



**CISMHE**

**FINAL REPORT  
MAY 2014**

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# **ENVIRONMENTAL IMPACT ASSESSMENT & MANAGEMENT PLAN OF PAUK HYDROELECTRIC PROJECT, Arunachal Pradesh**



## **Executive Summary**

*Prepared for:*  
**Pauk Hydro Power Pvt. Ltd., New Delhi**

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



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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 mid-sized run-of-the-river Hydroelectric Projects, which minimize the impact on the environment and local populations while allowing energy generation without greenhouse gas 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.

Pauk H.E. Project 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 sponsoring, welfare activities and employment even before the start of Project construction.

This is the philosophy as per which the Pauk Hydro Electric Project is proposed:

- ✓ Submergence area: 34.1 ha including 8.8 ha of river bed (net submergence impact of 25.3 ha).
- ✓ Land requirement & impact on forest: net surface land impact 79.1 ha.
- ✓ Arch Dam design, hence requiring much less concrete / weight than a traditional barrage.
- ✓ No displacement of people.
- ✓ No wildlife sanctuary affected.
- ✓ Minimum environmental flow to guarantee sustenance of downstream aquatic life & afforestation measures.
- ✓ Local people getting benefits right from the investigation phase.
- ✓ Total budget for environmental and social mitigation measures: Rs 4158.19 Lakhs.
- ✓ Rehabilitation measures and Local Area Development budget: Rs 884.5 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**

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

Pauk H.E. Project is located in Mechuka circle of West Siang district in Arunachal Pradesh (**Fig. 1**). The nearest road head at Chengrung is about 160 km from Aalo, the head quarters of West Siang district. Pauk Hydroelectric Project is a run of the river scheme proposed on the Yarjep (Shi) River (also known as Shi Chhu in the lower reaches), which is a right bank tributary of the Siyom River). The project Dam is located 1 km downstream of the confluence of Sae Chu with Yarjep (Shi) River, about 12 km downstream of Mechuka. The proposed dam site is located between 94°14'43''E longitude and 28°32'46''N latitude near Chengrung village. Proposed Power house site is located between 94°15'53''E longitude and 28°32'32''N latitude near Purying village. The nearest road heads are Hiri and Chengrung villages which are linked to Mechuka and Tato towns. From these villages foot tracks are used to access the proposed dam and power house sites. The nearest road is connected to National Highway-52 via state road and is about 375 km from Akajan in Assam. For Pauk HE Project, the nearest meter gauge rail head is at Silapathar (approx 374 km) and broad gauge at Naogaon (approx. 738 km) in Assam. From the project site, the nearest operational airport is around 522 km, located at Likhali in North Lakhimpur district of Assam and the nearest international airport is around 903 km located at Guwahati, the capital city of Assam. .

Pauk H.E. Project involves a 110 m high arch dam, a horse shoe shaped head race tunnel (HRT) of 2.3 km and a surface powerhouse with an installed capacity of 145 MW. Total catchment area of the project is 982 sq km. The standard projected flood (SPF) and maximum probable flood were calculated to be 3000 and 3700 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 and in Table 1. The Project is designed with a relatively small reservoir, which involves a net submergence area of 34.1 Ha. The Land requirement is about 91.7 Ha, including underground structures and river bed area.

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.

**Table 1. Salient features of Pauk H.E. Project in West Siang district of Arunachal Pradesh**

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### **LOCATION**

State	:	Arunachal Pradesh
District	:	West Siang
River	:	Yarjep

### **Location of Dam**

Latitude	:	28° 32' 46"N
Longitude	:	94° 14' 43"E

### **Location of Power House**

Latitude	:	28° 32' 32"N
Longitude	:	94° 15' 53"E
Nearest Airport	:	Dibrugarh
Nearest Rail head (Broad gauge)	:	Nagaon

### **HYDROLOGY**

Catchment area at dam site	:	982 sq km
Standard Project Flood	:	3000 cumecs
Maximum Probable Flood	:	3700 cumecs

### **DAM**

Type	:	Concrete Arch Dam
Dam top	:	EL 1550 m
Foundation Level	:	EL 1445 m
Maximum Height above deepest foundation	:	105 m

### **SPILLWAY**

Type of spillway -1	:	Free Ogee Spillway
Maximum discharge capacity at FRL/MWL	:	0 / 2820 cumecs
Energy dissipation system	:	Downstream dissipation basin
Type of Bottom outlet (Upper) -	:	Flushing Gate
Maximum discharge capacity at FRL/MWL	:	880 cumecs
Energy dissipation system	:	Downstream dissipation basin

