**214.52**
C.	**Micro-Planning & Overhead expenditure @ 3%**				-	0.55	-	2.00	-	1.67	-	1.30	-	0.92	-	**6.44**
D.	**Establishment Cost @ 7%**				-	1.30	-	4.74	-	3.87	-	2.99	-	2.12	-	**15.02**
E.	**Forest Infrastructure** Vehicles, Machinery & equipment, plants, etc.				-	7.00	-	8.00	-	8.00	-	7.00	-	7.00	-	**37.00**
F.	**Eco-restoration @ 1%**				-	0.18	-	0.68	-	0.55	-	0.43	-	0.30	-	**2.14**
G.	**Contingency @ 5%**				-	0.90	-	3.39	-	2.77	-	2.15	-	1.52	-	**10.73**
H.	**Monitoring and Evaluation**				-	2.00	-	6.00	-	5.00	-	4.00	-	3.00	-	**20.00**
GRAND TOTAL (A to H)																**305.85**

5.2
BIODIVERSITY MANAGEMENT & WILDLIFE CONSERVATION PLAN

5.2.1 INTRODUCTION

Biodiversity management is considered as a difficult task as it refers to diversity at all levels like genetic, species and community. The implementation of biodiversity conservation strategy is a challenging job especially in North-eastern part of India like Arunachal Pradesh as the area is predominated with various tribal populations, which consider themselves as an integral part of the forest ecosystem.

The formulation of a biodiversity management and wildlife conservation plan for a developmental Project is one of the steps towards the environment conservation. Human activities like agricultural expansion, road construction, urbanization, and other developmental activities are supposed to be major threats to biodiversity and wildlife, therefore, the most effective and efficient mechanisms for conserving biodiversity is to prevent further destruction of degradation of habitats. Four strategies required for the biodiversity management are *in Situ* strategy, *ex Situ* Strategy, reduction of anthropogenic pressure and rehabilitation of endangered species. These strategies will be followed for the proposed plan in Tato-I H.E. Project located on Yarjep River in West Siang district. Notably, there are 2 other hydro-electric Projects developed by Velcan Energy Group, which are proposed just upstream of Tato-I HEP. The influence areas (10 km radius) of such Projects overlap one with each other, and therefore, care was taken to avoid any dual plan for a particular area.

5.2.2 OBJECTIVES

i. To maintain a sustainable approach between customs and culture of tribes and biodiversity conservation,
ii. To establish inventory for the voucher specimen of threatened, new and endemic plant species,
iii. Special efforts for conservation of critical/important plant/animal species, if any, affected by the Project,
iv. To maintain data on ‘vaids’ (Kennapanna) and traditional knowledge on medicines,

v. To provide incentives for research, training and public education to increase awareness with respect to biodiversity.

vi. To prepare Forest Protection Plan

5.2.3 STATUS OF BIODIVERSITY IN THE SURROUNDINGS

The vegetation in the influence area, particularly in lower valleys of Project area comprises sub-tropical wet hill forests with many tropical semi-evergreen plant species. Wet temperate broad-leaved and dry temperate coniferous forests occur in the upper valleys. The entire influence area is covered by dense forests along the river banks or degraded open forests interspersed with settlements in upper reaches. There are nearly 356 species of angiosperms that have been recorded in the surroundings of Tato-I H.E. Project encompassing the valleys of Yarjep River and its major tributaries Sarak I, Sarak II and Sang Nalas. About 93 families of angiosperms are represented in these areas of which 76 are dicots and 17 are monocots. The dicotyledons are represented by 254 plant species belonging to 198 genera and 76 families (out of 2,917 genera and 327 families in India), while the monocotyledons are represented by 17 families, 71 genera and 102 species. Gymnosperms are represented by a single family i.e 1 genera and 1 species. The area is rich in medicinal and timber plant species.

The faunal diversity of influence area is represented by 32 species of mammals, 75 species of birds, 9 species herpetofauna and about 30 species of butterflies. total of 12 species (Capped Langur, Slow loris, Common leopard, Clouded leopard, Leopard cat, etc.) inhabiting catchment area are categorized as Schedule I species, while 7 animals (Assamese macaque, Rhesus macaque, Wild dog, Indian fox, etc.) are classified as Schedule II species). As per IUCN criterion, total of 5 species are placed under ‘vulnerable’ category while 3 are ‘endangered’.

Among the birds Only 5 species namely *Lophophorus sclateri* (Scalater's monal), *Tragopan temminckii* (Temminck’s tragopan), *Lerwa lerwa* (Snow partridge), *Accipiter nisus* (Northern Sparrow Hawk) and *Anthracoceros albirostris* (Great Indian Pied Hornbill) fall under the Schedule I while majority of the species have been categorized as Schedule IV species. None of the species is ‘endangered’ and ‘vulnerable’ as per the criterion of IUCN in the influence zone. The most common species of influence area are Common leopard, Assamese macaque, Leopard cat, Barking deer, Wild boar, Marten, and various bird species. Our field observations reveal that the tribal people have a vast knowledge of medicinal plants, Cultivar, folk varieties and land race, which they use for various purposes like food, medicines, etc.

5.2.4 PROPOSED PLAN

Proposed biodiversity management and wildlife conservation plan has been formulated in view of the scope of the same plans for other Projects in the area. Some of the mitigation measures have been covered in the two other upstream Projects, owned by the same authorities, and therefore not provided in the Tato-I HEP as the influence areas are overlapping. Similarly, the measures suggested in this section under the Tato-I HEP will be implemented in the influence areas other Projects.

5.2.4.1 Definitions

In view of the biodiversity conservation we have used a few terms, mentioned in the Biological Diversity Act (2002). Only those terms are defined in the following section, which are relevant to the proposed biodiversity Management Plan.

i. “Biological diversity” means the variability among living organisms from all sources and the ecological complexes of which they are part of and includes diversity within species or between species and of ecosystem.
ii. “Biological resources” means plants, animals and micro-organisms or parts thereof, their genetic material and by-products (excluding value added products) with actual or potential use or value but does not include human genetic material.
iii. “Bio-survey” means survey or collection of species, sub species, genes, components, and extract of biological resources for any purpose and includes characterization, inventorisation and bioassay.
iv. “Local bodies” means panchayats, and municipalities.
v. “Cultivar” means a variety of plant that has originated and persisted under cultivation or was specifically bred for the purpose of cultivation.
vi. “Folk variety” means a cultivated variety of plant that was developed, grown and exchanged informally among farmers.
vii. “Land race” means primitive cultivar that was grown by ancient farmers and their successor.

5.2.4.2 Management Measures

The measures like establishment of task force, preparation of peoples biodiversity register, conservation of voucher and threatened species through *ex Situ* conservation, awareness programs, removal of invasive species would also be applicable in this Tato-I Project through the EMPs of Pauk and Heo HEPs. In addition, some of the conservation measures are described below.

5.2.4.2.1 *Distribution of Artificial Trophies*

Tribes of the area are very affectionate and demonstrative of animal trophies and ornaments (skull, jaws, Teeth, hides etc) using them in their households, for own make up and for other use like case of large knife, etc. For this reason a large number of animals like Common leopard, Black bear, Macaque, barking deer, Wild boar, small cats, hornbill, etc. are hunted throughout the year. In order to discourage the animal hunting, such types of requirements can be fulfilled through distribution of artificial trophies, made up of fiber glasses. Once, it is established, there is possibility of development of small scale business in the area. Thus, dual benefits are anticipated in the area. These trophies would be copies of original trophies and hides. During the construction phase, the trophies would be distributed by NGO, a part of task force, suggested for Heo H.E. Project. The funds would be provided by the Project authorities. Total financial outlay for this purpose would be **Rs. 15.00 Lakhs (Fifteen Lakhs only).**

5.2.4.2.2 *Incentive for the Surrender of Guns*

Active hunters with guns are very common in the surrounding of the Project areas. Poor enforcement of forest rules in tribal area encourage the inhabitants to keep fire arms for the hunting purpose. The strict enforcement of rules is not sound alternative to protect the forest resources in tribal area, however, hunting may be discouraged through providing the attractive incentives for voluntary surrender of arms. There must be terms and conditions between incentive and voluntary submission of arms, so that one could not get the license of gun in future. Simultaneously awareness programme run in the area would encourage the surrender of fire arms. This plan may be strengthen by involving the locals in the Project works. These measures would be implemented by the concerned department of state government. The funds will be provided by Project authorities. Total financial outlay under this head would be **Rs. 30.00 Lakhs (Thirty Lakhs only)**.

5.2.4.2.3 *Establishment of germplasm bank and seed centre*

There are fair possibilities of various folk varieties, land races and cultivars growing in the forest area because inhabitants use various forest products as food and medicines. These species are not yet explored. The documentation of these species is proposed under the Heo H.E. Project, however, they would require a proper conservation strategy. Germ plasm bank and seed centre may be one of the important measures for the conservation of these species. Objective of germ plasm bank is to preserve the genetic material of species and replenishes the seeds samples when their germination falls below the acceptable level. The seed centre is the centre of production of seeds of good genetic and physiological quality. The establishment of germ plasm bank and seed centre would require infrastructure facilities, laboratory, research scientists etc. State horticulture department will be consulted by the Project authorities for the establishment of seed centre. The experts of horticulture department will select the location for establishment of seed centre. Project authorities would provide the funds for germplasm bank and seed centre. After completion of the Project work, it might be handed over to state government. The estimated cost for establishment of germ plasm and seed centre is **Rs. 40.00 (Forty lakhs**) only.

5.2.5 WILDLIFE CONSERVATION & FOREST PROTECTION PLAN

A separate Wildlife conservation and Forest Protection Plan is proposed for the Tato-I H.E. Project. Under this plan Project authority would assist the State Forest Department in strengthening the infrastructure facilities, which are poorly developed in the area. Various activities which are necessary for the forest protection plan are described in the following paragraphs. This plan will be implemented in the free draining catchment area of Tato-I H.E. Project because for each Project in the basin a separate plan is proposed.

i). For improvement of vigilance and measures to check poaching, check posts and watch towers will be needed. In order to strengthen the working capacity the officers of the State Forest/Wildlife Department they must be provided with necessary equipment such as a camera, wireless, binoculars and other minor equipment (altimeter, spotscope, search lights, sleeping bags, health kits, etc.) that would increase their capability and efficiency.

ii). Under the reward for informers program it is proposed to engage the workers of proposed task force who are well acquainted with the area and are resourceful in gathering information for anti-poaching (particularly of butterflies, medicinal herbs and endangered species) and better vigilance. These people could be hired on a contractual basis.

iii) The construction of bridges, inspection paths for more effective and meaningful patrolling of the staff should be undertaken.

iv). Creation of veterinary facilities and rescue camps for healthcare of wild animals and for controlling diseases. For this purpose it is essential to maintain a stock of medicines in addition to setting up of a *mobile-rescue-cum-publicity-van*.

v). Provision of fire lines within critical areas to protect the forest from accidental fires.

It would be a joint practice of proposed task force and State forest department. Project authorities would provide funds to State Forest Department. Total financial outlay under this head would be **Rs. 51.00 Lakhs** (**Fifty One Lakhs**) only. The break up of budget is given below.

Particulars	Total Amount (in lakhs)
i. Equipment (Camera, health kit, search light, binocular, etc)	13.00
ii. Watch Tower, patrolling path, bridges	18.00
iii. Veterinary facilities	5.00
iv. Mobile-rescue-cum-publicity-van	5.00
v. Reward for informers	10.00
Total	**51.00**

5.2.6 SAFEGUARD MEASURES

In addition to the various proposed plans, Project authorities are suggested to furnish appropriate guidelines to their workers as safeguard measures. Some of the measures to be followed are mentioned below.

i. Strict monitoring of laborers and associated workers for any activity related to endangering the life or habitat of wild animals and birds.

ii. Strict restrictions will be imposed on the workers at Project sites to ensure that they do not harvest any produce from the natural forests and cause any danger or harm to the animals and birds in wild.

iii. The Project authorities will be bound by the rules and regulations of the Wildlife Protection Acts or any such agency of the State, which may exist or will be promulgated from time to time for the preservation of habitats and protection of wild animals.

iv. It is to be ensured that the noise levels in no case go above 100-150 dB in the Project area. One of the measures that is proposed to be adopted is that the blasting is to be restricted during nights, early mornings and late afternoons, which are the feeding times of most of the fauna. Blasting will be resorted to only if necessary. For this strict blasting regime i.e. controlled blasting under constant and strict surveillance is to be followed. The suggested methodologies aim at reducing and mitigating noise so as to cause as little disturbance to the animals as possible:

v. Each worker shall be provided with identity card and would not be allowed access to forest areas without permission.

vi. The workers shall be discouraged for plantation of non native species in the surroundings of labor colony.

vii. Possession of firearms by Project workers shall be strictly prohibited, except for dedicated security personnel.

5.2.7 BIODIVERSITY MANAGEMENT COMMITTEE (BMC)

The monitoring and evaluation of Biodiversity Management and Wildlife Conservation Plan of Tato-I H.E. Project will be carried out by a Biodiversity Management Committee (BMC). The committee will follow the guidelines of National Biodiversity Authority, State Biodiversity Conservation Strategy Action Plans (SBCSAP) and State Forest Department to implement, monitor and evaluate the Biodiversity Management Plan of the proposed Project. The activities of BMC shall be under the direct administrative control of the Chief Wildlife Warden/Principal Chief Conservator of Forests, Arunachal Pradesh. The BMC will comprise of the following members:

i.	Chief Wildlife Warden/Principal Chief Conservator of Forests, Arunachal Pradesh	Chairman
ii.	Chief (Environment), Tato I HE Project	Member Secretary
iii.	DFO (s) (wildlife) of the concerned Division	Member(s)
iv.	Two experts form University or renowned R & D Institutions	Member
v.	Local Body's Representatives from at least 3 villages on a rotational basis	Member
vi.	Representative of a well known local NGO	Member

The Chairman of the committee will have the right to assign various activities to various members for proper functioning and result-oriented tasks. The committee will monitor the progress of the proposed plan for all three Projects, viz. Tato-I, Heo and Pauk H.E. Projects. The major share of budget for the BMC is provided in the Tato-I H.E. Projects. Total financial outlay for the BMC would be **Rs. 5 lakhs (Five Lakhs**) only.

5.2.8 BUDGET

Total budget for the Biodiversity Management & Wildlife Conservation Plan would be **Rs. 141.00 Lakhs (One Hundred Forty One Lakhs**) only. The break up of the budget is given below.

	Particulars	**Total Amount (in Lakhs)**
i.	Distribution of Artificial Trophies	15.00
ii.	Incentive for the Surrender of Guns	30.00
iii.	Germplasm bank & Seed Centre	40.00
iv.	Wildlife Conservation & Forest Protection Plan	51.00
v.	Biodiversity Monitoring Committee	5.00
Total		**141.00**

5.3
MUCK DISPOSAL AND REHABILITATION PLAN

5.3.1 INTRODUCTION

The proposed Tato-I H.E project would involve a large number of civil engineering activities leading to production of large quantities of muck. Hence, the disposal and rehabilitation of the muck generated from the related activities of the Tato-I H.E project is an essential part of the environmental management plan. Faulty practices and improper management would further deteriorate the landscape. Wrong management would augment the sediment load in the stream causing severe impact to the biotic components in the aquatic ecosystem as well as it will lead to sediment deposition, siltation etc. To mitigate and minimize such impacts, a environmentally sound muck disposal and rehabilitation plan is being proposed for Tato-I. Some quantity of the muck generated may be utilizable and the remaining muck will need to be rehabilitated in suitable dumping sites in a technically as well as ecologically sound manner. However, as a cautious approach it has been decided to consider that the full muck generated will have to be dumped.

5.3.2 MUCK SOURCE AND VOLUME

Muck would be excavated from the HRT & TRTs during the tunneling, construction of power house complex, approach roads etc. Even though some of the muck will be utilized for back filling, yet a large quantity of the excavated material will need to be relocated and dumped in such a manner that it does not impose any negative impact on terrestrial and aquatic environment. During the construction phase a total of 8,80,388 m^3 (including 10 to 20% of swelling factor depending on the type of muck) will be generated from excavation for different components of the Tato-I H.E Project (see Table 5.3.1). The muck will be dumped at 2 designated dumping sites (MDA-1 and MDA-2) which will have a total capacity of 9,76,993 m^3. The details of muck volume are given in Table 5.3.1.

5.3.3 SELECTION OF DUMPING SITES

There are several factors to be considered while selecting the dumping sites. Hence during the selection of dumping sites following criteria must be fulfilled at the sites.

a) To avoid the long distance transportation, dumping sites should be selected to the nearby adits and near the intake sites.

b) The slopes of the dumping sites should not be susceptible to landslides and moreover slopes do not have a possibility of toe-erosion related slope failure.

c) The foundations of the dumping sites must be at a higher elevation than the maximum flood level.

d) The dumping sites should not be an ecologically sensitive area and free of pristine habitats.

e) There shall not be any channel of small streams flowing through the dumping sites.

The dumping sites chosen by the developer in the DPR meets the requirements mentioned above.

5.3.4 MUCKS TO BE GENERATED

The total amount of muck to be generated from the different project related activities would be estimated to be 7,38,020 m^3. Afterwards, considering the swelling factor (20% for underground and rock excavations, 10% for common excavations) the total amount of muck to be rehabilitated would be 8,80,388 m^3 (see Table 5.3.1).

Table 5.3.1 Details of muck generation and rehabilitation

	Qty. of material excavated (in m^3)			**Qty. Of muck with swelling factor) in m^3**
	Common	**Rock**	**Underground**	
Cofferdam	3 000			3 300
Dam Site	348	3 132		4 141
HRT	17 938	161 446		213 467
Adit	6 270	13 564	22 170	49 778
Waterways HRT			210 432	252 518
Waterways DS		32 990	18 649	61 967
Powerhouse	24 808	223 273		295 216
TOTAL				**880 388**

5.3.5 MUCK DUMPING AREAS

Based on the criteria mentioned in paragraph 3, two dumping sites (MDA I and MDA II) were located near intake site and powerhouse site to rehabilitate the generated muck (Table 5.3.2, see **Figs. 5.3.1** and **5.3.2**). The MDA-I with a total area of 3.2 ha will be located near proposed intake site, and would receive the muck generated from intake, part of HRT, adits and channel of Tato I H.E project. Total quantity of muck (after considering the swelling factor) to be rehabilitated at this site would be 3,38,388 m^3 (see Table 5.3.2 & **Fig 5.3.1**). Dumping site MDA-II with a total area of also 3.2 ha would be located near the power house site (see Table 5.3.2 & **Fig 5.3.2**). This site would retain the muck generated from part of part of HRT, Adit, Surge shaft, Pressure shaft, Tail race and Power house site. Total amount of the muck to be disposed off at this site after the swelling factor is 5,22,000 m^3 (see Table 5.3.2).

Table 5.3.2 Location and capacity of muck dumping areas

Dumping Site	Area (ha)	Capacity of Muck to be Accommodated	Total muck to be dumped	No. of Cross section	HFL (m)
MDA-1	3.2	4,34,527	3,58,388	3-1272-1300 m	1205
MDA-2	3.2	5,42,466	5,22,000	2-1150-1225 m	1067

Cross sections of MDA-1indicate that the lowest base of dumping site is located from 1272 m to 1300 m while the highest flood level (HFL) was estimated at 1205 m (**Fig. 5.3.1**). The minimum horizontal distance between dumping site and HFL is measured to be 148 m. MDA-2 is located near power house site and its lowest base is located between 1150 to 1225 m while HFL at this site was estimated at a height of 1067 m. The minimum horizontal distance between base of the dumping area of MDA-2 and HFL is nearly 80 m (see **Fig. 5.3.2**).

5.3.6 REHABLITATION OF DUMPING SITES

All the proposed dumping areas are located alongside the river, therefore, these are susceptible to the soil erosion, if not managed properly. Beside, the loose soils are also prone to wind erosion and it would possibly blow in the air and may increase the concentration of suspended particulate matters in the air. Therefore to avoid and minimize such environmental impacts various mitigation measures are required.

5.3.6.1 Engineering Measures

5.3.6.1.1 *Compaction*

The compaction of loose soil makes it suitable for the plantation and other biological measures. Top surface would be leveled and graded to make the alternative use. Total budget for the compaction would be **Rs. 8.0 lakhs** only.

5.3.6.1.2 *Precautionary measures*

During the transportation of loose soil precautionary measures will be followed. All dumpers must be well maintained so that loose soil could be protected well during the transportation. All routes should be wetted prior to the dumping. Dumping would be avoided during the high speed wind, so that suspended particulate matters (SPM) level could be maintained. After the dumping, the surface of dumps must wetted with the help of sprinklers. The care should be taken that the loose soil could not be leached out in the nearby water body.

5.3.6.1.3 *Construction of retaining walls*

Carefully packed rock toe of 3 m height with side slope of 1.5:1 is enough to withstand the stress caused by the muck (**Fig. 5.3.3**). However, the natural ground terrain varies from gentle to semi slope and steep slope. Hence, Random Rubble masonry in cement mortar 1:5 is proposed to be constructed 2.5 m high continuous wall along the edge of rock dump towards the river side.

Total length of retaining wall at two dumping sites has nearly been calculated to be 963 m including the side walls at a few places. The average height of walls would be 2.5 m, including a 1 m foundation wall. The wall will be filled with plum concrete, provided with stone masonry of grade M15 (1:2:4). The foundation of retaining walls structures shall be of cement concrete of grade M10 (1:3:6). A stone filled layer will be placed at the side facing the dumped materials. They should have catty weep holes for the discharge of surface water during rainy season. These holes will be provided with filters. Total estimated volume of the excavated materials for the foundation would be around 1445 cum and volume of retaining wall would be around 2234 cum (1167 cum for foundation wall + 1067 cum). Total financial outlay for the retaining walls is **Rs. 116.59 lakhs**, given in Table 5.3.3.

Table 5.3.3 Cost estimates for retaining walls at the dumping sites in Tato-I H.E. Project. It includes the laborers' wages.

Particular	Volume (cum)	Rate per cum	Cost in Lakhs
Earth work excavation for foundation	1,444.5	500	7.22
Cement concrete for foundation	1,167.2	4,000	46.69
Cement concrete for retaining wall	1,066.96	4,000	42.68
Stone filling and filter	Estimated		20
Total			**116.59**

5.3.6.1.4 *Fencing*

Fencing is a bio-engineering measure. After rehabilitation of muck the dumping areas need protection for some time from disturbing by human and domestic animals. For this reason fencing over the muck deposits is required. Barbed wire strands with two diagonal strands, clamped to wooden/ concrete posts placed 3 m distance are proposed around the dumping piles. Approximately 1300 m barbed wire with 4 strands horizontal and two strands diagonal would be required for the fencing. Project authorities are suggested to establish temporary wind barrier around 3 sides of dumps, if the area is in close of settlement area. Total cost for the fencing will be **Rs. 3.50 lakhs only**.

5.3.6.2 Biological Measures

After the construction of retaining wall, dumping and compaction, a total available surface area including tops and slopes of all dumping area would be left with about 6 ha. This area will be used for the plantation so that vegetation cover could control the mechanical and hydrological effects on the slopes and would give the permanent stability to the muck. The biological measures include the following measures.

5.3.6.2.1 *Soil treatment*

Generally the excavated soils are not fertile, if not treated vegetation cannot be grown properly on such soil surfaces. In order to make it nutrient rich, the following Integrated Biotechnological Approach' is required.

i) Analysis of dumped material for their physical and chemical properties to assess the nutrient status to support vegetation. ii) Formulation of appropriate blends of organic waste and soil to enhance the nutrient status of rhizosphere. iii) Isolation and screening of specialized strains of mycorrhizal fungi, rhizobium, azotobacter and phosphate solubilizers (biofertilizers inoculum) suitable for the dumped material. iv) Mass culture of plant specific biofertilizer and mycorrhizal fungi. v) Use of locally available manure and compost.

The project authorities are suggested to consult a well reputed organization for implementation of VAM (Vasicular Arbuscular Mycorrhiza) technology, which can supply the strains of mycorrhizal fungi, rhizobium, azotobacter and phosphate solubilizers (biofertilizers inoculum). The important institutions are IMTECH, Chandigarh and IARI, New Delhi. Total cost for the soil treatment would **be Rs. 2.5 Lakhs only.**

5.3.6.2.2 *Selection of species*

To stabilize the muck and restore the disposal sites fast growing plant species are suggested. The grasses are suited to bind loose soil and shrub and trees hold soil up to deeper level. Taking the climate, soil and drainage conditions of the sites into account, selection of local plant species is generally preferred. Important tree species which can be used to rehabilitate the loose soil are *Alnus nepalensis, Altingia excelsa, Brassiopsis aculeata, Castanopsis indica, Erythrina arborescens, Gymnema arborea, Saurauia punduana and Schima wallichii. Shrubs that can be useful as soil binders are Bambusa tulda, Boehmeria macrophylla, Debregeasia longifolia, Hydrangea robusta and Oxyspora paniculata. Among tuft forming and fast growing grasses useful in soil binding are Chrysopogon gryllus, Digitaria setigera, Eleusine coracana, Eragrostis nigra, Eulaliopsis binata, Saccharum longisetosum and Thysanolaena latifolia*.

5.3.6.2.3 *Use of Geo-textile*

After treatment of soils, mats of coir jute will be spread over the dumping slopes and wetted suitably. These mats increase the water holding capacity and retain the water. After decomposition, they increase the fertility of soils. In all dumping areas, such types of geo textiles methodology will be adopted. Total budget for the use of geo textiles would be **Rs. 5.00 lakhs only.**

5.3.6.2.4 *Plantation*

The selected species will be planted after their nurseries have been developed. The dumping areas are very small, therefore, separate nursery would not be required. The nurseries developed for the implementation of CAT plan can be used for the rehabilitation of dumping areas. Nearly 1-2 years old saplings would be used for the plantation. The plantation can be carried out in lines across the slopes. Grass and herb species would be used in the inter space of tree species. They will help in providing the continuous chain of support in retaining debris, reinforcing soil and increasing the infiltration capacity of the area. Plant saplings would be raised in biodegradable pots and transplanted as such. The plantation should be done in monsoon season. Pits of 0.45 x 0.45 x 0.45 m will be dug and filled with some soil rich in nutrients. The compost from local organic waste can be used.

Approximately an area of 6 ha would be required for phyto-remediation measures. A total of nearly 6,000 plant saplings (@1000 plants per ha) including trees and herbs will be planted at two dumping sites. Total cost estimates for the biological measures are given in Table 5.3.4. This cost includes the cost of turfing of slopes, preparation of ground, spreading of manure, etc., providing 5 cm of soil cover and transportation and carriage. It also includes the cost of watch and ward and irrigation, etc. The total cost for the biological measures would be **Rs. 12.04 lakhs**.

The methodology consists in developing the formation width in half cutting and half filling, so that the materials obtained from cutting are utilized in filling. The excavation on hill side will be done to get a stable slope for the materials encountered. At places where there is problem of retaining the hill slope, breast wall, gabion walls shall be constructed in natural slope to retain the fill materials.

Table 5.3.4 Financial requirements for the biological measures to rehabilitate dumping sites of Tato-I H.E. project

Item	Quantity	Rate	Amount
Pitting	6,000 pits	Rs. 33.08/pit	1.98
Raising of plants (including nursery cost, manure, transport, etc.)	6,000 plants	Rs. 30.00/plant	1.80
Turfing, spreading of manure etc	Lump sum	-	4

Maintenance, watering, transport, etc	lump sum		4
Total			**11.78**

5.3.7 COST ESTIMATES

As given in Table 5.3.5 the total financial outlay for the relocation of muck and rehabilitation of dumping sites including engineering and biological measures would be **Rs. 148 lakhs** only.

Table 5.3.5 Break down of overall cost for Muck disposal plan.

S. No.	**Particulars**	**Total Cost in Lakhs**
1	Compaction	8
2	Cost of retaining wall	116.59
3	Fencing	3.5
4	Soil texture	2.5
5	Geo Textile	5
6	Plantation	11.78
	Total	**147.37 say 148**

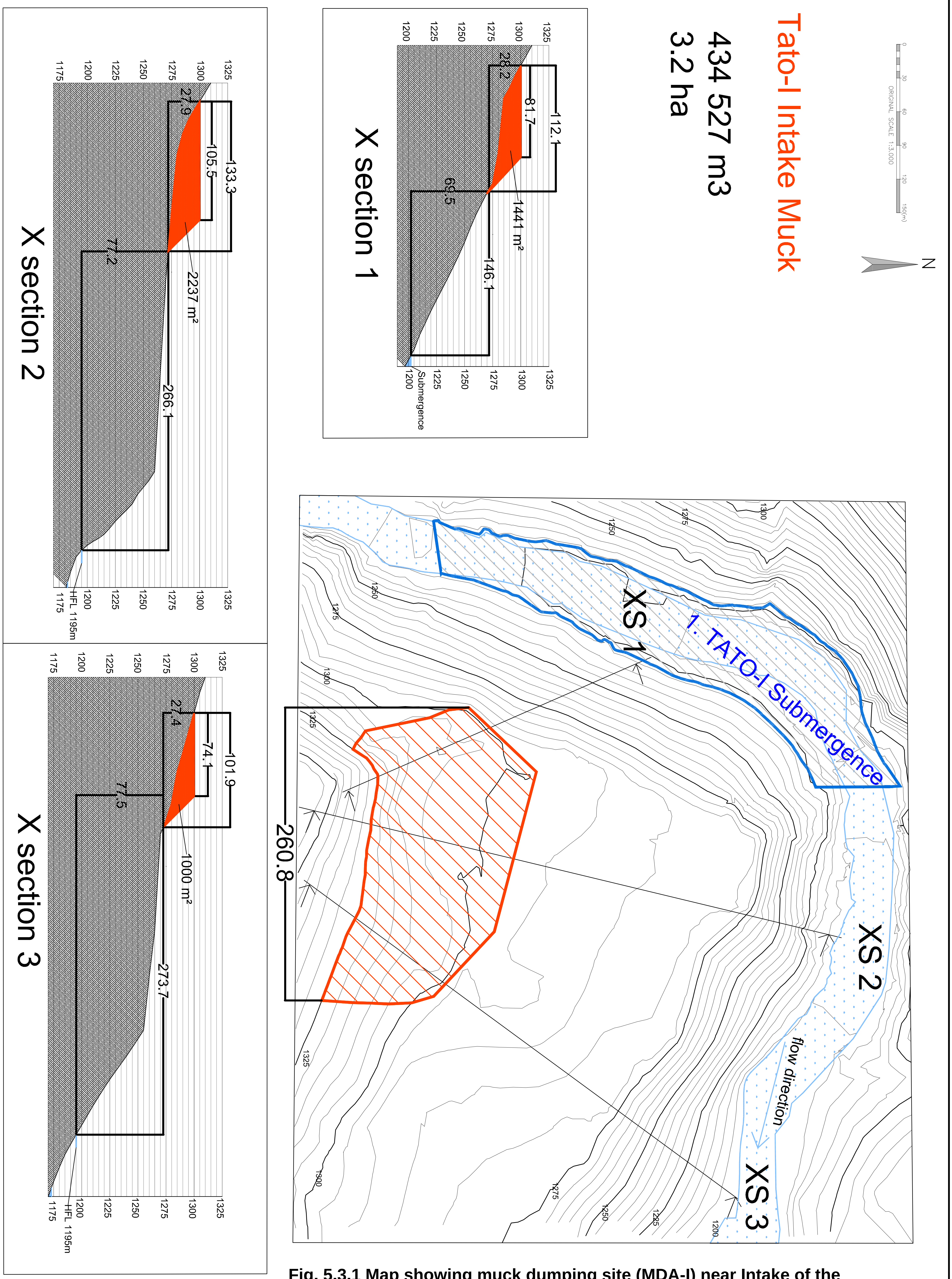


Fig. 5.3.1 Map showing muck dumping site (MDA-I) near Intake of the proposed Tato-I H.E. Project

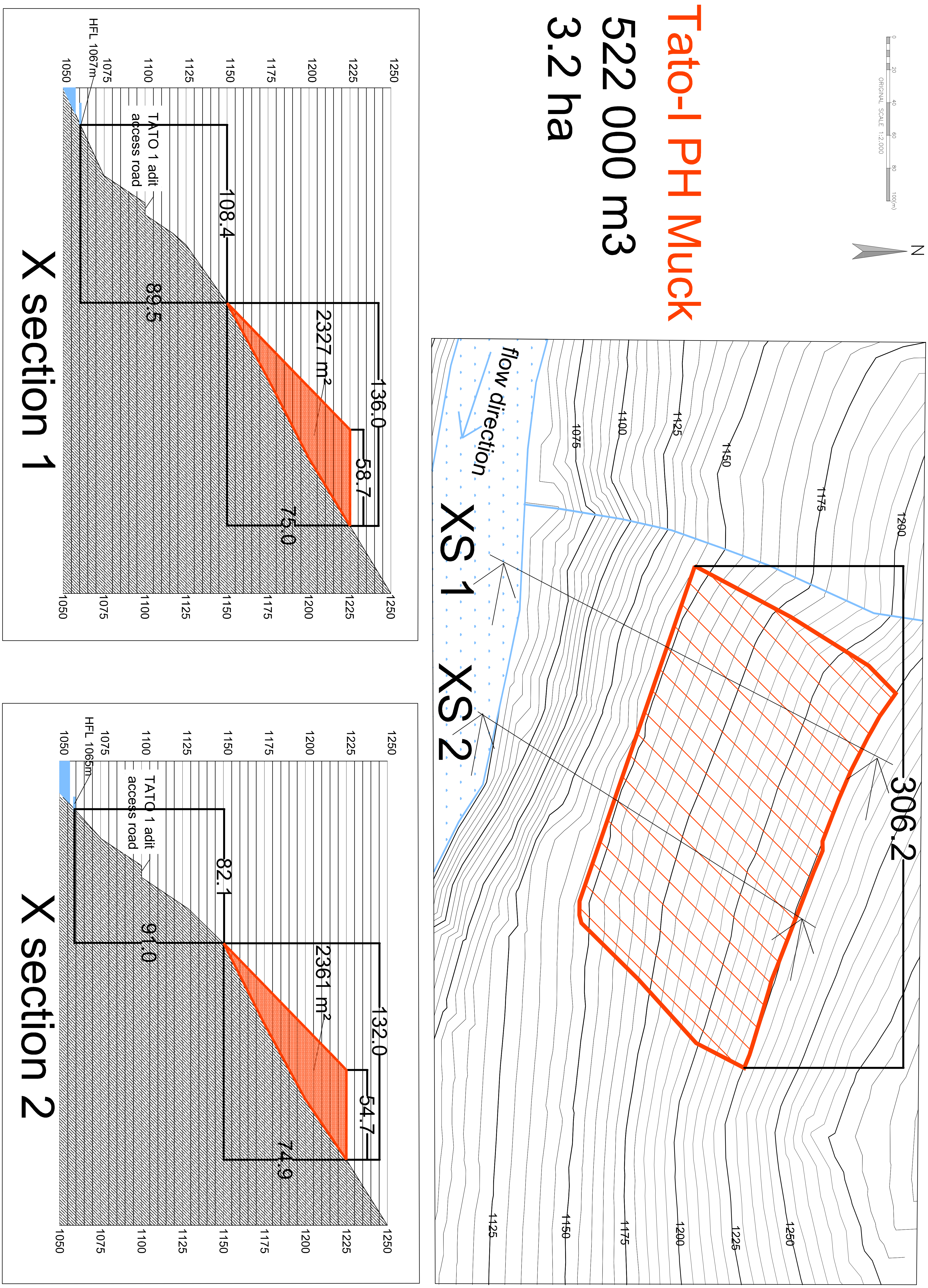


Fig. 5.3.1 Map showing muck dumping site (MDA-II) near Powerhouse site of the proposed Tato-I H.E. Project

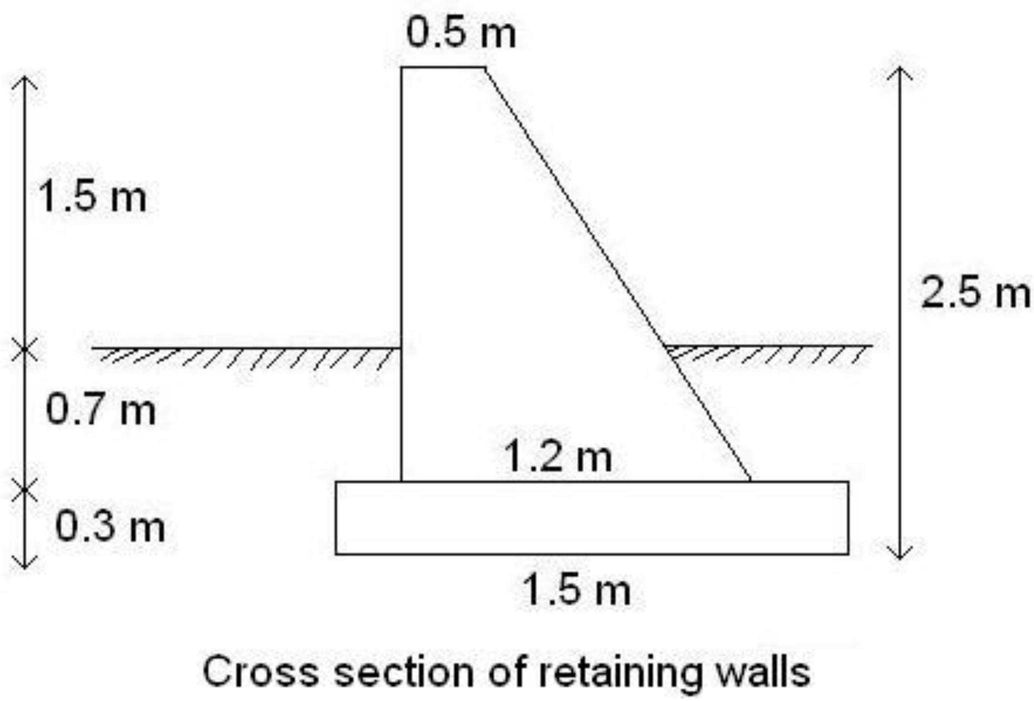


Fig. 5.3.3. Cross section of retaining wall proposed for the dumping sites of Tato I H.E. project

5.4
RESTORATION OF CONSTRUCTION AREAS AND LANDSCAPING

5.4.1 INTRODUCTION

The degradation of ecosystems occurs when a system loses its biodiversity, structure and processes of production resulting in decline ecosystem services. Therefore, it is imperative to restore ecosystem functioning for the persistence of biological community and economic well being of people. From an ecological point of view, restoration can be applied at the level of ecosystems, habitats, communities, water or soil quality or some other ecological characteristics of degraded or damaged area. Ecological Restoration refers to "the return of an ecosystem to a close approximation of its condition prior to disturbance" (NRC 1992). The activities necessary to bring a disturbed site into former or original state involves manipulation of nature to recreate species composition and ecosystem processes close to the state that existed before disturbance. It reestablishes the structure, productivity and species diversity of the original community.

The proposed Tato-I HE Project would involve construction of colonies for staff and laborers, roads linking to various components of project, offices, etc. During construction these activities could also result in accumulation of large amount of unused material at various sites which require proper restoration measures. Total area likely to be disturbed due to these activities is around 50 ha. This land also includes areas likely to be disturbed due to quarries and dumping of unused muck, weir complex area and powerhouse area. At present, the proposed project areas are covered with open/degraded or dense sub-tropical forest. This existing landscape will be totally modified or changed due to proposed project. Therefore, all areas disturbed by construction activity including access roads will be landscaped to reflect natural contours, restore suitable drainage paths and encourage the reestablishment of vegetation.

5.4.2 DISTURBED SITES AND THEIR RESTORATION

Around 47.7 ha of land (excluding river bed) will be directly disturbed due to various construction activities of the proposed project, like access roads, muck dumping sites, quarry sites, colonies, offices, etc which will change the existing land cover in the region. After completion of the construction work, it is required to restore the disturbed area to its original conditions wherever it is possible. Intake and Power House civil structures cannot be restored in their original shape, but Quarry sites, Colony and Office Complex and part of roads can. These areas can benefit from restoration measures, even though their entire areas cannot be restored in their original shape.

Restoration of dumping sites has been given separately in the chapter 5.3 of the EMP. Here, restoration of quarry sites, colony area, office complex and roads (areas totaling 21.2 ha) is discussed, and a detailed plan is given for the landscaping. Various engineering and biological measures have been suggested for the restoration of these areas. Proposed mitigation measures will also help to arrest soil erosion in the region.

5.4.3 RESTORATION OF QUARRY SITES

The quarry sites (QS1 and QS2) are located in the proposed intake quarry and power house quarry area for the excavation of land and rock material. Total area of the proposed quarry sites is around 0.8 ha. After excavation of the required material, these quarry sites will require restoration. Appropriate engineering, bio-engineering and biological methods are proposed for effective restoration of the quarry sites.

Removal of rocks from the quarry sites for different construction works will result in the formation of depression and craters. These will be filled up by the dumping materials consisting of boulders, rock, gravel and soil from nearby sites. To achieve this, appropriate measures would be adopted at various sites in the project area so that the restoration work will be scientifically executed. Various biological, bio-engineering and engineering measures are proposed for the restoration of the quarry sites.

5.4.3.1 Removal of Top Soil

The top soil (top 6-12 inch soil) should be removed before excavating the sand or rocks from the quarry sites. This soil contains all microbes (including earth worms) and important nutrients and organic matters which will be required at the time of restoration of these quarry sites.

5.4.3.2 Filling of Depressions

Removal of rocks from quarry sites for different construction works will result in formation of depression and/or craters. These depressions will be filled up by the dumping materials consisting of boulders, rock, gravel and soil from the nearby sites. After filling these craters, the top soil collected prior to quarrying will be spread as top layer. The top soil then should be covered with geo-textiles like coir, jute or by other locally available bio-degradable material. This will protect the top soil from erosion.

5.4.3.3 Diversion of Run-off

Effective drainage system will be provided to avoid the infiltration of run-off and surface waters into the ground of quarry sites.

5.4.3.4 Construction of Retaining Walls

Retaining walls will be constructed at the filled up depressions of quarry sites to provide necessary support particularly where there are moderately slopes.

5.4.3.5 VAM Fungi for Soil Reclamation

Top soil obtained from the project sites, before the start of quarrying activity would be reclaimed by using VAM fungi. The saplings of trees and shrubs should be raised using microbial inoculum like, VAM (Vesicular-arbuscular mycorrhiza), bacterial and fungal strains. The steps for raising plant saplings with mycorrhizal colony are given below:

A brief description of the procedure to be followed for the colonization of seedlings with VAM fungi and other soil microbes is given below:

1) Top soil collection from quarry sites before start of quarrying.
2) This soil which is rich in microbes should be used for the preparation of seed beds and should also be filled in polybags for raising saplings.
3) Isolation of VAM from the roots of juvenile seedlings particularly dominant tree species which are available in the region.
4) Suitable strain of VAM and other microbe can also be obtained from IARI, New Delhi and/or IMTECH, Chandigarh.
5) Preparation of mother culture and their appropriate dilution.
6) Growing of plant species which will be inoculated by specific and efficient strains,
7) Mixing the soil with the VAM inoculum and filling in the polybags.
8) Planting of saplings in the polybags two days after inoculating the soil with fungal microbial strains.

9) After thirty days of inoculation these saplings can be planted at the quarry sites.

5.4.3.6 Revegetation

In addition to the use of VAM fungi isolated from the roots of plant species growing in these areas and organic manure for enrichment of the top soil, revegetation of quarry sites would require the initial establishment of fast growing grasses like *Arundo donax*, *Cynodon dactylon*, and *Saccharum longisetosum*. These grasses spread by creeping rootstocks and will also help in binding soil. Perennial species such as *Calamagrostis emodensis*, *Eulaliopsis binata*, *Chrysopogon gryllus*, *Coix lacryma-jobi*, *Themeda arundinacea* will be established subsequently by seeding and planting them directly into the annual crop residue.

Along with annuals and perennials, nitrogen fixing herbaceous legumes (*Trifolium repens*, *Lespedeza juncea*) and non legume shrubs like *Hydrangea robusta* will be planted at quarry sites to increase the nitrogen levels of soil. *Trifolium repens* and *Lespedeza juncea* are also desirable food plants and are less aggressive and persistent as compared to other herbaceous legumes. These legumes with dense cover will retard or prevent the invasion and establishment of native plant species. Temporary crop cover of annuals and perennials will thus help in stabilization of the quarry sites, which will take approximately 5-6 years.

Once the initial establishment of perennials is complete and quarry sites are stabilized, the sites would be ready for plantation of tree species. *Alnus nepalensis* would be first among tree species that would be planted. In open areas mixed perennial shrubs and herbs such as *Bambusa pallida*, *Leucosceptrum canum*, *Saccharum longisetosum*, *Themeda arundinacea* and *Thysanolaena latifolia* will be planted which grow well on rocks and on open slopes.

5.4.4 RESTORATION OF COLONY AND OFFICE COMPLEX

Around 3.1 ha of land will be disturbed due to construction of colony areas, and office and storage complexes. (Table 5.4.1). All colony and offices sites are located on in the right bank of Yarjep River and downstream of weir intake. The land will be cleared of vegetation for the movement of heavy equipments required for different project related activities which would lead to degradation of slopes.

Table 5.4.1 Area of colonies, weir storage, offices in the proposed Tato-I H.E. Project

Sl. No.	Site specification	Area
1	Weir storage and colony area	1.7 ha
2	PH office and colony	1.4 ha

Notably on account of construction of office complexes, some area of right bank near Gapo and Heyo/Tato villages will be disturbed. Engineering and biological measures are suggested for the stabilization and beautification of the disturbed area. Following measures should be adopted for the restoration and landscaping of colony areas and construction sites.

1) Proper roads and lanes would be provided inside the colony area. Open area should be covered with vegetation. Ornamental plants and avenue trees should be planted along the roads and lanes.
2) The choice of the tree species for plantation will depend on agro-climatic conditions of the area.
3) Retaining walls should be built to avoid landslides and slips. Proper drainage would be provided inside colony for the outlet of the domestic/rain water.
4) Parks and play grounds would be developed.
5) After the completion of all the construction activity, the construction sites and other temporary settlements would be covered with the top soil which would support the growth of plant species.

Engineering Measures

During construction phase, some locales on the right bank area are likely to be prone to soil erosion. Construction of retaining walls would be necessary to stabilize the slopes. The budget kept for the construction of retaining walls and for other engineering measures is around **Rs. 7.00 lakhs**.

Biological Measures

The project construction would involve congregation of large labour and staff population. For meeting the requirement of fuel and material for construction, dependency on forest resources is inevitable. These activities would also involve substantial clearing of forest land unless proper arrangement for fuel supply is done. Therefore, significant adverse impacts on terrestrial flora are anticipated if proper mitigation measures are not taken. There is possibility that after construction, these degraded forests existing in the area will be further destroyed or damaged. Plantation of the tree species and shrubs are suggested in the colony area. Some of the local plant species are mentioned in Table 5.4.2. Total budget allocated for the purpose is around **Rs. 9.50 lakh** which includes maintenance cost also (see Table 5.4.3).

5.4.5 ROADS

Most of the project components are located away from the road connecting Tato village to Gapo and there is requirement of around 17 ha (about 6.2 km) of additional road. At the new road areas plantation of tree seedlings, grown in nurseries, will be done in rows alternating with rows of herbaceous plants. The tree growth and the growth of shrubs and herbaceous species will provide adequate erosion control and provide the habitat for wildlife, birds and insects. Around 17 ha of land will be disturbed due to construction of new roads. Due to construction of roads, the region will be disturbed and may also trigger minor slips and downfall movement of soil aggregates. Various measures are suggested for the stabilization of the disturbed area.

Engineering Measures

Road construction in the proposed project will disturb the hill slopes and result in excavated material (muck). Retaining walls and wire crate walls are proposed in the area to avoid slippage and land slides.

Biological Measures

Even though a muck disposal plan has been proposed, some of the excavated muck is likely to form thin apron on mountain slopes along the road. Provisions are made to cover such slopes with vegetation. Tree saplings and shrubs should be planted along the road. Seeds of herbs and grass species should be spread over the loose soil. Some plants for plantation are suggested in the Table 5.4.2.