Type of Bottom outlet (Lower)	:	Flushing Gate
Maximum discharge capacity at FRL/MWL	:	908 cumecs
Energy dissipation system	:	Downstream dissipation basin

**RESERVOIR**

Maximum Water Level (MWL)	:	EL 1548.5 m
Full Reservoir Level (FRL)	:	EL 1540 m
Area under submergence at FRL	:	34.1 ha
Total storage	:	11.5 M cum
Active storage	:	1.67 M cum

**INTAKE**

Number of Intakes	:	1 no.
Invert level of intake	:	EL 1521 m
Design discharge	:	121.65 cumecs

**HEAD RACE TUNNEL**

Head Race Tunnel	:	One
Internal section and type	:	6.5 m dia, circular
Design discharge	:	121.65 cumecs
Length	:	2.1 km (approx)

**SURGE SHAFT**

Type	:	Vertical Orifice
Size	:	15 m diameter
Vertical shaft height	:	75 m

**Pressure shaft**

Numbers	:	One
Diameter	:	5.75 m
Length	:	205 m

**POWER HOUSE COMPLEX**

Type	:	Underground
Installed capacity	:	145 MW
Number of units	:	3nos of 48.3 MW each
Type of turbine	:	Vertical Francis
Tail water level at outlet	:	EL 1401.0 m
Powerhouse size	:	19 m (W) x 37 m (H)
Length of Powerhouse	:	89 m



### **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 Pauk. 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 31<sup>st</sup> 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 120 MW accordingly, through the aforesaid Amendment dated 31<sup>st</sup> July 2009. Following the signature of this Amendment, involving new features, the Pauk H. E. Project had to be thoroughly designed again in order to arrive at a new PFR which was submitted in October 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 120 MW to 145 MW. Hence the Power Potential Studies have been approved with a capacity of 145 MW.

The Ministry of Environment and Forests, Govt. of India, granted to PHPPL 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 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.

Since June 2007, PHPPL 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.

Pauk 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 Pauk 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 Pauk HE 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 the catchment area, influence area (10 km radius of proposed dam and power house) and the project area (directly impacted area). Spatial database on physiographic features were taken from various sources including Survey of India (SOI) toposheet, 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 dam site is located on the Yarjep (Shi) River . This river forms one of the major tributaries of Siyom River in Arunachal Pradesh. In the middle stretch, Yarjep (Shi) (Shi) 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 Pauk project's influence zone is around 40155 ha. The drainage network of the catchment area up to the dam site is shown in **Figure 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 geology of the dam site consists essentially of gneiss with thin bands of schist. The fluvial morphology of Yarjep River exhibits deep gorges, narrow valleys and a steep gradient of the river itself.

The slopes of the abutment of dam are very steep to near vertical. Rock (quartzitic or quartzo-feldspathic gneiss) is visibly (from right bank) exposed on the left bank abutment throughout the entire height of the dam. The river bed is accessible in the vicinity of the intake structure. The drifting exploration showed that rock is mainly gneissic with thin schist bands. In the final portion, the HRT tunnel is aligned in northeasterly direction and is expected to be driven through mainly gneiss group of rocks with the foliation strike of the rocks across the tunnel alignment making it a favorable direction for tunneling. A village has settled there, where agriculture is easy. The Power House site is located at the toe of this landslide, on the upstream

extremity. Just upstream of this location, good quality gneiss outcrop allows anticipating good conditions regarding excavations and foundation for the structures

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.

### **5.1.3. Soil**

The study covers soil properties for the catchment area, project influence area and project area. Soil association of Lithic Udorthents – Dystric Eutrochrepts is predominant in these areas. All the project components like dam, HRT, powerhouse colony area, etc. are located on the soil association of Lithic Udorthents – Typic Udorthents. Soil is loamy skeletal and shallow to moderately deep which is susceptible to severe to very severe soil erosions. Physical, chemical and biological properties of soil, which impact the life span of the reservoir and the viability of the project, are developed further in the EIA study.

### **5.1.4. Land Use and Land Cover**

Land use and land cover mapping of the Pauk 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 Pauk 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 36.46% of the total 98200 ha area, as shown in **Figure 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 Pauk H.E project. Therefore land cover and land use maps will be examined within the 10 km radius of powerhouse and dam 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 include dense forest, which accounts for 44.86% of the total influence zone and it is prevalent along the right bank of the Yarjep (Shi) River.