Table 5.4.2 Some important plant species for plantation in the colony area/office complex, and along the road sides

	Botanical name	Local name	Family	Use
1.	**Colonies/ Office complex**			
Trees				
1	*Alstonia scholaris*	Satiana	Apocynaceae	landscaping
2	*Altingia excelsa*	Singri	Hamamelidaceae	landscaping
3	*Bischofia javania*	Urium	Bischofiaceae	landscaping
4	*Bauhinia variegata*	Kanchon	Caesalpiniaceae	landscaping
5	*Beilschmiedia roxburhiana*	Bonjolockia	Lauraceae	landscaping
6	*Garcinia cowa*	Theketra	Cluciaceae	landscaping
7	*Gmelina arboea*	Gomari	Verbenaceae	landscaping
8	*Gynocardia odorata*	Bandapele	Flcourticeae	landscaping
9	*Mesua ferrea*	Nahar	Clusiaceae	landscaping
10	*Pterospermum acerifolium*	Hatipolia	Sterculiaceae	landscaping
Shrubs				
1	*Alsophila spinulosa*	Tree fern	Cyathaceae	landscaping
2	*Asparagus racemosus*	*Satvari*	Liliaceae	landscaping
3	*Bambusa pallida*	Makal	Poaceae	landscaping
4	*Calamus erectus*	Jati bet	Arecaceae	landscaping
5	*Melastoma malabthricum*	Ke seng	Melastomataceae	landscaping
6	*Mussaenda roxburghii*	-	Rubiaceae	landscaping
7	*Rhaphidophora decursiva*	-	Araceae	landscaping
8	*Zanthoxylum acanthopodium*	Yokhung	Rutaceae	landscaping
Herbs				
1	*Anemone vitifolia*	-	Ranunculaceae	landscaping
2	*Amomum subulatum*	Cardamom	Zingibereceae	landscaping
3	*Asparagus racemosus*	Satavali	Liliaceae	landscaping
4	*Hedychium spicatum*	Ruksana	Zingiberaceae	landscaping
5	*Houttuynia cordata*	-	Saururaceae	landscaping
6	*Molineria capitulata*	Wurdo lago	Hypoxidaceae	landscaping
8	*Musa bulbisiana*	Kargok	Musaceae	landscaping
9	*Ocimum sanctum*	Tulsi	Lamiaceae	landscaping
10	*Pennisetum purpureum*	-	Poaceae	landscaping
2.	**Roadside/Avenues**			
Trees				
1	*Albizia lebbeck*	Siris	Mimosaceae	landscaping
2	*A. odoratissima*	Kalo Siris	Mimosaceae	landscaping
3	*Alnus nepalensis*	Utis	Betulaceae	landscaping
4	*Erythrina stricta*	Phaledo	Papilionaceae	landscaping
5	*Exbucklandia populnea*	-	Hamamelidaceae	landscaping
6	*Lannea coromandelica*	Jia	Anacardiaceae	landscaping
7	*Magnolia hodgsonii*	Boromthuri	Magnoliaceae	landscaping
8	*Phyllanthus emblica*	Aonla	Euphorbiaceae	landscaping
9	*Phoebe hainesiana*	-	Lauraceae	landscaping
10	*Persea robusta*	-	Rosaceae	landscaping
11	*Quercus glauca*	Musre Phalant	Fagaceae	landscaping
12	*Terminalia myriocarpa*	Panisaj	Combretaceae	landscaping

Shrubs				
1	*Asparagus racemosus*	Satavari	Liliaceae	landscaping
2	*Bambusa tulda*	Bijali	Poaceae	landscaping
3	*Dichroa febrifuga*	-	Saxifragaceae	landscaping
4	*Hydrangea robusta*	-	Hydrangeaceae	landscaping
5	*Oxyspora paniculata*	-	Melastomataceae	landscaping
6	*Schefflera bengalensis*	-	Araliaceae	landscaping
Herbs				
1	*Achyranthes aspera*	-	Amaranthaceae	landscaping
2	*Cymbopogon jwarancusa*	-	Poaceae	landscaping
3	*Cynodon dactylon*	Doob	Poaceae	landscaping
4	*Panicum antidotale*	-	Poaceae	landscaping
5	*Pennisetum purpureum*	-	Poaceae	landscaping
6	*Tagetus erecta*	Genda	Asteraceae	landscaping
7	*Themeda anathera*	-	Poaceae	landscaping

5.4.6 COST ESTIMATES

Cost estimates for different components of the landscaping and restoration are given in the Table 5.4.3. Around **Rs. 84.57 lakh** would be required to restore the disturbed area to its near original state.

Table 5.4.3 Cost estimates for Restoration Works and Landscape Designing

S.No.	Item of Work	Amount (Rs. in lakhs)
A.	**Quarry Sites**	
	(i) Engineering measures	
	a) Removal of top soil (transplantation and stockpiling)	6.00
	b) Filling of crates with muck, stones, etc.	7.00
	c) Retaining walls, diversion channels	12.00
	(ii) Bio-engineering measures	
	a) Carpeting with geo-textiles (coir, jute and other local fibers)	3.20
	b) Mulching	2.40
	(iii) Biological measures	
	(a) Planting of herbs and grass species	1.40
	(b) Planting of trees and shrubs (@ Rs. 18.64/plant (1600 plants/ha) Including maintenance and transportation	5.36
	Total (A)	**37.36**
B.	**Colony Area, Office Complexes**	
	(i) Engineering measures	
	(a) Retaining walls	7.00
	(b) Leveling the area	2,50
	(c) Development of parks, etc. (suggested in Muck disposal chapter)	Nil

	(ii)	Biological measures	
		(a) Planting of trees and shrubs(@ Rs. 18.64/plant (1600 plants/ha) Including maintenance and transportation	6.00
		(b) Planting of flowering plants and other herbs	3.50
	Total (B)		**19.00**
C.	**Roads**		
	Engineering		
	(i)	(a) Retaining walls (260 m3 @ 1211/m^3)	3.15
		(b) Wire crates (3 x 2 x 1.5 Cum 35 / 2400.00)	7.56
	(ii)	Biological measures – Planting trees, shrubs and herbs	3.5
	Total (C)		**14.21**
D.	**Development of Nursery**		
	(i)	Infrastructure including land cost (provision has been made under the CAT plan) Nil	
	(ii)	Collection of seeds (Lumpsum)	2.75
	(iii)	Raising of plants (Lumpsum)	7.50
	(iv)	Manpower to maintain the nursery (Lumpsum)	3.75
	Total (D)		**14.00**
Total (A + B + C + D)			**84.57**

5.5
GREEN BELT DEVELOPMENT PLAN

5.5.1 INTRODUCTION

Since project construction process emanates lot of dust due to excavation works, crushing of material and batching of aggregates, a green belt development is generally proposed around the project sites of hydro electric power. In addition, during construction and operation phases, the combustion of fossil fuels in automobiles and trucks produces several pollutants viz., nitrogen oxides, gaseous hydrocarbons, carbon monoxide and large quantities of particulates. The green canopy has the inherent capacity to absorb pollution, increase water retention by soil and decrease sediment transport. In order to combat different kind of pollutions and avoid land slips from the direct draining catchment into the intake site, the green belt in and around the project areas is an apparent choice.

Tato-I HE Project envisages the construction of a 7.5 m high intake weir (at RRL 1188 m elevation) over river Yarjep downstream of Meying village and will create only a very small pond. During the construction period of around four years the area will be disturbed, vegetation in the immediate vicinity will be destroyed and soil will become prone to erosion. There will be increased silt flow in the river from these surrounding areas. The plantation along the intake periphery will serve many purposes, such as it will protect the area from soil erosion and shall provide a shelter to birds and wildlife. Therefore, a green belt development plan has been proposed around the project area and along the project components in particular using the local flora.

5.5.2 DEVELOPMENT OF GREEN BELT

The green belt is proposed to be developed within the project area at the following places viz., along the network of approach roads, power house site and around the periphery of intake. Different kinds of strategies will be necessary for developing green belt around different components of the project. The general considerations for green belt plan are:

- Trees growing above 10 m in height should be planted along the approach roads and around project components.

- Planting of trees should be undertaken in appropriate encircling rows around the project site.
- Generally local/indigenous fast growing trees should be planted.
- The trees should be protected by plantation of non palatable shrub species to avoid browsing by animals.
- Placement of Bamboo/ Iron tree guards around the trees.
- The Plantation should be at a spacing of 2.5 x 2.5 m and about 1600 trees per hectare should be planted.

5.5.3 SPECIES TO BE PLANTED

A list of indigenous trees, shrubs and herbs was made after identification of species suitable for development of green belt around the project area. The species wise details of the plant are presented in Table 5.5.1 (a, b and c) indicating their season of flowering and method of propagation and other characteristics. Saplings of all listed tree and shrub species will be obtained from CAT nurseries for plantation in project areas. Species wise details of trees, shrubs and herbs indicating planting techniques and their usages are given in Table 5.5.1 (a,b and c).

5.5.4 GREEN BELT DEVELOPMENT

5.5.4.1 Road side Plantation

One row of each tree, shrub and biofencing has been proposed with a spacing 2.5 m x 2.5 m for trees and 2m x 2m for shrubs (to take care of the mortality in the next season). The pit size has been recommended as 45 cm x 45 x 45 cm for trees and 30 cm x 30 cm for shrubs. Along the 6.7 km stretch of access roads plantation will be done on both sides wherever feasible and about 12500 saplings will be planted. The budget for planting trees along the road sides is given in chapter 5.4 (Landscaping and restoration of construction area).

5.5.4.2 Green belt around intake site

Plantation at the intake site for about 1 ha has been proposed for control of erosion and landscaping. The total cost of planting 1600 saplings @ Rs. 24.38 (including transportation) per sapling works out to be **Rs. 39,008.00.**

5.5.4.3 Green belt around power house

Plantation around powerhouse need to be done in 3 lines i.e. first line of only flowering herbs/shrub, second line should be of shrub/hedge in close spacing and along the road of powerhouse a row of small trees. The planting cost of 2000 saplings @ Rs. 24.38 works out for **Rs. 48,760.00.**

Schedule

The construction period of the project is around 48 months. All engineering measures like retaining walls, wire crate walls, etc to stabilize landslips around steams will be carried out under the CAT plan. Plant sapling will be required for biological treatment measures. Plantation and maintenance will be carried out between 18-48 months from the date of inception of the projects. Between 1-18 months all the engineering measures for stabilization of slopes will be carried out under the proposed CAT plan.

5.5.5 BUDGET

The overall cost of green belt development is **Rs. 17.27 lakhs** (Table 5.5.2). The budget also includes maintenance of the executed work.

Table 5.5.2 Summary of cost for green belt development

S.No.	Component	Cost (in Lakhs)
1.	Cost of planting of sapling along roadside	Nil
2.	Cost of planting of sapling around intake site	0.39
3.	Cost of planting of sapling around power house areas	0.48
4.	Maintenance cost for 3 years-2 supervisor @150.00/day	3.30
5.	Barbed wire fencing (10km) for protection of natural regeneration from biotic interference	8.10
6.	Celebration of World Environment Day, etc @ Rs. 1.00 lakhs	3.00
7.	Contingency	2.00
Total		**17.27**

Table 5.5.1 (a) Species wise details of trees indicating planting techniques and their usages

Sl.No.	Botanical name	Common name	Furit/seed collection season	Seed longevity	Pre sowing seed treatment	Sowing season	Germination %	Age of normal planting stock (months)	Planting season	Method of Planting	Uses
1	*Aglaia spectabilis*	Amari	Sept.-Oct.	Short lived (1-6 months)	Not required	Soon after collection	60	12-24	June-July	Direct sowing, entire planting	Timber
2	*Alangium chinense*	Chika-maruli	Octo.-N0v.	Short lived (1-6 months)	Not required	Soon after collection	40	12-24	Jul-Aug.	Direct sowing, entire planting	Fodder, timber
3	*Albizia lebbeck*	Siris	January-Februrary	Very long lived (2years)	Scarification Hot water	March-July	60-90	12-24	July	Direct sowing, entire planting	Timber, fuel
4	*A. lucida*	Moz	January-Februrary	Very long lived (2years)	Scarification Hot water	March-July	70-80	12-24	July	Direct sowing, entire planting	Timber, fuel
5	*Alnus nepalensis*	Utis	Octo-Nov.	Short lived (1-3 months)	Not required	Soon after collection	50	12-24	July	Direct sowing, entire planting	Timber
6	*Alstonia scholaris*										
7	*Altingia excelsa*	Singri	May-June	Short lived (1-3 months)	Not required	Soon after collection	40-50	12-24	July	Direct sowing, entire planting	Timber

8	*Bauhinia variegata*	Kanchon	May-June	Moderate long lived	Not required	Soon after collection	95	2-3	June-July	Direct sowing, entire planting	Flower bud edible, fodder
9	*Butea monosperma*	Polah	May-June	Short lived (1-3 months)	Not required	Soon after collection	60	2-3	June-July	Direct sowing, entire planting	Flower bud, fuel-wood
10	*Castanopsis indica*	Hingori	May	Moderate long lived	Not required	June	90	2-3	June - July	Direct sowing, entire planting	Nuts edible; Timber, fodder
11	*Elaeocarpus spharicus*	Ludra-ashing	July	Short lived (1-6 months)	Not required	Soon after collection	70	12-24	August-Sept.	Direct sowing, entire planting	Ornamental, Timber,
12	*Engelhardtia spicata*	Tongtamasok	April-May	Short lived (1-6 months)	Not required	Soon after collection	60	12-24	June - July	Direct sowing, entire planting	Timber, fuel
13	*Exbuclandia populnea*	-	May	Short lived (1-6 months)	Not required	Soon after collection	50	12-24	June - July	Direct sowing, entire planting	Timber, fuel
14	*Gynocardia odorata*	Subetulpi	December	Moderate long lived	Not required	June	50	2-3	June - July	Direct sowing, entire planting	Fruits medicinal; Timber
15	*Garcinia cowa*	-	Sept.-Oct.	Short lived (1-6 months)	Not required	Soon after collection	60	12-24	July-August	direct sowing, entire planting	Ornamental

16	*Lannea coromandelica*	Jia	May-June	Short lived (1-6 months)	Not required	Soon after collection	50	12-24	July-August	direct sowing, entire planting	Timber, fuel , ornamental
17	*Lithocarpus elegans*	Arkaula	July-Aug.	Moderate long lived	Not required	Soon after collection	70	12-24	August-Sept.	direct sowing, entire planting	Timber, fodder
18	*Michelia kisopa*	Chanp	December	Short lived (1-6 months)	Not required	Soon after collection	40	12-24	July-August	direct sowing, entire planting	Timber, fuel , ornamental
19	*Mesua assamica*	Sia-Nahar	May-June	Moderate long lived	Not required	Soon after collection	70	12-24	July	direct sowing, entire planting	Ornamental
20	*Rhus succadanea*	Rani Bahlaio	August	Short lived (1-6 months)	Not required	Soon after collection	40	12-24	July-August	direct sowing, entire planting	Timber, fuel –wood
21	*Saurauia punduana*	Arongma shing	Februrary	Short lived (1-6 months)	Not required	Soon after collection	60	12-24	July-August	direct sowing, entire planting	Fruits edible
22	*Tetradium fraxinifolium*	Boraashing	October	Moderate long lived	Not required	Soon after collection	70	12-24	July	direct sowing, entire planting	Fruits medicinal; ornamental

Table 5.5.1 (b) Species wise details of medicinal plants indicating planting techniques and their usages

Sl. No.	Botanical Name	Common name	Plantatation method	Plantation time	Uses
1	*Abroma angusta*	Ulat kambal	Through seeds, cuttings	In rainy season	Soil conservation, fencing, fuel-wood
2	*Alsophila spinulosa*	Tree fern	Direct planting	In rainy season	Ornamental
3	*Bambusa tulda*	Shingane Bans	Through seeds, cuttings, root-shoot cutting	In any season	Culms are used for construction and the leaves as fodder
4	*Calamus erectus*	Bent	Through seeds, cuttings	In rainy season	Soil conservation, fencing, furniture
5	*Dichroa febrifuga*	Morru-towtung	Through seeds, cuttings	In rainy season	Soil conservation, fencing, fuel-wood
6	*Hydrangea robusta*	-	Through seeds, cuttings	In rainy season	Ornamental, fuel wood
7	*Ixora acuminata*	-	Through seeds, cuttings	In rainy season	Ornamental, fuel wood
8	*Luculia pinceana*	-	Through seeds, cuttings	In rainy season	Ornamental, fuel wood
9	*Mahonia acanthifolia*	-	Through seeds, cuttings	In rainy season	Reforestation of forest lands
10	*Mussaenda roxburghii*	Key Sengs	Through seeds, cuttings, root-shoot cutting	In any season	Ornamental
11	*Neillia thyrsiflora*	-	Through seeds, cuttings, root-shoot cutting	In any season	Ornamental
12	*Pinanga gracilis*	Fan palm	Through seeds, cuttings	In any season	Ornamental;fiber
13	*Rosa brunonii*	-	Through seeds, cuttings	In rainy season	Reforestation of forest lands; medicinal
14	*Zanthoxylum acanthopodium*	Yokhum	Through seeds, cuttings	In rainy season	Medicinal

Table 5.5.1(c) Species wise details of medicinal plants indicating planting techniques and their usages

Sl.No.	Botanical name	Family	Flowering time	Fruiting time	Parts used for curing the disease
1	*Agave sisalana*	Agavaceae	Feb.-March	March-April	Leaf juice is used as insecticide
2	*Aloe vera*	Liliaceae	Feb.-March	Apr. -May	Leaves juice used in skin teatment; facial
3	*Asaparagus racemosus*	Liliaceae	Apr.-May	July- Aug.	Roots are medicinal
4	*Centella asiatica*	Apiaceae	May-July	July-Aug.	Leaf juice is used as a tonic; intellect promoting for childrens
5	*Costus speciosus*	Araceae	Sept. -Oct.	Nov.-Dec	Rhizome is used in gout; as stimulant
6	*Curcuma longa*	Zingeberaceae	Aug.-Sept.	Oct-Nov.	Rhizome/root powder is useful in wound healing; spice
7	*Cynodon dactylon*	Poaceae	May-June	Aug.-Sept.	Decoction of leaf juice is useful in piles treatment
8	*Hedychium spicatum*	Zingeberaceae	Sept. -Oct.	Oct.-Nov.	Roots are medicinal
9	*Mintha longifolia*	Lamiaceae	Feb-March	March-April	Whole plant is aromatic; medicinal
10	*Molineria capitulata*	Hypoxidaceae	May-June	Sept.-Oct.	Roots are medicinal; fruits are edible
11	*Musa bulbisiana*	Musaceae	Jan. -Feb.	Oct.-Nov.	Fruits are nutitious and edible
12	*Osbeckia stellata*	Melastomiaceae	May-oct.	Oct.-Nov.	Flower are showy; roots are medicinal
13	*Sida rhombifolia*	Malvaceae	June-Aug.	Sept.-Oct.	Roots are medicinal
14	*Viola betonicifolia*	Violaceae	June-Aug.	Sept-Oct.	Whole plant is medicnal; cough and asthma

5.6
FISHERY DEVELOPMENT PLAN & DOWNSTREAM MANAGEMENT PLAN

5.6.1 INTRODUCTION

The main impacts and pressures on the river are hydro-morphological including impoundment (reservoirs/weirs), diversion of water and bank side engineering. The ecological impacts of such types of modifications are various, viz. change in water quality, biological parameters like algae, macro-invertebrates and fish and fisheries. Fish is one of the most vulnerable groups of stream regulation, affected directly by removal and modification of the habitat. It would be impossible to return stream to an original or good ecological status but a few management measures can minimize the impacts and improve the habitat of indigenous fish species.

The main objective of fishery development plan is to improve the habitat, to ensure the upstream and downstream movement of fish specially *Schizothorax richardsonii* and to improve the capture fishery status in the area. Considering the project planning, river flow and fish composition in Yarjep River, a sustainable approach has been adopted in the fishery development plan of Tato-I H.E. Project.

5.6.2 TATO I H.E. PROJECT

Tato-I H.E. project envisages a small weir of 9 m height to divert the additional water of the river. It directly utilizes the water of Heo Project. It proposes to construct an open box shaped channel of 6 m x 6.6 m dimension and 1100 m. length starting from outlet of Heo Power house site up to the headrace tunnel portal of Tato I. Thus, there is no free flow river stretch between outlet of Heo and tail of submergence of Tato I H.E. project. Taking the facts into account the fishery development plan emphasizes to conserve the fish fauna of tributaries and river stretch between the dam/barrage of Heo H.E. Project and weir of Tato I.

5.6.3 FISH FAUNA OF YARJEP RIVER & FISHERIES

Fish fauna of the catchment and influence area comprises 10 species belonging to families Cyprinidae, Balitoridae, Cobitidae, Siluridae and Sisoridae. Out of 10 species 7 are common in the catchment area and influence area while three species namely *Labeo calbasu*, *Danio* sp. and *Puntius ticto* are confined to the lower fringe of influence area. *Schizothorax richardsonii* and *Garra naganensis* are widely distributed in the catchment and influence areas. *Nemacheilus multifasciatus* and *Schistura rupecola* are also abundant in the study area. Even though prefer to inhabit tributaries, they are rarely caught in tributaries because they dwell the river bed.

During the primary survey *Labeo calbasu*, *Schizothorax richardsonii*, *Danio* sp. and *Garra nagenensis* were landed from Siyom river in lower part of the influence area in winter and pre-monsoon seasons while in the catchment fish catch comprised of *Schizothorax richardsonii* and *Garra naganensis.*

Fishing intensity is very low in the area under discussion. The door to door social survey of affected families has also confirmed that fish is not widely used for food by the local people.

5.6.4 PROPOSED PLAN

The proposed plan of fishery development was prepared taking the downstream and upstream projects in the same basin into account. These projects are located in short distance and have proposed/would propose detailed fishery development plans. The measures suggested in Heo H.E. and Pauk H.E. Projects were not included in the plan of Tato-I H.E except fish pass in dam of Heo H.E. Project. Project and vice versa, to avoid any repetition of measures because all projects are owned by the same developer. The main objective of the proposed plan is to conserve the native species and to improve the fisheries in the area. The majority of local people are non vegetarian in food habit and for that reason, people practice hunting. Our field investigation reveals that fishing activity is very low in the region and natives are generally reluctant to fish. In different seasons, during the field survey, 4 fishermen were found to engage in fishing activities between proposed weir site and proposed power house site and tributaries joining in between. Thus, fishery development in the area would encourage the people to fish, which ultimately reduce the pressures on wildlife. The proposed plan would include the involvement of the people in fish farming and downstream management plan.

5.6.4.1 Fishery Development

The establishment of hatchery has already been proposed under the Heo HE Project. The Tato-I HE Project proposes to train inhabitants to fish farming.

5.6.4.1.1 *Training for fish farming*

Inhabitants would be encouraged for fish farming. In order to implement this plan, project authorities in consultation with State Fishery Department would run training programme for fish farming. The project authorities would furnish the application forms. The interested persons would apply for the training in prescribed form and submit to office of the project authorities. This programme would be run for 3 years and 5 applicants will be selected every year. If the training facilities are not available in Arunachal Pradesh, it will be facilitated to outside the state. The project affected persons will be given preferences. The budget for the training including training fee, accommodation, travel, etc. will be borne by the project authorities. Total budget for the purpose would be **Rs. 5.00 lakh** only.

5.6.4.1.2 *Financial assistance for fish farms*

The farmers interested for fish culture will be provided with financial assistance towards the construction of fish farms. This assistance will be given to trained fellows, which have got training under the scheme of project authorities or from other sources. This scheme will be run for four years and 5 farmers will be selected every year. Project affected persons will be given preferences. If the candidates are not available among the affected persons, it will be extended to project affected villages and, to influence area. Each farmer will be provided with an amount of **Rs. 50,000** for the construction materials and other accessories with the conditions that if the work is not satisfactory the amount will be withdrawn from the beneficiary. The prescribed amount will be sanctioned after a detailed evaluation on feasibility of the site, availability of water channel in nearby place and adequacy of water, etc. Project authorities would evaluate the progress of construction of fish farm. After the completion of fish farm, fish seeds or ova would be supplied from the nearby hatchery, proposed for Heo H.E. Project at no cost. If, there would be other farmers, which are engaged in fish culture at their own, fish seeds would also be supplied to them at no cost. The beneficiaries would provide the land for the fish farm at no cost. Total cost for the plan would be **Rs. 10.00 lakhs** only.

5.6.4.2 Fish Pass/Ladder

The height of proposed weir of Tato-I is 9 m from the deepest foundation level, therefore, fish pass may be feasible in the proposed weir. The detailed studies shall be made at the stage of detailed designs of the weir and the provision shall be made since at the DPR stage it has not been done. The size of slot would depend on the amount of water to be released from the dam as environmental flow. The fish pass like simple sluice, rock rump fish ways, pool and weirs, vertical slot fish pass and baffle fish ways are used in the rivers. A fish pass in the weir of Tato-I H.E. Project if required should meet the following criteria

- It should be adapted to the requirements of the species concerned
- It should be of a pool type, rocky ramp type, or a vertical slot
- Flow velocities must not exceed the swimming capacity of fish
- It should provide passage for all fish sizes - large and small
- It should be provided with proper fencing, with total ban on fishing
- It should be provided with fish attractors like light or sound

The project authorities are suggested to explore expertise of fish passes having vast experience of designing of fish passes. No additional budget is kept for the provision of fish pass to the dam as it is the part of the Dam structure.

5.6.4.3 Downstream Management Plan

5.6.4.3.1 *Maintenance of flow*

The diversion of water leads to various environmental and socio-economic consequences in the downstream stretch. In the downstream stretch of Tato I weir, major adverse impacts on the aquatic life especially fish are foreseen. It would require a minimum environmental flow, sufficient to maintain ecosystem integrity and can sustain the aquatic life. About 4.9 km river stretch would undergo through scarcity of water after diversion. Though a few tributaries like Sittin Korong, an unnamed nalah and Pirpu Korong join Yarjep at 0.3 km, 0.9 km and 2.8 km downstream of the weir on left bank while a small tributary confluences at 1.1 km downstream of the intake on the right bank. Even though these tributaries contribute to certain amount of water, it may not be adequate to sustain the aquatic life. Therefore, in order to conserve the fish fauna of Yarjep River, a minimum flow will be maintained from the proposed weir. For this reason, an environmental flow study of Tato I H.E. project is under progress. The recommended flow must have adequate water discharge, water current velocity and depth of water column to sustain both column and bottom feeder species.

5.6.4.3.2 *River Channelization*

River channel in terms of width and depth varies from weir site to power house site, therefore, there would be possibilities of inadequate river depth, current velocity etc at many sites due to minimum environmental flow. These sites would require a few engineering measures like river channelization. It would include removal of large boulders and cutting to provide sufficient water current velocity and channel depth. Total budget for this measure would be **Rs. 25.00 lakhs** only.

5.6.4.3.3 *Maintenance of pools*

If water flow reduces significantly in the downstream, it triggers isolation of many pools, which may be of breeding importance. In the Yarjep River, a detailed survey was carried out to find out the potential breeding pools. Though, breeding pools could not be encountered during the survey but fry and fingerlings were observed from the shallow water zones indicating, Yarjep River as spawning ground. Probably fry and fingerlings belonged to *Schizothorax richardsonii*. In addition, fry and fingerlings were observed from tributary like Pirpu and Sitting Korong. These findings reveal that there should be certain pools where fish lay their ova. The project authorities are suggested to mark these pools after a detailed survey and to maintain them through engineering measures. The isolated pools would be connected to regular and adequate water currents. The total financial outlay for this measure would be **Rs. 15.00 lakhs** only.

5.6.4.3.4 *Maintenance of tributaries*

The deformation of the main river channel due to low flow results into the deposition of sand bar at the mouth of tributaries, which may hamper the movement of fish into tributaries. The removal of sand bars is an engineering solution, though it would be a regular practice because in every monsoon season, sand bar deposition would occur. Alternatively, the main river channel can be diverted in such a manner that it could confluence with tributary at its mouth so that sand bar deposition could be prevented. Total budget for this exercise would be **Rs. 15.00 lakh**.

5.6.5 BUDGET

Total budget for the fishery development and downstream management plan would be **Rs.70.00 lakhs** only.

5.7
PUBLIC HEALTH DELIVERY SYSTEM

5.7.1 INTRODUCTION

The United Nations' World Health Organization (UNWHO) has defined health as "a state of complete physical, mental and social well-being and the absence of diseases or infirmity". The main goal of public health delivery measures is to prevent rather than treat a disease through surveillance of cases and the promotion of healthy behaviors. For the last few decades, progress in the health status has been increased in terms of life expectancy but reduction in mortality and morbidity has remained serious challenges. In countries like India, public health is major issue, however, the budgetary outlay for the public health system in India is less than 2% of GDP. The government of India has launched a flagship programme under the banner of the National Rural Health Mission (NRHM) in 2005. This programme seeks to provide effective healthcare to rural population throughout the country with special focus on 18 states including Arunachal Pradesh. We observed during field surveys that the area is very poor in having health infrastructures due to its hilly, rough terrain and sparse population. In order to strengthen the health delivery system and to improve the health facilities in Arunachal Pradesh, Central and State Governments are running a Public Private Partnership Project (PPPP). This is a joint activity of the government at tandem with a private organization committee to improve health delivery system in the various areas of the state. In addition to it, Voluntary Health Association of India (VHAI) has been playing an important role in improving the health infrastructure in the State.

In Arunachal Pradesh, the health related facilities are directly related to the socio-economic factors and poor infrastructures. We found that the major diseases that are prevalent in the state are malaria, cholera, skin diseases and other water born diseases. Due to the lack of medical facilities, infant mortality is high in the state especially in rural areas. The main objective of the proposed PHM is to deliver effective and sustained health care to the rural population especially to women and children. The proposed Tato-I H.E. project is located in the remote area of Arunachal Pradesh, where existing medical facilities are in poor condition and highly inadequate. The agencies involved in the various developmental works in Arunachal Pradesh are expected to participate in developing and strengthening the public health management by establishing new health centre in the affected zone, opening up immunization centres in the villages, labour camps, providing services for pre-/ post-natal check up, etc. The following infrastructure facilities have been suggested for the project developers involved in Tato-I H.E. Project.

5.7.2 EXISTING FACILITIES

Most of the villages are connected to the roads and tele-communication. This is not the case for Purying, Meing and Heyo, but mobile phone telecommunications are being set up and mobile phone is already working up to Gapo. Only a Primary Health Sub Centre (PHSC) is located at Tato in 10 km surroundings, but none of the affected village has primary health centre and primary health sub centre. To access hospital facilities people living in the rural areas have to move to Aalo, which is more than 150 km from the project site.

5.7.3 PROPOSED PLAN

The proposed public health management (PHM) plan has been prepared considering the population density of affected villages, however the health facilities should be extended to surrounding villages also for their accessibility, and have been designed to benefit the influence zone. In order to provide adequate medical facilities in the influence zone, the project authorities are would strengthen existing medical facilities in the area, to open a new hospital and a primary health sub centre in the affected zone, to open immunization centres in the villages, labour camps, to provide services for pre /post natal check ups, etc.

The proposed PHM plan has been prepared as one single plan under Pauk HEP, Tato-I HEP and Heo HEPs. These three projects are located in the same area one after another in a cascade way on a 13 Km river stretch which extends approximately between the area downstream of Chengrung village (Upstream of Pauk HEP dam) and not far from Tato Village (Tato-I Power House site), and are owned by same authority. Therefore, one single plan may be considered to cover the zone of the three projects and such plan is proposed to be divided between in the Heo H.E. Project and the Tato-I H.E. Project. To avoid double measures/repetition and to cover maximum population under this plan, project authorities are suggested to implement this plan in consultation of the State Health Department.

The infrastructure facilities suggested in the area are described in following paragraphs.

5.7.3.1 Hospital

In the central and accessible place of the proposed projects, a 20 bed hospital is proposed. This hospital would provide services not only to the project staff but also to the project affected families and the local people of the region. The project authorities would finance the hospital operations for four years. State Government would provide the land for construction of the said hospital. The project authorities would construct the hospital and its running cost has been made for 4 years. After 4 years, the financial support of the hospital would be transferred to the state government. The plan would be promoted by the project authorities in consultation with state Health Department so that all the projects in the valley would be considered. The State Health Department will remain the responsible authority for delivery of Health services as per applicable regulations. The expenditure for project hospital is given in Table 5.7.1.

Table 5.7.1 Estimated cost for the setting up of a Hospital at Tato-I H.E. Project area.

S. No.	Particulars (Rs. in lakhs)	Amount
A.	**Non-Recurring Cost**	
	i) Building 6,000 sq ft	60.00
	ii) Ambulances (1 Nos.; including running cost)	15.00
	iii) Equipments for laboratory facility, furniture (Lump sum)	25.00
	Total (A)	**100.00**
B.	**Recurring Cost**	**Salaries/ wages**
	i) Medical Staff	
	(a) 3 Doctor x 4 yrs x Rs. 40,000/- x 12 months +AL	70.00
	(b) 1 Pharmacist x 4 yrs x Rs. 30,000/- x 12 months +AL	17.28
	(c) 2 Nurses x 4 yrs x 25,000/- x 12 months + AL	28.80
	(d) 1 Ward boy + 1 Ward girl x 4 years x Rs. 15,000/- x 12 months +AL	17.28
	ii) Medicines and miscellaneous expenditure @ Rs. 4 lakhs per annum for 4 years	16.00
	iii) Maintenance @ Rs. 2.0 lakhs per annum per ambulance	08.00
	Total (B)	**157.36**
	Total (A + B)	**257.36**

Allocation of salary budget includes annual increment (AI) on 20 % of the salary.
Total financial budget is prepared for 4 years only
The salaries are on the basis considering the revised pay band.

5.7.3.2 Veterinary Centre

The livestock population in the surrounding of proposed project comprises of mithun, cow, pigs and chickens. Foot and mouth diseases in mithun are common in the areas, which is one of the main sources of livelihood in the region. In order to protect the animals especially mithun from outbreak, project authorities are suggested to establish a well-equipped veterinary centre at centre place. Project authorities would provide the funds for four years to the State Animal Husbandry Department. After four years Veterinary centre would be handed over to Department. Total financial outlay for veterinary centre would be **Rs. 50.00 lakhs.** It includes cost of infrastructure development, salaries of medical and non medical staff, medicines, travel etc. This plan would also be shared with Heo H.E. Project in upstream.

5.7.4 STRENGTHENING OF MEDICAL INFRASTRUCTURE

5.7.4.1 Immunization Programme

Many deadly diseases like measles, mumps, rubella, hepatitis B, polio, diphtheria, and tetanus are very common, mostly in remote and rural areas. In order to immunize and vaccinate against such deadly diseases a door-to-door immunization and vaccination programme will be run in co-ordination with district administration in the surrounding villages that would be fixed for a particular day (Health day) of the month. The names of the surrounding villages (villages of the peripheral development plan) are given in Chapter 5.11.4 of EMP report. Regarding the time of administration for the immunization, vaccines may be given imperatively i.e. as a preventive measure, before exposure to a disease as in the case of polio or after exposure (a dog bite) as in the case of rabies. Vaccines also follow a specific time schedule that must be strictly adhered to for effective immunity to be conferred on an individual. The vaccination schedule for babies recommended by the Govt. of India under the Expanded Programme of Immunization (EPI) and the Indian Academy of Pediatrics (IAP) is provided in Tables 5.7.2 and 5.7.3. The work would be carried out by two teams with the help of village *Anganwari* workers in coordination with State Government. These teams will be based in the nearby health centres or hospital. The medical teams would also conduct the regular pre- and post-natal check ups in the villages. Project authorities would provide funds for immunization programme for four years. Total financial outlay for this programme would be **Rs. 10.00 lakhs** only. The same plan has been proposed for the Heo H.E. Project, therefore, care must be taken to avoid overlapping in the vaccination programme.

Table 5.7.2 EPI schedules as recommended by Government of India.

Age	Vaccine scheduled
0 -15 days	BCG + OPV (ZERO DOSE) + Hep B1
-6 weeks - 8 weeks	OPV1 + DPT1 + Hep B2
-10 weeks - 12 weeks	OPV2 + DPT2
-14 weeks - 16 weeks	OPV3 + DPT3
-6 months	Hep B3
-9 months (completed)	Measles vaccine
-15 months - 18 months	1st booster of OPV/ DPT
-4 years - 6 years	DT vaccine
-10 years	Tetanus Toxoid
-16 years	Tetanus Toxoid

Table 5.7.3 Indian Academy of Pediatrics (IAP) time schedule of routine vaccination.

Age	Vaccine scheduled
Birth -15 days	BCG + OPV (zero dose) Hepatitis B 1st Dose
-6 weeks - 8 weeks	OPV1 + DPT1Hepatitis B 2nd dose + Hib 1st dose
-10 weeks - 12 weeks	OPV2 + DPT2 + Hib 2nd dose
-14 weeks - 16 weeks	OPV3 + DPT3 + Hepatitis B 3rd dose + Hib 3rd dose
-9 months (completed)	Measles vaccine
-15 - 18 months	1st Booster dose of OPV + DPT + Hib + MMR vaccine
-4 - 6 years	2nd booster dose of OPV + DPT
-10 years	Tetanus toxoid
-16 years	Tetanus toxoid

5.7.4.2 Distribution of First Aid Boxes

Standard first aids kits of durable plastic boxes, fabric pouches or in wall-mounted cabinets will be distributed in the affected and surrounding villages of the proposed Tato-I H.E. project. The trained people in the villages will take responsibility of these boxes. One time training programme may be run in the project hospital. The trained fellows would receive medicines from nearby the health centres after submitting utilization records of the medicines used. The trained people will be paid a nominal amount as incentive. It is recommended that all kits are in a clean, waterproof container to keep the contents safe and aseptic. Kits should also be checked regularly and restocked if any items are damaged or expired out of date. Project authority would provide funds to State Health Department for four years. We observed during field visit that diarrhea is one of the causes of early age mortality in children. The project authorities are suggested to provide ORS (Oral Rehydration Salt) packs with first aid boxes at each village. The project authorities are suggested to run this program with the help of State Health Department and also taking into consideration other projects like Heo H.E. and Pauk H.E projects, so that this facility could be extended to maximum villages. Total budget for the distribution of first aid boxes and ORS would be **Rs. 5.00 lakhs.**

5.7.4.3 Free Medical Camps

The project authorities with the help of project’s doctors will organize free medical camps, at least twice in a year for four years. These camps will have a team of doctors specializing in the prevalent native diseases. Total financial outlay for the free medical camps would be **Rs. 10.00 lakhs**. This facility can be extended to the Heo and the Pauk H.E. projects areas.

5.7.4.4 First Aid Posts

In addition to the distribution of first aid boxes, two first aid posts are suggested at the project sites to provide easy and immediate access to the laborers as well as to the local people in case of any emergency. Total financial outlay for the first aid posts would be **Rs. 5.00 lakhs**.

5.7.5 SAFEGUARD MEASURES

The following measures are suggested to minimize the incidence of vector borne diseases.

i) Before joining the project, the migrant labourers and technical staff will have to pass through medical check up, which would be arranged by the project authorities.
ii) The site selected for labor camps should not be located along any natural drainage.
iii) Adequate arrangements should be in place to dispose storm water from the labor colonies.
iv) Adequate vaccination and immunization facilities to be provided for the workers at the construction sites.
v) Rapid deployment of sanitary inspectors and teams to disinfect an area of concern.
vi) The labor camps and resettlement site to be located sufficiently far away from any water body.
vii) Training and regular reorientation are emphasized as ways to remove some of the deficiencies in service delivery especially in the remotest area.

viii) The project authorities are advised to address environmental sanitation and personal hygiene to the project workers and to the local people to reduce vector-borne diseases taking helps from experts.

5.7.6 COST ESTIMATE

Total cost estimate for the health management plan of the proposed Tato-I H.E. project is **Rs. 337.36 lakhs** only. It includes establishment of a Hospital (**Rs. 257.36 lakhs**), setting up of a veterinary centre (**Rs. 50.00 lakhs**) immunization and vaccination programmes (**Rs. 10.00 lakhs**), distribution of first aid boxes in the surrounding villages (**Rs. 5.00 lakhs**), free medical check up camps (**Rs. 10.00 lakhs**), and first aid posts (**Rs. 5.00 lakhs**).

5.8
WASTE MANAGEMENT PLAN

5.8.1 INTRODUCTION

Waste management refers to the garbage and sewage management. It is related to inevitable by-products produced by human activities and is generally undertaken to reduce their effects on health, the environment or aesthetics. Solid waste management is the system or procedure of collection, transport, processing, recycling or disposal and monitoring of waste materials. In some instances, waste management is also carried out to recover resources from it. Solid waste management is categorized into solid, liquid, gaseous or radioactive substances; each requiring different fields of expertise and methods such as recycling programs, dumps and incinerators. There is a growing concern all over the world for the safe disposal of hazardous wastes generated from anthropogenic sources. However, the practices of solid waste management differ for developed and developing nations, urban and rural areas and for residential and industrial producers. Management for non-hazardous residential and institutional wastes in metropolitan areas is usually the responsibility of the local government authorities, whereas management for non hazardous commercial and industrial waste is usually the responsibility of the generator. In countries like India, the combination of a rapidly expanding economy with high levels of illiteracy and unemployment has been creating and/ or exacerbating the problems in effective management of wastes. One such problem is the collection and disposal of garbage or municipal solid waste compounded by increasing consumption levels of human population.

Generally, solid and liquid wastes generated in the rural areas of Arunachal Pradesh are disposed in open dumps and areas, which pose an eminent threat to public health as well as to the health of surrounding environment. The proposed project activities are confined to a small geographical area having clean and green environment in West Siang district of Arunachal Pradesh. However, the maintenance of the local aesthetic beauty and clean environment of the region is the sole responsibility of the project authority. During the field surveys it was noticed that the surrounding areas of the proposed Tato-I H.E.P. have low population density; however, it seems low but as long as humans have been living in settled communities, solid waste, or garbage, has been an issue for clean environment. A total of 2168 persons and 390 households were recorded within the

10 km radius of the project area (Census 2001). The influx of migrant laborers with their families in the proposed project area would exert additional pressure on the existing ecosystem. These workers include technical and non-technical staff and other service providers. In the absence of a proper management plan, the solid and liquid wastes may act as sources of environmental pollution. Here, we have proposed a waste management plan considering the migrant workers for the disposal of all types of wastes including the solid wastes generated from trees and shrubs removed during land clearing, demolition of existing structures (if any), building construction, packaging materials, scrap or surplus building materials, domestic wastes and highway planting wastes, etc. To ensure the aesthetic beauty of area and to avoid indiscriminate dumping of waste in and around the project area, appropriate sewage and solid waste treatment as well as disposal system would be developed by the project authorities. The main objective of waste management is to make proper planning in order to collect, treat and dispose off wastes generated by all groups of population in an environmentally and socially satisfactory manner using the most economical means available.

5.8.2 MIGRANT POPULATION

The construction of Tato-I H.E. Project would take about 4 years to complete. The number of laborer and technical staff requirement would vary each year depending upon the construction phase. The peak labor force required for the Tato-I H.E. Project has been calculated to be around 400. These workers including their families would definitely increase the population of the influence area, by more than 50%. The total expected migrant population has been calculated taking into consideration the periodic requirement of laborer based on the following assumptions

(i) It is assumed that 50% of laborers and 50% technical staff are likely to have families,
(ii) 80% of the married laborers will comprise of both husband and wife,
(iii) 50% of the technical staff will come with their families and only husband will work,
(iv) 2% of the total migrating population are assumed as service providers, and
(v) 50% of service providers will have families.
(vi) The average family size of laborers and technical staff is assumed to be of five persons, respectively.

Table 5.8.1 provides the detail of the migrant population in the region. Based on this calculation, a total population of nearly 1,160 is expected to come in the region. These migrant populations would be likely residing in the region at any given time of construction phase of the project.

Table 5.8.1 Total migrant population (peak time) expected for the Tato-I H.E. Project

Sl.No.	Particulars	Family/ Population
A.	**Migrant workers**	
	i) Peak migrant workers	340
	ii) Single migrant workers (50% of 340)	170
	iii) Married migrant workers (50% of 340)	170
	iv) Husband and wife both working (80% of 170)	136
	iv) Number of dependent family members @ 3/ family (170 x 3)	510
Total Population of A = 170 + 136 + (170-136) x 2 + (170 x 3)		**884**
B.	**Migrant Technical staff**	
	i) Total migrant technical staff	70
	ii) Single technical staff (50% of 70)	35
	iii) Married migrant technical staff (50% of 70)	35
	iv) Number of dependent family members @ 3/ family (35 x 3)	105
Total population of B = 35 + (35 x 2) + (28 x 3)		**210**
C.	**Service Providers**	
	i) Total service provider (2% of the total population, i.e., A+B)	22
	ii) Single persons (50% of 22)	11
	iii) Married service providers (50% of 22)	11
	iv) Number of families	11
	v) Number of dependent members (11 x 3)	33
Total population of C = 11 + (11 x 2) + (11 x 3)		**66**
Grand Total of A + B + C =		**1,160**

5.8.3 PRODUCTION OF WASTES

All the expected migrant persons of 1,160 in the region of Tato-I H.E. Project would stay for a transitory period of at least two years and maximum four years. To keep a cautious approach of the estimates for waste generation, it has been considered that the entire migrant population would stay at site for 4 years. Although it is transitory, these migrant populations would generate a large quantity of wastes that needs to be disposed off without polluting the land, air and water resources of the region. In India, the average dry weight per capita solid waste generated per day is reported to be around 468 g (Singhal and Pandey, 2001). For the Tato-I H.E. Project, annual generation of solid wastes by a migrant population of 1160 persons would be nearly 200 tones (0.468 x 1160 x 365 days = 1,98,151.2 kg). The following quantity of different types of solid muck are anticipated in the surrounding of the project. Per day generation of solid waste of the estimated 1160 migrant workers in the project area is based on World Bank Development Sector, Unit Solid Waste Management in Asia, 1999), and the break-up would be as follows:.

Type of waste	**Quantity (in kg)**
Metal	10.8
Glass	10.8
Plastic	21.7
Papers	32.5
Compostable waste	228.0
Others waste	239.0
Total	**542.8**

In India, consumption of water is nearly 135 litres per capita per day (including water for drinking, cooking, bathing and washing etc.). Of these, nearly 100 litres of consumed water goes into sewage, which is ultimately released into the rivers. The total production of wastewater (unusable water) by migrant population is calculated to be 1,16,000 litres per day, which would drain into the rivers. The project authorities would also ensure treatment of this wastewater (unusable water) before releasing it into the water body.

5.8.4 PROPOSED PLAN

For the disposal of all types of wastes including the solid waste generated in the labour camps, project colonies, offices and other sites of the proposed project a suitable management plan has been put forward for consideration. Following measures are suggested in and around the project areas for the management of the wastes.

5.8.4.1 Septic tanks

The septic tank in which sewage is collected and allowed to decompose is used for treating domestic sewage from individual households both in suburban and rural areas, where a piped-sewage system (i.e., a public sewer) is not available. Septic tank serves in settling of solid particles in sewage by means of sedimentation and partial or complete digestion of the sludge through bacterial activities before its disposal. The sanitary facilities would be provided in the colonies, which must be of standard municipal design for the hill areas. Septic tanks of not less than 25 m^3 would be constructed at appropriate sites in the colony areas. The organic wastes thus generated would be decomposed and to be used as manure while landscaping the project area. Non degradable waste would be incinerated. Neither the organic waste nor the garbage would be dumped in or around the project areas. One to two tanks or soak pits are proposed for each set of toilet. The total budget allocated for the purpose is around **Rs. 17.00 lakhs**.

5.8.4.2 Community toilets

Open urination and defecation in the region should strictly be prohibited. Provisions would be made for the community toilets in the labor colony. About 30 low cost public toilet sets have been proposed for laborers' colony site (15 proposed for colony of powerhouse site and 15 for the colony of weir site). At least 10 sets of temporary toilet facilities would also be provided at the working sites with proper water facilities. Each set will have 5 to 8 seats (WCs) depending on the number of users. The total budget estimated for the community toilets is around **Rs 18.20 lakhs.**

5.8.4.3 Bathrooms and washing places

For bathing and washing clothes, proper facilities would be provided in the colony areas of laborers near proposed power house and weir sites or wherever laborers' camp will be established. Around 15 bathrooms/ washing places fitted with the proper water supply system are proposed in the colony areas. The total budget estimated for this activity is around **Rs 10.00 lakhs**.

5.8.4.4 Sewage Treatment Plants

Wastewater generated from the kitchens, bathrooms and washing places, if not managed properly will end up in the nearby streams or river channels causing pollution of water ecosystem. A small sewage treatment plant has been proposed for the intake colony area. Such plant would be also used for the Heo Power House colony Site, which is located in the same area as the one of Tato-I intake site colony. Another small sewage treatment plant is proposed for the power house colony area. Properly treated water should either be reused or released into the draining channels. An estimated total budget for the two sewage treatment plants is around **Rs 70.00 lakhs**. The running cost of this plant for 4 years would be around **Rs 20.00 lakhs for both plants**. Total cost is **Rs 90.00 lakhs**.