## **5.2 Water Environment**

### **5.2.1 Hydrology**

Precise figures of rainfall are given in the study for Mechuka, Monigong, Raying, Kaying, Aalo and Tato R&G stations. The nearest R&G stations are Mechuka (ex), Mechuka (int) and Tato, where monthly rainfall ranges from 27 mm to 460 mm, 21 mm 431 mm and 21 mm to 683 mm, respectively. Minimum rainfall occurs in the months of December and January while maximum in the months of June and July. The monsoon rain decreases at the end of September

The optimization studies for the Pauk 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 128 to 194 cumec at dam site respectively, while the minimum and maximum are respectively 64 and 410 cumec during this period. The average 10-daily water discharge in Yarjep (Shi Shito) River at the dam site for 90% dependable year (1978-1979) and 50% dependable year (2003-2004) as shown in Figure 3.3.1.5. The peak discharge in the 90% dependable year was 224 cumec at the end of June. On the other hand, the peak discharge in the 50% dependable year was 295 cumec in the beginning of July. The minimum discharge was 11 cumec for both the 90% and 50% dependable years. The variation pattern of flood peaks shows that the peaks attain high level every 5 to 6 years for dam site axis. maximum discharge at the dam site was attained in the 2007-08 with a total cumulative discharge of 3348.432 Mcum

### **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 Pauk Power house in West Siang district of Arunachal Pradesh was conducted in three seasons for two phases. 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 (Shi Shito) and its tributaries waters indicate a good water quality. Though physical and chemical and biological parameters showed temporal and spatial variation. Regarding the physical and chemical characteristics especially Electrical conductivity, higher concentrations of hardness, Alkalinity and TDS Yarjep river, and two tributaries showed different pattern indicating that physical and chemical characteristics are mainly regulated by watershed characteristics rather than flow of water. The local inhabitants generally use the spring water for drinking purpose. Though, Shongsh Bu recorded higher concentration of alkalinity, hardness, total dissolved solids, but remain under the desirable limit. 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

### **5.3 Air Environment**

#### **5.3.1 Meteorology**

The Yarjep basin experience cold temperature during the winter months from December to January. The maximum temperature recorded was 28.7°C during monsoon season at Chengrung village whereas the minimum temperature was 5°C recorded during winter at Mechuka. Relative humidity was highest during the pre-monsoon period for Mechuka with 86.7%. The relative humidity during the winter scales down to 37.8% at Rapum.

#### **5.3.2 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 of 83.61 to 311.00  $\mu\text{g}/\text{m}^3$ . RSPM varied in the range of 13.75 to 137.61  $\mu\text{g}/\text{m}^3$  and SO<sub>2</sub> and NO<sub>x</sub> are significantly lower than the tolerable levels. 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.

## 5.4 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 the diverse floral and faunal diversity.

### 5.4.1 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/catchment area of the Pauk H.E. Project, and the EIA gives an exhaustive list of the floral species within each category.

In the influence and free draining catchment area, nearly 340 species of angiosperms have been recorded in the free draining catchment of Pauk H.E. Project encompassing the valleys of Yarjep (Shi Shito) River and its major tributaries i.e. Purying and Rego Nalas. These species belong to 240 genera and 79 families. Out of 79 families represented in the area, 63 are dicots and 16 are monocots. The dicotyledons are represented by 240 plant species belonging to 170 genera, while the monocotyledons are represented by 70 genera and 100 species. Gymnosperms are represented by 3 families, 3 genera and 3 species

The present ecological study in the project area of Pauk 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). A total of 145 species of plants were recorded under the ecological investigation during different sampling seasons. Out of which 35 were trees, 26 shrubs and 84 herbs. The ground vegetation comprised of ephemeral, annual and perennial species of grasses, sedges, legumes and non legume forbs .

As per IUCN red list, two plant species viz., *Centella asiatica* and *Cephalotaxus griffithii* are categorized as least concerned and near threatened categories from project and influence area, respectively. However, there are around 4 species of flowering plants from low hills (in the altitudinal range of 300-1500 m elevation) of the state that have entered the Red Data Book of Indian Plants.

### 5.4.2 Faunal diversity

The Abor hills, where the proposed project is located, forms a phytogeographic node for the mingling of Chinese, Malaysian and Himalayan flora. Mani (1974) considers the state of Arunachal Pradesh as the “Indo-Chinese amphitheatre” The study of Pauk 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 26 mammals species are expected to inhabit in the catchment area of Pauk H.E. Project on Yarjep (Shi) River. Out of 25 species, 21 are common in the catchment and influence areas. Avifauna is represented by a total of 75 species in 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 residents while 37.7% are widespread residents. Primary surveys for three seasons also indicate poor diversity of herpetofauna in the catchment and influence areas. The reported species are mainly confined in lower parts of the influence area. *Hemidactylus brookii* (reptilian) and *Bufo Himalayan* and *Rana cyanophlyctis* (Amphibia) are common herpetofaunal species of the influence area. Important threatened species are *Neofelis nebulosa*, *Panthera uncia*, *Ursus thibetanus*, *Moschus chrysogaster*, *Naemorhedus caudatus*, *Lophophorus sclateri*, *Tragopan temminckii* etc

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 Pauk H.E. structures.

### 5.4.3 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 (Shi) and its tributaries.

Yarjep (Shi) 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



(Shi) 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. Species *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.

## 5.5 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 H.E. project activities.

The district headquarter of West Siang is located at Aalo. As per Census (2011) the total population of West Siang district is 1,12,274 with sex ratio of 930 (females to 1,000 males), which is marginally higher than the State average of 920. The population density of the district is 13 individuals per sq. km, nearly same as that of the State (17 person/sq km). The scheduled tribe (ST) population accounts for 82.6% 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. Influence area of the Pauk H.E. Project includes a total of 20 villages in which 18 come under the jurisdiction of Mechuka circle and 2 villages are under Tato circle. Total population of villages of influence area is 1257 associated with 234 households (Table 3.6.1.1) (Census, 2011). Surprisingly influence area of Pauk shows negative decadal growth of around 9%. Average sex ratio in these villages is 1041. Age group 0-6 year accounts for 15.7% of the total population. Schedule tribes are predominant in these villages accounting for 97.8% of total population. Average literacy rate in these villages is 31.8%, considerably higher in male (38.1%). Nearly 56% of the total population is engaged in the various works, of which only 19.8% are main workers. Female and male populations account almost equal work force as compared to male population.

The lands near four villages namely, Chengrung, Rapum, Hiri and Purying are affected due to the various components of the project. Total population of affected villages is 263 people belonging to 46 households (Census 2011). The average sex ratio is 1070 (Table 3.6.1.4). Age group 0-6 year accounts for 16.7%. Schedule tribe population accounts for 98.4% of the total population. Decadal growth of 5.2% was recorded in the affected villages. Territory of Hiri and Purying villages would be used for the power house complex while the

dam complex would be located near Chengrung and Rapum villages. A total of 202 persons coming from 24 households (55 families) are affected in the proposed project. The sex ratio in the project affected families is 957. All project affected persons belong to Scheduled Tribe, which are mainly 'Adi' tribes and its sub-tribes. Average literacy rate in the project affected families is 52.3%. The socio-economic and cultural profiles of these villages and families are given in the EIA report.

## **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 Pauk 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. A total of 79.1 ha of land would be required for the surface works. The forest area will be cleared for the purpose, which would result into land use and land cover changes. Around 34.1 ha of land would be required for the submergence. Some of the negative impacts are local and temporary, as they are expected to last mainly during the construction phase. Other long term

major impacts on land would be the submergence area (34.1 ha) and the place dedicated to project components, mainly dam and power house.

Both sides of the Yarjep (Shi) River, downstream and upstream of the plant will be impacted. Water diversion from the main channel is anticipated to various impacts on the aquatic ecosystem. The reduction of the water in the downstream stretch would decrease the self purification capacity of water and most of the physical and chemical characteristics would be affected adversely. The water may be prone to deterioration due to project activities and workers. The physical and chemical characteristics would affect the biological composition and fisheries. The dearth of water would not be able to sustain the large column feeder fish and would affect the fish movement adversely. These impacts are anticipated in the operation phase, they are long term, permanent and irreversible.

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

A dam of 110 m height is expected to hamper the fish movement and exert a negative impact on the fish fauna. In addition, reservoir would also be non conducive and act as area of fragmentation for bottom dwellers. The proposed reservoir would increase the possibilities of reservoir fisheries, therefore, it is considered as positive impact. These impacts are foreseen in the operation phase of the projects. The impacts are permanent in nature.

A total population of around 1548 persons would generate 265 tons of solid waste comprising of plastic, metals, papers, domestic garbage and others. A total of 1,54,800 liters of water per day is expected to be generated from the 1548 migrant population.

The high concentration of SPM, NO<sub>x</sub> and SO<sub>x</sub> are anticipated in the immediate vicinity (in the periphery of 500 to 1000 m) of the project construction site. These pollutants are anticipated to create human health problem like asthma, irritation, bronchitis

A total of about 1548 persons including the family members of peak labour force are expected to enter the area of the project works, It would double the total population in influence area during the labour force peak of the construction period. Change in the demography may trigger the cultural tensions 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’ 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 adversely. In addition, the migrant population could carry new diseases.

Apart from the environmental consequences, the care must be taken for structural aspects because MCT (Main Central Thrust) passes from a nearby locality Yapik. The blasting activities may lead to regular vibration in the area, however, no settlements are identified along the HRT alignment.

## **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 Pauk project. Each management plan budget is detailed in the report, as it will be integrated in the costs of the overall project.