5.8.4.5 Segregation of waste & installation of dustbins

Organic and inorganic garbage would also be generated in the colony areas, road sites, working area and labor camps. It would be better to segregate the waste at the source. For this purpose, dustbins of good and long-lasting quality would be installed at different places to collect organic, plastic, glass and other garbage separately. Two types of dustbins would be installed at each site, which will be marked as recycled and not-recycled. Recycled marked dustbins would be used for paper, glass, plastic and metals while non recycled marked dustbins will be used of compostable and other waste. The organic garbage would be converted into organic manures. Metal and glass garbage may be sent for recycling and other garbage may be dumped at landfills. **Rs 2.10 lakhs** has been allocated for the installation and maintenance of the dustbins in colony area for four years. The waste collected in the dustbins will be unloaded daily basis.

5.8.4.6 Landfills

Nearly 239 kg of daily solid waste would be of mixed nature, which cannot be segregated. This quantity of waste would be dumped at landfills at designated sites. The landfills area must be located far from forested area and settlement. The landfills would be fenced suitably so that stray animals and wild animals could not go there. The process of combustion of waste would be applied at landfill areas from time to time. Project authority would apply all measures to prevent the leachate from the landfill area. After the construction of project (4 years) most of the workers would be homed, the project authority would ensure the closure and restoration of landfills in environmentally sound manner. Total budget for the landfill areas would be **Rs. 2.00 lakhs** only.

5.8.4.7 Construction of Compost pits

Total quantity of compostable waste from the project areas would be around 228 kg per day. The compostable waste would be dumped at compost pits. Project authorities would establish about 20 low cost compost pits in affected villages and nursery areas. The capacity of each compost pit would be 200 m^3. The manure of compost pits, established in the villages would be used by villagers while manur of compost pits in nursery areas would be used for the CAT plan. Total cost for the construction and maintenance of compost pit would be **Rs. 10.00 lakhs** only.

5.8.4.8 Dumpers and wheelbarrows

Dumpers and wheel barrows will be required for the collection and transportation of garbage from one spot to another in the colony area. One dumper and six wheelbarrows (double wheel) are proposed in the plan. An estimated total budget including purchase and maintenance of dumpers and wheelbarrows is around **Rs 13.00 lakhs**. The budgetary allocation for the driver of dumper for four years would be **Rs 6.50 lakhs**.

5.8.4.9 Working staff

Staff for the maintenance, cleaning and upkeep of various facilities at various places like colony areas, construction sites, etc. is proposed in the plan. Operating staff for garbage collection, dumping, sewage treatment plant and incinerators are also provided. A total budget of **Rs 15.50 lakhs** is proposed in the plan as salary for the staff of 5 persons who will keep the project area clean for 4 years.

5.8.4.10 Water and toilet facilities for the villages

The proposed facilities like community toilets, septic tanks, dustbin would also be extended to the affected villages. There are 4 affected villages, namely Gapo, Meying, Tato and Heyo in the project area having a population of 493 individuals (Census 2001). Majority of the residents in these villages do not have access to proper sanitation. Project authorities would provide adequate water supply and sanitary facilities to these villages. This will go a long way in extending the help and assistance of the local population and enhancing the acceptability of developmental projects among them. Effort of this kind plays important roles in local development of the area. A separate budget estimated for the purpose of water supply schemes is around **Rs 40.00** lakhs.

Besides, community toilets at public places are lacking, therefore provision would also be made for the construction of community toilets. Although a number of houses in the villages have access to toilet facilities but they are far from their work places. Around 6 sets of public toilets are proposed for the villages. The number of seats in each set may vary according to the number of users in the villages. A budget of **Rs. 3.00 lakhs** is proposed for the installation of these facilities including maintenance charges for four years. Gapo and Meying villages are also affected under the Heo H.E. project. To facilitate some of the services for these villages, the project authorities may consult with the developer of the Tato-I H.E. project for setting up the common infrastructures.

5.8.5 COST ESTIMATE

In order to manage the solid waste generated from the population of more than migrant persons, a number of machine tools for handling and disposing solid wastes are also proposed. A total budget of **Rs 224.30 lakhs (Two Hundred Twenty Four Lakhs and Thirty Thousand Rupees** is proposed in the plan. The estimates of cost for the solid waste management for Tato-I H.E. Project are given in Table 5.8.2.

Table 5.8.2. Estimated cost (rupees in lakhs) for the Waste Management

Particulars	Number/ unit	Installation cost	Maintenance cost	Total cost
1. Septic tanks and soak pits @ Rs. 0.40 lakh per pit				
a) Labour colony at intake site	35 pits	14.00	3.00	17.00
2. Community toilets				
a) Labour colonies at intake site, @ Rs. 0.40 lakh per set (one set with 5 to 8 seats)				
	25 sets	10.00	3.00	13.00
b) Community toilets at construction site, @ Rs. 0.40 lakh per set (one set 5-8 seats)				
	10 sets	4.00	1.20	5.20
3. Bathrooms and washing places				
a) Labour colonies at intake site @ Rs. 0.50 lakh per bath room				
	15 sets	7.50	2.50	10.00
4. Sewage treatment plant				
a) Labour colonies at intake site	1	35.00	10.00	45.00
b) Labour colonies at PH site	1	35.00	10.00	45.00
5. Landfills				
a) Labour colonies at intake site	-	1.50	0.50	2.00
6. Dustbins (@ Rs.5000/unity)				
a) Labour colonies at intake site	10	0.50	0.20	0.70
b) Working sites	10	0.50	0.20	0.70
c) Roadsides	10	0.50	0.20	0.70

7. Dumpers				
a) Labour colony at intake site	1	8.50	3.00	11.50
8. Wheel Barrows				
a) Labour colony at intake site	6	1.50	-	1.50
9. Driver for Dumper				
Salary for 4 years @ Rs 11716/ + AI	1 Person	6.50	-	6.50
10. Compost pits	20	8.00	2.00	10.00
11. Staff for cleaning and maintenance				
Salaries and wages for 4 years	5	15.5	-	15.50
12. Facilities extended to affected villages including septic tanks, community toilets				
Vats and water supply system	02 villages	40.00	-	40.00
Total		**188.50**	**35.80**	**224.30**

The plan would be implemented by the project authorities in consultation with other project authorities of the projects located in down and upstream stretches of the Yarjep River.

5.9
FUEL WOOD ENERGY & BIO-RESOURCE CONSERVATION

5.9.1 INTRODUCTION

Forests and poorest people of rural areas are inextricably linked and the rural poverty is concentrated in areas where the bio-resource is most threatened. Understanding of local patterns of resource use is essential in order to enable conservation strategies of bio-resources to be better adapted to local livelihoods. This will provide benefits particularly on woodland conservation. Per capita fuel wood consumption is three-fold higher in Northeastern states of India including Arunachal Pradesh as compared to the Northwest Himalayan region (Bhatt et al, 1994). The extraction of fuel wood by the local people in the region has already led to the severe loss of wilderness. Local people residing in the surrounding villages of the proposed Tato-I H.E. project are dependent on fuel wood of nearby forests. Nearly 7% households in the rural areas of Arunachal Pradesh use LPG as fuel cooking purpose. The equipments used in the villages are cook stove, kilns etc. made up of local materials. The traditional stoves are very poor in quality, smoky, unhygienic, inconvenient and inefficient. There is always a large scope for the improvement in fuel conservation. Population of the surrounding areas of the proposed Tato-I H.E. project use wood as fuel collected from forests. In addition, a bulk of migrant labourers of the said project would require fuel for cooking and other purposes thereby increasing the magnitude of the existing pressure on forest and forest resources. Based on the information recorded on socio-cultural and economical aspects of the region, several measures towards the conservation of energy and bio-resources are suggested in the following sub sections.

Project authorities of the proposed Tato-I H.E. Project are would provide the technologies regarding the use of smokeless chullahs and efficient cooking stoves in addition to the provision of LPG depot, Kerosene depots and community kitchen, etc. These facilities would be extended to affected as well as influenced families of the proposed project. Need of fuel woods are to be substituted as far as possible with sources like bio-gases, LPGs, and solar energy. Fuel-efficient "Chulhas" as a measure of conservation of fuel wood needs to be popularized in rural areas. Keeping in view the fuel requirements of migrant workers and households of the affected and influenced villages located around the project, the project authorities are suggested to provide the following alternatives. Project authorities are suggested to provide alternatives not only to the workers of the project but project affected families. These facilities can be extended to the direct impact and influence zone. In order to conserve the fuel wood, following measures are suggested.

5.9.2 PROPOSED PLAN

5.9.2.1 LPG Depot

One LPG depot is proposed at Gapo, in order to cater to the population of influence areas of Tato I. HEP, Heo HEP and Pauk H.E.P projects. The depot would fulfill the requirements of about 600 connections including the villagers and migrant labourers. The project authorities would provide one time grant to each household in the affected villages for LPG connection including stoves. This facility would be extended to poor families in the surrounding villages. Total budget for LPG depot and connections would be **Rs. 25.00 lakhs** only.

5.9.2.2 Kerosene depot

At least three kerosene depots at affected villages will be opened by the project authorities. These depots will cater to all affected families and inhabitants of influence zone. Total cost for the Kerosene depots would be **Rs. 3.00** Lakhs only.

5.9.2.3 Community kitchens/ canteens

Community kitchen is an efficient way of energy conservation. It saves time and increases working efficiency of workers. The community kitchens/ canteens are proposed at colony area, camp area and the hostel. It would be part of contract agreement of the contractors and its establishment would be ensured by the project authorities. Project authorities would provide all necessary infrastructures for community kitchen and canteen. Under this plan **Rs.5.00 lakhs** has been allocated.

5.9.2.4 Distribution of improved *Chulahs* and solar cookers

Various energy conservation techniques and measures for efficient cooking, such as pressure cookers, solar cookers and installation of smokeless chulahs would be made available by the project authorities for affected families which are not connected to roads, are remotely located and do not have access to LPG connection. A total of 390 households are located in the influence area, though, most of them could be covered under the plan of Heo H.E. Project. Out of 390 there would be provision of Chullahs and solar and pressure cockers for nearly 150 households. Considering 150 households in influence area, migrant families and poor families in the other areas of catchment, the provision of 600 improved chullahs (@Rs. 800/chullag), 300 pressure cookers (@ Rs. 1500/cooker) and 50 solar cookers (@ Rs. 15,000 /cooker) Total budget for this plan would be **Rs. 10.00 Lakhs** only.

5.9.3 FINANCIAL OUTLAY

Total financial outlay for the provision of fuel would energy conservation plan would be **Rs. 54.80 lakhs**. The break up of the budget is given in **Table 5.9.1**.

Table 5.9.1 Budget allocation for fuel wood energy and bio-resource conservation measures in the Tato-I H.E. Project area

Sl .No.	Particulars	Amount (Rs. in Lakhs)
1	LPG depot	
	(a) Construction of LPG Depot (1Nos.)	5.00
	(b) LPG connection for nearly 750 families	25.00
2.	Kerosene Depots (3 Nos.)	3.00
3.	Community Kitchen / Canteens (1 Nos.)	5.00
4.	Pressure cookers	4.50
4.	Solar Cookers	7.50
5.	Installation of Smokeless chullahs	4.80
	Total	**54.80**

5.10
MANAGEMENT OF AIR, WATER QUALITY AND NOISE LEVEL

5.10.1 INTRODUCTION

Developmental projects or anthropogenic activities are directly related to the air and water quality and noise level. These activities lead to wasteful use of freshwater, discharge of effluents, dispose off excavated materials into water bodies and long-range atmospheric transport of pollutants. Also, noise level due to construction activities increases significantly. These endings are generally referred as pollutants, which are not only harmful to human health, wildlife and other biotic communities but creates an obnoxious environment in the surroundings. In order to avoid the negative impacts of the project activities on the water quality, air quality and noise level, a monitoring of these parameters at regular intervals are warranted for the Tato-I H.E. Project. The main reason for the management of the quality of the aquatic, air and noise environments is to maintain the observed water and air quality properly within desirable limit. Most of the aspects of water quality has been covered under the various plan like waste management, muck disposal plan, health delivery system etc. however, some precautionary measures are suggested in following paragraphs.

5.10.2 PROPOSED MEASURES

5.10.2.1 Air Quality

The following mitigation measures for air quality would to be followed during the construction of the project.

- Air quality monitoring at regular interval is required. Detailed budget for monitoring is given in separate chapter of EMP report.
- The contractor(s) will be responsible for maintaining properly functioning construction equipment to minimize exhaust.
- Construction equipment and vehicles will be turned off when not used for extended periods of time.
- Unnecessary idling of construction vehicles to be prohibited.

- Effective traffic management to be undertaken to avoid significant delays in and around the project area.
- Road damage caused by sub-project activities will be promptly attended with proper road repair and maintenance work.
- Pre wetting of the ground to the depth of anticipated cuts should be followed.
- The grading operation shall be suspended when the speed of wind is very high.
- Water shall be applied prior to any land cleaning and on the roads of frequent movements.
- The roads near the residential areas shall be paved or blacktopped.
- All storage piles shall be adequately wetted or covered with plastic to ensure that no visible dust crosses the residential areas.
- Wind barriers of 50% porosity shall be installed three sides of all storage piles.
- All workers must be provided with dust mask

Most of the measures are precautionary while a few are included in the construction methodology. However, financial outlay for the miscellaneous work towards the maintenance of air quality would be **Rs. 13.00 Lakhs** only.

5.10.2.2 Water Quality

The following mitigation measures are suggested to be followed during the construction of the project.

- Water quality monitoring at regular interval would be required for decision making. The provision of budget is given in separate chapter.
- Adequate river water shall be secured to meet the requirements of riparian people, livestock, and wild animals and to sustain the aquatic ecosystem.
- Accumulation of oil wastes in depressions should be minimized in order to avoid possible contamination of the ground water system.
- Surface runoff from oil handling areas/devices should be treated for oil separation before discharge into the river. If oil wastes are combined with sanitary sewage, oil separation will be necessary at the wastewater treatment facility.
- All effluents containing acid/ alkali/ organic/ toxic wastes should be processed by treatment methods. The treatment methods may include biological or chemical processes.

- The impact due to the suspended solids may be minimized by controlling discharge of wastes that contain suspended solids; this includes sanitary sewage and other wastes. Also, all activities that increase erosion or contribute nutrients to water (thus stimulating algal growth) should be minimized.
- For wastes containing high TDS (Total Dissolved Solids), treatment methods including removal of liquid and disposal of residue by controlled land filling to avoid any possible leaching of the fills. All surface runoffs around quarries and excavation areas should be properly channelized and taken care of.
- The growth of aquatic weeds is to be monitored in the reservoir and excess weeds will be removed.
- Fish production in the reservoir will be monitored for any possible decrease. If any unexpected negative impact occurs, fish will be restocked. Technical support will be provided to the fish farming activities in the reservoir.

The budgetary provision has been made under the waste management section of EMP, however, a budget of **Rs. 10.00 Lakh** only is kept for the miscellaneous activities.

5.10.2.3 Noise Level

The following mitigation measures for noise level are suggested to be followed during the construction of the project.

- If construction work occurs within 100-150 meters of a residential area, the work hours should be limited depending on convenience of the local people.
- Depending on market availability, the construction equipment to be used should be designed, with a high quality muffler system
- All stationery noise generating equipment such as air compressor, power generator should be kept away from the residential area.
- Regular monitoring of equipments and vehicles shall be carried out.
- The total sound power level, Lw, of a DG set should be less than, $94+10 \log_{10}$ (KVA), dB(A).
- Noise from the DG set should be controlled by providing an acoustic enclosure or by treating the enclosure acoustically.

- The Acoustic Enclosure should be made of CRCA sheets of appropriate thickness and structural/ sheet metal base. The walls of the enclosure should be insulated with fire retardant foam so as to comply with the 75 dBA at 1m sound levels specified by CPCB, Ministry of Environment & Forests.
- The DG set should also be provided with proper exhaust muffler with insertion loss of minimum 25 dB(A).
- Proper efforts will be made to bring the noise levels due to the DG set outside its premises, down within the ambient noise requirements by proper setting and control measures.
- A proper routine and preventive maintenance procedure for the DG set should be set up and followed in consultation with the DG set manufacturer which would help prevent noise levels of the DG set from deteriorating with use.

All the measures are precautionary, therefore, no special budget has been provided for the maintenance of noise level. It is advisable to the project authorities to appoint an officer, not below the rank of Senior Manager to look after these precautionary measures in and around the project components' area. A total budget of **Rs. 13.00 lakh** is suggested for the monitoring work. It includes salaries and wages of workers for four years. Total financial allocation towards the water, air and noise management would be **Rs. 36.00 lakh** only.

5.11
REHABILITATION & RESETTLEMENT PLAN

5.11.1 INTRODUCTION

There are many linkages between environmental, social, cultural and economic factors, which form an integral part of decision making. A project may affect the society/community positively and/or negatively. When the developmental project is executed, it has impacts on day to day quality of life of people and communities. Socio-economic studies for a developmental project involves a consideration of the impacts on health, livelihood, culture, employment, social structure, services, etc. The Rehabilitation and Resettlement Plan (R & R Plan) is aimed to compensate the society directly or indirectly by providing relief packages, providing employment and by improving infrastructures in the area. Thus, the proposed R & R plan is framed out to minimize the negative impacts of the project, to grant benefits to the project affected families or persons, to compensate the loss of livelihood of people, if any, to consider all cultural, traditional and social aspects and to furnish infrastructure development in the project area. The preparation of R & R plan for Tato-I H.E. Project is more challenging, because the project is located in a tribal area.

In order to provide the best packages to project affected families and to implement a sound developmental plan, Government of India has framed out detailed guidelines in the form of National Policy on Rehabilitation and Resettlement (2007). This is a general policy and is considered across the nation. However, it does not highlight the regional issues, which are relevant to a particular area. Therefore, a few states of India including Arunachal Pradesh where the proposed project is located, have formulated separate policies on Rehabilitation and Resettlement suggesting better packages and addressing regional issues imperatively. The Government of Arunachal Pradesh has issued a new policy named as Rehabilitation and Resettlement Policy of Arunachal Pradesh Government (2008). The guidelines of this policy have been followed in preparing R & R Plan of Tato-I H.E. Project.

The proposed plan for Tato-I H.E. Project has been formulated considering the cascade development. There are two other upstream projects which will be owned by the same agency. Therefore, any repetition in the implementation of R & R plan has been avoided.

5.11.2 GENERAL METHODOLOGY

Because of the absence of land revenue records in the area, the survey was carried out taking into account the community lands. Families belonging to the concerned communities were considered as affected families. The land impacted by the project was ascertained by the project authority and the concerned communities were identified with the help of panchayat members, Gram Budha and local people of concerned villages/areas.

Door to door socio-economic survey of the project-affected families was conducted to collect the base line data which has been used in preparation of the R&R plan. Discussion was held with all project affected families/persons, who have expressed their willingness to accept project. The existing socio-economic profile of the project-affected area has been given in the EIA report chapter 3.6.

A detailed social survey will be performed again during the procedure of land acquisition, and before the time of implementation of the plan in order to have the most up to date information and in order to implement the most targeted and efficient R & R plan.

The Developer has applied to the State Government for acquisition of land and has requested the State Government to conduct a property survey. The procedure for land acquisition will be continued under the exclusive authority and jurisdiction of the State Government.

In any case, the mitigation measures and various compensations under this plan will be applied to all the concerned families whenever their land holdings have been impacted by the Project, whether the rights of the said families over such land are community rights, customary rights over forest or agricultural lands or individual rights.

The ultimate purpose of identifying Affected Families is to properly implement a well targeted Rehabilitation plan properly. The land required falls under two communities on both banks of the Power House site and also under the two directly affected villages on both banks of the intake site, i.e Gapo and Meying villages.

Land of Gapo and Meying villages' areas are also impacted by Heo HEP components and structures but they are considered only under the Tato-I H.E. Project for the purpose of Rehabilitation and Resettlement plan of the EMP. Therefore, the families belonging to the Communities of Gapo and Meying villages and to the Communities holding the land of the power house site (or from whom individual land is to be acquired under the project land requirement, if any) will be considered affected families of the Tato-I H.E. Project.

5.11.3 BRIEF SOCIO-ECONOMIC PROFILE

Tato-I H.E. Project is the most downstream project of a cascade of 3 schemes developed by Velcan Energy Group. The Tato-I H.E Project and its influence area are located partially in Tato circle, and partially in Mechuka circle of West Siang district of Arunachal Pradesh. In this chapter a brief discussion on the socio-economic profile of the influence area, the affected villages and the affected families, which is directly related to Rehabilitation and Resettlement Plan, is given in the following paragraphs. The detailed socio-cultural and economic profiles of the area and the affected families are given in the chapter 3.6 of EIA report.

Influence Area: A total of 19 villages under the jurisdiction of 3 administrative circles Tato, Mechuka and Pidi are located in the influence area (10 km radius) of Tato-I H.E. Project. The total population of the villages of influence area is 2168 belonging to 390 households (Census, 2001). Average sex ratio in these villages is 974. Except Tagurshit, Tadogito villages and Tato Head Quarters all villages are inhabited by Scheduled tribe population (ST). ST population accounts for 97.6% of the total population of the influence area.

Educational infrastructures are poorly developed in the villages of influence area. Nearest centres for secondary education are located at Tato and Mechuka. Average literacy rate in these villages is 45.5%, considerably higher in male population. About 44.5% of the total population is employed in various works, of which 39% are main workers and remaining are marginal workers. The majority of the main workers are involved in cultivation including jhum. Maize, Millets and rice are main crops in these villages.

The villages of influence zone under Mechuka and Tato circles like Rego, Hiri, Gapo, Padusa, Tato, Tadogito and Tato head quarters etc. are connected to the national highway while the villages of Pidi circle like Hirong and Lungte are connected with link road. Most of the villages have facilities of tap water, supplied from springs, though, it is not treated. To avail the facilities of bank, post office, secondary school and primary health facilities, Mechuka and Tato are the main centres in the area.

Affected Villages: Land near four villages, viz. Gapo, Meying, Heyo and Tato village are affected by the various project components the Tato-I H.E. Project. Intake site would be located near Gapo and Meing villages. The proposed power house site is located in community lands near Heyo and Tato villages.

Gapo and Meying villages will also be affected by the implementation of the upstream Heo HEP, as the Heo HEP Power House and the Tato-I HEP intake will share the same site around Meying and Gapo villages. However, Gapo and Meying and their inhabitants will benefit from the R&R Peripheral Plans under the Tato-I HEP only to avoid overlapping and double counts.

The total population of affected villages is 493 and comes from 91 households (Census, 2001). Average sex ratio in these villages is 1037. All inhabitants of the affected villages belong to Scheduled Tribes. Average literacy rate in the affected villages is 40.8%. About 47% of the total population is employed in various works, in which main workers account for 44.6%. The main workers category is dominated with male population while females are predominant in marginal workers category. Most of the population is engaged in cultivation of *jhum*. Maiz, millets, rice and pulses are main crops in these villages. Tato and Gapo villages are located alongside the National highway connecting Aalo and Mechuka. These villages have the facilities of primary education while infrastructure for the secondary education is available at Mechuka. Tato head quarters cater to primary health, telecommunication and market facilities to affected villages. The village areas are not electrified. Inhabitants use spring water, tapped untreated. Transportation facilities are very poor in these villages. The villages are lacking of proper sanitation. The villagers located alongside the roads use LPG while others use fuel wood. Majority of the houses are kachha, made up of bamboo, wooden poles and thatching grasses.

Affected Families: The land to be acquired falls under two Communities on both banks of the Power House site and also under the two directly affected villages on both banks of the intake site, i.e. Gapo and Meying villages. Land of Gapo and Meying villages' areas are also impacted by Heo HEP components and structures but they are considered only under the Tato-I HEP for the purpose of Rehabilitation and Resettlement plan of the EMP. Therefore the families belonging to the Communities of Gapo and Meying villages and to the Communities holding the land of the power house site (or from whom individual land is to be acquired under the project land requirement, if any) will be considered affected families of the Tato-I H.E. Project. A detailed socio-economic profile of the affected families of these Communities is given below.

The 77 households (88 families) belonging to the communities of the two affected villages and the communities holding affected lands of Power House site will be affected due to the implementation of land of the Tato I H.E. Project. Total population of these households is 301 persons with a sex ratio of 846. All households belong to Schedule Tribe category. Average literacy rate in affected villages is 51%. The members of affected families are employed in various works like government services, cultivation, small scale business, and labour work. Nearly a third of the total population comes under the worker's category. The majority of the inhabitants are engaged in cultivation including Jhum. Livestock population of affected families comprises of cows, mithuns, goats, horses, pigs, chickens etc. Mithun, goat, pig and chicken are main source of protein in the area while cows are main source of milk. BPL family members, Scheduled Tribe family members, widows, destitute, and handicapped persons are considered as vulnerable persons. All affected persons belong to Scheduled Tribe while 30 families come under the BPL category. All project affected families are users of fuel wood, supplemented by LPG and kerosene. Nearly 66% and 80% of project affected families of Tato and Gapo villages have access to LPG while only 6% of the families of Heyo village have LPG.