### **7.1 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 14800 ha, and 8717.10 ha are concerned with severe to

very severe erosion. The total surface area to be treated would be around 5954 ha. The State Forest Department will be in charge of the activities and the total budget estimated for this plan would be **Rs 2156.36 lakhs**.

### **7.2 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 Establishment of a Botanical Garden, Butterfly park, Natural Resource Management and implementation of an Awareness Programme. It would also involve a forest protection plan and strict safeguards measures. The total cost estimated for this plan would be would be Rs. 227.00 Lakhs.

### **7.3 Muck Disposal Plan**

Muck would be excavated from the HRTs & TRTs during the tunneling, construction of power house complex, approach roads etc. 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.

Project would be around 8,18,020 cum (Table 5.3.1.1). Considering the swelling factors (20% for underground and rock excavations, 10% for common excavations), the volume of muck to be rehabilitated would increase to about 9,17,209 cum. One single dumping site has been identified for the disposal of muck which is located at half distance between Chengrung and Rapum villages with a total area of 5.1 ha. Altitudinally, the minimum height between the dumping site and HFL is 135 m while it is 180 m horizontally. Both engineering and biological methods will be adopted for rehabilitation of muck. Engineering method includes the construction of retaining wall and compaction while biological method includes plantation with geo textiles technology. Total financial outlay for the relocation of muck and rehabilitation dumping sites including engineering and biological measures would be **Rs 121 lakhs**.

#### **7.4 Restoration of Construction Areas and Landscaping**

Around 62.3 ha of surface land (excluding river bed area) 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. 72.20 lakhs.**

#### **7.5 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 area draining directly into the reservoir, 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 reservoir and will contribute to the aesthetic and beautification of the project area. For the Pauk H.E. Project, the areas to be treated are around the dam site, power house sites and around the periphery of the reservoir. Budget is expected to be **Rs. 24.63 lakhs.**

#### **7.6 Fishery Development & Downstream Management plan**

The plan of fishery development was also formulated for Tato I and Heo H.E. Projects. The measures suggested in Heo and Tato I H.E. projects were not included in the plan of Pauk H.E. Project to avoid any repetition because the three projects are owned by the same developers. The plan for Pauk HE Project includes training for fish farming and financial assistance for fish farms.

The downstream management plan is to regulate 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. The total financial outlay for this plan is estimated to be **Rs. 55 Lakhs.**

### **7.7 Public Health Delivery System**

One single plan has been considered to cover the zone of the three projects and such plan is divided between Heo H.E. Project and the Tato-I H.E. Project. However, an additional budget has been planned under the EMP of Pauk HE Project, which includes setting up of three child welfare centres, immunization and vaccination programs, and distribution of first aid boxes in the surrounding villages. Total financial outlay estimated for the health management system of the proposed Pauk H.E. Project is **Rs. 100.00 lakhs**.

### **7.8 Waste Management Plan**

As it is essential to collect, treat and dispose of all types of wastes generated by native and migrant populations on the site, a proper waste management plan has been set up for Pauk 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 1548 persons, producing a total amount of solid waste of around 265 tons per annum. Therefore, placement of dustbins at colony areas and public places, septic tanks, community toilets, bathrooms and washing places, sewage treatment plant, dumpers and wheel barrows, and water and toilet facilities will be installed in the project area. The total estimated cost would be **Rs 225.4 lakhs**.

### **7.9 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) connections, 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 downstream projects of Heo and Tato-1 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 49.5 lakhs**.

### **7.10 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 40 lakhs**.

### **7.11 Resettlement and Rehabilitation Plan**

The R & R plan for the affected persons or families of Pauk H.E. Project follows the guidelines of Rehabilitation & Resettlement Policy of Government of Arunachal Pradesh (2008). The plan addresses all regional and national issues. It includes relief package to project affected families, compensation against rights and privileges, and a comprehensive social development plan.

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 eligible person family grant, 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, training on various courses for income generation, adoption of a village, community welfare centers, construction of rain shelters and footpath, provision of sanitation facilities and skill upgradation for handicrafts. Total budget for the Rehabilitation and Resettlement Plan and Peripheral Development Plan would be **Rs. 884.50 Lakhs**. It does not include Local Area Development Fund.