A detailed social survey will be performed again during the procedure for land acquisition, and before the time of implementation of the plan in order to have the most up to date information and in order to implement the most targeted and efficient R & R plan.

5.11.4 AREA OF EXECUTION OF PERIPHERAL DEVELOPMENT

Tato-I H.E. Project is a part of cascade development and is located in between Heo and Tato-II H.E. Projects, thus, a part of the influence area is common in between Tato-I and Tato-II H.E. projects and Tato-I and Heo H.E. Projects. Also, the influence area of Tato-I overlaps with Hirong

H.E. Project. In order to implement an effective R & R plan, the area of execution has been demarcated. The villages that will be considered for the peripheral developmental plan are Gapo, Meying (Mechuka Circle), Pabungying (Pidi circle), Tato village, Heyo, Tagur, Tadogitu and Tato H.Q. (Tato circle). Total population of these villages is 1343, coming from 250 households (Census 2001).

5.11.5 PROPOSED PLAN

The proposed plan is divided into three sections:

- Rehabilitation & Resettlement Plan
- Rights & Privileges
- Peripheral Development Plan

5.11.5.1 Rehabilitation & Resettlement Plan

Resettlement and Rehabilitation package is based on the Rehabilitation and Resettlement policy of Arunachal Pradesh Government (2008) which has been supplemented by National Policy on the Resettlement and Rehabilitation (2007). However the Project land requirement does not require any displacement of families, and therefore the Plan proposed by the Developer involves only Rehabilitation measures.

Such measures aim at compensating the concerned families whenever their land holdings have will be impacted by the Project, whether the rights of the said families over such land are community rights, customary rights over forest or agricultural lands or individual rights. It is to be understood that the various compensations under this rehabilitation plan will be provided in addition to the rightful compensation to be made as per the Land Acquisition Act (1894) under the exclusive authority of the State Government, or any equivalent applicable regulation as the case may be, whenever applicable.

The proposed rehabilitation measures also aim at directly improving the socio-economic situation of the affected families.

5.11.5.1.1 *Definitions*

The various terms which are relevant to the proposed project are described in the following paragraphs. The definition of the various expressions used in this policy is the same as defined under the chapter III of NPRR (2007) except 'community', 'Affected area', "Affected Villages" and 'Jhum'. The definition of the "Affected Families" is also larger in this R&R plan than in the National R&R policy:

- in order to take into account the particularities of the tribal areas of Arunachal Pradesh, the definition includes the families members of a community / clan, in case of acquisition of community land (which belongs collectively to a clan).

(a) *"Administrator for Rehabilitation and Resettlement"* means an officer not below the rank of District Collector or commissioner in a State appointed for the purpose of rehabilitation and resettlement of affected persons.

(b) *"Affected family"* means:

(i) a family whose primary place of residence or other property or source of livelihood is adversely affected by the acquisition of land for a project or involuntary displacement for any other reason or

(ii) any tenure holder, tenant, lessee or owner of other property, who on account of acquisition of land (including plot in the *abadi* or other property) in the affected area or otherwise, has been involuntarily displaced from such land or other property; or

(iii) any agricultural or non-agricultural labourer, landless person (not having homestead land, agricultural land, or either homestead or agricultural land), rural artisan, small trader or self-employed person; who has been residing or engaged in any trade, business, occupation or vocation continuously for a period of not less than three years preceding the date of declaration of the affected area, and who has been deprived of earning his livelihood or alienated wholly or substantially from the main source of his trade, business, occupation or vocation because of the acquisition of land in the affected area or being involuntarily displaced for any other reason.

(iv) Any family member of a community / clan, to whom community land is acquired (case of acquisition of community land, i.e which belongs collectively to a clan).

(v) Any family which is permanent inhabitant of Gapo or Meying Villages for a period of not less than three years preceding the date of declaration under section 4 of the Land Acquisition Act, or any equivalent declaration as per applicable regulations from time to time

(c) *"Affected area"* means area of village or locality notified by the state government under paragraph of 7.2 of the R & R policy of state Government under paragraph 6.1 of this policy;

(d) *"Agricultural labourer"* means a person primarily resident in the affected area for a period of not less than three years immediately before the declaration of the affected area who does not hold any land in the affected area but who earns his livelihood principally by manual labour on agricultural land therein immediately before such declaration and who has been deprived of his livelihood.

(e) "A*gricultural land*" includes lands being used for the purpose of

(i) agriculture or horticulture;

(ii) dairy farming, poultry farming, pisciculture, breeding of livestock or nursery growing medicinal herbs;

(iii) raising of crops, grass or garden produce; and

(iv) land used by an agriculturist for the grazing of cattle, but does not include land used for cutting of wood only;

(f) *"Appropriate Government"* means,

(i) in relation to the acquisition of land for the purposes of the Union, the Central Government;

(ii) in relation to a project which is executed by the Central Government agency or undertaking or by any other agency on the orders or directions of the Central Government, the Central Government;

(iii) in relation to the acquisition of land for purposes other than (i) and (ii) above, the State Government; and

(iv) in relation to the rehabilitation and resettlement of persons involuntarily displaced due to any other .reason, the State Government;

(g) *"BPL family"* The below poverty line (BPL) families shall be those as defined by the Planning Commission of India from time to time and included in a BPL list for the time being in force.

(h) *"Commissioner for Rehabilitation and Resettlement"* means the Commissioner for Rehabilitation and Resettlement appointed by the State Government not below the rank of Commissioner' or of equivalent rank of that Government.

i) *"Family"* includes a. person, his or her spouse, minor sons, unmarried daughters, minor brothers, unmarried sisters, father, mother and other relatives residing with him or her and dependent on him or her for their livelihood; and includes *"nuclear family"* consisting of a person, his or her spouse and minor children.

(j) *"Holding"* means the total land held by a person as an occupant or tenant or as both.

(k) *"Land acquisition"* or *"acquisition of land"* means acquisition of land under the Land Acquisition Act, 1894 (1 of 1894), as amended from time to time, or any other law of the Union or a State for the time being in force.

(l) *"Notification"* means a notification published in the Gazette of India or, as the case may be the Gazette of a State.

(m) *"Occupiers"* means members of the Scheduled Tribes in possession of forest land prior to the 13^{th} day of December, 2005;

(n) *"Requiring body"* means a company, a body corporate, an institution, or any other organization for whom land is to be acquired by the appropriate Government, and includes the appropriate Government if the acquisition of land is for such Government either for its own use or for subsequent transfer of such land in public interest to a company, a body corporate, an institution, or any other organization, as the case may be, under lease, license or through any other system of transfer of land;

(o) "Community" means the residents of a village as a whole, clan, sub-clan or kindred.

(p) "Jhum Land" means jhum land as defined in Section 2(b) of the Balipara/Tirap/Sadiya Frontier Tract Jhum Land Regulation.

5.11.5.1.2 ***Applicable policies***

In addition to the rightful compensation related to the acquisition of Land (Section 23 of Land Acquisition Act and mentioned in Para 7.2.1 of R & R policy of State Government) whenever applicable, the following Rehabilitation and Resettlement Packages are proposed in the applicable policies under discussion, depending on the situation of each family.

(a) Any affected family owning houses and whose house has been acquired or lost shall be allotted free of cost house and a plot for the house site to the extent of actual loss of area of the acquired house but not more than 250 square meter of land in rural area or 150 sq. m. in urban area

or

The family which opts not to take the house offered at the resettlement site, shall get one time financial assistance for house construction and the amount shall be **Rs. 2,00,000/-**

(b) Each BPL family which is without homestead land and which has been residing in the affected zone for a period of not less than 3 years preceding the date declaration of the affected area and which has been involuntary displaced from such area shall be entitled a house of minimum 100 sq. m in rural and 50 sq. m in urban areas

or

The BPL family which opts not to take the house offered at the resettlement site, shall get one time financial assistance for house construction and the amount shall be **Rs. 75,000/-**.

(c) Each affected family owning agricultural land in the affected area and whose entire land has been acquired or lost may be allotted agricultural land or cultivable waste land to the extent of actual lost, subject to a maximum of 1 ha of irrigated land or 2 ha of cultivable unirrigated land

or

Family shall be paid as one time grant of **Rs. 1,75,000/-** per ha. If the family is rendered landless after acquisition, the family shall be paid an extra grant of **Rs. 50,000/-** for one time.

(d) Besides, each of the affected families who are left with less than 1 ha of land after acquisition shall be paid an additional grant of Rs. **40,000/-** In case of allotment of degraded or cultivable waste land, the adult member in the household shall get an amount of **Rs. 25,000/-** per ha for land development. In case of allotment of agricultural land, the adult member in the household shall get an amount of **Rs. 20,000/-** per ha for agricultural production.

(e) **Compensation for trees**: compensations for trees standing on the acquired agricultural land would be payable to the owners families as per valuation done by the State horticulture department.

(f) **Livelihood grant**: (i) The rendered landless family, who has been not provided employment shall get 1000 day minimum agricultural labour wage or **Rs. 1,00,000**/- (ii) The family that is left with less than 1 ha of land after acquisition shall get 750 day agricultural wages or **Rs. 75,000/-**

(g) Each affected person who is a rural artisan, small trader, or self –employed person and has been displaced shall get one time financial assistance of **Rs. 25,000**/- for construction of shop.

(h) **Transportation grant**: Each displaced family shall get financial assistance of **Rs. 20,000/-** for transportation of the household goods, cattles etc.

(i) **Cattle shed grant**: Each displaced family shall get financial assistance of **Rs. 15,000**/- for construction of cattle shed.

(j) **Recruitment and Award of work /skill development:** The companies setting up hydro projects shall reserve the following categories of posts for the local tribal people, subject to the incumbents fulfilling the job requirement and subject to the availability as per the criteria given below

(i) Managerial /Professional post	25%
(ii) Clerical post	50%
(iii) Skilled jobs	25%
(iv) Unskilled jobs	75%

The preferences shall be given to project affected families or local people for jobs and contract etc.

(k) **Subsistence allowances**: Each affected family which is involuntary displaced shall get a monthly subsistence allowance equivalent to 25 day agricultural wages or **Rs. 2,500**/- per month for a period of one year.

(l) **Pension for life to vulnerable person**: A vulnerable person shall get Rs. 500/- per month for life.

(m) **Compensation against Diversions of Unclassified State Forest and Reserve Forest**: 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

Unclassified State Forests (USF) and @ Rs 0.78 Lakhs/Ha from Reserved Forest Land. In addition to this, the community will be paid a sum equivalent to 25 percent of Net Present Value (NPV) of the USF, as decided by the government of India from time to time, in case of diversion of USF as compensation towards extinction of their traditional rights over USF land use. Community land without forest cover and land under WRC (Watershed Research Cooperative) will be paid @ **Rs 1.75 lakhs/ha**. Compensation for crops will be paid @ Rs 1.25 lakhs/ha for land under jhum cultivation and Rs 1.5 lakhs/ha for land under WRC.

(n) **Scheduled Tribe Grant**: Each affected family belonging to Scheduled Tribe shall be compensated with a onetime grant @Rs.50,000/- only

5.11.5.1.3 *Land Requirement*

Total land required for the various components of Tato I H.E. project 52.8 ha, in which 50 ha is surface land and remaining is underground. In the surface land 2.3 ha is river bed. Entire land is categorized as Unclassified State Forest (USF) (Table 5.11.1).

Table 5.11.1 Project component wise break up of land in Tato I H.E. Project

Purpose wise break-up of total land Required for TATO-I HEP					
S No	**Project Component**	**Surface Area (Ha)**		**Underground Area (Ha)**	**Total Area (Ha)**
		Surface Land	**River Bed**		
1	Submergence area	1.2	1.8		3.0
A	**Surface Structures**				
2	Intake complex area	8.2	0.5		8.7
3	Intake Muck Disposal area and construction platform	3.2			3.2
4	Intake Storage and Colony area	1.7			1.7
5	Intake Quarry site	0.3			0.3
6	Power House Area (including penstocks and Tail Race)	8.8			8.8
7	PH Construction Platform and Muck Disposal	3.2			3.2

Purpose wise break-up of total land Required for TATO-I HEP					
S No	**Project Component**	**Surface Area (Ha)**		**Underground Area (Ha)**	**Total Area (Ha)**
		Surface Land	**River Bed**		
8	PH Storage Area, Office and Colony	1.4			1.4
9	PH Quarry Site	0.5			0.5
10	PH Access Road	10.7			10.7
11	Adit Area	1.9			1.9
12	Adit Access Road	6.6			6.6
	Total of surface areas	**47.7**	2.3		50.0
B	**Under Ground Structures**				
13	Head Race Tunnel (including Adits tunnels)			2.8	2.8
	Total	**50.0**		**2.8**	**52.8**

5.11.5.1.4 *Eligible Persons*

Tato-I H.E. Project being the most downstream project of a cascade of 3 projects, the Tato-I HEP intake site is also the site of the immediately upstream Heo HEP Power House, Because of such site sharing between the 3 projects, it is necessary to allocate the different community villages holdings project wise, in order to avoid repetition and wrong double counting.

Therefore, the families from the communities of Gapo and Meying villages (or from whom individual land is to be acquired under the project land requirement, if any) are eligible to the rehabilitation grant only under the Tato-I H.E Project, as provided under by the definition under 5.11.5.1.1 (b). The Families from the two Communities holding lands of the Power site will also be rehabilitated only under the Tato-I H.E Project. Tato-I HE Project does not involve any displacement of family, and therefore none of the concerned families is losing its home. In the same way no family is rendered landless.

Project authorities have decided to consider all affected families for the onetime livelihood grant of Rs 75,000, such amount being equivalent to 750 days of agricultural minimum wage (equivalent to the livelihood grant under to the provision under 5.11.5.1.2.(f)).

In addition, the communities will receive appropriate compensations against the loss of their customary rights on USF land. The summary of land to be acquired and eligible persons is given below:

Total surface land to be acquired	47.7 ha
Total No. of households affected	77
Total No. of family affected	88
Total No. of Scheduled Tribe family	88
Total No. of BPL family	30
Total No of vulnerable persons	7

It is to be noted that the land requirement has been defined based on the latest project features used for DPR and same land details have been submitted in forest application for diversion of forest land. The legal status is given as per the findings of the survey carried out so far.

However the actual and final location of project components, the land requirement and the final ownership status may change as per various future procedural requirements as the requirements of the Techno-Economic Clearance, the assessment of the State Land Acquisition officer (SLAO) and as per the provision of Forest Conservation Act, 1980.

Another property survey will be carried out by the State Government during the land acquisition procedure in order to confirm/update the features and status of the Land required for the Project and number of affected families.

The final actual compensations shall be paid as per the final procedures of the State Government, using the package per family described below.

5.11.5.1.5 *Relief Package*

Relief and rehabilitation package for the affected families for the project affected families are given in Table 5.11.2.

Table 5.11.2 Relief package for the affected families of proposed Tato-I H.E. Project

	Particulars		**Amount (in Rs.)**
i)	Total No. of project affected households	77	
ii)	Total No. of project affected families	88	
iii)	Eligible person family grant	88	
	All Affected Families @ Rs 75,000		**66,00,000**
iv).	Scheduled Tribe Grant	88	
	All Affected families @ Rs 50,000		**44,00,000**
v)	BPL Family grant	30	
	Number of BPL families @ Rs. 75,000		**22,50,000**
vi)	Pension for vulnerable persons		
	Number of Vulnerable persons	7	
	@ Rs. 500 per person per month for lifetime		
	Estimated for 40 years		**16,80,000**
vii)	Free Electricity grant		
	100 units per month for PAFs for 10 year	88	
	No. of families		
	@Rs. 5.00/unit (lump sum rate) (100 x 5 x 99 x 12 x 10)		**52,80,000**
	Grand Total		**202,10,000**

(One crore eighty three lakhs and forty thousand only)

5.11.5.1.6 *Application for Grant and Grant Distribution*

The Deputy Commissioner or his/her representative not below the rank of ADM/ SDM from West Siang district will be the sanctioning authority for the rehabilitation grant, which shall be provided by the project authorities. Each family will be eligible for one package only, and will not be entitled to apply for a package under the Tato-I HEP relief programs if it has already applied for such package under the relief programs of the Heo HEP or the Pauk HEP. Affected family/ persons will apply on a general prescribed format, which will furnish the information of the village, details of community land or individual land acquired, family & community status, and any other document required by project authorities, etc. The form will be submitted to the project office and evaluated by Land Acquisition Officer and General Manager of the Requiring Body. After receiving the list of PAFs by Deputy Commissioner, the options, if any, will be invited from head of the affected family on stamp paper and this will be rooted through SDM concerned. Deputy Commissioner/District

Magistrate shall be the final authority to sort out the disputes between affected families and the project authorities. All stamp duty and fees of registration shall be born by the project developers. After submitting all necessary document R&R cell would disburse the compensatory amount to the affected persons, upon the completion of the land acquisition. If there is any dispute between affected person and the project, Deputy Commissioner / DM can interfere to sort the disputes out.

5.11.5.2 Rights and Privileges – Compensation for USF Community land

In addition to relief packages, the concerned Communities will receive appropriate compensations against the loss of their customary rights on USF land.

The process of community land procurement required by the project authorities will be dealt between requiring body, affected families and Government of Arunachal Pradesh. The Affected families shall be compensated as per the norm of State Government.

In order to compensate for rights and privileges, the tribal communities shall be compensated **@ Rs. 1.56 Lakhs/ha** for the loss of their customary rights and privileges to collect and use forest produce (traditional land use) from unclassified state forests (USF). In addition to this, the community will be paid a sum equivalent to **25** percent of Net Present Value (NPV) of the USF, as decided by the government of India from time to time, in case of diversion of USF as compensation towards extinction of their traditional rights over USF land use. For that purpose, the project developer shall provide a total amount of **Rs. 1,82,62,600** (subject to changes that may occur in NPV rates as per Government of India or in the findings and final results of the application of diversion of Forest under the Forest Conservation Act–1980)**.**

		Area (ha)	**Unit Rate (lakhs)**	**Total (lakhs)**
	a.Land procurement	47.7	1.56	74,412
NPV	b.Dense forest	40.5	9.39	380,295
	c.Degraded forest	3.8	7.3	27,74
	d.Open forest	3.4	7.3	24,82
Total compensation [a. + (b.+c.+d.)*0.25] :				**182,626**

5.11.5.3 Peripheral Development Plan

5.11.5.3.1 *Scope and principles*

Peripheral Development Plan shall be executed by the project authorities for the social upliftment of the local inhabitants and to help them to fulfill their aspirations. Taking the Pauk H.E. project and Heo H.E. Project into consideration, the proposed plan will be preferably implemented in 7 villages as listed under paragraph 5.11.4 of this chapter.

The project authorities directly as well as through their contractors would ensure that local population gets good number of jobs. The jobs, however, would be determined by the qualifications and experience of the persons wanting to be employed. It will also provide an opportunity to many unskilled youth to become skilled. By gaining technical knowledge and experience, their chances of gainful employment will be greatly enhanced. By enhancing the local people's skills and opportunities for employment, the project would result in uplifting the standard of living and the existing quality of life of the local inhabitants. This would go a long way in making the area economically self-sustaining.

Besides generating local employment for the skilled and un-skilled labourers, the project would also provide an opportunity for the local people to compete for various contracts related to project works, depending on their economic status. The participation in this process would, however, be guided by the usual process of tendering. The project authority would ensure as far as possible, to engage local labourers in various skilled/non-skilled jobs depending on a candidate's qualifications and experience. In addition, local people would be beneficiaries of the following facilities, established in the periphery.

The area is poor in the education facilities. The project authorities would establish educational institutions in the area for the children/wards of their project employees. At some places, grants would be provided for the maintenance and upgrade of existing educational institutions which would be a great benefit for the local residents. The project authorities would establish healthcare facilities in terms of healthcare centres and primary health centre at a few affected villages and for their employees. These centres shall extend services to the local people. Project authorities would provide mobile vans for emergency services in the area.

The project authorities would construct and establish club/playgrounds for the project employees/ sports competitions and sports meets would be organized between the local players and project employees which would ensure the local participation. This will also provide them with the necessary facilities for excelling in sports of their choice. These facilities would go a long way in honing and nurturing the local talents in the field of sports and competitive games.

In addition to education, health and sports facilities, the requiring body would play a vital role in strengthening the communication and transportation facilities. The various other programmes like skill up gradation, merit scholarship programme, training programme etc. will be run in the area. Provision of green belt in the periphery of the reservoir, landscaping and establishment of botanic gardens will enhance the scenic beauty and tourist spots of the area and attract the local and outside tourists. The influx of outside labourers would provide fair possibilities of marketing and small scale business in the area. These activities would add surplus income of local inhabitants.

5.11.5.3.2 *Grants for Peripheral Development*

(i) ***Merit Scholarship Programme***

This programme follows the clause 7.13.1(c) of NPRR, requiring body shall offer scholarships and other skill development opportunities to the eligible persons from the families of influence area per the criteria fixed by the appropriate Government. To improve and encourage the literacy and educational standards in the project affected area and to create a pool of potential candidates, Requiring Body is suggested to introduce a Merit Scholarship Scheme for the wards of the inhabitants of influence zone. The wards of the project affected families will be given preference. The wards should be studying in school, college or any other educational institute recognized by State or Central government or a reputed private institution. The students should not be receiving any other scholarship of State and Central governments.

A total of 10 students (preferably from the 250 households of the selected villages, as discussed above under paragraph 5.11.4) every year will be selected for the scholarship on the merit basis. The scholarship would be divided on the basis of standards and disciplines, viz, senior secondary school (3 students), vocational training (3 students), diploma (2 students) and Degree in science, engineering, medical etc. (2 students). The scholarship for an individual will last for the tenure of course. The scholarship @ Rs.1000/-, Rs.1500/-, Rs.2000/- and Rs.2500/- per month would be provided to the students of secondary school, vocational training, diploma and degree, respectively. The project authorities are suggested to run this scheme at least for 5 successive years. After completion of the scheme, Requiring Body reserves the right to restart or terminate this scheme.

The eligible students may apply for the grant of scholarship as per the format given by the project authorities (Annexure III). The amount of the scholarship shall be released on a half-yearly basis. The submission of application for scholarship shall not guarantee the grant of scholarship. Requiring body management shall reserve the right to accept or reject any or all application without assigning any reasons. Requiring Body also reserves the right to reduce/ increase the number of beneficiaries or change the number of beneficiaries in different standards depending upon availability of the students.

Duly completed application form should be submitted along with attested copies of marks sheets of previous annual examinations, certificates of domicile or land acquisition from LAO, as the case may be, and two passport size photographs attested by the principal/head of the institute. Total budget for the Merit scholarship including increment would be **Rs. 30.00 lakhs**.

(ii) ***Training Programme***

Following the clause 7.13.2 of NPRR, the affected persons shall be offered the necessary training facilities for development of entrepreneurship, technical and professional skills for self-employment. Training on the mushroom cultivation, computer courses, apiculture, vermiculture, eco-tourism, poultry farming, dairy farming, knitting, sewing etc. could open new areas of self employment in the region.

Requiring body would invite trainees among the affected families for the training on various courses. The requiring body would select 10 trainees every year for the period of 5 years (training period for a batch is one year). If the applicants are not available among the affected families the training programme can be extended to the affected villages and/or villages located in the 10 km radius as described above. The applicants can obtain application form at no cost from the office of requiring body. Applicant would submit application form along with certificate of domicile or certificate of land acquired, as the case may be, from the LAO (Land Acquisition Officer) of Requiring Body, income certificate from DC/SDM/, certificates of educational qualification, caste certificate issued by an officer not below the rank of executive magistrate and verification certificate of the concerned Gram Pradhan/Panchayat member. The scheme is only a welfare measure for the PAF's and inhabitants of the influence area, it does not confer any right on the PAF's for financial assistance. If the requiring body is not able to develop all infrastructural facilities for all the training programmes, it may consult the concerned department of the state to facilitate training to the applicants. The requiring body would bear all expenditure including accommodation, travel etc. of the trainees and charges of the concerned department. Total financial out lay for the training programme would be **Rs. 18.00 lakhs** (@ Rs. 3000/- per month for a trainee).

(iii) ***Education Facilities***

The area is poor in having the education facilities. Two primary schools are proposed under the Heo HEP. A middle school is already proposed at one of the 9 selected villages under Tato-II HEP, the project authorities will select a village for the middle school, which is not covered under the same scheme of Tato II H.E. Project. Also, the selected village must be located at the central place. The school will be operated by the concerned department of the State Government. The project authorities would provide all the infrastructure, salaries and maintenance grant for the school for at least five years. The land for the school buildings would be provided by the State government. After five years, the funding of the school will be handed over to the state Government, if requiring body desires. In addition to the establishment of a new school, requiring body would provide the funds for strengthening of existing schools. Total budget for the proposed school including buildings, salaries and maintenance would be **Rs. 106.00** lakhs. The break up of the budget is given below

	Components	**Amount (in lakhs)**
A.	Salaries/wages	
	Middle School teacher (No. 06) (Basic pay @ Rs. 11,170/ pm + Annual increment)	40.00
	Peon (No. 01) (Basic pay Lump sum @ Rs. 9000/- + Annual increment)	6.50
Sub-total A		**46.50**
B.	School buildings (1 Middle School)	15.00
C.	Play ground	2.00
D.	Maintenance grant	7.50

E.	Miscellaneous grant	10.00
F.	Budget for strengthening the existing schools	25.00
Total A+B+C+D+E+F)		**106.00**

(iv) ***Communication Facilities***

The entire region is poor in telecommunication facilities. The provision of telecommunication facilities would play a significant role in the infrastructure development in the region. Communication facilities include ground based T.V. towers, ground and rooftop cell phone towers. In order to strengthen the communication facilities, the project authorities would establish the telecommunication infrastructure at the central place, considering the Heo and Pauk H.E. projects. After five years, these infrastructures would be handed over to Central Government, thereafter, Central Government would maintain these facilities. The total budget for the communication facilities would be **Rs. 300.00** lakhs. The break-up of the budget is given below. Project authorities are suggested to establish all equipment in such a manner that it could cover entire area.

Particulars	Amount (Rs. in Lakhs)
Ground based T.V tower (including maintenance grant)	150.00
Ground and Rooftop cell phone towers (including maintenance grant)	150.00
Total	**300.00**

(v) ***Transportation Facilities***

The transportation in the region mainly depends on the light vehicles, which ply generally in the morning and evening hours. Tato and Mechuka are central places, where inhabitants require access for daily needs, health and education facilities. The project authorities will provide one bus on Tato – Mechuka highway. This facility would be provided at least for five years. Total budget for the purpose would be **Rs. 75.00 lakhs**. It includes running cost, salaries and cost of bus.

(vi) ***Adoption of a village***

In order to establish harmonious relationship between project authorities, State Government and local people, requiring body would adopt a village as a model. The selection of village will be decided by the project authorities in consultation with State government, considering the same plan of other upstream and downstream projects. It should be one of the 7 villages, mentioned above (preferably Gapo, Meying, Quying, Pabungying, Tadogitu, Heyo). The village would have school, health, telecommunication, water supply, sanitation, road or footpath facilities. Also, the activities of landscaping and beautification will be carried out in the adopted village. Total budget for the adopted village would be **Rs. 101.00 Lakhs**. The break up of the budget is given below:

Particulars	**Amount (in lakhs)**
School (already exist or proposed above)	-
Health centre (proposed in Health Delivery System)	00.00
Sanitation (toilet and bathroom at each households for 30 households)	15.00
Construction of *Pucca* houses	40.00
Construction of footpath (lump sum)	4.00
Electrification (at each house holds and street light)	9.00
Water supply (each household will be connected to tap water	15.00
Provision of dust bins	2.00
Community hall	2.00
Plantation	2.00
Beautification	2.00
Miscellaneous budget	10.00
Total	**101.00**

(vii) ***Construction of Rain shelters and Footpath***

Requiring body shall provide rain shelters along Tato-Gapo road for 11 km. The remaining stretch will be covered under the peripheral developmental plan of Heo and Pauk H.E. projects. The area is sparsely populated and there are no other means for the purpose. About 11 rain shelters are proposed along side the road. In addition, to provide easy access to the road, *pucca* footpaths from village to nearest road are also proposed. The villages like Quying, Pabungying, Tadogitu, Heyo would require footpaths (average 5 km each). Total length of footpath to be constructed is estimated to be 20 km. The cost of footpaths is calculated to be **Rs. 27.00 lakhs** only. Total budget for rain shelters and footpath is estimated to be **Rs. 35.00 lakhs** only.

(viii) ***Provision of Sanitation Facilities***

Each household of the selected villages as under para 4 above shall be provided with toilet set and bathroom. Taking the decadal growth rate into consideration, this facility would be facilitated for nearly 313 households (Total households are 250 as per Census 2001). Total budget for the sanitation would be **Rs. 117.40 lakhs** (@Rs. 37,500/set).

(ix) ***Skill Upgradation for Handicrafts***

Local inhabitants are very good weavers and are very fond of handicraft which can be seen in their cane and bamboo works like baskets, trays, hats, mats and headgears. Though, due to lack of market facilities and proper training, it could not be developed as a business. The project authorities can provide training programmes towards skill upgradation and market strategy. Total budget under this head would be **Rs. 10 lakhs** only. This programme would cater to the villages located in the vicinities of Tato I, Heo and Pauk H.E. Projects.

5.11.5.3.3 *Financial Outlay*

Total financial outlay for the peripheral development is Rs. 792.40 lakhs. The break up of the financial outlay is given below.

S.No.	Heads	Amount (Rs. in Lakhs)
i).	Merit Scholarship Programme	30.00
ii).	Training Programme	18.00
iii).	Education Facilities	106.00
iv).	Communication Facilities	300.00
v).	Transportation facilities	75.00
vi).	Adoption of a village	101.00
vii).	Construction of Rain shelters and Footpath	35.00
viii).	Provision of Sanitation Facilities	117.40
ix).	Skill Upgradation for Handicrafts	10.00
	Total	**792.40**

5.11.6 MONITORING & EVALUATION

The land and compensation related issues are generally critical and become the matter of disputes. Therefore, in order to sort out these issues an independent committee is required for evaluation and monitoring, especially the Rehabilitation and Resettlement Plan. The State Government shall constitute a standing Rehabilitation and Resettlement Committee under the chairmanship of the Deputy Commissioner of the respective district to monitor the progress of

Rehabilitation and Resettlement plan. The composition, powers and function and other matters relating to the functioning of Rehabilitation and Resettlement Committee shall be prescribed by the State Government. Any affected person, if aggrieved, for not being offered the benefits admissible, may move a petition for redress of his/her grievances arising out of the matters covered under the policy. Any disputes related to the compensation will be disposed of as per applicable rules. The proposed R & R committee would comprise of the following members

i)	Deputy Commissioner, West Siang District	Chairman
ii)	Managing Director, Siyota Hydro Power Pvt ltd	Member
iii)	General Manager (Project), Siyota Hydro Power Pvt ltd	Member
iv)	Head of R & R Cell (Project), Siyota Hydro Power Pvt ltd	Member Secretary
v)	A representative from Corporate Finance Dept.	Member
vi)	Head, Corporate Social Responsibility Cell	Member
vii).	Panchayat members of affected villages	Members
viii).	Woman (social worker) from the affected area	Members
ix).	Representative of well known NGO in the area	Member

The financial budget for the day to day expenditure of the committees would be **Rs. 30.00 lakhs** only.

For the effective implementation of R & R plan and peripheral development plan project authorities are advised to constitute Rehabilitation & Resettlement Cell (R & R Cell) of project and Corporate Social Responsibility Cell (CSRC). R & R Cell will be responsible for the effective implementation of R & R plan and rights and privileges issues while CSRC will take the responsibility of peripheral development. Both will assist Rehabilitation and Resettlement Committee in the monitoring and evaluation.

5.11.7 TOTAL BUDGET

Total budget for the Rehabilitation and Resettlement Plan and Peripheral Development Plan would be **Rs. 1207.12 Lakhs** (One thousand, two hundred, twenty seven lakhs and twenty one thousand only). The break up of budget is given below.

S.No.	Plan	Amount (Rs. in lakhs)
i).	Rehabilitation & Resettlement Plan	202.10
ii).	Rights and Privileges	182.62
iii).	Peripheral Development Plan	792.40
iv)	Monitoring and Evaluation	30.00
	Total	**1207.126**

5.11.8 DEVELOPER MESSAGE

The Tato-I H.E. Project is a midsized Run-Off-the River HEP, which involves only a small pond and a small submergence area. The Project does not require any displacement of people. The Tato-I H.E. Project has been developed right from the beginning with the cooperation of local inhabitants on the field investigations and feasibility studies, and compensations and benefits have been allocated through sponsoring, welfare activities and employment even before the start of Project construction.

Due to a very small submergence area (3 ha including 1.8 ha of river bed, being a net submergence impact of 1.2 ha) and a small land requirement (net surface land impact 47.7 ha), the Tato-I H.E Project is having a small impact on local inhabitants, and the number of Project Affected Families remain very low (88 estimated families). A total budget of **Rs 1207.126 lakhs** has been located for Rehabilitation measures, Rights and Privileges, Peripheral Development Plan and Monitoring (do not include the compensations per the Land Acquisition Act, which will be paid in addition whenever applicable).

5.12
DISASTER MANAGEMENT PLAN

5.12.1 INTRODUCTION

Disaster Management Plan is refers here to the mitigation measures as a result of failure of dam/barrage/weir. The failure of such structures are due to natural events like catastrophic flood, therefore, pose poses serious threat to life and property, located downstream from the dam structure. However, failure of dam (barrage) is a low risk but high impact hazard as they do not occur often but can be extremely catastrophic if occurred. The catastrophic natural events can not be controlled but quality of relief efforts can be improved by an effective use of the available technical resources. The time, quality and quantity of resources are important factors while formulating an effective disaster management plan. Using these factors in a well planned manner, disaster managers can control the damages as result of failure of these structures.

The Tato-I H.E. Project envisages the construction of 7.5 m weir across the river that would create a small pond behind the weir. Due to small structure, the requirement of a dam break modeling could not be realized. However, a disaster management plan has been prepared in the condition of failure of weir. If the water level rises above the weir top, and weir begins to fail, it may be considered as a flooding condition. Information of this scenario should be immediately passed on to the project head office and the district administration.

5.12.2 TATO-I WEIR & HYDROLOGY

The river is called as Barpu Sikyo in the head water region of the catchment. Barpu Sikyo is joined by large numbers of the snow fed, spring fed, glacial fed and seasonal rivers. These streams flow in the elevational region between 4000 to 4430 meters above the sea level (m a.s.l). The headwater region of the Yarjep River is snowfed and springfed stream and its headwater region is covered with thick forests. It originates from the region above 4000 m a.s.l. Yarjap chhu is a spring fed, snow fed and lake fed river. Some of the tributaries on the left bank of Yarjep chu are Lungkhor Dem, Sheshirong Ishi, Netsrang Gongphu Chhu, Nangso Sokang, Gaptse Chhu, Endashokong, Nyangapa rang, Teden, Chanajung, Dutangphu Chhu, Dohak Sokang and Dasong Siding. Some of the tributaries along the right bank of Yarjep chu are Bum Chu, Segang shuru, Jenrang, Enda Sokang, Shuru Phujo, Tamding Phujo, Tachenpaogo Sokang, Kangdang Sila, Siligomang, Kartesho Kong, Namrangong, Ering Sokang and Sae Chhu.

The total annual inflow rate in the Tato-I H.E Project site during June 1978 to May 1994 and June, 2000 to May, 2009 water years is presented in Chapter 3.3 EIA volume. In most of the years, the annual inflow shows above 2000 Mcum. The maximum inflow of 3960 Mcum recorded in the year 2007-08, while the minimum of 2343 Mcum was recorded in the year 1992-1993. The salient features of weir and its components of Tato-I H.E. Project is given in Table 5.12.1.

Table 5.12.1 Salient hydrology and flood features of Tato I H.E. project in West Siang district of Arunachal Pradesh

HYDROLOGY		
Catchment area at dam site	:	1154 sq km
Design Flood	:	3400 cumecs
SPILLWAY		
Design Flood	:	3400 cumecs
NO RESERVOIR		
INTAKE		
Number of Intakes	:	1 no.
Type	:	Trench weir intake coupled with Heo PH outlet
Length	:	55 m
Design discharge of transverse intake (max)	;	10 cumecs
Total design discharge	:	133 (130.2 from Heo + 2.8) cumecs

5.12.2.1 Other Hydro Projects on Yarjep River

There are 6 more HE proposed projects upstream of the Tato-I H.E. Project on Yarjep River. Tato-I H.E. Project proposes 7.5 m high weir. Weir failure is a catastrophic event which is most-unlikely to occur. The standard project flood at weir site is estimated to be 3400 m^3/s. In case of weir failure the immediate downstream H.E project that will be affected is the proposed Tato-II H.E project. The spillway of Tato-II has a capacity of 7985 cumec, which is large enough to hold the capacity of 5400 cumecs (estimated SPF of 3400 cumecs and 2000 cumecs from the small pond of Tato-I HEP). Thus, the downstream project Tato II has sufficient capacity to hold the water discharge after failure of Tato I, however, a proper coordination between the two projects is required. The proposed disaster management plan has been formulated in purview of weir failure of Tato I and its effect on downstream project.

5.12.3 PROPOSED PLAN

5.12.3.1 Prevention

Due to the uncertainty always existing about the reliability of hydrological records, the surveillance and monitoring of dam safety measures becomes a major constraint, especially in estimating and formulating the minimum standard of protection. In such a case disaster prevention is needed and therefore following measures are taken for the disaster prevention.

5.12.3.1.1 *Surveillance*

The surveillance and monitoring programs are required to be implemented and incorporated during design and investigation phases, construction, early operation period and operation and maintenance phases of the life cycle of the weir. In the surveillance system an effective flood forecasting system must be established with hourly gauge reading at suitable upstream locations with real time communication capability. An effective weir safety surveillance, monitoring and observation along with periodic inspection, safety reviews and evaluation must be put in place. This needs to be in optimum functional during the monsoon season. In order to create such a facility we propose a total financial outlay of **Rs. 4.00 lakhs**.

5.12.3.1.2 *Infrastructural Development*

The essential infrastructures such as existing network of hydro-meteorological stations and rainfall and stream gauging stations need to be upgraded and modernized. For this purpose a financial allocation for the infrastructure development is kept at **Rs. 8.00 lakhs**.

5.12.3.1.3 *Preventive Action*

Once the likelihood of an emergency situation is foreseen, action has to be initiated immediately to prevent a failure. The point at which each situation reaches an emergency level, shall be specified and at that stage the vigilance and surveillance shall be upgraded. At this stage, a thorough inspection of the weir shall be carried out to locate any visible signs of distress.

The anticipated need of equipment shall be evaluated and if these are not available at the intake site, the exact locations and availability of this equipment shall be identified. A plan shall be drawn on priority for inspection of the weir. The weir, its sluices and non-overflow sections would be properly illuminated.

5.12.3.2 Preparedness

5.12.3.2.1 *Emergency Action Plan*

An emergency is defined as a condition of serious nature which develops unexpectedly and endangers downstream property and human life and requires immediate attention. Emergency action plan shall include all the potential indicators of likely failure of the dam, since the primary concern is for timely and reliable identification and evaluation of potential emergency. This plan presents warning and notification procedures to be followed in case of potential failure of the weir. The purpose is to provide timely warning to nearby residents and alert key personnel responsible for taking action in case of an emergency.

5.12.3.2.2 *Administrative and Procedural Aspects*

The Administrative and procedural aspects of emergency action plan consists of a flowchart depicting the names, addresses and telephone numbers of the responsible and coordinating officials. In order of hierarchy, the following system will usually be appropriate. In the event of potential emergency, the observer at the site is required to report it to the Engineer-in-charge through a wireless system, if available, or by the fastest communication system available. The Engineer-in-charge shall be responsible for contacting the Civil Administration, *viz*. Deputy Commissioner.

Each person involved with the emergency plan would be made aware of his/her responsibilities/ duties and the importance of work assigned under the Emergency Action Plan. All the villages falling under the flood prone zone or on the margins would be connected through wireless communication system with backup of standby telephone lines. A centralized siren alert system would be installed at all the Village Panchayats so that in the event of a warning all villagers can be alerted through sirens rather than informing every body through messengers which is not feasible in such emergency situations. A financial allocation of **Rs.8.00 lakhs** has been made in the project cost for setting up of emergency control room and installation of siren/hooter alert systems at various locations.

5.12.3.2.3 *Communication System*

An efficient communication system and a downstream warning system are absolutely essential for the success of an emergency plan especially when time is of great essence. The difference between a high flood and a dam break situation shall be made clear to the downstream people in advance through awareness programmes. All the villages falling under the flood-prone zone or on the margins are required to be connected through wireless system backed by stand-by telephone lines. A centralized siren system is to be installed at Panchayats so that in the event of a warning, all the villagers will be informed.

i) ***Merits of Satellite Communication System***

Keeping the disaster scenario in mind, any terrestrial system such as land lines or even cellular towers, etc. are likely to be the first casualty in earthquakes or floods. The restoration of such systems is time consuming. Moreover, the maintenance of such lines becomes a great problem in emergency even for the technical personnel who are required to reach the site of fault, which may be struck by the disaster. The system, therefore, cannot be made operational soon enough. The fault repairs and restoration of communication services are usually not possible for a considerable period of time after the calamity has struck. Moreover, it is critical that the communication systems are restored at the earliest so that relief/medical teams and other personnel can be arranged at the earliest possible time. All the subsidiary help depends solely on the communication system. As this criterion is paramount, existing systems such as telephones and telex, etc. are practically of little use in case of such events and situations. Similarly, microwave links are expected to be down due to collapse of towers, etc. Restoration of towers and alignment of equipment is again a time consuming activity.

Keeping in view the urgency of services and their dependability during emergency relevant to the disaster conditions, satellite based systems present an ideal solution. The satellite based system usually comprises following components.

i) A small dish of approximately one meter diameter

ii) Associated radio equipment

iii) A power source

The deployment of the system is not dependent on the restoration of land routes. The existing satellite based communication systems are designed in such a manner that they are able to withstand fairly high degree of demanding environmental conditions. Secondly, the restoration of the satellite based system can be undertaken by carrying maintenance personnel and equipment by helicopters at a very short notice. Even the fresh systems could be inducted in a matter of an hour or so because most of these are designed for transportability by air. The deployment takes usually less than an hour. The power requirements are not large and can be met by sources such as UPS/batteries/ generators. Satellite phones are the other option that could prove very useful for such situations and must be considered by the project authorities as critical to their operations.

ii) *Financial Outlay for Installation of a Satellite Communication System*

The cost of deployment and maintenance of a telecommunication system in disaster prone areas is not as important as the availability, reliability and quick restoration of the system. The cost of both satellite bandwidth and the ground components of the satellite communication system has been decreasing rapidly like that of V-SAT (Very Small Aperture Terminal) based systems supporting a couple of voice and data channels. Some highly superior communication systems in VSAT without time delay are marketed by National agencies like HECL, HFCL and HCL Comet. There are two different types of systems with the above mentioned capabilities available in the market *viz*. SCPCDAMA and TDMA. However, the first one named SCPCDAMA has been recommended for Tato-I H.E. project. In all three projects, such systems would be installed at different sites in the area. The estimated cost of installation of such a communication system has been given in Table 5.12.2.

Table 5.12.2 Estimated cost of satellite communication system

Sl.No.	Product	Amount (Rs. in lakhs)
A.	Setting up of V-SAT communication system	
1.	Product Name : SCPCDAMA (2 sites) @ Rs.19.00 lakhs per site a) Antenna 2 x 2.4 M b) RF 2 x 2 W c) Modem 2 x 1No.	38.00
2.	Generators 2 Nos. (2 KVA)	4.00
3.	UPS 2 Nos. (2 KVA)	2.00
4.	Installation and maintenance of system, maintenance and running cost of UPS, generators, etc. @ 10% of the total cost for 7 years	31.00
	Total	**75.00**

5.12.3.3 Response and Recovery

5.12.3.3.1 *Evacuation Plans*

Response and recovery includes evacuation plans and procedures for implementation based on local needs. These are :

- Demarcation/prioritization of areas to be evacuated.
- Notification procedures and evacuation instructions.
- Safe routes, transport and traffic control.
- Shelter areas
- Functions and responsibilities of members of evacuation team.

The flood-prone zone in the event of weir break of the proposed Tato-I H.E project shall be marked properly at the village locations with adequate factor of safety. As the flood wave takes sufficient time in reaching these villages, its populace shall be informed well in time through wireless and sirens, etc. so that people may climb uphill or to some elevated areas beyond the inundation zone which has been marked previously.

The Evacuation team would comprise of :

i) D.M/or his nominated officer (To peacefully relocate the people to places at higher elevation with the help of state administration)

ii) Engineer-in-Charge of the Project (Team Leader)

iii) S.P./or his Nominated Police Officer (To maintain law and order)

iv) C.M.O. of the area (To tackle morbidity of affected people)

v) Sarpanch/Village Headman/Gram Budha of the affected villages to execute the resettlement operation with the aid of state machinery and project proponents

vi) Sub-committees at village level

The entire evacuation team will be well equipped with rescue team, medical team, medicines, emergency vans, boats, and other means of transport. The Engineer-in-Charge will be responsible for the entire operation including prompt determination of the flood situation from time to time. Once the red alert is declared the whole state machinery will come into full swing and will start evacuating people in the inundation areas delineated in the inundation map. For successful execution demo exercise will be carried out, annually. The district magistrate will be the nodal officer to monitor the entire operation. Total financial outlay for the recovery, evacuation and rescue operation has been kept at **Rs. 16.00 lakhs**.

5.12.3.4 Mitigation and Rehabilitation

In event of a weir break, project authorities would provide adequate relief and resettlement package to the inhabitants of the flood affected areas against the loss of life (livestock) and property. The package includes the cost of accommodation, sustenance grant, livelihood grant, medical grant and rights and privilege grant on forest resources during the crisis period. Considering the number of villages located in the downstream flood prone areas, an allocation of Rs. **8.00 lakhs** has been made in the project cost.

5.12.3.5 Notifications

In emergency action plan Notification procedures are an integral part of any emergency action plan. Separate procedures shall be established for slowly and rapidly developing situations and failure. Notifications will include communications of either an alert situation or an alert situation followed by a warning situation. An alert situation will indicate that although failure or flooding is not imminent, a more serious situation can occur unless conditions improve. A warning situation will indicate that flooding is imminent as a result of an impending failure of the weir. It will normally include an order for evacuation of delineated inundation areas. For a regular watch on the flood level situation, it is necessary that two or more people manage the flood cell so that an alternative person is available for notification round the clock.

In addition, a few guidelines to be generally followed by the inhabitants of the flood prone areas, which form part of public awareness for disaster mitigation include:

- Listen to the radio for advance information and advice.
- Disconnect all electrical appliances and move all valuable personal and household goods and all clothing out of reach of flood water (in case there is time on hand).
- Move vehicles, farm animals and movable goods to the highest ground nearby.
- Move all dangerous pollutants and insecticides out of reach of water.
- Do not enter flood waters on foot, if it can be avoided.

Total budget for the notification and publication procedures would be **Rs. 16.00 lakhs**. In addition, **Rs. 8.00** lakhs has been kept for miscellaneous expenditure.

5.12.4 COST ESTIMATES

The estimated total cost of execution of disaster management plan including the equipment would be **Rs. 143.00 lakhs** and it is given in **Table 5.12.3**.

Table 5.12.3 Cost estimates of disaster management plan of Tato-I H.E. Project

Particulars	**Total cost (Rupees in lakhs)**
Surveillance and monitoring	4.00
Infrastructure development for prevention	8.00
Administrative and Procedural Aspects	8.00
Communication System	75.00
Recovery, Evacuation and rescue operation	16.00
Mitigation and Rehabilitation	8.00
Notification and Public awareness	16.00
Miscellaneous	8.00
Total	**143.00**

5.13
GOOD PRACTICE

Safeguard and precautionary measures can play a vital role in protecting the environment and social values in and around the project. There are a large number of small but important issues, for which separate management plans are not prepared. Such types of measures are included in good practice. Also, the various mitigation measures suggested in the EMP report can be supplemented and strengthened through good practice. These measures are helpful not only in maintaining a sound environment but maintaining a harmonious relationship between project authorities and local inhabitants.