### **7.12 Disaster Management Plan**

The present study for the Pauk H.E. Project comprises of the following hydrodynamic simulations due to occurrence of:

- PMF with Dam break with initial reservoir level at top of the dam
- PMF without dam in place (virgin condition)

The study comprises of prediction of outflow hydrograph due to dam breach and routing of dam breach flood hydrograph through the downstream valley, routing the design flood hydrograph through the reservoir and downstream valley without dam breach and channel routing the design flood hydrograph through the downstream valley in the virgin condition of Yarjep (Shi) i.e. without Pauk Dam to get the maximum discharge and water



level at different locations of the river downstream of the dam. In the instant case, MIKE 11 model developed by Danish Hydraulic Institute has been selected for the present study because of its wide acceptability in India and abroad. Disaster management plan of Pauk H. E. project includes surveillance, emergency action plan, administrative and procedural aspects, preventive action, communication System, etc. The estimated total cost of execution of disaster management plan including the equipment would be **Rs 117.60 lakh**.

### **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 measures are proposed/ suggested in the Environment Management Plan (EMP) to reduce the adverse impacts of proposed project on the environment and biodiversity of the area as well 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. Various environmental variables would require a regular monitoring like air, water, noise, etc. In addition, various other agencies are involved in the monitoring and evaluation of some mitigation measures. Total budget allocated for the Implementation and Environment Monitoring programmes would be **Rs.60 lakhs** only.

### 7.15 Summary of Costs

Table 2.

S.No.	Plans	Amount (Rs in Lakhs)
1	Catchment Area Treatment Plan	2156,36
2	Biodiversity Management and Wildlife Conservation Plan	227
3	Muck Disposal Plan	121
4	Restoration of Construction Areas and Landscaping	72,2
5	Green Belt Development Plan	24,63
6	Fishery Development and Downstream Management Plan	55
7	Public Health Delivery System	100
8	Solid Waste Management Plan	225,4
9	Fuel Wood Energy & Bio-Resource Conservation	49,5
10	Management of Air & Water Quality and Noise Level	40
11	Rehabilitation and Resettlement Plan	884,5
12	Disaster Management Plan	117,60
13	Good Practice	25
14	Implementation & Monitoring Programme	60
	<b>TOTAL</b>	<b>4158.19</b>

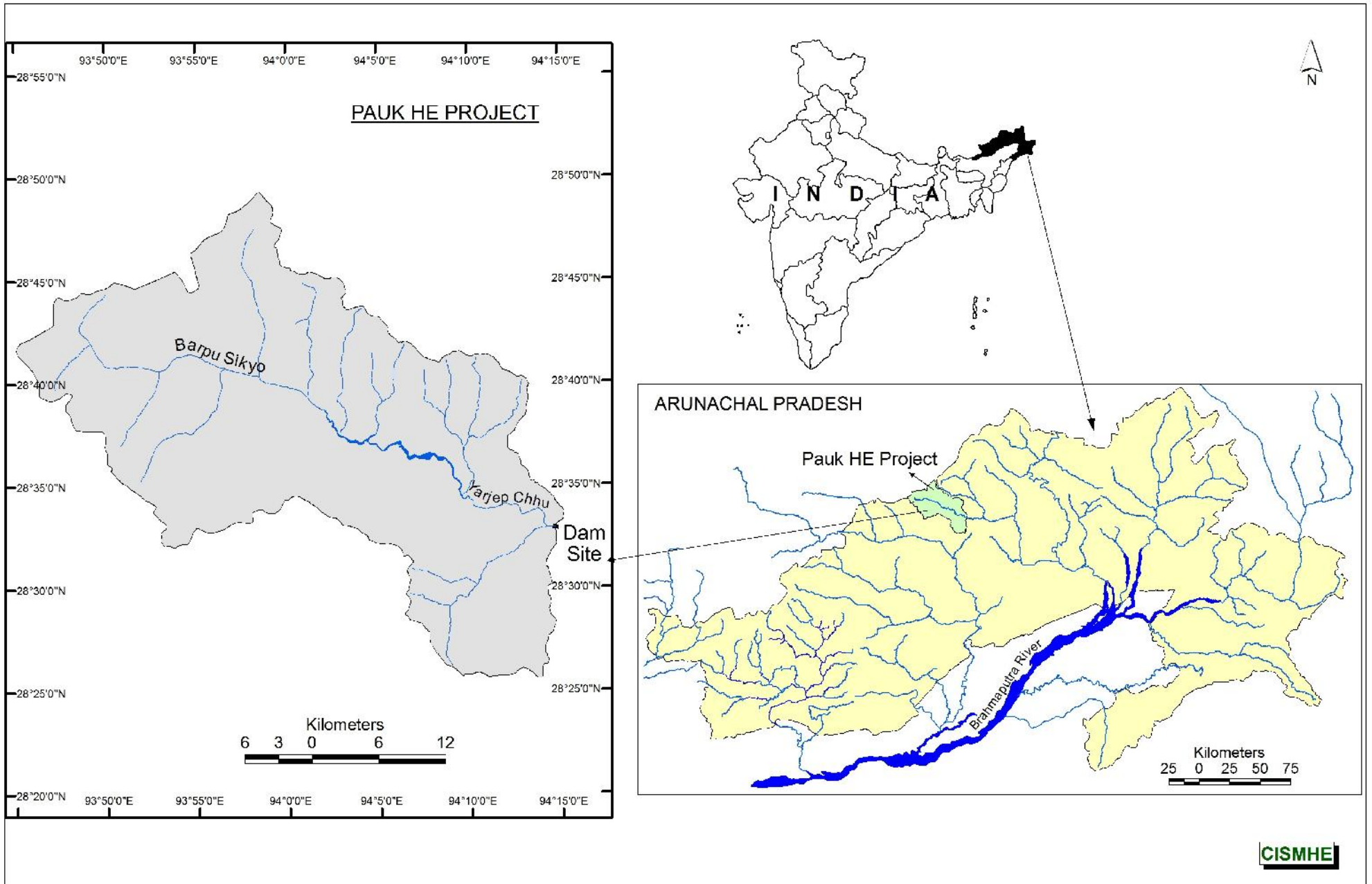


Fig.1 Location map of Pauk H.E. Project Stage-I

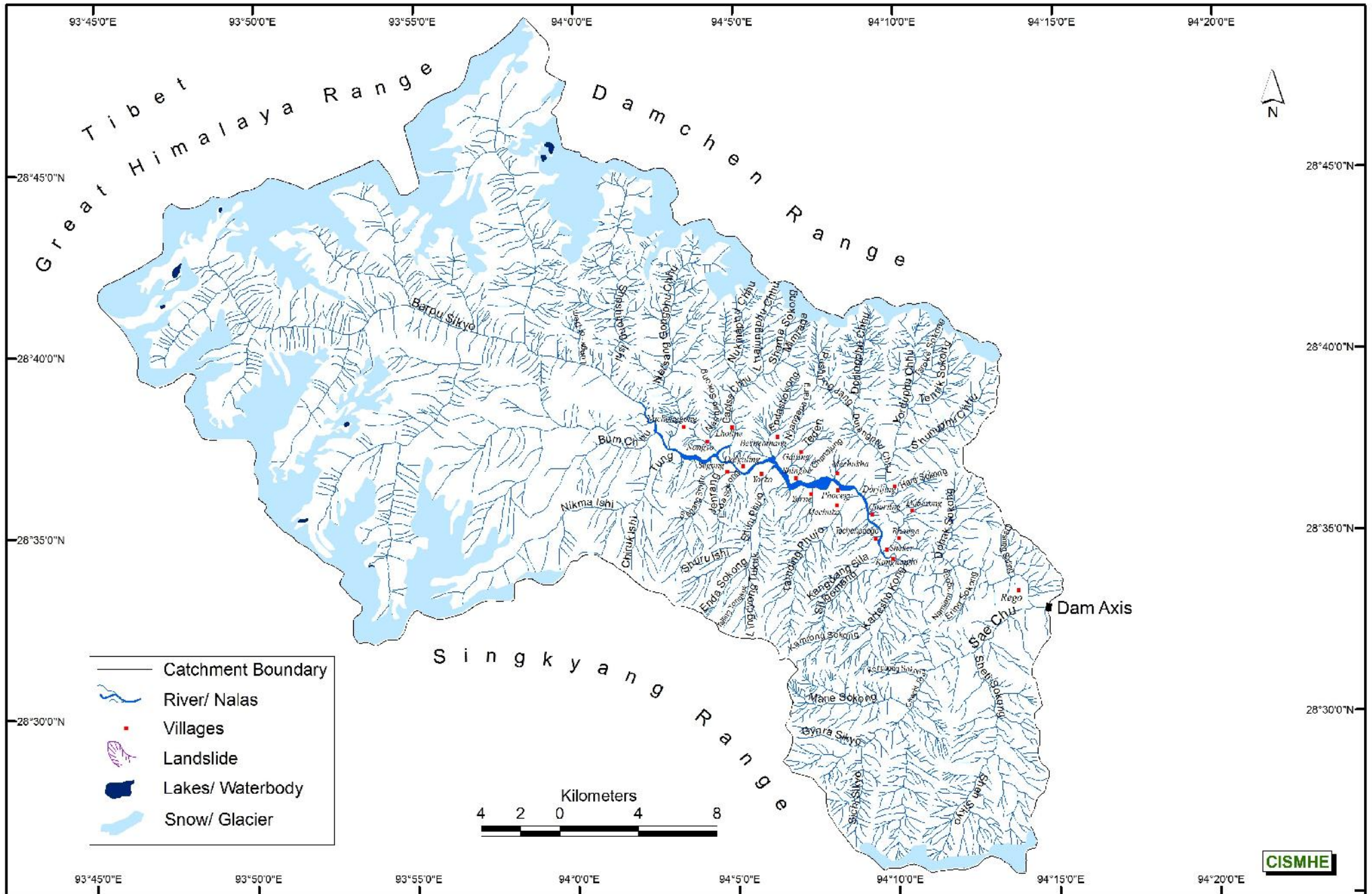
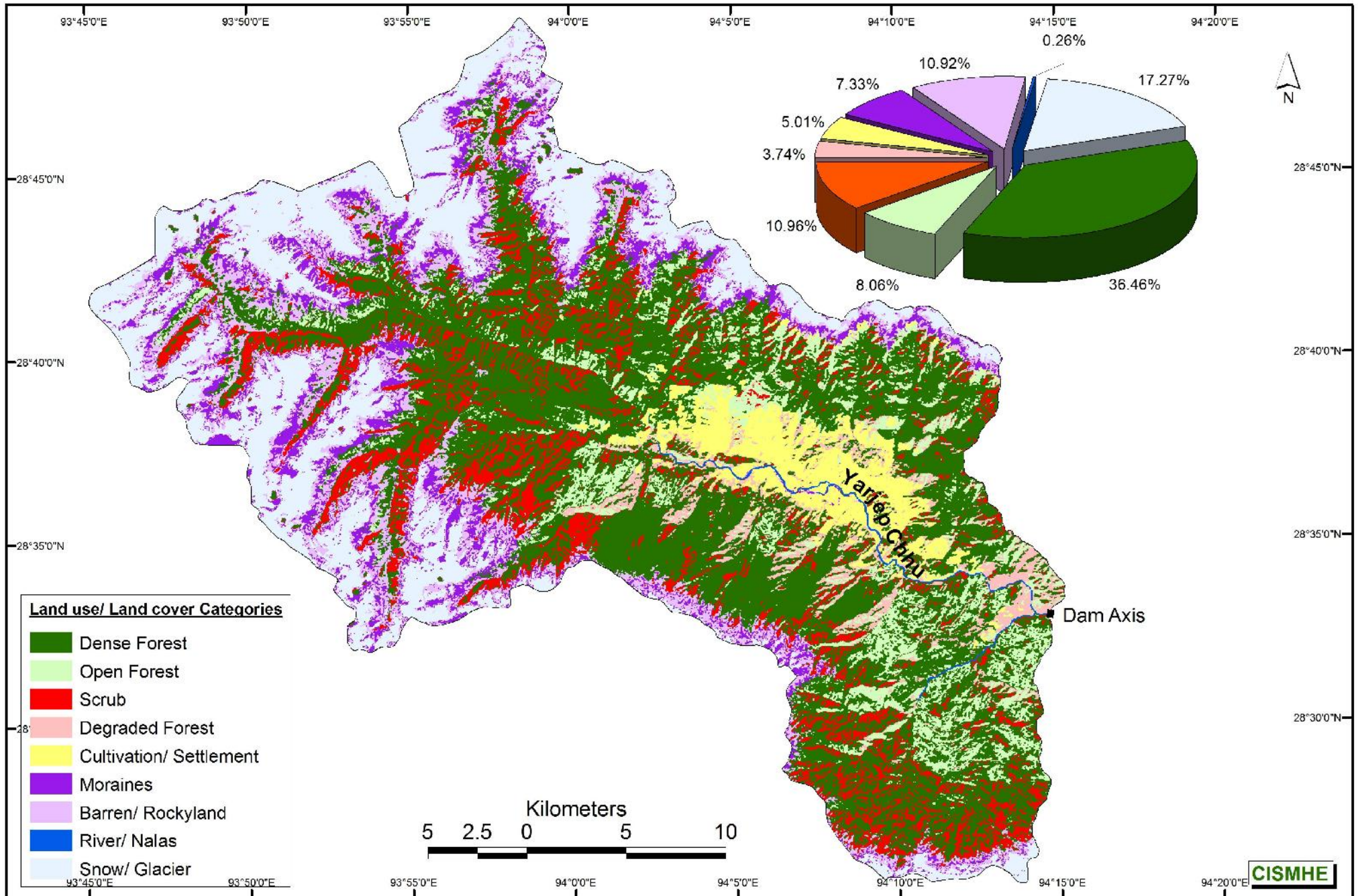


Fig.2 Drainage map of Yarjep Chhu in the catchment area of the proposed Pauk H.E. Project up to the proposed dam site



**Fig.3 Land use/ land cover map of the Yarjep Chu catchment of the proposed Pauk H.E. Project**