5.13.1 Environmental Training for the Project Workers

Project authorities and contractors would prepare a training plan to their workers emphasizing the work scenario, importance of environmental conservation and social values of the area, maintaining a good relationship with local inhabitants, waste management, health care, use of explosive, chemicals and other equipment.

5.13.2 Rules and Guidelines

The project authorities would issue guidelines related to the environment protection and social relation in the area. There must be provision of penalties on violation of rules and guidelines.

5.13.3 Awareness Programme

Project authorities would organize awareness programmes regarding the values environment and society and their role in the development of project. The workers of project and local people would participate in the programmes. The awareness programmes would be run though workshop, pamphlets, posters and volunteers.

5.13.4 Conservation of Biodiversity

Project authorities and contractors would take the responsibility of their workers not to damage the forest and streams, not to be involved in forest firing, fishing, poaching and hunting. A detailed guideline would be issued by the authorities to the workers. All workers must be provided with an identity card, and should not be allowed in the forest areas without permission or/and any valid reason. There should be provision of rules and penalties.

5.13.5 Waste Management

The project authorities would ensure the maintenance of surface water quality and terrestrial ecosystem. Open defecation alongside the roads, river and improper dumping of garbage would be strictly prohibited. Authorities would deploy a few persons among the labourers at various sites to monitor these issues.

5.13.6 Health Aspects

Project authorities/contractors shall follow a strict quarantine procedure for their labourers coming from outside. Each labourer should pass through a proper check up to avoid any possibility of spread of communicable diseases. In addition, the workers involved in excavation, tunneling, dumping etc. activities should be provided with breathing masks. All safety measures for the workers should be strictly followed. All workers must be registered under the contractor or project authority with their full address. During the appointment in the project, he/she must pass through proper checking.

5.13.7 Social Aspects

There is always a possibility of cultural confliction between locals and migrants. To avoid any confliction due to culture, social evils etc. suitable measures will be taken by the project authorities. There should be a clear demarcation of the project construction area. All project workers must be provided with identity cards by contractors or project authorities. The workers should not be allowed access to villages or forest area without permission or/and without valid reason. There should be provision of rules and penalties.

5.13.8 Storage, Handling and Emergency Response for Hazardous Chemicals and Explosives

There should be a proper management for the storage of hazardous chemicals and explosives. The storage of fuel, oil and chemicals should not be permitted within 100 m of river water. In case of an accidental spill overflow, release of fluid occurs into the stream open surface, emergency measures should be followed by the contractors and project authorities. There will be appropriate rules and regulations and penalties towards the misuse of chemicals and explosives.

5.13.9 Cultural Meet & Renovation of Cultural Sites

Project authorities shall organize cultural meet at least once a year. Also, financial help will be provided for the local festivals in the area. Project authorities would take care of cultural sites in the area.

5.13.10 Establishment of Creche

It was observed that labourers do have their families, stationed alongside the road. Their infants do not have facilities of nursery and primary education. Therefore, project authorities are suggested to open creches to look after and to educate them.

5.13.11 Videography

It was observed that people were concerned about the blasting operation in the tunnels, which leads to vibration and cracks in the houses and damage the natural springs lying on the HRT alignment. Though there are not much *pucca* houses along the HRT alignment, however, project authorities are suggested to conduct videography of all houses and natural springs fall near the HRT prior to the construction works. If such types of adverse impact would occur during the construction phase the project authorities would provide the compensation.

5.13.12 Control on Non-biodegradable Wastes

Adequate measures for the collection, reuse and refuse of non biodegradable waste have been suggested in the Waste Management Plan. However, regular monitoring of disposal of plastics carry bag is required around the project working sites. There will be ban on the use of plastic carry bags in shops within project area. In addition, awareness programme would also take this issue into account.

5.13.13 Public Relation Cell

Project authorities would open a public relation cell to sort out the complains of locals towards workers, activities, etc. It would be helpful in maintaining the harmony between project authorities and locals.

The project authorities would establish their Environment Cell and Corporate Social Responsibility cell. All the good practices will be executed and monitored by Environment Cell and Corporate Social Responsibility Cell. There is a provision of total Budget of **Rs. 25.00 lakhs** to implement the good practice in the area.

5.14
IMPLEMENTATION AND MONITORING PROGRAMME

5.14.1 INTRODUCTION

Various mitigation measures suggested in the EMP report would rely on the most effective implementation and monitoring programme. The implementation programme addresses the issues of schedule of execution, responsibility and accountability while monitoring programme highlights the role of independent and project level monitoring committees. Various departments and agencies in the project authorities and in the State government have been suggested to implement various actions. Simultaneously, action level monitoring team has also been suggested. Above the various monitoring team an independent monitoring team would evaluate the progress of all plans and action level monitoring while a project level coordination team would assist the independent monitoring team.

5.14.2 ENVIRONMENT CELL & CORPORATE SOCIAL RESPONSIBILITY CELL

Project developers would constitute Environment Cell (EC) and Corporate Social Responsibility Cell (CSRC) for the project. The function of EC and CSRC would be to monitor and evaluate various sub plans or be a part of action based monitoring committees. EC will be associated to the environmental related activities while CSRC will be associated to the social works.

5.14.3 IMPLEMENTATION

Table 5.14.1 gives the details of actions, implementing agencies and monitoring team. Various agencies of State government and project authorities are involved in the implementation of mitigation measures.

5.14.4 MONITORING & EVALUATION

As mentioned above, there are many plans and actions to be implemented to mitigate and protect the environment. Various agencies will implement and monitor these measures in the region. However, it would require a proper coordination among these agencies for smooth functioning. For the reason, two committees are suggested for the monitoring and evaluation.

Table 5.14.1 Detailed implementation plan for Tato-I H.E. Project

Plan	Actions	Agency	Responsibility/Monitoring
1. Biodiversity Management Plan	i. Distribution of artificial trophies	Project authority/ Local Panchayat	Environment Cell, project
	ii. Surrender of guns	District authority	DC, West Siang
	iii Germ Plasm bank/seed centre	Research Institute	State Forest Department
	v. Forest Protection plan	State Forest Department	State Forest Department
	vi. Safeguard Measures	Environment Cell	Environment Cell
2. CAT Plan	i. Construction of Check dams/ Brushwood, etc	State Forest Department	State Forest Department
	ii. Terrace Benching	State Forest Department	State Forest Department
	iii. Afforestation	State Forest Department	State Forest Department
3. PHDS	i. Establishment of PHC	Planning Division, Project/ State Health Department	State Health Department, CSRC, Project
	ii. Establishment of Veterinary	Planning Division, Project/ State Health Department	Animal Husbandry Dept./ CSRC, Project
	iii. Immunization/vaccination, Distribution of first aid box	State Health Department	CSRC, Project
	iv. Medical camp	State Health Department	CSRC, Project
4. Fishery Development & Downstream management	i. Fishery Development	Project authority/ State Fishery Department	State Fishery Department
	ii. Downstream Management	Project authority	State Pollution Control Board
5. Waste Management	Construction of compost pit, Septic tanks, Community toilets, Bathrooms, sewage treatment plant	Planning Division, Project	State Pollution Control Board
6. Energy Conservation	i. Distribution of LPG	CSRC, Project	GM/Director, Project
	ii. Distribution of improved Chullahs, solar cookers, etc.	CSRC, Project	GM/Director, Project
	iv. Community Kitchen	Planning Division, Project	GM/Director, Project
7. Management of Air, Water & Noise	i. Precautionary Measures	EC, Project	State Pollution Control

			Board
	ii. Regular Monitoring	State Pollution Control Board	State Pollution Control Board
8. Rehabilitation of Muck	i. Construction of retaining wall	Civil Division, Project	GM/Director, Project
	ii. Plantation	EC, Project	EC, Project
	iii. Precautionary measures	EC, Project	GM/Director, Project
9. Landscaping & Restoration	i. Rehabilitation of disturbed site	EC, Project	GM/Director, Project
10. Restoration of quarry sites	i. Rehabilitation of quarry sites	EC & Civil division	GM/Director, Project
11. Green Belt	i. Biological measures	EC, Project	GM/Director, Project
12. R & R Plan	i. Relief package for PAFs	R & R cell, Project/ District Administration	District Magistrate, West Siang District
	ii. Developmental activities in project areas	R & R Cell, Project	Chairman, R & R Monitoring Committee
	iii. Peripheral development	R & R Cell, Project	Chairman, R &R Monitoring Committee
13. Disaster Management Plan	i. Telecommunication	Planning Division, Project	Planning Division, Project
	ii. Emergency Action Plan	Planning Division, Project/ District Administration	District Magistrate
	iii. Rescue Operation	District Administration	District Magistrate
	iv. Rehabilitation	R & R cell, Project District Administration	District Magistrate
15. Environmental Monitoring	i. Implementation & Monitoring	Various agencies	Project Level Committee/ Independent Committee

5.14.4.1 Independent Committee

The independent committee would be notified by the State Government. The committee will be headed by a senior state level officer, not below the rank of Deputy Commissioner. The committee will evaluate and monitor over all progress in the implementation of various plans. All sub committees, suggested for the various plan, would submit their reports to the independent committee. The committee would comprise of the following members

State Level Senior Officer (not below the rank of DC)	Chairman
Director of Project	Member Secretary
Deputy Commissioner	Member
Block Head	Member
Concerned MLA	Member
Renowned Ecologist	Member
Member of State Level NGO	Member

5.14.4.2 Project Level Committee

Project Level committee will assist the independent committee. The committee will arrange the meetings between various sub committees and independent committee. After the detailed evaluation and monitoring by the independent committee, all merits and demerits will be communicated to the project level committees to complete it in specified time. The committee would comprise of following members:

Director, Project	Chairman
Head, Environment Cell, Project	Member Secretary
General Manager, Project	Member
Head, Corporate Social Responsibility Cell	Member
Circle Head	Member(s)
Heads of Panchayat of Affected Villages	Members
Social Activist of Affected Zone	Member

5.14.5 MONITORING SCHEDULE

Various environmental variables like water, noise, air, etc are critical and would require a regular monitoring to avoid deterioration of quality while other actions as mitigation measure need sound evaluation. Table 5.14.2 gives details of work, schedule and agencies, which will be involved in the monitoring and evaluation.

Table 5.14.2 Detailed plan for evaluation and monitoring of various environmental variables and mitigation measures

S.N.	Parameters	Time Schedule	Agency
1.	Monitoring of water quality (pH, temperature, DO, BOD, Alkalinity, Hardness, TDS, Nutrients, Sulphates, Silicates, Heavy metals, coliforms, etc)	Quarterly	State Pollution Control Board
2.	Monitoring of Air Quality (SOx, NOx, CO, SP)	At an interval of 15 days	State Pollution Control Board
3.	Monitoring of Noise Level	Randomly	State Pollution Control Board
4.	Evaluation of Waste Management	Quarterly	State Pollution Control Board
5.	Monitoring of Afforestation	Quarterly	Environment Cell, Project
6.	Transportation and Dumping of	Monthly	State Pollution Control Muck Board
7.	Distribution of relief package	All days during Implementation	District Magistrate or His/her representative
8.	Progress in peripheral development	Randomly	Evaluation and Monitoring Committee (R & R)
9.	Water level in downstream	Randomly	State Pollution Control Board

5.14.6 BUDGET

The budget would be required for the routine meetings between various committees, and project authorities. The project authorities are suggested to provide an office for the scheduled meetings. It would include the outlay for furniture, stationeries, travel, etc. Total cost estimates for this purpose would be **Rs. 40.00 lakhs** only. In addition, various other agencies are involved in the monitoring and evaluation of some mitigation measures. For most of the agencies budgets have been allocated, however, a budget of **Rs. 20.00 lakhs** has been earmarked for a few agencies like State Pollution Control Board. Total Financial outlay for the monitoring and evaluation would be **Rs. 60.00 lakh** only.

5.15
SUMMARY OF COST ESTIMATES

The environment management plan, proposed for Tato-I H.E. Project is useful during and after its development. It embodies 13 different management plans viz. biodiversity conservation management plan, catchment area treatment plan, rehabilitation and resettlement plan, muck disposal plan, fishery development plan, disaster management plan, solid waste management plan and some other important plans. It is believed that implement of all these plans would ameliorate the condition of the environment that is likely to be resulted due to negative impacts during and after the development of the proposed project and also bring in socio-economic development of the region. The total financial layout proposed to meet the measures suggested in various management plans is **Rs. 2854.27 Lakhs.** Two Thousand Eight Hundred Fifty Four Lakhs and Twenty Seven Thousand Rupees only)

Table 5.15.1 Cost estimates for the implementation of EMP*

S.No.	Plans	Amount (Rs. in lacs)
1.	Catchment Area Treatment Plan	305.85
2.	Biodiversity Management and Wildlife Conservation Plan	141.00
3.	Muck Disposal Plan	148.00
4.	Restoration of Construction Areas and Landscaping	84.57
5.	Green Belt Development Plan	17.27
6.	Fishery Development and Downstream Management Plan	70.00
7.	Public Health Delivery System	337.36
8.	Waste Management Plan	224.30
9.	Fuel Wood Energy & Bio-Resource Conservation	54.80
10.	Management of Air & Water Quality and Noise Level	36.00
11.	Rehabilitation and Resettlement Plan	1207.12
12.	Disaster Management Plan	143.00
13.	Good Practice	25.00
14.	Implementation & Monitoring Programme	60.00
	Total	**2854.27**

* This does not include the cost for Compensatory Afforestation and cost of land to be acquired.

Annexure - I

Table for Computation of Silt Yield Index

Sub-watershed code	Erosion intensity	Area* (ha)	Weightage	Area x weight-age	Delivery ratio	Gross silt yield	Sediment yield index
Sk1	a	105,78	17	1798,26	0,95	1708	
	b	304,59	16	4873,44	0,9	4386	
	c	225,35	14	3154,9	0,85	2682	
	d	1,67	11	18,37	0,80	15	
Total		**637,39**				**8791**	**1379,19**
Sk2	a	56,84	19	1079,96	0,95	1026	
	b	424,42	17	7215,14	0,85	6133	
	c	454,47	16	7271,52	0,85	6181	
	d	12,06	15	180,9	0,8	145	
Total		**947,79**				**13484**	**1422,71**
Sk3	a	0,00	0	0	0,00	0	
	b	5,90	17	100,3	0,85	85	
	c	567,15	15	8507,25	0,85	7231	
	d	60,67	12	728,04	0,8	582	
Total		**633,72**				**7899**	**1246,43**
Sk4	a	16,77	18	301,86	0,90	272	
	b	251,58	17	4276,86	0,85	3635	
	c	406,92	14	5696,88	0,85	4842	
	d	9,96	12	119,52	0,8	96	
Total		**685,23**				**8845**	**1290,80**
Sk5	a	0,00	0	0	0,00	0,00	
	b	315,35	15	4730,25	0,85	4021	
	c	1177,42	14	16483,88	0,85	14011	
	d	69,29	12	831,48	0,8	665	
Total		**1562,06**				**18697**	**1196,96**
Sk6	a	3,02	17	51,34	0,85	44	
	b	200,55	15	3008,25	0,85	2557	
	c	640,42	13	8325,46	0,8	6660	
	d	18,58	11	204,38	0,75	153	
Total		**862,57**				**9414**	**1091,42**
Sk7	a	52,37	19	995,03	0,85	846	
	b	313,53	17	5330,01	0,8	4264	
	c	1467,42	14	20543,88	0,8	16435	
	d	67,40	12	808,8	0,7	566	
Total		**1900,72**				**22111**	**1163,30**

Annexure-II(a)

Afforestation cost/ ha of plantation

S. No.		Description	Cost
A.	**Execution**		
I.	**Wage Component**		
1.	Survey of plantation area and preparation of maps	@ Rs. 68.21	68.21
2.	Climbers cutting, removal of brushwood	@ Rs.292/ha	292.00
3.	Construction of inspections path 60cm 180Rmt	@ Rs.5.05/Rmt	909.00
4.	Fencing of area of barbed wire 4 strands horizontal and 2 strands diagonal (mp-5cm 400m/ha)	@ Rs. 27/running metres	10800.00
5	Digging of pits 45 cm^3	700 nos @ Rs.638.20/ 100	4467.96
6.	Digging of pits 30 cm^3	400 nos @ Rs. 318.20/100	1272.80
7	Filling of pits 45 cm^3	700 nos @ Rs. 182.28/100	1275.96
8.	Filling of pits 30 cm^3	400 nos @ Rs. 157.21/100	628.84
9.	Plantation of plants in pits	1100 nos @ Rs. 140.85/100	1549.35
10.	Cost of raising seedlings in nursery	@ Rs. 3.00/ plant	3300.00
	Total (A)		24564.12
11.	Add 18.93% increase		4649.99
	Total		**29214.11**
II.	**Cost of material**		
i)	Cost of materials for raising saplings	1100 nos @ Rs.4 / plan	4400.00
ii)	Cost of compost	Lump sum	2000.00
iii)	Filling of polybag and maintenance	Lump sum	200.00
	Total		**6600.00**
III.	**Maintenance of saplings planted saplings during execution period**		
11	Cost of protection (Lump sum)	@ Rs. 500.00	
12.	1st weeding during (July/August)	@ Rs. 850/500 san	1700.00
13.	2nd weeding during (Aug/Sep)	@ Rs. 850/1500 san	566.00
14.	Add 18.93% increase		428.95
	Total		**2694.95**
Total (A)			**38509.06**
			Say Rs. 39000/-
B.	**Maintenance cost**		**5000.00**
	Grand Total (A+B)		**43509.06**

Annexure-II(b)

Assisted Natural Regeneration Area (per ha)

S. No.		Description	Cost
A	**Execution**		
I.	**Wage Component**		
1.	Survey of Plantation area and preparation of maps	@ Rs. 66.85/ha	66.85
2.	Cleaning and un-saleable thinning (non commercial) in regeneration	@ Rs. 1158.22/ha	1158.22
3.	Bush cutting	@ Rs. 57.95/ha	57.95
4.	Digging of pits 45 cm^3	700 nos @ Rs.623.56/100	4364.92
5.	Filling of pits 45 cm^3	700 nos @ Rs. 178.64/100	1250.48
6.	Planting of Plants in pits	700 nos @ Rs. 87.25/100	610.75
7.	Carriage of Plants in polythene bags and nacked root plants at least 4½ km	700 nos @ Rs.12.00/100/km	378.00
8.	Moisture retention Intervention	@ Rs. 1500.00/ha	1500.00
9.	Cost protection	Lump sum	502.25
	Total		9889.42
	Add 18.93% increase		1872.49
	Total		**11,761.91**
B.	**Maintenance**		**247.64**
Grand Total (A + B)			**12009.55**

Annexure-II(c)

NTFP REGENERATION / MEDICINAL PLANTS CULTIVATION

Planting norms	= 1500 patches /ha
2/3 (66.66%) patches are suitable for planting	= 1000 patches /ha
No. of plants to be planted per patch	= 15
Therefore No. of plants required per ha	= 15000

S.No.	Description	Cost (Rs.)
A.	**Execution**	
1.	Procuring planting materials (including planting out the patches)= 15000 Nos. @ Rs.2.016	30,240.00
	Add 18.93% increase	5724.43
2.	Fencing of individual plant sapling or patch of land	598.10
	Total	**36562.53**
B.	**Maintenance**	**6894.74**
	Grand Total	**43457.27**
	Say	**Rs. 44900.00**

Annexure-II(d)

Pasture Important

S. No.		Description	Cost
A.	**Execution**		
I.	**Wage Component**		
1.	Climber cutting/bush cutting in Plantation area ½ ha	@ Rs. 68.21	146.00
2	Survey of Plantation area and preparation of maps	@ Rs. 68.21/ha	68.21
3.	Digging of pits 45 cm^3	700 nos @ Rs. 936.25/100	6553.75
4.	Filling of pits $45cm^3$	700 nos @ Rs. 482.28/100	3375.96
5.	Planting of Plants in pits for $45cm^3$	700 nos @ Rs.233.85/100	1636.95
6	Carriage of Plants	700 nos @ Rs. 167.5/100/km	1172.5
7	Preparation of patches for	250 nos @ Rs. 266.85/100	667.12
8	Sowing of patches for grass sowing	250 nos @ Rs. 48.70/100	121.75
9	Cost of protection	Lump sum	400.00
10.	Collection of grass seed		97.00
	Total		**14239.24**
	Add 18.93% increase		2695.49
	Total (A)		**16934.73**
II.	**Cost of Material**		
	Cost of compost		3,000.00
	Grand Total (A+B)		**19934.73**
B.	**Maintenance**		**607.41**
Grand Total (A + B)			**20542.14**

ANNEXURE III

SIYOTA HYDROPOWER PRIVATE LOMITED

TATO I H.E. PROJECT
WEST SIANG, A. P.
APPLICATION FORM FOR THE
MERIT SCHOLARSHIP SCHEME

Attested photograph

1.	Name of the applicant (in block letters):		-------------------------------
2.	Father's Name	:	-------------------------------
3	Date of birth	:	-------------------------------
4.	Qualification	:	------------------------------
5.	Residential Address	:	------------------------------
6.	Correspondence address	:	------------------------------
7.	Name of head of family From whom land acquired (PAP)	:	------------------------------
8.	Relation of applicant with head of family (PAP)	:	------------------------------
9.	Cast	:	Gen SC OBC ST
10.	Land details		
	a) Name of the village (S) from where land acquired.	:	
	b) Area of the land acquired : (in ha.) and taken possession By requiring body		
	c) Land left (in ha)	:	-------------------------------
	d) whether the family has been declared landless by R&R Officer	:	-------------------------------
	e) Whether the family member has got employment in Tato I Project under R&R scheme.	:	Yes No.
	f) If Yes Name of employee :		------------------------------
	g) whether SC/ST/OBC/Gen. :		------------------------------
11.	a) Present occupation of the applicant.	:	------------------------------
	b) Annual income from the	:	------------------------------

occupation.

12. Name of the school/institute/University: ----------------------------------
In which applicant studies

13. Name of the class/ course/diploma/degree ----------------------------------
for which scholarship is applied

14 Tenure of the class/course/diploma/degree ----------------------------------

15. Certificates enclosed

i)

ii)

iii)

iv)

13. Declaration:

I here by declare that all the particulars furnished in this application are complete are true to the best of my knowledge. I shall abide by the rules and conditions mentioned in this scheme for PAFs.

Signature of the applicant
Name :
Date :
Place :

Verified that the particulars of the applicant Sh/Smt./Km. ----------------------------- /daughter/wife of ------------------------------------- are true.

Signature of Principal
Name with stamp
Date

Signature of Gram Pradhan
Name with stamp:
Date :

ANNEXURE IV

Attested photograph

SIYOTA HYDROPOWER PRIVATE LOMITED

TATO I H.E. PROJECT
WEST SIANG, A.P.
APPLICATION FORM FOR
TRAINING PROGRAMME

1.	Name of the applicant (in block letters):		-------------------------------
2.	Father's Name	:	-------------------------------
3	Date of birth	:	-------------------------------
4.	Qualification	:	------------------------------
5.	Residential Address	:	------------------------------
6.	Name of head of family From whom land acquired (PAP)	:	------------------------------
7.	Relation of applicant With head of family (PAP)	:	------------------------------
8.	Cast	:	Gen SC OBC ST
9.	Land details		
	a) Name of the village (S) from where land acquired.	:	
	b) Area of the land acquired : (in ha.) and taken possession by Tato I HEP		
	c) Land left (in ha)	:	-------------------------------
	d) whether the family has been declared landless by R&R Officer	:	-------------------------------
	e) Whether the family member has got employment Tato I HEP under R&R scheme.	:	Yes No.
	f) If Yes Name of employee :		------------------------------
	g) whether SC/ST/OBC/Gen. :		------------------------------
10.	a) Present occupation of the applicant.	:	------------------------------
	b) Annual income from the	:	------------------------------

occupation.

11. Choice of vocations for :
For which applied
(please put a tick mark
:

i) Food processin
ii) Mushroom cultivation
iii) Computer course
iv) Dairy farming
v) Poultry farming
vi) Organic farming
vii) Sericulture
viii) Apiculture
ix) Fish culture
x) Knitting
xi) Sewing
xii) Any other please specify

12. Certificates enclosed
i)
ii)
iii)
iv)

13. Declaration:

I here by declare that all the particulars furnished in this application are complete are true to the best of my knowledge. I shall abide by the rules and conditions mentioned in this scheme for PAFs.

Signature of the applicant
Name :
Date :
Place :

Verified that the particulars of the applicant Sh/Smt./Km. ------------------------------ /daughter/wife of -------------------------------------- are true.

Signature of Gram Pradhan
Date : Name with stamp: