CONTENTS

CHAPTER – I

INTRODUCTION

Sikkim is a beautiful tiny Himalayan state situated on the flanks of Eastern Himalayas at the latitude of 27º00'46" to 28º 07' 48" and 88º00'58" to 89º55'20' longitude north. The state is bounded by Tibet in the North and North-East, Bhutan in the South- East, Nepal in the West and West Bengal in the South.The Pangolakha Range of mountains separates Bhutan, Singalila range separates Nepal and Chola range separates Tibet from Sikkim. Sikkim has a very rugged topography defined with towering mountains and deep valleys. Even though the total geographical area is only 7096 sq.kms, its altitude varies from 244 mt. at Melli to 8,598 mt. at Mt. Kanchandzonga forming the mountaineering climate. The other important peaks in the state such as Kumbhakana (7,711 mt.) Penden (6706 mt.) Narsing (5,825 mt.) Kabru Dome (6,545) are also found in the Kanchandzonga range. Glaciers descend from these mountaineering peaks to form the source for important rivers like Teesta and Rangit in Sikkim. State economy which is mainly supported by agriculture and other small scale industries at present offers a lot of potential for Hydel Projects and Tourism development. Since the state is drained by large number of perennial rivers, all of the tributaries join one or the other. There are many no. of small rivers but the two main river systems are the Teesta and the Rangit. The free flowing rivers can feed the Hydel Projects for power generation. This huge potential encouraged the then Political Officer of the Government of India in Sikkim to have discussion with the erstwhile Ministry of Irrigation and power in 1974 and requested to take up the investigation of hydro power projects in Sikkim.

Due to its rugged topography, land locked condition and altitudinal variations the state is facing backwardness compared to the other states in India and the richness of flora, fauna, water falls, hot springs, Orchids, Rhododendron, snow capped mountains, adventure trekking, world renowned Monasteries, river rafting, customs & culture offer a great potential for tourism development.

Being a hilly state it is blessed with a large potential for hydro-power development in the field of micro, Mini and Mega hydel schemes. However only a small portion has been

explored so far. The potential of river Teesta was investigated by the Central Water Commission (CWC) cascade development and has been identified to be in six stages. Out of these six stages, Teesta stage- V (510MW) is under the verge of completion by the National Hydel Power Corporation (NHPC). The other stages have been allotted to the private developers and NHPC, all are reviewing the capacity and required studies are under going.

The installed capacities of different stages of Teesta project are given below:-

Stages	**Installed capacity**
Teesta I	320
Teesta II	850
Teesta III	1200
Teesta IV	495
Teesta V	510
Teesta VI	500

The state Government has allotted Teesta stage –VI hydro electrict project to the Lanco Energy Private Limited. Its original detailed project report was prepared by the CWC which identified an installation capacity of 360 MW with the proposed under ground power house location at Subinkhor and with Dam at Khanitar. Accordingly DPR was prepared by the CWC with a dam height of 76 mt. This dam would have totally submerged the existing Sikkim Manipal institute of Technology (SMIT), Indian Oil Corporation Depot, a part of National Highway, huge no of house holds and few agriculture lands. At the time of issuing letter of intent the state Government has requested to protect these structures, accordingly the Lanco Energy Private limited has utilized the services of the experts to review the project for protecting the structures and to review the project capacity. After completion of necessary survey and investigations it was established that the submergence of the above properties and displacement of house holds could be effectively avoided by shifting the location of the Dam from Khanitar- Mamring to Sirwani and the capacity of the project could also be enhanced from 360 MW to 500 MW.The dam was also replaced by a Barrage. The final DPR for 500 MW has been prepared after detailed technical studies.

This project power house is situated in South Sikkim, about 52 kilometers (km) from Gangtok city and is located next to a sparsely populated rural area about seven km from Rangpoo and around 400mt from National highway 31A. Site location studies were conducted in 2005 by a team of experts from the State Power Department, CWC and subsequently by Lanco Energy Private Ltd, and the site was selected subject to the Environmental clearance and FCA-1980 for the involved Forest land from the MoEF, Govt. of India. In 2005, a Master Plan study including some preliminary design studies were also conducted by some other agencies.

Construction and operation facilities can cause habitat fragmentation, generate noise and vibration, and impact wetlands and other natural ecosystems—as well as affect historic resources, community cohesion, and other social and community characteristics. Because of the wide range potential, impacts to the natural and human environment, and legal requirements under the EIA notification issued by the Ministry of Environment and Forests, Government of India, the user agency i.e. Lanco Energy Private Limited has entrusted the responsibility of preparing a Environment Impact Assessment (EIA) report, Catchment area Treatment Plan and Environment Management Plan (EMP) for the Hydel project to the Department of Forests, Environment and Wildlife Management, Government of Sikkim. This report was prepared with the help of house experts and technical experts from outside the Department.

Because of its land locked scenario and wide altitudinal variations the state can only be approached by road through West Bengal. The nearest rail head is at New Jalpaiguri - 115 Km from the state capital and the nearest airport is at Bagdogra is 125 Km away; both in West Bengal. The state has been recognized as a peaceful state and has ample scope for tourist development along with the Hydel project potential but due to non availability of direct air route or any second alternative route tourist in-flow is not up to the mark. Hence the state can inhance itself for upliftment next to tourism by hydel projects.

CHAPTER – II
OBJECTIVES

One of the features of the Hydel project is that while many of the benefits are spread across society as a whole, much of the adverse impacts are also distributed unevenly. People living near the project have to live with the immediate effects of water, noise, air quality problems and increased congestion on local roads. Urbanization sometimes associated with Power development projects can also have adverse impacts on landscape and habitats. Action can be taken to mitigate these adverse effects, but it is seldom possible to eliminate them altogether.

At global level, the greenhouse gases emitted from all these activities into the atmosphere make a significant and growing contribution to climate change. At the local level, decisions about the location of new power project construction must properly reflect environmental concerns. Adverse impacts should be controlled, mitigated and, where relevant, be made subject of suitable compensation. The following basic principles are fundamental to achieve these objectives. They provide an essential framework within which additional local controls should operate to manage the local environmental impact of aviation, on power project construction and development:

- Targets on water quality and air quality which have been agreed to protect human health and the wider environment should be respected;
- Power project construction and developments should be consistent with existing arrangements for the control of soil erosion and excessive runoff and its impact on downstream areas;
- Air, water and noise impacts should be minimized;
- Further procedures and regimes for managing water should be adopted.

Local controls should operate within these principles to manage the environmental impact while development, so that:

- Loss of landscape and built heritage is avoided wherever possible or otherwise minimized and mitigated to the greatest extent.
- All relevant water quality and other mandatory environmental standards are met;
- Impact of soil erosion and surface runoff on downstream areas is minimized;
- Local air quality is maintained within legal limits across all relevant pollutants in order to protect human health and the wider environment;
- Surface access to project is designed to help limit local environmental impacts;
- Noise impacts while construction are limited, and where ever possible reduced over time;
- Impacts on biodiversity, such as disturbance of habitats and species, are minimized;
- Steps are taken to check the soil erosion and landslides by way of appropriate engineering and biological measures;
- In addition, landscaping is taken up in the sub-watershed area and plantation is taken up in the entire watershed area and surrounding areas for aesthetic improvement which will also help in soil erosion and noise abetment;
- Mitigation of environmental impact by taking up appropriate measures including engineering works for restoration of perennial water sources, controlling damage caused to seasonal jhoras, taking up block plantations on vacant lands and on the approach road from Barrage area to the Powerhouse for overall environmental improvement.

A wide-ranging and balanced approach is needed to deliver these objectives, which will include steps to be taken by the agency responsible for construction of the power project and its operation in future and will include:

- Applying increasingly stringent technical standards to limit emissions and noise at source;
- Encouraging developers to adopt the cleanest and quietest operational practices;
- The operators should ensure better environmental performance;
- Using economic incentives to encourage noise and emission reductions, and the use of best available technology;

- Working with industry and universities to research, develop and introduce cleaner and quieter technology, land-use planning and management measures.

These measures need to be applied with full regard for safety considerations, technical feasibility, and economic reasonableness, including equity issues. In many respects, the international nature of the industry means that action to tackle these problems must be taken in collaboration with governments and institutions world-wide. The national Government should ensure that we meet our international commitments and obligations; and we continue to play a major role in seeking to develop new solutions and stronger actions by the appropriate international bodies.

Finally, it needs to be ensured that aviation meets its external costs, including its environmental and health costs. The Project developer has a responsibility to reduce its impacts under the 'polluter pays' principle. The biggest impact in monetary terms due to construction activities envisaged is change in soil erosion and runoff rates in the down stream areas and its mitigation costs apart from aviation's contribution to climate change for which a longer term solution has to be found out. In the meantime it is expected that the power industry and international bodies address the 'polluter pays' problem seriously, responding creatively to the common challenge of global warming.

The following chapters are set out in more detail our policies to address local impacts on various ecosystems, soil erosion and noise, local air quality and climate change. The measures suggested will be supplemented by specific and in many cases locally determined, environmental controls and will be accompanied by stronger mitigation and compensation measures. At the local level mitigation measures need to be taken so that the problems related to adverse impact on soil water regime, excessive surface runoff, habitat loss of endemic species, noise pollution are minimized.

CHAPTER – III
METHODOLOGY

Different kinds of problems may be faced during and after construction activities of the proposed power project which if not treated timely may affect the functioning of various components of the local ecosystem adversely. Analytical task of a manager is to define the problem, identify the key variables in any situation, to predict the possible outcome of any changes in the variables and to select the ones that can be and should be influenced. Diagnosis of the problem is therefore, a key management function that can lead to an effective formulation of an EIA report and for solving the dilemma EMP report suggests various prescriptions. The problem solving process in an EIA exercise is thus an elaborate process. It involves various steps including identification and selection of a problem and its careful analysis in order to find various factors contributing to the problem.

To meet the information needs gathering of secondary data preceded collection of primary data. Secondary data was collected from periodicals, books, government publications and internal resources of the department including various reports. Wherever gaps were identified primary collection of data was undertaken in order to test and validate the findings. Once the critical contributing factors are identified various alternative ways to minimize or eliminate these adverse factors are conceived .Each one of these solutions is evaluated to determine its efficacy and finding out the optimal method of improving the existing scenario.

The broad parameters which are adopted in the present EIA and EMP studies include:

- Compliance with relevant environmental legislation;
- Promotion of the commitment to sustainable environmental management to all stakeholders including land owners whose land has been acquired, those living in the vicinity of the proposed site, tenants, adjacent landholders employees, and the community at large;
- Continual improvement of environmental management, consequences and activities;
- Identification, prevention, control and minimization of environmental performance impacts associated with Hydel project construction and operations;
- Integration of environmental issues with project Operation Plans;

- Measurement, monitoring, reporting and improvement of any environmental issues arising from project operations;
- Sustainable management of resources;
- Appropriate management of matters of natural, indigenous or heritage value;
- Contribution to research on natural temperate grasslands and associated endangered species, their protection and preservation.
- Broad consultation with the community, government agencies and other major stakeholders.

There are many techniques available for collecting the information necessary for analyzing a problem. Some of the methods and techniques employed in the present study are as follows:

(i) Review of available literature,
(ii) Employing GIS techniques and Remote sensing data to assess the change in surface runoff due to increase of impervious surface area
(iii) Soil survey by Land Use and soil
(iv) Geological studies by involving State Mines and Geology department and with the guidance of Geological survey of India, Gangtok branch.
(v) Socio-economic impact analysis by sampling and survey and consulting available literature
(vi) Impact on flora by actual enumeration of trees likely to be felled in the acquired area
(vii) Impact on flora and fauna by detailed survey and interviews
(viii) Meetings with National and local government officials,
(ix) Site visits to the proposed areas and surrounding areas,
(x) Discussions with inhabitants near the site,
(xi) Ambient noise, air quality and water quality sampling and testing in the project area and in the laboratory by the State Pollution Control Board (SPCB),
(xii) Public hearing as provided for in the EIA guidelines of MoEF by the State Pollution Control Board (SPCB) and
(xiii) Application of professional knowledge, expertise and experience.

DATABASE

The remotely sensed primary data was obtained in digital form (CD Rom) from NRSA, Hyderabad, and Project area was demarcated from the full scene with following details:

Satellite	Sensor	Path/Row	Date	Date type & bands
IRS-IC	LISS-III	107/51	28/6/2003	Digital -1,2,3,4,
IRS-ID	PAN	107/52	24/7/2003	Digital –A,B,C,D

For the Secondary data, Survey of India Topo- sheets on 1:50,000 or 1:25,000 scale was referred for the preparation of base map and drainage map.

For vegetation mapping standard methodology of digital image processing was adopted which included the use of image elements. Like tone, texture, shape, location, association, pattern, etc. and ancillary information like elevation and landforms. These interpretation elements were followed by the preparation key.

BASE MAP PREPARATION

The preparation of base map of the study area was the first step in this direction. Various permanent features like roads, rives settlements, Gumpas or any other land based features were transferred to the base map. (Only main features were considered for this purpose). Thereafter preliminary interpretation of Satellite data was carried out and a preliminary interpretation key was prepared. The preliminary interpreted maps thus prepared were discussed with the Field staff of the project area and finally taken to the field for ground checking and discussion with the local public.

Reconnaissance survey was carried out in the month of June, 2005, this trip was undertaken basically to understand the terrain, vegetation and vegetation associations of the study area: During this visit the preliminary interpreted data was tested and necessary corrections were made. The physiographic features on satellite data appearing in different tones and textures were used to correlate image elements and ground features for accurate identification. The field visits were, therefore, undertaken to collect the necessary ground truth throughout the study area. The interpretation key was finalized and the satellite images were interpreted as per the objectives of the project and all the thematic details were then transferred to base map on 1:50,000 scale. The preparation of final maps was followed by ground checks, which form the most essential part of the mapping.

FOREST TYPES AND FOREST COVER

The details on forest types & forest cover in the project area were based on our survey, enumeration and the details available with the Department .The major forest types encountered in the site were described based on the classification of Champion and Seth (1968).

FLORISTICS

The detailed account of flora, floristic ecology and plant communities has been described based on the 100% enumeration in the project area and sample survey in the forest areas outside the project. These surveys were undertaken during different seasons of the year to account for most of the flora elements found in the area. The complete inventorisation of the flora was carried out after consulting the existing literature on the flora of these areas. Of particular help were the floral accounts of Anderson, 1869: Chaudhury, 1951: Hooker, 1949-51, and 1954: Rao, 1964; Smith & Cave, 1911; Hajra & Verma, 1996; Singh & Chauhan, 1998. The inventory of flora thus prepared was used to asses the quantum of endemics, monotypics and other specialized taxa present in the area. A detailed inventory of plant species was prepared separately for the Forest and Private lands, along with the sample surveys in in the surrounding Forest areas.

FAUNA

Faunal surveys were carried out through field visits and direct and indirect sightings, Transact methods and Interaction with the local residents. The presence of wildlife was also confirmed from the local inhabitants depending on the animal sightings and the frequency of their visits in the Project area. In addition to these, secondary sources mainly literature was referred to for preparing checklists and other analysis in the study of animals and wildlife in the region.

PHYSIOGRAPHY

Survey of Indian Topo-sheet has been taken as spatial database on physiographic features along with the satellite data, Geographic information System (GIS) tools and the ground realities. All these data were collected, arranged and presented according to the EIA methods used in the study. These data were organized and presented in the form of general drainage map of the sub-watershed. A slope model for entire project area was digitized from the contours of Survey of India topographical sheets at 1:50,000 and 1:25,000 scale, where available, following a 100m contour interval. The contours were traced from the toposheets, scanned and digitized using I _ Geo Vec software from ERIDAS and ARC packages. From the digital data, a digital elevation model (DEM) for the entire sub watershed was generated. Similarly, thematic maps for elevation- relief and aspect were also generated. The area for each slope category was calculated for the entire catchment. Percent area under various slope categories namely gently slopping, moderately slopping, high sloping, very high and steep was done. Settlement map for Pachey sub water shed has also been developed. Aspect map for the entire project area has been developed. Along with the satellite, Toposheet, GIS details, more emphasis has been given to the ground realities / ground truthing. A map showing all the available features with in the radius of 7 Km has also been developed for the better understanding of the Physiography of the project area.

HYDRO-METEOROLOGY

Monthly rainfall data and Temperature data for the nearby station (Tadong) was taken from 1991 to 1999 from Indian Meteorological Department. Services of the Central Water Commission have been fully utilized to complete the study. The recommendations made by the CWC are also mentioned in the reports.

LANDUSES AND LANDCOVER

Land use and land cover mapping was carried out by standard methods of analysis of remote sensing data and followed by ground truth collection and interpretation of satellite data. For this purpose digital data on CDROMs was procured from National Remote Sensing Agency (NRSA), Balanagar, Hyderabad. Digital image processing of the satellite data and the analysis of interpreted maps were carried out by using Image Analyst, IRAS-1B, IRAS-1C, LISS-III and PAN datas.

AQUATIC ECOLOGY

Proper attention has been given to study the aquatic Ecology. All the water sources from the Sub watershed are joining the Teesta river hence all the studies are concentrated mainly on Teesta river. The Survey was conducted in Teesta in the East district of Sikkim during the months of April and May, 2006. The sampling was carried out at downstream and upstream near by the project area. The sampling of various biological parameters were conducted in three replicates at the site and a mean value of each characteristic was computed for final result. For these purpose services of Zoology department, Govt. Degree College has been taken and their observations and suggestions are reflected in the report.

GEOLOGY AND SOIL

Since the proposed project is directly depending upon the Geology of the area detailed Geological study of the site and its surroundings has been given to State Mines and Geology department for detailed Geo-Technical investigation of the proposed project area. Preliminary study has been conducted by involving the Geological survey of India, Gangtok branch. Steps taken for the preparation of weighted curve no. Map for the sub watershed to study the soil erosion and surface runoff are as follows:

1. From the toposheet, boundary of the Watershed was digitized and it was saved as segment map.
2. Segment map was converted into polygon and finally polygon map was converted into raster form.
3. From the soil map and land use map of Sikkim AOI (area of interest i.e. sub Watershed) was separated to prepare soil map and land use map for the watershed.
4. Hydrological Sol Group Map was generated as an attribute of Soil map of sub Watershed of Sikkim.
5. Two dimension tables was prepared by assigning different curve no. to the prevailing land use and hydrological soil group in sub Watershed and graphical values of AMC III were also calculated.
6. Using 2 Dimension table Land Use map and Hydrological Soil Group map was combined to generate the Curve number map of the Sub Watershed
7. Boundary map of Sub Watershed was crossed with the Curve number Map of the Sub Watershed to obtain weighted curve number within the watershed.
8. In the weighted curve no table with the help of aggregation function average weighted curve no (CNII) was found out.
9. The values of weighted curve no (CNIII) were found from the graph.
10. Using rainfall data of 5 days for 24 hours during last 20 years for the peak season, values of original runoff were calculated.
11. With expected change in land use pattern like construction of Barrage, Powerhouse, residential buildings etc. the runoff values were re- calculated using the same rainfall data.

SEISMOTECTONICS

For this studies the works of Verma et. al.(1995) has been used for better understanding of the area proposed for Hydel project. Alongwith Verma *et.al.,* (1995) the two other works by Narula *et.al.,* (1998) and Kayal et.al (2001) also provide the most recent synthesis on the present status of Knowledge on the seismic activity in the Himalayas. In this report we have highlighted the critical aspects of seismicity in Sikkim Himalaya and adjacent regions vis a vis their environmental implications on the Project.

SOCIO-ECONOMIC SURVEYS AND STUDY

Detailed socio-economic door to door surveys were conducted in the proposed project area. Collection of data was completed at two levels, at village and individual household level by using the local literates. The Socio-economic survey at the village level was aimed at finding out the status and extent of amenities and resources at the disposal of villages. The household surveys were conducted with the main aim of evolving and preparing compensatory packages for Families whose lands would be affected by taking up this project. The aim of household survey was also to understand the aspirations of the local people from the proposed project and also their willingness to accept the project. Though the Survey was essentially a random one, care was taken to cover a large sample size well represented by social and economic groups from among the villagers .A complete set of questionnaires for village level and household level surveys was given to get the clear picture of the Socio economics in the project area.

WATER, NOISE AND AIR ENVIRONMENT

Water analysis was conducted in Teesta in the East district of Sikkim during the months of January and February, 2006. The sampling was carried out at downstream and upstream of the near by the project area. The sampling of various Physical and chemical parameters were conducted in three replicates at different sites and a mean value of each characteristic was computed for final result. Services of State pollution control board were fully utilized and their observations including the mitigative measures are reflected in the report.

IMPACT PREDICTION

Prediction of impacts has been based on a broad matrix group ecosystem constituted by physical and biological components. The vulnerability of an ecosystem to various impacts resulting from an activity or multiple activities was identified and accordingly impacts were predicted. A generalized scheme for an ecosystem based impacts approach is outlined below. Using this model a matrix of activities having impact on an environmental valuable was constructed. This matrix is very close to the Environmental Evaluation System (EES) of Battelle Columbus Laboratories in USA described by Dee et al .(1979).

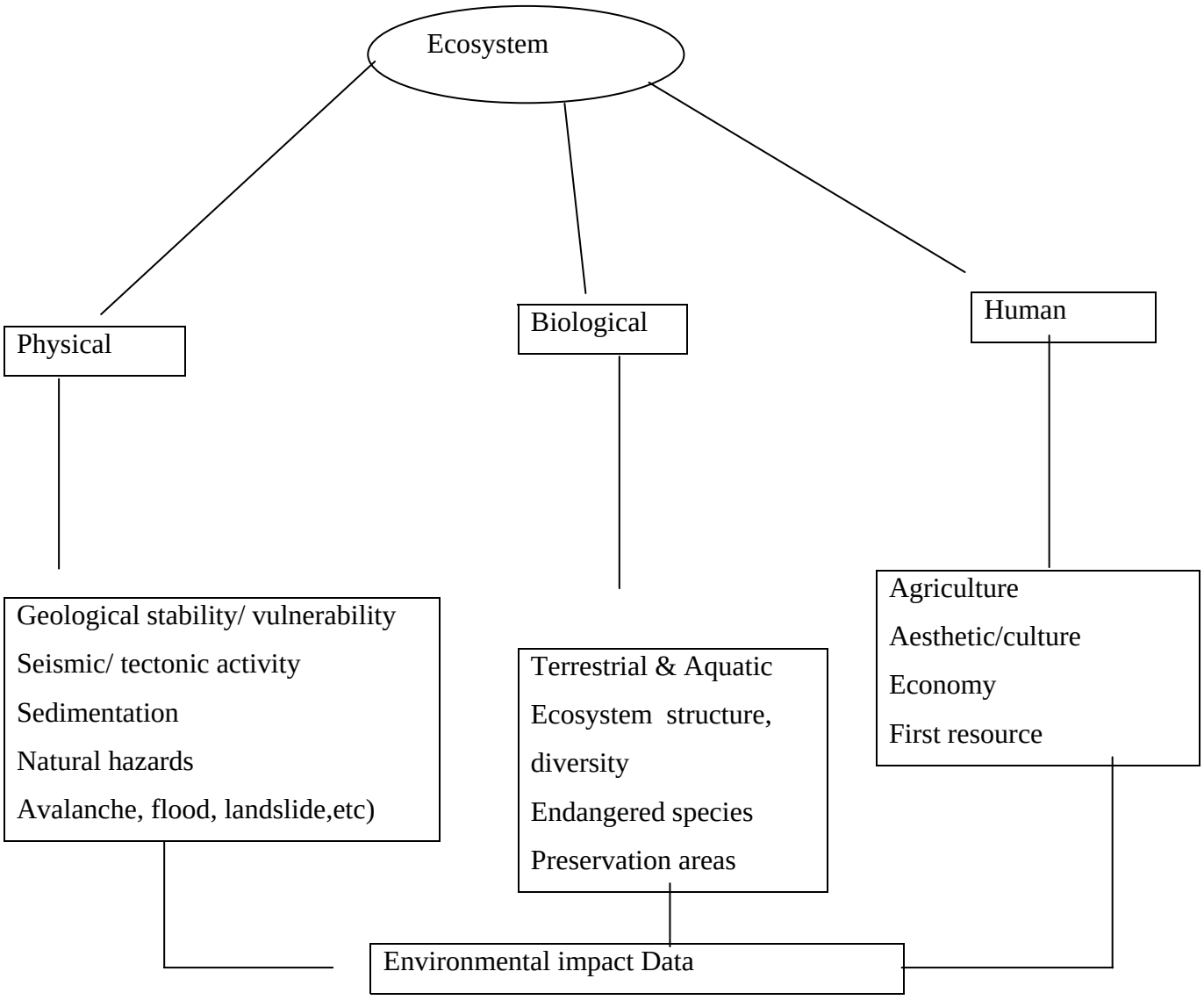


Fig. A simplified model for assessing environmental impacts of water resource projects.

The main theme of the ecosystem approach in visualizing impacts on various sets of environmental data revolves around the projection that natural processes and patterns are likely to be affected under impacts of a developmental activity. In natural ecosystems, the impacts would surely change the existing state of equilibrium. In managed ecosystems and human societies impacts could be of positive as well as negative consequence. Similarly, in case of

natural ecosystems likelihood of negative impacts could be seen in terms of direct and or indirect, temporary or payment impacts. Also, what is evident from this model is the preparation of a baseline data, which could be of great use for understanding actual post-project impacts.

There are however, limitations in most of these methodologies of impact prediction. In absence of long –term data availability on various environmental variables and also the paucity of studies on their likely responses to changes under developmental activities, it is difficult to predict impacts with a high degree of exactness and certainty. For example, it will not be possible to predict impacts of such a developmental activity on the behavioral patterns of animals and bird populations except for the fact that their habitats may come under stress. In that sense these predictive impacts could be said to have a limitation.

CHAPTER IV

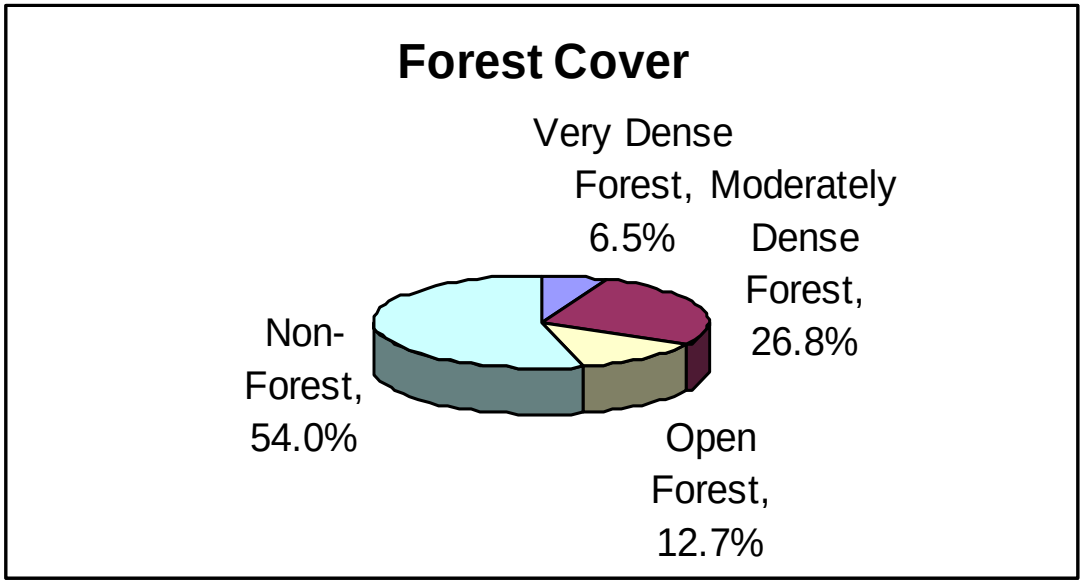
BIOLOGICAL ENVIRONMENT

FLORA, VEGETATION AND FOREST TYPE

As per the **State of Forest Report** of the Forest Survey of India, Ministry of Environment & Forest, Government of India, the Forest cover assessment status in different reported year is as under:

(Area in sq. kms)

Year	1987	1989	1991	1993	1995	1997	1999	2001	2003
Forest Cover Assessment	**2,756**	**3,041**	**3,041**	**3,119**	**3,127**	**3,129**	**3,118**	**3,193**	**3262**
Percentage of Geographical area	**38.84%**	**42.86%**	**42.86%**	**43.95%**	**44.06%**	**44.1%**	**44%**	**45%**	**46%**



Forest Cover (2003)	
Very Dense Forest	458 km^2
Moderately Dense Forest	1,904 km^2
Open Forest	900 km^2
Total	3,262 km^2
Of State's Geographic Area	45.97%
Of Country's Forest Cover	0.48 %

The state has its unique geographical position, varied topography, high annual precipitation, maximum humidity and varied elevation aspects make one of the richest botanical area of the country. According to the forest Survey of India, nearly 46% of the total geographical area of the state is covered by the Forests. Even though the percentage of the states geographical area is 0.1% there are 33% of the flowering plant varieties (about 4500 Species of Flowing plants) distributed throughout the state. As per the Survey of India's 2003 report there is an increase of 69 Sq kms Forest cover in Sikkim from the last two years (i.e 2001 to 2003). According to the Champion and Seth's classification, the vegetation of Sikkim can be classified under following heads.

1. **Tropical semi – evergreen forests.**
2. **Sub- tropical broad leaved hill forests.**
3. **Himalayan wet temperate forests.**
4. **Sub alpine forests**
5. **Moist alpine**
6. **Dry alpine**

1. Tropical semi – evergreen forests $2B/C_{1b}$

These type of forests are mainly confined to foot hill regions in Rangit valley bordering to the West Bengal upto an Elevation of 900 m. with Sal as the main species along with a few deciduous components. These forests comprise of three main sub type of forests namely, Sal, Dry mixed and mixed forests. In some places Chir pine *(Pinus roxburghii)* are also reported with the Sal forest. Dry mixed forest are mainly deciduous and occur on ridges and south facing slopes. Wet mixed forests are mainly confined in deep valleys with a very humid climate. The common species are viz. *Shorea robusta Goertn. Agalaia lawii (Wight)*

Ramamurthy, Tectona grandis, Alstonia neriifolia D.Don, A.scholaris (L) R Br .Bombax ceiba L ., Chukrasia tabularides A .Juss, Bauhinia Purpurea Linn. Lagerstroemia parviflora Roxb .ex DC. Walp., Terminalia myriocarpa Heurck, T. alata Heyne ex Roth, T. chebula Retz., T. belerica (Gaertn.) Roxb., Phyllanthus embilica L., Ficus palmata, Ficus hirta Vahl, Mangifera sylvatica Roxb ., Tetrameles nudiflora R,Br., Albizzia gamblei Prain, A procera (Roxb.) Benth. and A .odoratissima (L.f.) Benth. It is a climax type of vegetation in the foot hills of the state influenced by physiographic, biotic and edaphic factors.

2. Sub- tropical broad leaved hill forests 8B/ C_1

As altitude increases from 900m to 1800m the forest type changes from Tropical to Sub-Tropical comprising of the species of *Macaranga denticulata, Schima wallichii, Eugenia sp., Sapium sp., Castanopsis sp* and *Alnus nepalensis and Emblica officinalis.* Beside that along the road side as avenue trees *Delonix regia, Acacia auriculiformis, Pinus roxburghii, Gravillea robusta and Lagerstroemia floxeginae* have been planted. A pure stand of *Ficus elastica Roxb.* Ex Hornem have been observed near Manpari busty. The shrubs and under shrubs of tropical zone are *Mallotus Philippinenisis (Lamk.) Mueller, Buddleja asiatica Lour, Clerodendron japonicum (Thunb.) Sweet, C. viscosum Vent., Adhatoda zeylancia Medic, Barleria cristata L.,B.strigosa Wild, Woodfordia fruticosa, Mikenia scandens etc*. Amongst the lianas and climbers a few can be mentioned such as *Beaumontia grandiflora (Roxb.) Wall., Bauhinia vahlii wight & Arontt ., Chonemorpha fragrans (Moon) alston, Cryptolepis buchaniana and Bauhinia variegate wight & Schutt. Bulbophyllum clarkeanum king & Pntl. and Dendrobium spp.* are the common orchids of this zone.

3. Himalayan wet temperate forests(1800-2700m) 12/C_{3a}

The vegetation gradually changes from subtropical to sub- temperate in the altitudinal range of 1800- 2400m and beyond that the vegetation becomes that of distinct Temperate forest. In this region the dominant species *are Tsuga (Hemlock), Acer, Michelia, Juglans, Rhododendron, Ilex associated with Rosa, Rubus, Berberis and Viburnum. The Typical temperate forests like Quercus (Oak), Acer, Populus, Larix and Abies densa* will dominate the region between 2400 m and 2700m. The Himalayan wet temperate forests comprise of coniferous species with needle shaped leaves easily differentiable from broad leaves species

4 Sub- alpine forest (2700m-3700m) 14/ C_2

The vegetation from tropical temperature type gradually changes to sub-alpine type at higher elevations. The tree species of *Rhododendron* are found predominantly mixed with a variety of species like *Gaultheria, Euonymus, Viburnum Juniperus, Lyonia, Pieris, Lycesteria, Lonicera, Rosa, Eurya, Symplocos,Rubus etc.*

5 Moist Alpine forest (3700m-4000m) 15/ C_1

The vegetation in this Zone mainly comprises of typical alpine meadows where tree growth is completely arrested. Quite a few stunted bushy growth species of *Rhododendron* mixed with tough clumps of *juniperus, Salix Barberis, Rosa and Lonicera* are common.

6 Dry Alpine forests (above 4000m) 16/C_1

The vegetation is practically of scattered scrubs, often barren. Most of the species are of stunted thorny scrubs nature. Some of the common species are *Berberis, Juniperus and Salix.* The Dry alpine zone has been delineated into three categories as alpine barren with no vegetative cover, alpine scrub with scattered bushy vegetation and alpine meadows / pastures predominantly of grasses.

Area Surveyed and Explored: All along the Teesta in the South District the area of survey begins from Bermiok in the north to Suminkhor Turung in the South. The southern boundary is demarcated by Seti Khola Chalamthang, Kalej Khola, Jholung, Kumle (Kabre in upper catchment), Naiam (Namthang in the lower catchment), Nalam, Kanan (Pamphok) Suminkhor.

In the left flank of the river Teesta the area included Sirwani, Singtam and Rangpoo in the east district of Sikkim. The area further extents from Rangpoo in Sikkim to Tarkhola of DGHC in West Bengal. The entire catchment area on both flanks of river from barrage site at Sirwani to Sumin Khor/Setikhola where power house is proposed is composed of Tropical deciduous to semi evergreen mixed forest type along the river Teesta.

Landuse, Forest Types and Forest Density: Oak and Middle hill forests are the dominant forests of the catchment area. The type and density classification is as follows:

Landuse, Forest Type and Forest Density Statistics of Catchment Area

Forest Type	Forest Density	Area	Pixels	Code	%Image
		ha			
Snow and Ice		8.78	166	1	0.03
Alpine Meadow		19.31	365	2	0.07
Alpine Scrub	Dense	86.54	1636	3	0.31
	Open	292.64	5532	4	1.05
Conifer Forest	Dense	507.79	9599	5	1.83
	Open	20.15	3423	6	0.07
	Degraded	160.92	38005	7	0.58
Oak Forest	Dense	4607.33	87095	8	16.60
	Open	768.00	36134	9	2.77
	Degraded	1143.49	19553	10	4.12
Middle Hill Forest	Dense	3059.10	57828	11	11.02
	Open	2168.11	58287	12	7.81
	Degraded	915.28	39914	13	3.30
	Scrub	531.01	10038	14	1.91
Subtropical	Dense	1492.73	28218	15	5.38
	Open	1940.32	83918	16	6.99
	Degraded	2498.94	24386	17	9.00
	Scrub	140.56	2657	18	0.51
Sal Forest	Dense	327.45	6190	19	1.18
	Open	114.69	18720	20	0.41
	Degraded	875.60	16718	21	3.15
Forest Thicket		467.58	8839	22	1.68
Sand		143.04	2704	23	0.52
Water		236.94	4479	24	0.85
Rocky barren		440.08	8319	25	1.59
Agriculture		4789.04	90530	26	17.25
Total		**27755.41**	**663253**		**100**

Cultivated land under Private holdings. The major cultivated crops are **paddy, millet, maize, soya bean** etc. Seasonal vegetations like **crucifers, cabbage, cauliflower, beans, cucurbits** are generally cultivated. Cash crops like **Ginger, Turmeric, Large Cardamom** etc are common.

Farm Forestry: Practice of farm forestry is customarily common through out the catchment. Timber and fuelwood species such as *Terminalia myriocarpa, Duabanga sonneratioides,*

Bischofia javanica, Castonopsis hystrix, Alnus nepalensis, Bombax ceiba, Erythrina stricta, E. arborescence, Schima wallichii, Spondias axillaries, Albizia sp etc are common in the area. In the agro forestry sector in large cardamom plantations *Alnus nepalensis* and *Macaranga denticulata* are prominent. In the marginal wastelands and farm boundaries fodder trees mostly members of Moraceae viz. *Ficus hookeriana, Ficus cunia, Ficus benjamina* are preferred. *Sauraria s*p are other fodder trees: *Thysanolaena maxima* is widely cultivated in the farm bunds and marginal lands for its fodder and broom.

The herbaceous plants available in the area are: *Ageratum conyzoides, Eupatorium odoratum, Cyanotis vaga, Commelina maculata sp, Curcuma zeodoaria, Urtica parviflora, Cyathula prostrata, Plantago erosa, Desmodium styracifolium, Drymaria cordata, Persicaria sp, Paspalum conjugatum, Arundinella nepalensis, Digitaria cruciata, Cyperus cyperoides, Chrysopogon gryllus, Imperata cylindrica* etc. Various types of Ferns and climbers are also available.

Bamboos: *Chimonobambusa hookeriana* (Pareng*), Dendrocalamus patallaris (Niva), Bambusa tulda (Malabans), Dendrocalamus Sikkimensis (Bhalubans), Dendrocalamus* hamiltonii (Choyabans), *Drepanostachyum intermedium* (Nigalo), Drepanostachyum falcatum (Sigane bans), *Phyllostachys edulis* (Kattabans) Exotic.

Fungi: Members of polyporales and aganricales are common in the area some of them are *Agaricus bisporas, a. Campestris, A. arvensis, A latipes, polyporus betulinus, P.agariceus, P.circinatus, P.cubensis* are common.

Mosses and lichens: Among the *Lichens Graphis duplicate, Lecanora distance, Evertiastrum cirrhatum,, Peltigera rufescens, P. polydactyla, Gyrophora cylindrical, usnea aspera, Ramalina himalayensis, R.calicaris, Anthracothecium variolosum, Diptoschistes rampodens,* are common.

Bryophyte: *Riccia fluitans, Marchantia nepalensis,`M.`Palmata, Anthoceros sp, Funaria hygrometrica* are common.

Exotic and invasive species: *Cryptomeria japonica* introduced in the state occupies the most dominant position among the exotics. Monoculture of the conifer is common in the middle and upper reaches of catchment. Teak in the lower reaches is equally prominent planted exotic. *Eucalyptus sp*. is not so much common. *Lantana camara* introduced as a hedge plant shows dominant patches is some areas. *Agave americana* and *Jatropha curcas* are noticed here as live hedges. *Macaranga sp* is dominant in some areas in the lower reaches.

Plant succession:

The following plant succession at different elevations are observed in the area:

Elevation 250 – 400m

Dillenia, Amoor, Eugenia, Bauhinia, Shorea, Lagerstroemia, Terminalia, Garuga, Albizzia, Duabanga, Callicarpa, Erythrina

Elevation up to 1500 m:

Schima, Ostodes, Castanopsis, Michelia, Magnolia

Elevation upto 1500m-1800m

Englehardtia,Castanopsis,Schima,Sauraria, Leucosceptrum

Elevation upto 2100m

Quercus,Betula,Bambusa,Magnolia

Non-Timber Forest Produces including Medicinal plants The role of Non-Timber Forest Produce or non wood forest produce is significant in supporting the livelihood in rural Sikkim. NTFPs in the form of fruits, fiber, fodder, flowers, vegetation, other culinary items, roots, dye and various herbal plants for medicinal purposes are collected and used by the rural masses. Bamboos and thatch grass are used extensively in the villages for minor as well as major constructional materials.

Some of the NTFPS: *Dryopteris cochleata* (Ningro) is a edible fern shoot collected consumed and marketed. *Aconogonun molle* a member of *polygonaceae* locally known as Thotne is used as a vegetable. Other NTFPs used as vegetable are *Nasturtium fontana* (Seem raya), *Urtica dioca sp, Amaranthus viridis, Agaricus campestris, Momordica dioca, Bamboo Shoots, Oroxylum indicum, Zanthoxylum acanthopodium* (Boke timbur), *Evodia fraxinifolia*

(Khanakpa), *Morchela esculenta* (Chora cheaw), *Trichosanthes anguina* (Indreni), *Tupistra nutans* (Nakima).*Edgeworthia gardneri* (Argaily), Bamboos of many varieties viz. *Bambusa, Arundinaria, Dendrocalamus etc. Sterculia villosa, Agave sp.* are generally known for fibers.

The fruit plants popular in the area are *Rubus ellipticus* (Aiselu), *Spondias axillaris* (Lapsi), *Bassia butyraceae* (Chewri), Artocarpus integrifolia, *Oroxylum indicum* (Totala), *Syzygium cumini* (Jamun), *Berberis edgeworthiana* (Musleri), *Machilus edulis* (Lapche kaulo).

Orchids: *Orchids mostly epiphytic are dominant in the area, the following are some of the important ones - Vanda cristata, Dendrobium aphyllum, D. nobile, D. eriaeflorum, D. cumulatum, Cymbidium pendulum, Eria pania, E. paniculata, E. bambusifolia, E. stricta, E. graminifolia,, Cryptochilus sanguines, Parpax elwesii, Bulbophylum hirtus, B. bisectum, B. affine, B. scabratum, B. thomsonii, B. cauliflorum, C. fimbriata, C. cristata, Liparis cordifolia, Malaxis acuminata, M. latifolia, Pholidota recurva.*

Oil bearing seed plants: *Pyrularia edulis* (Amphi*), Gynocardia odorata* (Gantee), *Viburnum mullah* (Ghora Khari), *Bassia butyraceae (*Chiwri), J*uglans regia* (Okhar) are important ones. *Thysanolaena maxima* (Amliso) is recently recognized as economically important grass having multipurpose uses such as broom grass for its inflorescence, fodder grass, soil conserving plant and also as firewood.

Medicinal Plants: In the tropical zone the followings are some of the important medicinal plants: *Terminalia chebula* (Harra), *Terminalia bellerica* (Barra), *Emblica officinalis* (Amla) are less frequently available. *Costus speciosus* (Bet Lauri), *Dioscorea bulbifera* (Githa tarul), *Piper retrofaction* (Chaba), *Piper longum* (Pipla), *Calotropis gigantia* (Ank), *Gloriosa superba* (Langare tarul). The natural habitats of Gloriosa are over exploited. *Ocimum Sanctum* (Tulasi), *Adathoda vasica* (Asuru), *Melia azadirachta* (Bakaina) *Azadirachta indica* (Neem), *Aegle marmelos* (Belpata) very rare in occurrence, V*itex nigundo* (Sewali), W*oodfordia fruticosa* (Dhunyeri), *Bacopa monnieri* (Brahmi), *Alstonia scholaris* (Chatiwan), *Bassia butyraceae* (Chiwri), *Garuga pinnata* (Dabdabe), *Oroxylum indicum* (Totala), *Tinospora cordifolia* (Gurjo), *Aloe barbadensis* (Ghew kumari), *Holarrhena antidysentrica* (Karingi), *Aristolochia*

sp. (Kiramar), *Smilax sp* (Kukurdaine), *Lawsonia inermis* (Mehendi), *Boerhavia diffusa* (Punarva*), Moringa oleifera* (Sajana).

The middle hill is equally rich the following are some of the important ones:

Drymaria cordata (Abijalo), *Zingiber officinale* (Adwa), *Achyranthus aspera* (apamarg), *Centella asiatica(Ghor tapre), Mentha piperita*(Babari), *Fagopyrum esculentum* (Phapar), *Dioscorea bulbifera* (Githa Bhegur), *Dioscorea febrifuga* (Basak), *Costus specious* (Bet Lauri), *Buddleja asiatica* (Bhimsenpathi), *Kaempferia rotunda* (Bhuin champa), *Acorus calamus* (Bojho), *Solanum khasianum* (Boksi kanra), *Rhododendron arboreum* (Laligurans), *Camellia sinensis* (Chiya), *Amomum subulatum* (Bada elaichi), *Digitalis purpurea* (Fox glove), *Cannabis indica* (Ganjah), *Aloe barbadensis* (Ghew kumari), *Rumex nepalensis* (Halhalay) *Viscum articulatum* (Harchur), *Curcuma longa* (Harde), *Garcinia cowa* (Kaphal), *Tetradium fraxinifolium* (Khanakpa), *Eleusine Coracana* (Kodo), *Asparagus racemosus* (Kurilo), *Rubia manjith* (Manjito), *Polygala arillata* (Marcha), *Lycopodium japanicum* (nagbeli), *Tupistra nutans* (Nakima), *Entada scandens* (Pangra), *Clematis buchananiana* (Pinase lahara), *Rhus Javanica (*Bakimlo), R. succedenia (Bhalaya) *Hedychium spicatum* (Doodh sara), *Nasturtium fontana* (Seem rayo), *Urtica dioca* (Sisnoo), *Stephania glabra* (Tambarki), *Artemisia vulgaris* (Titepati), *Swertia chirata* (Chiraita), *Astilbe rivularis* (Buriokhati).

In the temperate zones: *Swertia chirata*, *Aconitum ferox*. (Anphalae bikh), *Aconitum heterophyllum* (Atibikh), *Panax bipinnatifidus* (Magan), *Taxus baccata* (Dhengresalla), *Rumex nepalensis* (Halhalay), *Nardostachys grandiflora* (Jatamansi), Rhododendron sp. (Gurans), *Astilbe rivularis* (Buriokhati), *Betula utilis, Picrorhiza kurooa* (Kutki), *Arisaema sp* (Janphoma makai), *Ephedra gerardiana* (Somlata), *Dactylorhiza hatageria, Juniperus macropoda* (Dhupi), *Arundinaria microphylla* (Deo nigalo) Valeriana jatamansi, V. hardwickii

Sub- alpine forests (2700 to 3200): The forests of this zone are also ever green mainly composed of Rhododendron and conifers. Following species are commonly found in these forests viz, *Abies densa, Picea spinulosa, Tsuga dumosa, Juniperus sp. Acer caudatum, Rhododendron sp, Liparis glossula*, *Goodyera repens, polygonum sp, Eiplobium* and *Aster sp.*

Rare and endangered species of plants: No rare, endangered and endemic species are recorded during the study in the submergent area. Some of the quadrant studies of trees, shrub and herbs made in different locations of the catchment area are as under.

VEGETATION ASSESSMENT

The detailed survey was therefore undertaken to have the exact information about the specified area, because the biological components are one of the most important factors of environment. It helps to know about the exact status and nature of the area thereby providing ample opportunities to go for area specific projects. It is therefore of utmost importance that study on biological environment is undertaken as it is primary requirement in environment impact assessment which help to conserve the environmental quality. Biological components comprises of both plants and animal communities which interact not only within and between themselves but also with the abiotic (physical and chemical) components of the environment.

Available biological community is generally dependent on the availability of resources present around its niche and slight change may have adverse affect on its environment. The change in the composition of biotic communities is reflected in distribution pattern, diversity, dominance of the natural species of flora and fauna in an ecosystem.

General vegetation of the proposed project area consists of mixed evergreen species, grasses and bushes. Elevation, geological formation, temperature, soil and rainfall seem to be the controlling factors. Forestry is the most dominant land use in the state. According to forest survey of India 46% of the total geographical area of the state is covered by forest and over 32% is under dense canopy cover. The per capita cover ranges between 0.47-1.0 ha in different parts of Sikkim. Based on the altitudinal and climate variation forests can also be categorized as (i) Lower hill forest (ii) Middle hill forest (iii) Upper hill forest (iv) Sub –alpine scrub and alpine meadows.

The classification of vegetation under different zones is due to marked variation in temperature and altitudes. On mountains Temperature, rainfall and edaphic factors are seen to be major factors for vegetation type at different altitudes.

METHODOLOGY:

In order to assess the flora of the proposed project area entire area demarcated for the project has been enumerated. Along with sample plot was selected at different forest areas under

Namthang, Melli and Singtam Ranges to study the species availability, its distribution, Endemic and Endangered nature of the available species in the project area.

Sample plot of the size 30m x 30m quadrant was selected for girth perimeter, Height and canopy cover for assessing the nature and structure of the forest at different locations and their density and frequency were studied. Detailed information of sample plot is reported.

Sample Plot : Sirwani Khasmal, Singtam Range (30m X 30m Quadrant) Altitude: 450m

Sl. no	Local name	Botanical name	Girth (cm)	Height (m)	Canopy cover (m)
01.	Saur	*Betula alnoides*	175.20	20.554	10.980
02.	Siris (seto)	*Albizzia procera*	182.08	16.023	18.06
03.	Lapatey	*Duabanga indica*	98.13	8.687	9.56
04.	Lampatey	*Duabanga indica*	92.05	6.437	8.24
05.	Siris (Seto)	*Albizzia procera*	192.00	18.430	14.04
06.	Saur	*Betula alnoides*	67.51	12.080	10.93
07.	Mahuwa	*Engelhardtia spicata*	65.86	13.099	11.12
08.	Uttis	*Alnus nepalensis*	80.67	10.778	12.83
09.	Uttis	*Alnus nepalensis*	108.08	12.955	16.15
10.	Uttis	*Alnus nepalensis*	155.02	14.022	23.68
11.	Uttis	*Alnus nepalensis*	65.62	7.651	9.14
12.	Malata	*Macaranga denticulata*	80.00	10.952	13.65
13.	Gokul	*Canarium sikkimensis*	125.00	17.661	10.36
14.	Chilaune	*Schima wallichii*	86.00	11.558	14.26

SHANNON WEAVER DIVERSITY INDEX

It is defined as: H' = -SUM{pi*ln(pi)} Where,

H = Shannon Weaver Diversity Index

pi= Percentage distribution of i^{th} species

ln(pi) = Natural logarithm of pi

The higher value of H show more diversity indicating a healthy ecosystem and the lower value show disturbance in an ecosystem under environmental stress.

Sirwani Khasmal, Singtam Range (30MX30M Quadrant)
Altiude: 450M

Sl. No:	Local Name	Botanical Name	N(I)	pi	ln(pi)	pi*ln(pi)
1	Saur	*Betula alnoides*	2	0.1	-2.14007	-0.25177
2	Siris (seto)	*Albizzia procera*	2	0.1	-2.14007	-0.25177
3	Lampatey	*Duabanga indica*	2	0.1	-2.14007	-0.25177
4	Siris (seto)	*Albizzia procera*	1	0.1	-2.83321	-0.16666
5	Mowa	*Engelhardtia spicata*	1	0.1	-2.83321	-0.16666

6	Uttis	*Alnus nepalensis*	4	0.2	-1.44692	-0.34045
7	Malata	*Macaranga denticulata*	1	0.1	-2.83321	-0.16666
8	Gokul	*Canarium sikkimensis*	1	0.1	-2.83321	-0.16666
9	Chilaune	*Schima wallichii*	2	0.1	-2.14007	-0.25177
10	Kainjal	*Biscofia Javanica*	1	0.1	-2.83321	-0.16666
			17	**1**		**-2.18084**

There are 10 Species. Therefore, Species richness = 10
There are 17 individuals.
Shannon Index (H')
H' = -SUM{pi*ln(pi)} = -(-2.18084) = 2.181

Shrubs within 10MX10M Quadrant Lower Manphing

Sl. No:	Botanical Name	N(I)	pi	ln(pi)	pi*ln(pi)
1	*Crotalaria cytisoides DC*	1	0.08	-2.6	-0.1973
2	*Boehmeria rugulosa Wedd*	3	0.23	-1.5	-0.33839
3	*Solanum torvum Sw.*	2	0.15	-1.9	-0.28797
4	*Maesa chisia Buch.Ham.*	2	0.15	-1.9	-0.28797
5	*Rubus moluccanus L.*	2	0.15	-1.9	-0.28797
6	*Mimosa himalayana Gamble*	1	0.08	-2.6	-0.1973
7	*Datura metel L.*	1	0.08	-2.6	-0.1973
8	*Rhamnus nepalensis (Wall.) Lawson*	1	0.08	-2.6	-0.1973
		13	**1**		**-1.99151**

There are 8 Species. Therefore, Species richness = 8
There are 13 individuals.
Shannon Index (H')
H' = -SUM{pi*ln(pi)} = -(-1.99151) = 1.991

Herbs within 10MX10M Quadrants

Sl. No:	Local Name	Botanical Name	N(I)	pi	ln(pi)	pi*ln(pi)
1	Talwaray	*Belamcanda sp.*	4	0.1	-2.584	-0.19502
2	Udhasay	*Galintsaga parviflora*	5	0.1	-2.36085	-0.22272
3	Sisnu	*Urtica parviflora Roxb.*	4	0.1	-2.584	-0.19502
4	Banso	*Digitaria Crusiata*	5	0.1	-2.36085	-0.22272
5	Selaginella	*Selaginella sp.*	14	0.3	-1.33123	-0.35165
6	Ilamay	*Ageratum conyzides*	9	0.2	-1.77307	-0.30109
7	Kuro	*Bidens biternatta (Lour) Mers*	6	0.1	-2.17853	-0.24663
8	Gangleto	*Pilea scripta*	6	0.1	-2.17853	-0.24663
			53	**1**		**-1.98147**

There are 8 Species. Therefore, Species richness = 8
There are 53 individuals.
Shannon Index (H')
H' = -SUM{pi*ln(pi)} = -(-1.98147) = 1.981

Pielou Index or equitability

It is defined as

$$E = \frac{H}{H\ max}$$

Where E = Equitability index (Range 0-1)

H = Observed species diversity

H max= Maximum species diversity-Log2 S

S= No of species in the community

The equitability or evenness of allotment of individuals among the species of an ecosystem increases with increase in diversity of the species. Point centered quarter method was used to study the diversity and equitability indices of the Forest ecosystem.

IMPORTANT VALUE INDEX

Important value index = Relative density + Relative frequency + Relative dominance.

Relative density = $\frac{\text{Number of individuals of the spp.}}{\text{Number of occurrence of all the spp.}} \times 100$

Relative frequency = $\frac{\text{Number of occurrences of the spp}}{\text{Number of Occurrence of all spp.}} \times 100$

Relative dominancy = $\frac{\text{Total basal area of the species}}{\text{Total basal area of all the species}} \times 100$

A single importance value has been calculated based on relative density relative frequency and relative dominance for a species and the value has been converted to 100 points scale. This generates a composite value relative to each species in a stands or number of stand. The importance value allows comparison among of the species in a stand or with the species in another stand with respect to ranking the vegetation for their uniqueness, commonness or degree of disturbance.

In the East of the river species density was observed to be very low which may be attributed to high human impact at the periphery but in West of the river the species density was partially higher which may be due to less disturbance in the core region. Besides the trees a good

number climbers and epiphytes were also observed growing on the trees. Some of the trees were observed to be infected by pests. Orchids were quite common in most of these areas. Mosses were also observed on most of the tree trunks along with the lichens.

Forest trees at Mamring site was observed to be and well distributed the stratification of varieties of species was also observed in the forest. *Alnus nepalensis* was a common species in the project area. At power house (Sumin khore) the steep rocky mountain had very less species which was due to poor soil formation. The mountain contained patches of grass species.

IMPORTANCE VALUE

The data collected has been used in assessing the characteristics of the forest community such as species composition of the vegetation, role of relative importance of individual plant , species (such as dominance and rarity), relationship between plants, species distribution ,number of individuals of each species and the structure of plant community. The plant cover basal area and the aerial spread of crown of each species are used as the main measures of dominance.

Mamring, Manpari busty areas are rich in forest vegetation . There forests consists of varieties of tree species. Chilauney (*Schima wallichii*) is the most dominant plant species available in the area with highest relative density of 69.2, relative dominance of 70.1 and highest importance value index (1V1) of 69.23 at Kalej Khola area where as *Toona ciliata* showed the lowest relative density, relative dominance relative frequency and importance value index.

Forest management and landuse system:

Lands in general have been categorized as Reserve Forest, Khasmahal, Private holding, Barrens and Bhir/Rocky area /snowbound areas. Natural forests of mixed vegetation of broad leaved category without any trace of conifers dominates the lower, middle hill and lower reaches of upper hill forests upto 1800 elevation pure patches of artificially created *Cryptomeria japonica* is frequently noticed in the middle hill and upto lower reaches of temperate zone. *Taxus baccata* does appear as the natural element of conifer in the lower temperate zone. This is followed by another natural conifer member *Abies densa* in the temperate zone.

Mixed broad leaved plantation generally of *Michelia sp, Toona ciliata, Chukrasia tabularis, Gmelina arborea* is practiced in lower tropical zones. Pure patches of *Tectona grandis* in the

tropical zone are common. Thus practice in a sloppy area is not advisable considering the status of soil erosion which is very high in the slopes due to the heavy drip action of water collected and released in large quality in the huge foliages of *Tectona grandis*. Similarly, in the upper hills the pure monoculture of *Cryptomeria japonica* has adverse effect on the bio-diversity and soil. Both of these could be considered in the management plan for needful treatment of thinning followed by introduction of desired broad leaved associates. These is non-wood based industrial unit in the area. Illicit collection and trade of timber is checked due to the presence of check posts.

Conclusion:

Over all area of the project does not involve removal of forests factual assessment of NTFP and medicinal plants need to be done. In view of the above observation, Survey and study made on various aspects of Environmental factor is concluded that the vegetation and floristic element falling under the project areas are similar to the other catchment areas of the project. No Endangered and Endemic Species are available at the time of study in the proposed project area. The management plan of the area should be able to accommodate management of NTFP, creation of NTFP plantation, Study of NTFP and medicinal plants. The governance and the public in general should be made aware of the NTFP contribution in the human life and society. So that a comprehensive managements plan is prepared and implemented properly in the watersheds under compensatory afforestation schemes to rejuvenate the forest wealth. Under the same programme a provision should be kept apart to appreciate the people's contribution in greening the land or helping in creating carbon sequestration system in the nature. Besides meeting up this domestic need of people it generate cash flow in rural area later. The surplus production of tea leaves can be sent for processing in Temi tea factory located in the vicinity of the area. To compensate the vegetation losses it is also proposed to plant ten no's of seedlings in place of each felled tree , for this purpose a scheme has to be prepared to take plantation with the cost of user agency in the vacant forest land according to the provisions of Sikkim Private and other non Forest land tree felling rules 1998.

LIST OF SHRUBS, UNDER SHRUBS, HERBS, CLIMBERS AND GRASSES RECORDED IN THE PROPOSED PROJECT AREA.

SHRUBS AND UNDER SHRUBS

Thuja orientalis L.

Crotalaria cytisoides DC.

Boehmeria rugulosa wedd.

Solanum torvum Sw.

Boehmeria platyphylla Don.

Rhamnus nepalensis (wall)Lawson.

Maesa chisia Buch – Ham.

Rubus moluccanus L.

Datura metel L.

Mimosa himalayana Gamble

CLIMBERS

Trichosanthes bracteata (Lamk) voight

Rubia manjith Roxb .Ex Flem.

Hydrocotyle javanica

Dioscoria bulbifera L.

HERBS

Didymocarpus puleher C.Bclarke

Lysinotus serrata D. Don

Lindernia ciliata (Colsm) Pennell

Equisetum diffusum D.Don

Impatiens scabridus DC

Euphorbia hirta L.,

Curcuma zedeoria Rosc

Bidens biternata (Lour) Mers & Scherff ex Scherff

Gynura napalensis DC.

Ageratum conyzoides L.

Persicaria nepalensis (Meissn) H. gross.

Urtica parviflora Roxb.

Cyanotis barbta C.B.Robinson

Asclepias curassavica L.

Solanum barbisetum Nees

Syndrella nodiflora (L) Gaertn.

Cyathula prostrate (L) Bl.

Clinopodium umbrosum (M.Brieb) C. Koch.

Palhinaea cernua (L) Franco & Vasc

Costus speciosus (Koenig) Sm.

Knoxia sumatraensis (Retz.) DC.

Impatiens longipes Hook .

I.pulchra Hook .f & Thomas.

Achyrospermum densiflorum Blume.

Eupatorium adenophorum

GRASSES.

Kyllingia brevifolia Rottb.

Pogonatherum crinitum L.

Cyperus rotunds L.

C. cyperoides (L) Oktze

Coixlacryma jobi L.

Carex condensata nees

Arundinella nepalensis Trin

Sporobolus Spp.

Eleusine indica L.

Setaria palmifolia (Koen) Stapf.

Erioporum comosum Wall.

Digitaria cruciata Nees.

FAUNA AND WILDLIFE

INTRODUCTION

The Teesta stage –VI HEP 500 MW project is proposed in Subin Khore in the right bank of river Teesta at Tarkhola in the South district of Sikkim. The catchments area up to barrage site is 4500 sq Km. The major components of the projects are construction of barrage in 500 m downstream of L.D.Kazi Bridge on river Teesta at Sriwani, a head trace tunnel of 11.5 km and under ground power house of installed capacity of 500 MW. The field study reveals that the vegetation in the upstream of the main barrage site is sparse and mainly falls in the private land of different individuals in both side of Teesta river n East and South Sikkim The down stream site of the project area near the power house covered with Sal forest with miscellaneous species. The entire area of the project area falls within the stream of Teesta river and considerable amount of vegetation of sal with miscellaneous forest are found. Sriwani Bazar is situated in fringes of dam site in northern direction and human population is quite thick. The human habitation in the entire project area are thickly populated . The main villages falls within the project area are Sriwani, Dalep, Namping, Tokal Bermiopk, Chalamthang, Karek, Kabrey, Samardung, Mamring, Donak, Turung, Panphok, Suntaley and Suminkhor in South Sikkim. Similarly Sriwani, Singtam,Bardang, Majhitar ,Rangpoo along the Teesta river belt are situated in the East Sikkim of the project area. In the process of impacts assessment of faunal elements of the project area, the faunal composition, its distribution, status of wildlife, avifauna, reptiles, butterflies etc have been studied and enumerated during various seasons of September- October 2005 till June 2006.

FIRST IMPRESSIONS:

1. The area is dominated by rice fields, parts also by orange orchards and vegetable gardens
2. The area has above it a broad swathe of forest cover all along its upper boundary, which falls outside the proposed area.
3. The area is very good bird habitat as there are both open rice fields with flocking birds like Russet Sparrows *Passer rutilans,* and common urban birds like House Crows, Blue Rock Pigeons and Common Myna (nesting in the bazaar area in trees or buildings). We saw a huge flock of about 50+ Russet Sparrows fly up from the field into a dry tree.

There are also many forest birds like Grey-headed Flycatchers, Laughing thrushes, Warblers and Magpies. Such areas with both open as well as forest areas and edges are rich in birds. Their numbers would be more obvious in the breeding season around March-June.

4. The household at the head of the Mamzey Pass informed that during season, the valley is a flyway for Eagles and even Vultures. Other villagers also informed that during Feb-March migratory waterfowl locally called 'Karang-Kurung' fly through the valley. However they can be heard at night or early morning.
5. Small mammal presence was recorded from local people including the Forest Staff. They include Barking Deer, Civet Cats, Wild Boar, Jackals and squirrels; Himalayan Black Bear are reported from Mamring. Kalij Pheasants and Common Hill Partridge 'Peura', Laughingthrush 'Kolkoley' are some of the larger birds.
6. It is possible that the forest swathe along the upper boundary with good bird population could be a cause for concern.

OBJECTIVES

- Preparation of check list of animals and birds of the catchments area.
- Identification of area and endangered species and their breeding and feeding vis a- vis habitat degradation .
- Migration pattern.
- Impact on fauna & Wildlife due to cutting /filling of the area.
- Measures proposed to salvage and rehabilitate.
- Broad details of endemic fauna.
- Wildlife development in the area, their monitoring, safeguards and mitigation measures pre and post execution of the work.

MERTHODOLOGY

The following methodology and parameters have been adapted, in order to acquire the requisite information on the status of wildlife abounding in the project area.

- **Through Transact Line**

A transact line was drawn in upstream and downstream of the project site at a stretch of 10 km from where vertical lines from the base line were further drawn considering the frequency and relative abundance of wildlife at an interval of 2 to 2.5 km irrespective of status of land. The direct sighting and observation were made along the cruise line up to 2 km from the start all together 5 number of cruise lines were established and efforts were made to cover as much area as possible in order to maximize the probability of findings direct or indirect evidences of wildlife trails within the project area with the assistance of local inhabitants as informers. All sightings and observations made on relative abundance of wildlife were recorded Simultaneously, the vegetation observed along the trials were also enumerated as far as possible and the key species identified along with major habitat of wildlife abundance in the area.

- **Through Night Drive**:

The observation made from the transacts were mostly nocturnal mammals and to confirm and supplement the observation, night drives were organized on 05.04.2006 along the road between Mamring, Donak,Turung area. Many nocturnal animals like lesser cats are reported by the night drivers like Leopard cat, Palm Civet cat, Jackals even Leopard in few occasion.

- **Through interview with local peoples**:

Frequent interview and meeting were held with the local people in order to collect the information regarding occurrence of wild animals and bird.

Information on IBA species recorded as sighted or reported from area under Teesta stage-VI

Out of the 233 bird species from the Important Bird Area (IBA) list for Sikkim, 105 species important bird species could occur in the project area. This does not include the migratory water birds which over fly the proposed project area during annual return migration in spring and could pose a potential hazard.

The most important of these are as follows:

1	Indian White-backed Vulture	*Gyps bengalesis*	CR*
2	Long-billed Vulture	*Gyps indicus*	CR
3	Red-breasted Hill-Partridge	*Arborophila mandellii*	VU*
4	Rusty-bellied Short wing	*Brachypteryx hyperythra*	VU
5	Beautiful Nuthatch	*Sitta Formosa*	VU
6	Hoary-throated Barwing	*Actinodura nipalensis*	RRS*
7	White-napped Yuhina	*Yuhina bakeri*	RRS
8	Black-browed Leaf-Warbler	*Phylloscopus cantator*	RRS

(* CR = Critically Endangered; VU = Vulnerable; RRS = Restricted Range Species)

OTHER FAUNA:

Many invertebrates such as insects like butterflies, moths, beetles, bugs, spiders, flies, etc. form an important food source for many bird species which spend major part of the morning and evenings looking for them. The exact current status for most species could not be assessed as the time of study and observation was restricted to six month Therefore seasonal changes of flora and migration of some species might have been unaccounted. However, within the time available entire project site was covered and fruitful observations, enumerations and sightings were made in different hours of the month.

The sighting of the mammals during the transact survey was minimum, but large number of the birds, butterfly were recorded. The sighting of mammals was perturbed by the firewood collectors, grazers and traffic playing through the road. The observations were also made along the animal strolls and rubbing of horns on the trunks of trees and poles were recorded. The scats and facial matters were later examined with naked eye and hairs of rabbit, color bones of birds and fowls were found. There were burrowing sites of porcupine, roosting truck of bats, tree habitat of Fling Squirrels, dry Chewed pulp of fruit spat by flawing fox seen along the cruise line.

There are woods, bushes, Scrub jungle with host of frog, Snakes crabs insects berries fruits root along the trial indicating rich biomass of leopard cat Rats, mice, Lizards, centipedes provided congenial food web for common mongoose in the project areas, The rocky boulders caves cultivated field bushes and hallow trees are the main habitat of the species reported.

The study of faunal elements of the project falling within the entire catchments of river Teesta have been conducted by adopting suitable method of field survey and sampling. Field visits in different seasons were conducted for collection of information on residential population of mammals, birds, reptiles, butterflies etc by adopting methods of direct sighting, by interviewing local peoples. Accordingly, studies on local migration and permanent visitors of fish- eating ducks and cormorants on river Teesta have also been made which is of immense importance in view of management of rare and threatened species of ducks , pheasant and other migratory birds.

MAMMALS

Composition and Distribution

The faunal composition of the project area has been broadly classified on the basis of the frequency of occurrence is a form of relative abundance which has determined the distribution of the different species of Mammals, Birds, Amphibians, Reptiles and Rodents. in the project area.

The study of faunal elements of the project falling within the entire catchments of river Teesta have been conducted by adopting suitable method of field survey and sampling. Field visits in different seasons were conducted for collection of information on residential population of mammals, birds, reptiles, butterflies etc by adopting methods of direct sighting, by interviewing local peoples. Accordingly, studies on local migration and permanent visitors of fish- eating ducks and cormorants on river Teesta have also been made which is of immense importance in view of management of rare and threatened species of ducks , pheasant and other migratory birds.

As per the field study and observation within the project area the following Mammals, Birds, Amphibians, Reptiles and Rodents are the residential population are reported in the project area.

PRIMATES

Local Name	**English Name**	**Scientific Name**
Bander	The Rhesus Macaque	*Macaca assamensis*
Langur	The Common Langur	*Presbytes entellus*

CARNIVORA

Chitua	The Leopard Cat	*Panthera pardus*
Jangali Biralu	The Jungle Cat	*Felis chaus*
	Marbled cat	*Felis marmorata*
Chitua Biralu	The Leopard Cat	*Prionailurus bengalensis*
Malsapro	The Himalayan Palm Civet	*Paguma larvata*
Gidder	The Jackal	*Canis aureus*
Siyal	The Bengal Fox	*Vulpes bangalensis*
Uoth	The Common Otter	*Lutra lutra*
	The Stone Marten	*Marten foin*

RODENTS

Rajpankhi	The Pari-coloured flying squirrel	*Hylopetes alboniger*
	The Common stripped squirrel	*Sciurlus palmarum*

BATS

Chamera	The Indian Fruit Bat	*Pteropus medius*

HERBIVORA

Dumsi	The Bengal Porcupine	*Hystrix bengalensis*
Kharayo	The Common Indian Hare	*Lepus ruficandatus*
Ghoral	The Brown Ghoral	*Nemorhardus hodgsoni*
Mirgha	The Barking Deer	*Muntiacus muntjak*
Bandel	The Indian Wild Boar	*Sus Cristatus*

REPTILES

Azinhgar	The Indian Rock Python	*Python molurus*
Gurbey	The Himalayan Pit-Viper	*Ancistrodon himalayanus*
Naga	The Common Cobra	*Naia tripudians*
Nagraja	The King Cobra	*Naia bungarus*
Dhaman	The Common Rat Snake	*Zamenis m*

BUTTERFLY

The field study and observation revealed that amongst the total of about 700 species of butterflies recorded in Sikkim about 30% of butterflies recorded from the project area. The subfamily Amathusiinae occurred mainly in the Teesta valley. It is reported that the best altitude to observe butterflies in the project area is between 900-1200 meters and Swallow tails, Nymphalids are abundant. Few species based on the direct sighting are recorded are as follows:

Great Zebra	Pathysa xenocles phrontis
Spotted Zebra	Pathysa megarus megarus
Glassy Bluebottle	Graphium cloanthus
Tailed Jay	Graphium agammemnon
Red Bodied Swallow tails	Atrophaneura latreillei
Common Rose	Pachliopta aristolochiae
Great Mormon	Pricepes memnon agenor
Red Helen	Pricepes helenus helenus
Common Peacock	Pricepes polyctor ganesa
Krishna Peacock	Pricepes Krishna
Chocolate Albatross	Appias lyncida elenora
Chestnut Angle	Odontoptilum angulata

The abundance of butterflies mainly depends on the availability of the larval food plants which are generally secondary growths of nester bearing plants. The total studies of the indigenous variety of species of butterflies of the project area cannot be determined within a short period of time and needs comprehensive study using longer period of time for assessment of behaviors and ecology of butterflies.

The main objectives for conservation of butterflies mainly for recycling of nutrients and play significant role in the maintenance of soil structure and fertility. This is one of the important food chain components of the birds, reptiles, spiders and predatory insects .Butterflies are also good indicators of environmental changes as they are sensitive and are directly affected by changes in the habitats,., atmosphere, temperature, and the weather conditions. Destruction of habitats by way of construction of dam reservoir, barrage and abutments s, head race tunnel, tailrace tunnels ,power house, water conductor system, desilting chamber etc will definitely

leads to environmental hazard and adverse impacts for management of one of the most beautiful and colorful creatures like butterflies.

STATUS

Many species of mammals, birds, reptiles etc found in the project area are considered to be threatened species. Like *Panthera pardus (Leopard), Felis bengalensis (Leopard Cat), Felis marmorata (Marbled Cat)* and many species of birds, butterflies and reptiles. It needs greater attention for conservation, management of these rare and threatened species of fauna and avifauna, reptiles etc.

ASSESMENT OF ENVIRONMENTAL IMPACTS

]The environmental impacts of the proposed Hydel Electric Project shall be assessed on the basis of the different constructional activities of dams, headrace tunnel, roads, power house, temporary and permanent houses, labour colonies, biotic pressure in the general wildlife habitat by quarrying of constructional materials, muck disposal, and movement of vehicle and vibration of machineries causing detrimental to the existing wildlife population. Flora and fauna and avifauna. The impacts shall be measure on various degree of welfare factor of an area for a species depends on the adequacy of supply and particularly of the distribution of arrangement of the essential requirement for existence of the wildlife in the area for food , shelter ,resting ground, breeding ground, wildlife corridor for local migration. It has direct impact caused by biotic pressure of species such as affect on pray- predator relation , unfavorable weather condition, disease, starvation due to lack of food, accident, hunting poaching and no-breeding leading to depletion of rare and threatened species. Breeding potential of the different species of wildlife, avifauna, reptiles etc are directly affected due to lack of ideal conditions being caused by heavy environmental degradation in the project area. The density of the wildlife of different species also affect due to non-availability of food and cover reducing the environmental resistance causing high mortality of the offspring leading to the depletion of flora and fauna of the surrounding area. Apart from this, there will be serious impacts on the human society in terms of socio-cultural and socio-economic structure of the area directly and indirectly related with the proposed project activities. The impact will also be presumed leading to heavy habitat disturbance, degradation of terrestrials and aquatic ecosystem, fragmentation of wildlife population and destruction of natural environment.

CHAPTER V
PHYSIOGRAPHY

GENERAL PHYSIOGRAPHY OF TESTA BASIN, SIKKIM

PHYSICAL FEATURES

Sikkim being part of inner mountain range of Himalya, is entirely hilly with an altitude varying from 231m in the south at Melli Bazar to above 8500 m (Mt. Khanchendzonga 8598 m) in the north west and Pauhuuri (7056m). The human habitable areas are limited only upto the altitude of 2100m constituting only about 20% of the geographic areas.

RELIEF AND ASPECT

The elevation of Teesta Basin varies 213 m to 8598 m within the distance of about 100 km. The river descends from 5280 m up to the confluence of Rangit River with it at Melli Bazar along its traverse of about 175 km. More than 59% of the catchments of Teesta basin lies above 3000 m. Therefore the Teesta Basin of Sikkim can be classified as high altitude basin. Only 25% of the catchments lies below 2000m. These are ridge, rocky, cliff, escarpment, landslide zone, morainic zone, low mountain (>1000m).

SLOPE

The altitude varies from 213 m to 8598 m within an aerial distance of about 100m. More than 52% of the basin lies in the slope category above 27^0 – steep to very steep class. As much as 10.32 % of the catchement area is either rocky cliffs or escarpments i.e $65^{0.}$ The catchments area under moderately steep slope category is only 8.61 %. About 4.37 % of the basin has area of gentle slope

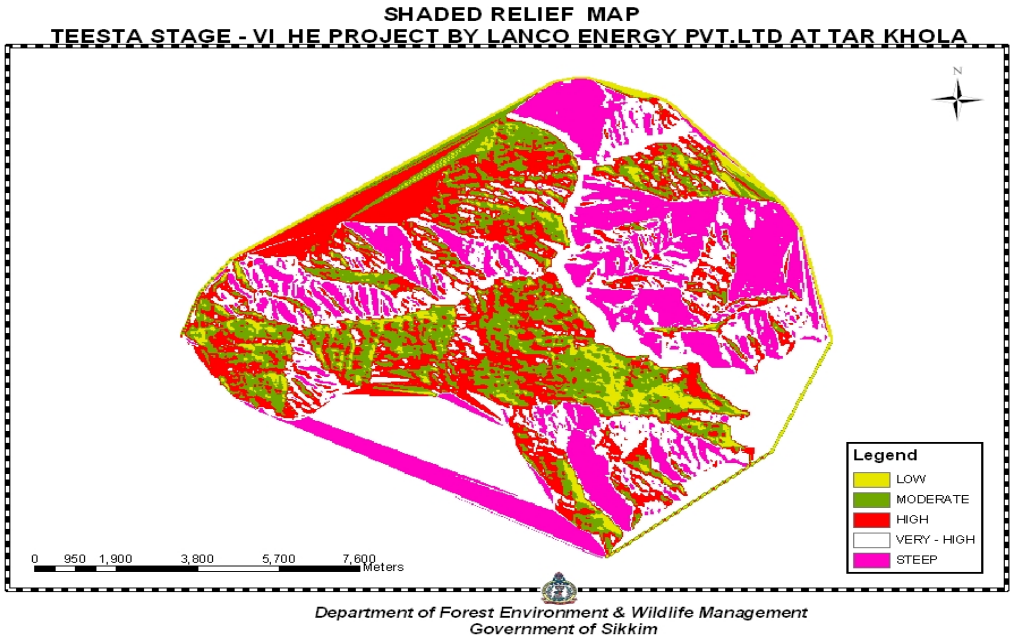
GEOMORPHIC PROFILE

The terraces and flood plains, valley side slopes, and land slide slopes alluvial cones of different types and generations, tors, kettle shaped depressions, terrace – isles, sickle shaped ranges, beveled plains, undulating plains and deeply dissected valleys, glacial or periglacial deposits, related sedimentary structure, crevasses, etc., are the distinctive geomorphologic features of the Teesta basin in Sikkim. The landforms assemblages are the result of continuous denudation and deposition process that are constantly modifying the newly formed landforms in upper reaches and burying the existing landforms in the lower reaches. Middle and lower parts of basin are marked by subduded relief, slopes, wash slides and slips, scourge and filling, abandoned channels, etc,

PHYSIOGRAPHY IN THE PROPOSED TEESTA STAGE – VI PROJECT AREA

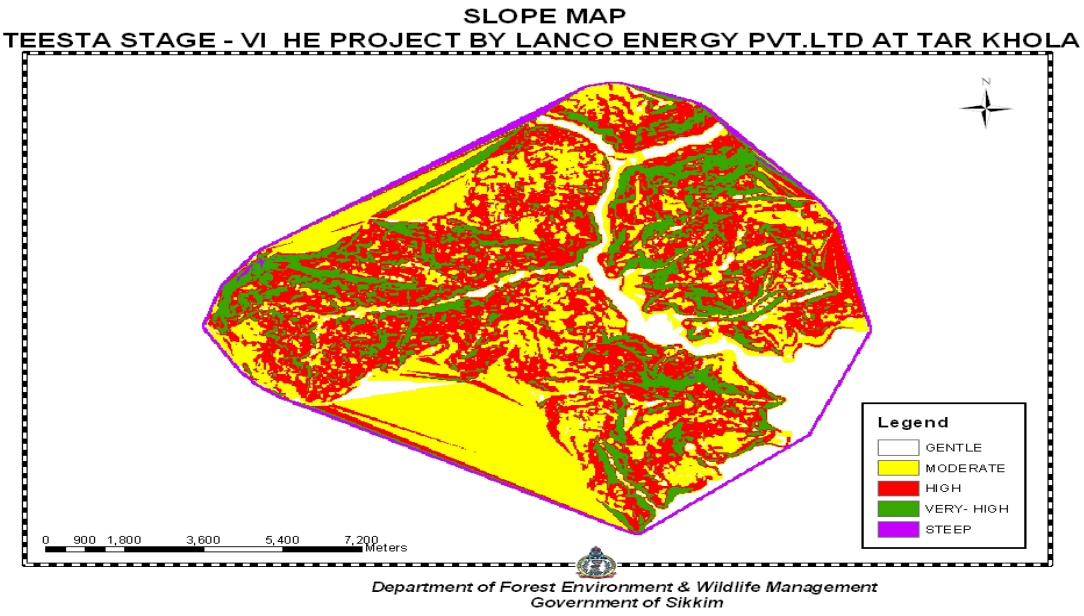
RELIEF AND ASPECT

The elevation of project area varies from 338 m to 230 m within the distance of about 7-8 km. The elevation difference between the Barrage site and the Power House is about 108 meters. The barrage site is located in between the Singtam town and the Power house location of the Teesta V. The proposed barrage is located about 100 meters down stream of the Bridge connecting the east and south Sikkim. The power house is located at the left bank of the Teesta River at 230 meters in south Sikkim. The aspect map of the project area is placed below.

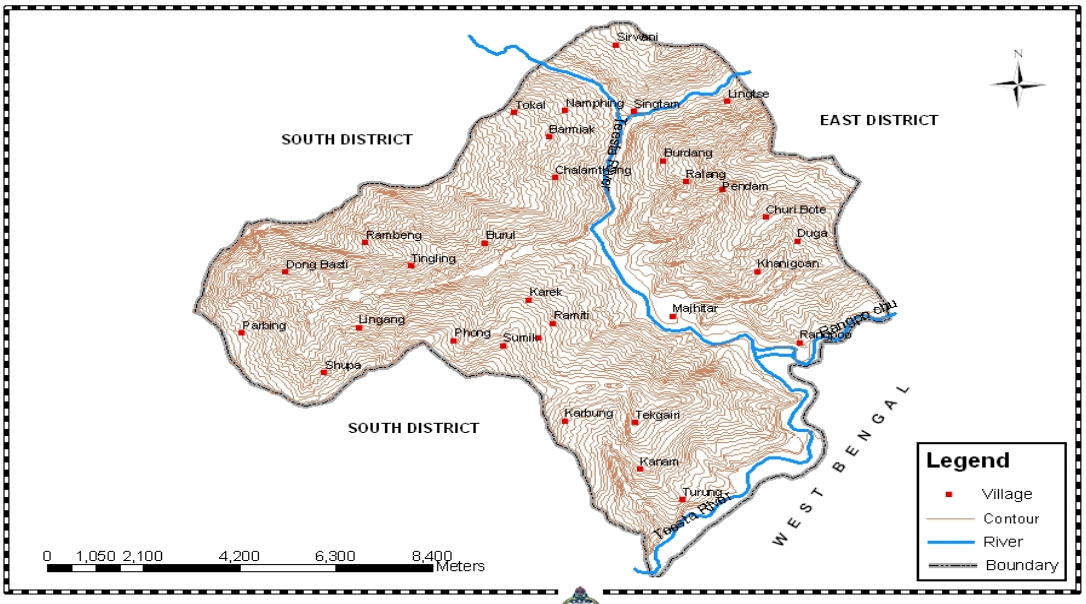


SLOPE

The project area is located in a moderate to High slope category. There are gentle slopes available near to the Barrage site and along the proposed tunnel area. There are steep slopes found near to the Power house site. The slope characters found in the project area are found suitable for the project. The slope map and the contour map of the project area are placed below.



CONTOUR MAP
TEESTA STAGE - VI HE PROJECT BY LANCO ENERGY PVT.LTD AT TAR KHOLA

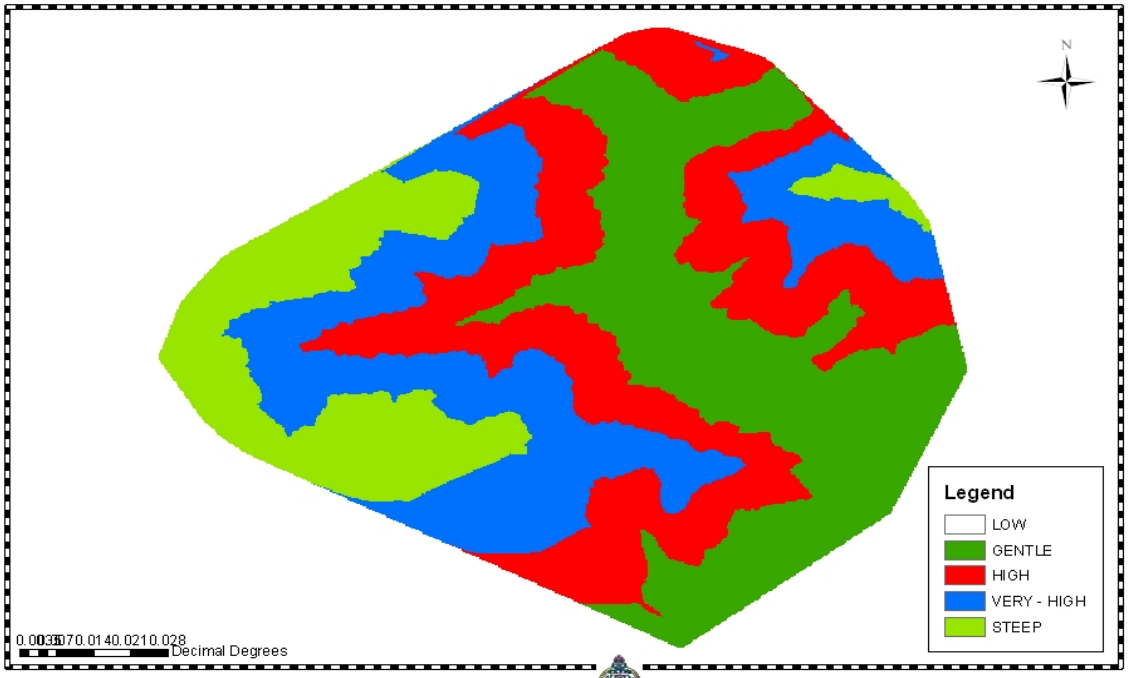


Department of Forest Environment & Wildlife Management
Government of Sikkim

THE DIGITAL ELEVATION MAP OF THE PROJECT AREA

As discussed above, most of the project area has a combination of Gentle to High elevation areas. There are certain locations which have steep slopes as revealed from the DEM map below.

DEM MAP
TEESTA STAGE - VI HE PROJECT BY LANCO ENERGY PVT.LTD AT TAR KHOLA



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Government of Sikkim

THE BARRAGE SITE

The site is located in between the Singtam town and the Power house location of the Teesta V. The proposed barrage is located about 100 meters down stream of the Bridge connecting the east and south Sikkim.

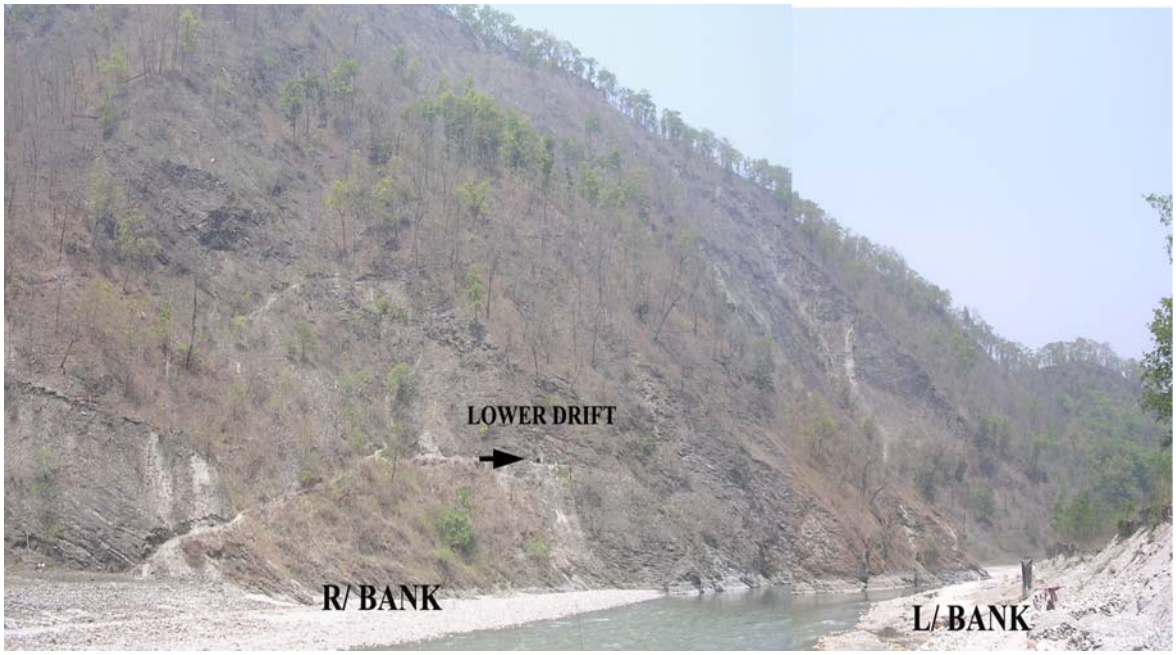
The altitude of the barrage site is 338 meter. The physiographic features of the barrage site is a mix of terraces and flood plains, valley side slopes and land slide slopes alluvial cones of different types and generations, beveled plains and undulating plains. They fall under the category of low mountains. There are a lot of inhabitation around the barrage site, of course about 3 km away from the Singtam town. The height of the barrage is proposed at 23 meters from the river bed and is a run off river barrage. Hence, the construction of barrage at the site may not have any serious impact on the existing physiography. On the other hand physiographic features seems to be favorable for the project activities at the Barrage site.

THE TUNNEL AREAS

The altitude variation between the Barrage site and the Power house. The relief, slopes along the proposed tunnel areas also fall under the low mountain range with the undulating hillocks, plains valley side slopes.

THE POWER HOUSE SITE

The power house is proposed to be located on the right bank of the Teesta river in south Sikkim about 50 meters before the confluence of Kanam Khola with the Teesta river. The power house locations have a few Steep slopes and moderate slopes. The altitude of the power house site is 230 meters.



Power House Site:

CONCLUSION

The physiographic features of the project area of the proposed Teesta VI project may not have any negative impact to the project. The project components to be established near to the steep slopes may have to have an in-built component of protective engineering measures in order to have greater stability. However, the project may not have perceptible negative impact on the Physiography of the project location.

CHAPTER VI

HYDRO-METEOROLOGY

INTRODUCTION

Mountain river basins provide the best opportunity to understand the complex relationship between climate, hydrology, ecology and human activities as well as their impacts on the production and transport of sediment at different elevation zones. Water discharge, which is called 'power' of stream is a result of various interacting characteristics like Geology of river channel, Physiography, rainfall, temperature regime direction of wind and its velocity,soil type, vegetation cover, infiltration, evapo-transpiration, etc. for the quantitative assessment of water availability Some of the parameters have been analyzed below for the purpose of feasibility study of the proposed Teesta H.E. Project.

BACKGROUND

The Govt of Sikkim has proposed to undertake the construction of Teesta HE stage VI project and construction works are to be taken up by the Lanco Energy Private Ltd. The location of the project has been identified at Sumin khore in South Sikkim. As per the Ministry of Environment and Forest, Government of India guidelines, Environmental Impact Assessment is necessary to obtain Environmental clearance of the Government of India for the Hydel Project. Hence it is important to study the natural drainage of the area. It is understood that the project involves construction of Barrage, HRT, Penstock, Surgeshaft, Powerhouse, Roads, Quarters and other associated structures. Further, the major construction involves the construction of HRT's which is understood to be 2 X 11.8 km long and 9.5 m wide. There is need to assess the effect on natural drainage of the area due to blockage of natural flow and percolation system.

RAINFALL

The rainfall data is available for last ten years (1989-1999) for rain gauge station located at Tadong, near to Ranipool area. The average annual rainfall recorded here is about 3,600 mm with a maximum being in the year 1991 and minimum in 1994. On the basis of observed rainfall the year can be divided into four seasons. The rainfall during the winter season (November to February) is about 5.6% which increases to 9.4 % in pre-monsoon season (March-April). The maximum rainfall is found to be 66.1% (May- August). Details are mentioned in the DPR of the project.

WEATHER AND CLIMATE

The climate of the state varies generally from sub-tropical to alpine depending upon the altitude of the place. Within the same catchment watershed of a stream, sub-tropical or even tropical climate is often observed at the lower end of the watershed in the valley, where in temperate climate prevails in the upper reaches of the stream.

Mean annual rainfall varies from 200 mm to 500 mm with intensity ranging from drizzle to torrential rain. Rainfall is heavy and well distributed from May to September during which July is the wettest month in most of the places. Rainfall is moderate in the months of April and October. It is generally low during the months of November to February. Rainfall pattern is essentially monsoon-controlled. Due to the wide variation of sharp edged mountains present throughout the state, there is a large variation of rainfall and temperature. Temperature varies with altitude and slope aspects. It generally decreases with increase in altitude. Three soil temperature classes have been identified- thermic, mesic and isofrigid. Throughout the year the relative humidity remains above 70% in most parts of the state. The maximum and minimum temperature varies from 28^0 C in summer to - 10^0C in winter.

RELATIVE HUMIDITY

Relative humidity remains above 70% at most places in Sikkim throughout the year. Normally a higher relative humidity of 85-95% is recorded during the monsoon period of May to Sep.

TEMPERATURE

Temperature in Sikkim falls rapidly with rise in altitude at about 6-10^{0}C per Km. From Apr-Oct, Gangtok records a mean maximum temperature about 23^{0}C and a mean minimum temperature of about 15^{0}C. From Dec-Feb, the mean maximum temperature ranges from 13-16^{0}C and the mean minimum temperature ranges from 4-6^{0}C. The mean daily bright sunshine hours ranges from 2.5 - 6.0 hrs with an annual average of 3.7 hours per day. The mean daily evaporation at Gangtok has been found to range from 71.6 mm in different months of the year with an average of 1.1mm. Mean cloud amount and average wind speed during an year are reported to be 4.9 Octas at 8.30 hours and 6.4 Octas at 17.30 hours in respect of the cloud amount and 3.4 km per hour in respect of wind speed.

EFFECTS OF CONSTRUCTION

As per the actual report, for the construction of the HE project on the hills, a huge quality of slope cutting on one side and filling on the other side, tunneling would be involved. Further, there, would be construction of associated structures and residential buildings totaling a huge amount of cemented surface in the project area.

Due to change in the natural slope and terrace construction, there would be change in surface runoff which would result in change of infiltration. Further, due to cemented construction, there would be blockage of natural infiltration system of soil and there would be excess runoff in adjoining soil. These conditions may alter the natural percolation of sub – surface and alter the ground water conditions further, due to excess runoff and interflow in adjoining area, there would be higher soil erosion during the storm runoff.

CHAPTER VII
AQUATIC ECOLOGY

INTRODUCTION

The Teesta river is a glacier fed river, originating from the Jhoras located from the Lachenchu and Lachung chu in North District of Sikkim. The present study deals with the impact of this project on the aquatic ecology and water quality of Teesta river.

METHODOLOGY

The survey was conducted in Teesta in the East district of Sikkim during the months of April and May, 2006. The sampling was carried out near the proposed barrage site at Sirwani and near by the power house area at Subin khor. The sampling of various biological parameters was conducted in three replicates at the site and a mean value of each characteristic was computed for final result.

BIOLOGICAL CHARACTERISTICS

Among the biological parameter, presumptive test was followed for the total coliforms for the site. For Plankton samples 50 liters of water was filtered by using fine silk cloth plankton net. Three replicates obtained from sampling site were pooled and preserved in Lugols solution. The further analysis was conducted in the laboratory of Government Degree College, Tadong, Gangtok. Before further treatment of samples, the density was computed by using Sedgwick Rafter cell. Each sample was made upto 100 ml in volume. The diluted sample was mixed thoroughly and 1 ml of each sample then transferred into SR cell. The diatoms were counted randomly in 100 chambers. The total density was computed as follows.

No. of Cells /litre $= \frac{a \times b}{1} \times 1000$

Where 'a' is average number of cell per chamber; 'b' –volume of concentrated sample in ml; '1' – volume of filtered water in litres. Phyobenthic epilithic samples were obtained by scrapping the rock and boulder surfaces (3 mm^2) with the help of sharp edged knife. Three replicates obtained from each site were pooled and preserved in Lugol's solution till further analysis. For the quantitative analysis of the diatom samples, the total volume of the scrapings was made up to 100 ml with distilled water. The diluted samples were thoroughly mixed and 1 ml of each sample was then transferred to Sedgewick Rafter cell Diatoms were counted randomly in 100s on ambers. The total density was computed as follows.

$$\text{Cells } (MM^2) = \frac{N \times At \times Vt}{Ac \times Vs \times As.}$$

Where N is the number of Organisms counted; At – the total area (mm^2) of Chamber bottom ; Vt – the total volume (ml) of original sample Suspension, Ac – the area (mm^2) counted; Vs – the sample volume (ml) used in chamber and As – the surface area of substrate.

For the estimation of relative abundance, percentage composition and diversity indices of the planktonic and phytobenthic samples permanent amount were prepared. The samples were centrifuged at 10,000 rpm for 10-30 main and supernatant was decanted. The diatom samples obtained were cleaned with nitric acid and potassium dichromate and left for overnight. Consequently, pellet was washed twice with 100% iso- propanol followed by a single wash with xylene. The pellet was suspended in distilled water and slides were prepared. The identification was made with the help of Sarod and Kamat (1984) and Hustedt and Jensen (1985).

The macro- invertebrates were obtained with the help of square foot surber's sampler. 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 materials was sieved through 100 mm sieve. Three replicates were obtained and pooled for further analysis. The organisms obtained were then counted after identifying them up to order level by

the procedure described by Pennak (1953) and Edmondson (1959). Fish samples were also collected from local fisherman and the information about fishery status were gathered from the secondary sources. The relative abundance for all biotic communities was computed as suggested by APHA (1992).

RESULT AND DISCUSSION

BIOLOGICAL CHARACTERISTICS AND TOTAL COLIFORMS

The presumptive test showed absence of coliforms in Teesta. This indicated the nature of clear water due to the absence of anthropogenic activities in the vicinity of the river.

PHYTOPLANKTON

The density of phytoplankton was recorded to be 408 cell/l at the sampling site, the low density of plankton can be attributed to project site at upper reaches of this hill stream where true plankton are absent (Welch,1952) Of the total phytoplankton diatoms shared more then 95% of the density. From the widespread studies it is clear that the phytoplankton was always more abundant than the zooplankton with the dominance of diatoms (Hynes, 1970).Though the stream harbored low density but 28 species were recorded from the site. The *Navicula minima var. atomoides* was found to be most dominant species, exhibited a relative abundance of 17.2% The *Achnanthes biasolettiana* accounted 10.7% to be second abundant species. A large number of species contributed less than 1% of the total density.

PHYTOBENTOS

Due to the hilly drainage the filamentous from were few and diatoms were the main component of phytobenthos, accounted more than 90% of the total density. Holmes and Whitten (1981) stated that diatoms grow best at low temperature as recorded from the sampling site. The density of phytobenthos was recorded to be 3150 cells/mm^2 at the sampling site. A total of 31 species were recorded from the site. *A. minutissima and A. gibberula* were the most dominant species, contributed 7.6 % and 11.6%, respectively at the sampling site. The large numbers of species were found to contribute less than 2% in the river Rangpo.

DENSITITES OF DIFFERENT BIOTIC COMMUNITIES IN THE TEESTA

Biotic communities Density:

Total coliforms		
Phytoplankton (cell/ lit)		408
Phytobenthos (cell/ mm2)	3150	
Macro-invertebrates (indiv./m2)	1368	

Species composition of the phytoplankton and phytobenthos in river Teesta

Species	**Phytoplankton**	**Phytobenthos**
Fragilaria capucina	+	+
F.familiars	-	+
F.Pinnata var. subrotunda	-	+
F. construens	+	+
Ceratoneis	+	+
C.arcus var amphyoxys	+	+
Raphoneis amphiceros linearis	+	+
Synedra ulna	+	-
S.ac	+	+
S. Ulna var amphirhyn Chus	+	+
Eun prearuta	+	+
De Spp.	+	-
Dia vulgare var linearis	+	+
Cocconeis vulgare var.linearis	+	+
C.placentula var. lineate	-	+
Achnanthes affinis	+	+
A biasolettiana	+	+
A brevipes var. intermedia	_	+
A exigua	_	+

A gidderula var genuine	+	+
A lanceolata	-	+
A microcephala	+	+
A minitussima	+	+
A minutissima var. cryptocephala	+	+
Anomoeoneis serians var . modesta	+	_
Navicula minima var. atomoides	+	+
N. radiosa	_	+
Navicula spp.	_	+
N.mitica colini	+	_
N.microcephala	+	_
C.affinis	_	+
C ventricosa	+	+
C.ventricosa var .arcuata	_	_
C.microcephala	+	+
C. leptoceros rostrata	+	_
C.amphicephala	+	+
Gomphonema intricatum	+	+
G.olivaceum	_	+
G.olivaceoides	+	+
G.parvulum	+	_
G.undulatum	+	_

	28	**31**

(1). The water characteristics of river Teesta revealed the following data.

Sl.No.	Parameters	Barrage site	Station site
1.	pH	6.4	6.2.
2.	Suspended solids (mg/l)	198	232
3.	Dissolved solids (mg/l)	86	75
4.	Conductivity (µmhos/cm^2)	326	337
5.	Carbon dioxide (mg/l)	2.0	3.6
6.	Dissolved oxygen (mg/l)	6.4	4.4
7.	Nitrate Nitrogen (mg/l)	18.0	22.0
8.	Silicate (mg/l)	1.26	1.32
9.	Phosphate (mg/l)	0.02	0.03
10.	Calcium (mg/l)	24.4	23.6
11.	Magnesium (mg/l)	4.6	8.4
12	Total Hardness (mg/l)	28.0	32.0

(2). The qualitative analysis of periphytons was undertaken and the data are presented as follows:

Sl.No.	Genus present	Barrage site	Station site
1.	*Navicula*	+	+
2.	*Pinnularia*	+	+
3.	*Surirella*	+	+
4.	*Tabellaria*	+	+
5.	*Nitzschia*	+	+
6.	*Synedra*	+	+
7.	*Melosira*	+	+
8.	*Cosmarium*	+	+
9.	*Scendesmus*	+	+
10.	*Spirogyra*	+	+
11.	*Mougeotia*	+	+
12.	*Oscillatoria*	+	+
13.	*Zygnema*	+	+

(3). The Zooplankton community revealed the following qualitative characteristics

Sl. No.	Genus present	Barrage site	Station site
1.	*Difflugia*	+	+
2.	*Archella*	+	+
3.	*Brachionus*	+	+
4.	*Keratella*	+	+
5.	*Philodina*	+	+
6.	*Lecane*	+	+
7.	*Cypris*	+	+
8.	*Bosmina*	+	+
9.	*Mesocyclops*	+	+

Relative abundance (%) of dominant species of phytoplankton and phytobenthos in Teesta

Species	Barrage site
Phytoplankton	
Navicula minima var. atomoides	*17.2*
Achnanthes biasolettiana	*10.7*
Phytobenthos	
Achnanthes minutissima	*12.6*
A.gibberula	*11.6*

MACRO INVERTIBRATES

The total densities of macro-invertebrates were recorded to be 1368 individuals /m² at the site. Thirteen different families belonging to five orders (Ephemeroptera, Diptera, Coleoptera, Plecoptra and Trichoptera) were recorded from the river Teesta. Simulidae (Diptera) was observed to be most abundant group (247 indiv./m²), followed by Chironomidae (228 indivi./m²), Helicopsychidae (Trichoptera) and Perlidae (Plecoptera) each represented by 19 indiv /m² were least abundant groups.

Density of macro –invertebrates in Teesta

Taxa	**Density (per m²)**
Ephemerellidae	114
Baetidae	114
Heptagenidae	190
Leptophelbidae	38
Hydropsychidae	114
Helicopsychidae	19
Perlidae	19
Psephanidae	76
Psycodidae	76
Simulidae	247
Chironomidae	228
Tabanidae	76
Other Diptera	57
Total	**1368**

CONCLUSIONS

The temperature and other geo-physical characteristic provided a fair ecological nich for the trout fishery in the river Teesta and Rani khola. The cultural fishery was found to be completely absent from this catchment, whereas very little practice of capture fishery was seen in the vicinity of the project area. No migratory and threatened fish species were recorded from the river Rani khola, Rangpo Chu, and Teesta below the project areas.

Thus on the whole, it is seen that the river Teesta will bear the brunt of the construction processes. Because of cutting of the soil, the erosion of the soil particles will definitely bring about the siltation into the river that may prove deleterious to the aquatic lives therein. Further, on the completion of the project and the subsequent habitation and simultaneous mushrooming of the adjoining area with buildings, may create the sanitary problem for the river that is why the sewerage disposal system has to be well planned before hand and meticulously designed so that the health of that river is maintained.

The site for the hydel project as such would not have much impact on the quality of water but would have a deleterious impact on the organisms. In the stretch of river Teesta, starting from the barrage till the power station downstream will definitely have few adverse effect on the existing aquatic flora and fauna even the river Rani khola and Rangpo khola feeds Teesta. These feeder streams will also help in migration of the resident fishes particularly the mahaseer during their breeding periods. During the lean seasons of the year, the biomas have to face the danger of stressful conditions.

MITIGATE MEASURES

Since many a project of the kinds are springing up in the state, it would not be out of place to mention that a full fledged research of Limnological studies be carried out to have the basic facts on the present status of our riverine systems before and after the barrage constructions or impoundments in such projects.

FISHERIES

The fish composition changes along the altitudinal gradient of river Teesta and its tributaries due to changes in physical and chemical characteristics of water. The water temperature plays a vital role in the distribution of fish in Himalayan Rivers. Sehgal (1983) classified Himalayan Rivers into three zones with respect to fish distribution. The streams in the upper most zones above 1400 m dominated by exotic trout are known as 'trout' streams. These streams are characterized by low temperature, low turbidity, low alkalinity and hardness. The substratum comprises of boulders and rocks while water carries coarse silt. The streams of middle zone from 850 to 1,400 m, inhabited mainly by snow trout are called as 'snow trout' streams. These streams record relatively higher temperatures, turbidity, alkalinity and hardness. The water carries fine soil particles while riverbed is provided with boulders and stones. The streams of lower zone below 850 m are comprised of a large meandering zone and have much higher temperature and lowest water current velocity. The substratum is comprised of pitted rocks and stones. This zone is inhabited by carp species knows as 'mahseer' streams. The dominant fish species in accordance with these zones in Teesta river system are given in Table.

Tamang (2001) mentioned about 48 species of fish from Sikkim Himalaya. However, species like Neolissochilus spinulosus (Ta and Jhingran, 1991) and Pseudeutro plus antherinoides, Ompok bimaculatus and Puntius clavatus (Menon, 1999) were not recorded in that report. A documentation of published information on the number of fish species and field survey during these studies indicate the presence of more than 50 species of fish in the waters of Teesta river. The present studies on fish and fisheries were carried out in all major streams viz. Teesta river, Rangpo Chu, Rangit River, Rangbang Khola, Rishi Khola, Rani Khola, Talung Chu, Dik Chu, Lachen Chu, Lachung Chu, etc. The fishes were collected with the help of local fishermen, which were found to land fish by using cast nets, rod and lines and hooks. About 37 fish species were recorded from the river Teesta and its tributaries, which comprise Salmonidae, Cyprinidae, Cobitidae, Sisoridae, Chanidae, Schilbedae and Anguiilidae.

Important fish species of three different zones of river Teesta in Sikkim

Trout streams	Snow trout streams	Mahseer streams
Elevation (m) Above 1400	850— 1400	Below 850
Streams Lachung Chu and Lachen Chu	Teesta from Mangan to Chengthang	Teesta below Mangan
Fish species *Salmo trutta fario*	*Schizothorax richardsonii*	*Tor putitora*
Euchiloglanis hodgarti	*Schizothoraicthys Progastus*	*A. crossocheilus hexagonolepis*
Schizothorax richardsonii	*Garra lamta*	*Labeo dero*
Garra spp.	*Garra gotyla gotyla*	*Barilius bendelisis*
Nemacheilus spp.	*Euchiloglanis hodgarti*	*B. vagra*
	Glyptothorax spp.	*Schizothorax richardsonhi*
	Semiplotus semiplotus	*S. progastus*
		Anguilla bengalensis

i) STRESSES ON FISH POPULATIONS IN SIKKIM

Several hydrobiological studies have suggested that natural and man made factors greatly influence the biological productivity of waters (Pant and Bisht, 1981; Dobriyal and Singh, 1988). In the monsoon surface run off, landslides, road construction activities, etc. increase the suspended load in river and lake water that results into deterioration of water quality and that of fish food. The siltation and high turbidity in water adversely affects the fish population and monsoonal floods cause the high mortality of fish in the Himalayan rivers. The water current velocity, water discharge and water level are important factors for the survival of spawn and fertilization of fish (Joshi, 1991). The natural and man made alterations in these factors may cause downstream drift of hill stream fish. Such types of natural stresses are common in Himalaya including Sikkim.

The man made alterations like stream regulations change the physiological rhythm of fish (Jhingran, 1989). The barrages and dams generally hamper the fish migration and destroy the breeding grounds of fish. Mahseer is one of the main sufferers in Himalayan rivers. In

addition, overexploitation and faulty fishing techniques like poisoning, damming and use of dynamite, etc. are also responsible for the elimination of fish. The maximum fishing activities were observed in Rani Khola. On the other hand except for water diversion in small streams there were no illegal fishing methods in use.

Only the Teesta River harbours more than 28 fish species in the State. They are of both food and game value. The most dominant fish species of economic value are *Schizothorax* (Asala). *Acrossocheilus Hexagonolepis* (Katley), *Garax species* (Buduna) *Pseudochenesis sp* (Kabrey) Glyptothorax sp (Kaaray) followed by other fish species like *Labeo sp* (gardi) (Theyr) etc. The most important game fish available in river Teesta is *Tor Putitora (Mabaseer)* which is also commonly known as king of the game fish. Most of the fish species available in Teesta water migrate for a short distance for feeding and breeding. But there are some fish species like Mahaseer and Balm which migrates for a long distance in the river for feeding and breeding.

The fish species available in the Teesta river provides income generation and entertainment for a large number of people/ Fishermen/ Anglers residing not only along with river banks but also from the nearby villages and Town. There are 341 fishing license holders registered by the Fisheries Directorate for fishing in the rivers of Teesta and it's tributaries falling in the East District only. The annual fish catch by this registered fishing license holder is estimated to be 52 MT annually. Each Mahaseer angling license holders catches 7 to 10 Mahaseer fish of weight ranging from 17 to 22 Kg. annually at the river confluence of Singtam, Rangpo and Rorathang. Due to illegal fishing domestic and 1ndustrial sewage pollution, soil erosion, aquatic habitat destruction due to quarry, the population of fish in the river Teesta and it's tributaries are in the process of declining. The river valley project for Hydro Electric Generation is bound to put more pressure on survival of fish population and fishing economy.

Teesta stage VI H.E. Electric Project stretching from it's barrage site near Sirwani to generation point down beyond Rangpo will definitely have adverse impact in the fish and fisheries of river Teesta and it's tributaries. As there is no means or device so far developed to assess the extent of likely damage to fisheries due to coming up of Hydel Projects, it is difficult to estimate the compensation of such loss in terms of financial requirement directly. However, it is felt that broadly the adverse effect will be on habitat destruction in terms of quality and

quantity parameter of river water for survival of fish population and also obstruction to fish migration for feeding and breeding.

REMEDIAL MEASURES

The construction of fish ladder in the dam across the river to facilitate movement of fish from down stream to the reservoir above has been suggested by many scientists in the country. A fish ladder is a passage which connects the reservoir with the river downstream and through which fishes can pass up and down. A survey of the fish ladder and passage in the dam constructed in the country showed that most of them were ineffective partly because of their design, insufficient water supply during dry months and poaching of large fish from the ladder (Khan. 1949). But in case of this project Rani khola is going to feed teesta river below 200 to 300 mt distance from the barrage and Rorachu is also joins after 10 km from the barrage. As such it is advisable to construct fish ladder to avoid obstruction to fish migration for feeding and breeding to maintain their population in the affected river.

In order to conserve the fish germ plasm in the stretch of Teesta river to be effected by Hydel Project stage VI and also to sustain the fishing as an economic activity a long term & short term approach may have to be adopted. Under the short term approach the fish seed of affected fish species has to be produced artificially in the fish farm to be constructed in an ideal site and continue stocking of such fish seeds regularly. The long term approach consists of pre-impoundment and post impoundment survey of river ecology, aquatic micro and benthic oreganos fish and fisheries of the river stretch affected by the Hydel project by establishing a Fisheries Research Center at the barrage site in order not only to find a solution to a number of problems pertaining to fisheries that are likely to emerge in future but also to study the possibility of developing reservoir fishery. The Mahaseer fish species is likely to be affected mostly by the stage VI Hydel Electric Project.

CHAPTER VIII
GEOLOGY

Sikkim is a part of the lesser Himalayan terrain of eastern sector. Tectono-stratigaphically it has been classified under four tectonic belts viz. i) foot hill belt (ii) inner belt (iii) axial belt and (iv) transaxial belt.

Foothill belt comprising essentially rock is exposed Siwalik group of sedimentary rock near Sevok. The state is predimentary covered by the unfossiliferous metamorphic and crystalline rocks grouped under the inner and axial tectonic belts. The higher region to the north and beyond is covered under the transaxial belt is essentially made up of metasediments and miner development of Buxa group of rocks. The Axial belt exposes the cystallines of Central region and intrusive granites.

There are two predominant zones viz. Gnessic and Daling group and also with some intermediatories.

The rock belonging to gneissic group constitutes the main body of the Himalayas. Two forms of gneiss are usually common in Sikkim (i) in south Sikkim, gneiss is highly micaceous and frequently passes into mica schist. Both muscovite and biotite occur at places. The gneiss is well foliated and exhibits strongly marked features of disturbances (ii) in north Sikkim, gneiss is less micaceous,. Muscovite is rare or entirely absent. Scrol and hornblende are chief accessory minerals. Intrusive rocks occur as dykes and sheets.

Delling group consists predominantly phyllites. At the boundary between this and gneissic rocks they pass into silvery mica schists. Dark clay slates with thick quartzite bands prevail in certain areas; silt stone and silicious lime stones are also found in certain areas.

The geology of the project area is very simple without any major geological features save for some localized faults, minor folds and a suspected 'window' upstream of Kalej khola. The rock sequence in the area is represented by quart-sere cite phyllite, quartz-sere cite-chlorite phyllite, varved and carbon phyllite, quartzite's (pure white, metallic grey etc.), quartzose phylite with garnet like crystals & ferruginous quartzite.

Most of the litho units as enumerated above occur in a monotonous repetitive sequence. Two thin bands of pelitewacke/ greywacke occur around Turung-Mamring area. The amphibolites exposure at kanam above Daragoan appeared as a sill, however, its spatial extension is untraceable (Map). The foliation planes of all the rocks dip down the slope & the headrace tunnel (HRT) as proposed appear to run along the strike of the litho units.

The stratigraphic sequence of the region can be summerised as follows.

Formation	**Lithounits**
Kanchanjunga Gneiss Formation	Mignatite & Augan Gneiss
Chungthang Formation	Clac Gneiss,Marbles Quartzite
CENTRAL CRYSTALLINE ZONE	
Darjeeling Formation	Kyanite & Sillimanite bearing garnetiferous Biotite gneiss and quartzose gneiss with occasional inclusion of pyroxene granulite & amphibolite.
GRADITIONAL PASSAGE	
Ringli Formation	Flaggy Quartzite, Garnetiferous Biolite schist and chlorite Sericite Schist.
CATACLASTIC PASSAGE	
DarjeelingGroup	
Lingse Gneiss Formation	
Foliated streaky gneiss,	
Augen Gneiss with Graphite Schist.	
GRADITIONAL PASSAGE	
Dailing Group	
Slaty Quartzite	
Chlorite Phyllite	

CHAPTER IX
SEISMOTECTONICS

INTRODUCTION

Sikkim is a part of the mighty Himalayas which is geologically very young. The area experiences mild tremors in the recent past. One earthquake of magnitude 6.0 in the Richter scale was recorded on 20th Nov.1980. The impact area falls in Zone-IV of seismic zoning map of India as per IS 1893-1984. The proposed area for Teesta stage-VI is situated in the Himalayan arc which shows two well developed hairpin type of structures-Assam syntaxis in the east (29º-19º N, 95º –96º E) and Hazara-Kashnir syntaxis in the west (34º –35º N, 73º –75º E) (Verma etal,1995). On the basis of major seismic events recorded in the Himalayan arc this area has been classified (Verma *et al.,* 1995) into five distinct types as below.

a) Devastating Earthquake (Mb> 8.0),
b) Large Magnitude Earthquake (Mb> 6; Ms> 7.0-7) ,
c) Moderate Magnitude Earthquake (Mb=5.0-5.9),
d) Small magnitude devasting earthquakes (Mb4.0-4.9)
e) Very low damage risk earthquake(Mb<4.0)

Along with Verma *et.al.,* (1995) the two other works by Narula *et.al.,* (1998) and Kayal *et al.,* (2001) also provide the most recent synthesis on the present status of Knowledge on the seismic activity in the Himalayas. In this report we highlight the critical aspects of seismicity in Sikkim Himalaya and adjacent regions *vis a vis* their environmental implications on the proposed H.E Project.

SEISMOTECTONIC ENVIRONMENT

According to Narula *et.al.,* (1998) and Kyal (2001) the northern part of the area is occupied by poorly metamorphosed sequences (Tethan), folded during Himalayan origeny. Similar tectonic packets, representing Godwana sequence, crop out within the Rangit window as well as lenticular Tethyan belt is followed successively to the south by high grade complex of the Central Crystalline and low grade complex of the lesser Himalayan rock, reworked during Himalayan orogenly .South of MBT the foothill region is occupied by the sequence of the frontal belt (Siwalik), which was affected by the terminal phases of the Himalayan orogeny. Like other part of the Himalayan this area is also traversed by MCT and MBT. The former separates the high grade central Crystallines from the comparatively lower grade Lasser Himalayan packages, which are separated from the shiwalik belt by the MPT.At places particularly towards east several subsidiary thrusts, approximately N-S trending gravity faults are present particularly within the northern Tethyan belt and the southern Foothill belt (Narula *et.al.,*, 1998).

In the Tethyan belt these N-S faults defined some well known graben structures such as Pum Qu Garban and Yadong Gulu Graben. In the former, faults affecting the Quarternary glacial deposit are clearly evident. The latter grabens is considered to be the longest one in the Tibetan Plateau. It is segmented into several N-S smaller grabens . Rangpur Ridge is a prominent tectonic future in the east which is bounded on all sides by major fault and Kathiar – Nailphamari fault several subsidiary faults, Parallel to Teesta fault forming grabens are reported from this ridge (Narula *et al.,* 1998). Many northeasterly and northwesterly trending lineaments also cut across the Himalayan belt in this region. Some of them are :I) the Arun Lineament (NE-SW) believed to represent the northern extention of the east Patna Fault, ii) the Kanchendzonga Lineament (NW-SW) extends from the foredeep to well inside the Himalayan belt, iii) Teesta Lineament (NW-SE), and iv) Purnia- Everest lineament (NW-SE).

The Spatial distribution of seismic activity in the region during the period 1964-1992 suggests that the regional seismcity of Sikkim Himalaya is relatively high to the north of the Main Boundary Thrust (MBT) and the activity decreases progressively southward from the Lesser Himalaya to the foredeep region, under sediment cover (Nath *et.al.,*,2000). The central main Himalayan block with considerable seismicity separates the northern Tethyan block and

southern foredeep block with subdued seismic activity (Narula *et.al.*,, 1998). In this area most of the earthquakes are shallow focus (<40 km) and are commonly of 4.5-5.5 magnitude range.

The Sikkim-Darjeeling Himalaya geo-environmental setting has been divided into four well defined tectonic belts by the Geological Survey of India and other workers. Sikkim falls mainly within the Inner and Axial Belts. The Teesta Hydro Electric Project Stage VI is within the Inner Belt consisting of low grade metamorphites of the Daling group of rocks.

The tectonic frame work and the seismicity of the North Eastem States including Sikkim are considered as a result of collision tectonics in the Himalayan arc and subduction tectonics below the Myanmarese arc. Studies have indicated a very complex tectonic setting of the region due to constant movement of the Indian plate from South to North & the Myanmarese from East to West. The two G major structural elements in the eastem Himalaya are the Main Central Thrust (MCT) and the Main Boundary Thrust (MBT). There are also a large number of prominent Lineaments in this region, some of which are reported to extend for several kilometers beneath the Himalayan fore deep. The Teesta lineament which passes through Parbatipur area of Bangladesh to Bhadrapur area of Nepal, is considered to demarcate the western limit of eastern Himalaya seismicity.

The North eastern India was subjected to severe shaking by a number of damaging earthquakes. The systematic account of which is available from the middle of nineteenth century only. The most damaging and macroseismica1ly studied ones, on record are the great Assam Earthquake (1897), Srimangal Earthquake (1918), Dhurbi Earthquake (1930), Assam Earthquake (1950,1975), Manipur-Burma (1988) etc. In the eastern Himalayas, the seismicity is considered as a result of collision tectonics & correlated with the MBF and MCT. The MCT is shown passing through East of Gangtok towards East of Mangan and from there towards North-East of Tsungthang & after taking a turn to Lachen. From Lachen another turn is taken towards Tolung from where the- thrust passes through Karchi- LabdangTashiding-Pelling-Kaluk and Soreng.

Chronological listing of some earthquakes of magnitude > 4.5 Sikkim (after Narula *et.al.*,,1998) (Source International seismological centre)

Sl.No.	YY	MM	DD	H	M	S	LAT	LONG	MS	MB	Depth (Km)
1	1964	08	30	02	35	07.3	27.36	88.21	-	5.1	21
2	1972	08	21	14	04	33.9	27.33	88.01	-	4.5	33
3	1972	08	21	18	55	07.2	27.23	88.08	-	5.1	33
4	1975	01	23	01	37	42.9	27.44	88.37	-	4.5	33
5	1979	11	16	19	17	27..7	27.90	88.70	-	4.6	39
6	1980	11	19	19	00	45.0	27.40	88.80	6.1	6.0	47
7	1982	04	05	02	19	41.2	27.38	88.83	4.6	5.0	09
8	1982	08	18	18	01	07.6	27.04	89.26	-	4.6	51
9	1985	05	25	00	28	18.7	27.60	88.48	-	4.6	33
10	1986	01	07	20	20	00.4	27.40	88.43	-	4.7	41
11	1988	05	26	16	30	05.5	27.45	88.61	-	4.7	42
12	1988	09	27	19	10	10.0	27.19	88.37	4.6	5.0	23

SEISMIC ZONING

Seismic zoning map of India (IS: 1893:1970), encompasses five zones named I, II, III, IV, and V. The mercalli scale intensity and horizontal force corresponding with seismic map zones of India are shown. According to the seismic zoning map of India (IS: 1893:2002) Sikkim falls under Zone-IV which translates to high spatial distribution of seismicity in the state. However, in spite of continuous effort to update the seismic maps, they are only a guide for any important construction. Therefore, detailed study of the site and its surroundings is essential for a more precise estimate of seismic hazard.

Seismic zones of India with corresponding MM (or MSK) scale intensity and horizontal force.

Seismic Zone	Hazard intensity	MM (or MSK) Scale intensity	Force n (H)
I	Very Low Damage Risk Zone	V or less	0.01
II	Low Damage Risk Zone	VI	0.04
III	Moderate Damage Risk Zone	VII	0.05
IV	High Damage Risk	VIII	0.05
V	Very High Damage Zone	IX and above	0.08

Forces (H) =Horizontal force as fraction of building weight

ISOSEISMAL ZONES

Temporal variation of seismicity in the area show that there is burst of earthquake for a year or two preceded by a quiet period of 3 to 4 years (Nath *et.al.,* 2000).The Bihar –Nepal earthquake of 1988 was distinctly felt in Sikkim. According to National Earthquake Information Centre, USGS report this earthquake of 20th September 1988 occurred at 23.09:09.5 PM. The epicenter was located at lat: 26.76ºN and long: 88.62ºN and the hypocentral depth estimated as 57 Km. The damages in the distinct isoseismal zones are outlined in the Table. The isoseismal VII passé through Gangtok town in an approximately NE-SE direction, several buildings in Gangtok were badly damaged and the death toll went up to 1003.

Effects of Bihar –Nepal Earthquake (1988) Sikkim

ISOSESISMAL ZONE	DAMAGE
VIII	Pass through Phulbazar and phulbazar and chakum in a NNE-SSW direction A triangular areas west of this isoseismal VIII up to Nepal border experienced severe ground shaking where damages in buildings were extensive.
VII	South of Gangtok it passess in an approximate NE-SW direction North of Gangtok it has a northerly trend up to Lachen .The impact of damages on power generation units roads aluignments were mainly in the from of subsidence and landslides the masonary walls of the builduings cracked and at places resulted in complete collapse.
VI	Lachung (1400m) lie in this area.The area experienced strong vibration of the ground resulting in general damage to houses, subsidence of grounds and incipient cracks in the buildings. The ground movement was shaking type and people reported to have felt tossing type of shock.

Source: Sinha ,1993

Sikkim region lies within the ambit of the Seismic Zone IV of I.S code 1893- 1993-1994/1998. With reference to the MSK intensity scale used for all engineering design purpose the region lies in the very high damages risk zone (IX).Therefore, there is always a necessity to consider the factor of safety for highest earthquake intensity while designing an engineering construction.

Proposed prject site falls in the VI isoseismal zone of the great Bihar-Nepal earthquake of 1988. This project area lies at the northeast of MCT ..usually, the zone at the north of MBT appears to be seismically active. But the seismicity decreases gradually towards the N,NW and NE of MCT and in this respect the project site appears to be very stable.However ,in Sikkim, towards the North and NW of the project site,there exists a cluster of epicenters and the faultplane solution of two tremors (1980 and 1982) indicate strike –slip mode of rupture along NW-SE and NE-SW direction.This region lies within the 20^{km} radius from the project site. The estimated depth for the 1980 earthquake was 47km and that for the 1982 earthquake was 9km.It is important to note here that the trend of the Teesta parallels the NE-SW shear dipping towards NW.

ENVIRONMENTAL IMPLICATIONS

This seismotectonic study has the following environmental implications for the proposed H.E project site and the adjoining region.

- The micro seismic activity analysis indicates that the project area is surrounded by seismic zones within 20km radius towards the E,NE, SW, and therefore it is proposed to have a suitable network to keep record on the seismicity of the region. A suitable seismic monitoring mechanism shall be put in place

Many transverse lineaments, subparallel to the outline of the subsurface ridges underlying the foredeep ,displace not only the MCT and MBT, but even the surface trace of the siwalik –Quarternary sedimentary contact well within the foredeep and appear to be seismically active. The neotectonic deformation in the Nepal –Sikkim Himalayas is mainly guided by the conjugate shear planes with attitudes NW-SE /dipping towards NE and NE – SW/dipping towards NW as indicated from the focal mechanism result. The proposed project site though appears to be seismically stable the presence of a cluster of epicenters at the NW of the region and the parallelism between the trend of the Rangpo Chu river and the NE- SW Shear do not rule out any future large magnitude tremor in the region. Therefore suitable seismic designing for the Terminus and other structures as well as necessary excavation and grouting of the geologically weak zones in the region are required to ensure the stability of the structure during the future events of large magnitude tremors.

CHAPTER : X

SOIL

INTRODUCTION:

Soils are our most precious natural resource. High productive soil maintenance is essential for enhancing basic biological needs on sustainable basis. The efforts have been attempted at various levels to achieve self sufficiency in food production, but our efforts should also be targeted towards over all quality of our environment. It is therefore, essential that soil and water resources are used rationally not only for sustainable agricultural production but also to ensure a better heritage for prosperity.

The knowledge of soils in respect of their extent, distribution, characterization and potential use is highly important for optimizing land use and safeguarding the area. The wise use of our finite resources is extremely inadequate as a result the process of soil degradation has been continued.

The proposed Hydroelectric Power Project in Teesta Stage VI extending over various type of land formation covering total catchment area of 27755.413 Ha and total project area 105 ha has significant impact on soil and water resources.

PHYSIOGRAPHY AID RELIEF AND DRAINAGE:

The physical evidences indicated in general about the project site and catchment area of recent tectonics expressed by topographic features are of prominent relief. The major geographic elements are both structural topographic high and low depression and also flats and slopes sculptured in a semi linear position. The physiographic expression of the area is imparted by approximately South-East and East-South of catchment trending steep, mostly anticlinical longitudinal hill ranges and synclinal valleys with the series of dendrite hummocks or topographic ‘High’ like Tendong in South and Fambonglho in East.

The other geomorphic elements are the high dissected ridges with the formation of deep gorges, like Pabong Watershed, Rangpo Watershed, Samardong, Narakjhora, Seti-khola, in South flank of Teesta River and Alichi Jhora, in east flank of the main drainage and spur, keel

and cols which have developed due to intensive erosion during isotatic adjustum. The differences of elevation between valley floors and hill tops greatly various from east to west and south to east as against south to north ranging between 680m and 2411m steep hilly ranges and mountain ranges are toward north-west and south-east.

The major drainage pattern having different bifurcation rating follow the north-south trending depressions and gorges in the low level topography separated by high land topography in between them. The depressions and gorges in most cases are the physiographic expression of the faults or other structural features. The tributaries and streamlets forming angular, sub-angular, sub-parallel and dendrite drainage pattern run along the topographic depression, the slope of the streams are moderate to steep and sometime very steep.

CLIMATE

The general climate of Sikkim is variable type. The climatic condition of the foot hill and lower valley along the Teesta- River bank of the project site and the catchment area is almost tropical condition prevails. However, with the rise of altitudes, temperature decreases and rainfall increases with intervention of local factor change in quantity of rainfall even in the same altitude. Thus, at the vicinity of Gangtok which is at the elevation of 1677m it is about 2000mm and in the high elevation at the same height the rainfall is noticeably decreasing trend towards north. Presence of high ridge on south usually regards most of precipitation from the monsoon clouds. In many cases the higher the elevation the climate is temperate and moist.The rainy seasons usually starts in May and continues till the beginning of October. However the trend has been almostly changed in recent years with unprecented rainfall too. Showers occurred in the later part of March and April usually accompanied by hailstone. The occasional showers do occur in the peak winter month calling snowfall in the higher regions.

TEMPERATURE

The temperature varies a great deal, depending upon the elevation. Again even at this same altitude, local variation is due to the proximity of permanent snowcapped. The maximum temperature of 42^0C is recorded in July and minimum temperature of 5^0C in December. The temperature of the place near 1524 m and 1829 m altitude is more or less same and varies

between 5^0C to 7^0C. In the regions of 3449 m the altitude it varies from 2^0C-8^0C. However, the project site has extreme temperature very cold in the month of December-January and not in the month of May-June. It has been noted that the temperature fluctuation in the local area are very high due to abrupt change in demography and biotic interferences.

PRESENT LAND USE:

REVENUE CLASSIFICATION:

On the basis of productivity and soil texture, the lands have been grouped by the revenue Department into the following three classes.

CLASS "A" LANDS:

These are mostly well terraced lands with very deep soils, provided with irrigation and are capable of producing crops without drought affect; such lands are mostly located on mild slopes and protected with suitable bunds.

CLASS "B" LANDS:

These are mostly well terraced lands with moderately deep soils supplied with limited irrigation. Productivity is medium. These lands are generally located at higher elevations.

CLASS "C" LANDS:

These are moderately deep to shallow soils and are terraced but bunds are not properly made or maintained. Irrigation facilities are not also sufficient and productivity is also low. These are away from the water source and susceptible to drought, forest and sometimes snowfall.

PRESENT LAND USE:

The total geographical area of the surveyed catchment area is 27755 ha and project area of 105 ha. About 6252 ha is under cultivation. Vegetables taken up 33.5% in homestead area are very limited. No specific area is covered under orchards. Some seasonal fruit trees are planted in the field bunds of agricultural lands without much care. Cardamom plantations are

included under forest because there is no separate area for this crop. At the elevation of 1700 metres or above generally farmers do not cultivate any farm crop but they grow horticultural plants and cardamom. The mountain slopes and ridges above 1700 meters are mostly under dense mixed forest. In the entire surveyed area the majority of terraced lands which are under cultivation of different crops are located in northern aspects whereas southern aspects are either bare rocks or some bushes are in pockets. Rock cornishes are common. Talus deposites have been brought under terraced cultivation.

AGRONOMIC PRACTICES:

Maize, Paddy, Kodo, Wheat and Potato are the major crops grown in kharif and rabi season. Some of the farmers are adopting double cropping as early season paddy, peas, maize, potato, maize paddy, potato early potato late. The limiting factors for successful agriculture in the area are as follows.

a. Faulty management practices.
b. Lack of scientific knowledge.
c. Meager use of manures and fertilizers, pesticides, insecticides, improved seed.
d. Improper irrigation and drainage system.
e. Bad economic conditions of farmers.
f. Low temperature during seed formation in some pockets of the surveyed area.

PASTURE LAND:

Most of the grass lands are located near the forest areas which are not fit for cultivation below (about 2680m) are under grass and forest whereas the area above (about 2600m) elevation are under cover and their extent is upto (about 3250m) elevation. Above (3250m) elevation some bushy type forest trees and some conifers and grasses come up only in spring season and people from down valley shift their animals to these areas for grazing mostly in the month of June-July and return in the month of September-March, the grazing of livestock in the forest area has been banned by the government since last two years. The grazing in the upper region has been controlled to some extent.

METHODOLOGY:

The reference of Soil Resource Mapping of the state, landform analysis map of the state was available with the Department, which form the base maps for undertaking field survey. The basic data of soil classification done by the National Bureau of Soil Survey and Land Use Planning (Indian Council of Agriculture Research) Nagpur and Soil Survey Report of All India Soil Survey and Land Use Organization, Department of Agriculture Co-operation, Ministry of Agriculture and Rural Development, Government of India has been referred as these report are relevant to the project site and catchment area. On the basis of document, records, information and report the field findings were analysed and appropriate measures and suggestions are proposed in the environmental impact assessment of the Hydroelectric Power Project proposal to produce 100MW for the Teesta Stage VI.

SOIL ANALYSIS

Soil analysis has been carried out by traversing and examining 15 soil profiles and 20 trail pits. Besides, many gully and road cuts landslide zone were also observed alongwith more than 15 auger bore identification and correlation of soils. Soil profiles are exposed upto 2 meters depth or to a lithic/paralithic contact at some selected sites to study the morphological characteristics of the soils. The procedure and methology followed for descriptions of the soil profiles are specified in soil survey manual of the All India Soil and Land Use Survey. Soil samples from respective soil profiles were collected layer wise for laboratory analysis. Characteristics like slopes relief, surface drainage, erosion condition, stoniness and rockiness, physiographic position, vegetation and present land use also recorded carefully.

Soils that have profiles almost alike make up soil series except for surface texture. All the soils of a particular site have major horizons similar in thickness, arrangement and other important characteristics. Each soil series is mainly named after a village geographic feature. The series are further divided into types on the variations in the texture of the surface horizons and into phases, slopes erosion, stoniness, reckiness etc.

Example: - A Mapping unit series N3dG3R

N: Village geographic feature – Namcheybong

3: Moderately deep (25cum-50cum)

d: Sandy loam surface texture

G: Steep slope (25-33%)

3: Severely eroded

R: Slightly rocky

GENERAL DESCRIPTION OF SOIL OF THE CATCHMENT AND PROJECT AREA:

Soil is derived from rocks under the influence of the climate, living organism, relief, terms and parent materials (Mieckenhausen, 1936). Soil body consists of soil particles of variable sizes ranging from molecules to large boulders. The soil possesses certain physical and chemical characteristics due to the action and interaction of climatic factors which have a profound influence on vegetation and other structures. The soils are also results of physiographic and biological processes operating upon the earth crust. The soils of the area are heterogeneous in characteristic due to their occurrence on varied geomorphological units, limate and vegetation. The change in relief seems to be responsible for different difference in moisture regime, drainage layout, erosion intensity etc. The project area is geomorphologically divided into the following major units which are responsible for development of various soils in the area.

PHYSIOGRAPHIC UNITS OF PARENT MATERIAL

1.	Mountain talus slope and spur	Darjeeling granite gneiss and biotite
2.	Hog beck	Granite gneiss
3.	Escarpment	Granite gneiss and biotite
4.	River terrace	Alluvial

The soils developed over Darjeeling granite gneiss on mountain talus slopes consists of very deep, sandy loam to loam, well drained soils distributed below 2000 m elevation under average temperature of more than 8^0c and have mixed vegetation composition.

The surface layer ranges from 15 cm to 20 cm in thickness with very dark greyish brown, sandy loam of single structure. The sub-soil is about 80 cm thick, dark brown or dark yellowish brown in colour, but the colour of submerged area on right bank is grey or greyish white with reddish mixed with black on the top of left bank. The red colour is prominent on higher regions. Soil of gravelly sandy clay loam and decomposed parent materials are also available.

These soils are slightly eroded. Most of the land is under terraced paddy field, majority soils are being under permanent cardamom plantation in the middle and upper ridges.

DESCRIPTION OF SOIL SERIES:

Another series reported are moderately deep, sandy loam, well drained soils, developed over granite gneiss on gently sloping to steep hog backs at an elevation below-3000m under Quarcus type vegetation.

The surface layer ranges in thickness from 10 cum to 20 cum and is dark reddish brown, sandy loam with crumbs structure. The sub-surface horizon ranges in thickness from 20cm-30cm and is dark reddish brown colour underlain by parent rock materials of Darjeeling granite gneiss.

The qualities of these soils are severely eroded and are under dense forest trees with creepers, runner, climber and variety of grasses covering the soil surface with healthy growth. These soils are fit for crop production.

The third series of soil relevant to the catchment area and the project site are well drained, moderately deep, sandy loam soils developed over granite gneiss and biotite on very steep escarpment at an elevation lesser than 3000 meters with temperature more than 8^0c. The mixed deciduous vegetation is reported.

The colour varies from dark brown, sandy loam of weak crumbs structure, varying in thickness from 10 cm-15 cm in the surface layers. The sub soil is yellowish red to dark reddish

brown, loam to silty loam of weak, single grain structure, varying in thickness from 30cm to 39cm underlain by hard rock pan. The greatly of these soils and susceptible to erosion and landslides causing great loss of land and forests. They are mainly located in the upper ridges of catchment area at Manzing, Narakjhora, Seti-khola, Tokal Marchak in south flank of river Teesta and Alichikhola jhora, Samdong, Sangbal, Khamdong, Dipu Dara, Dhanbari etc. along east bank of Teesta River.

The fourth important series are consists of deep, loam to silly loam, with drained soils, developed over granite gneiss and biotite. These soils occur at elevation below 2000 meters under average annual temperature higher than 8^0 C. The vegetation mainly comprises of Schemes, Termiralia, Siris and other deciduous and evergreen species.

The surface layers of these soils range from 12-20 cm in thickness with dark brown loam of crumb structure. The sub soil is reddish yellow to dark brown, clay loam of weak sub-angular blackey structure of 54 cm to 60 cm thick underlain by reddish yellow, silty loam soils with gravels and other rock fragments.

These soils are mostly terraced and bunded, paddy and maize field vegetable are also grown; i.e potato, tomato, cabbage etc. On the basis of the investigation, the following observations have been reflected.

In the sample one the distribution of soil varies very deep, deep, moderately deep and shallow soils are 11.6%, 14.3%, 14.7% and 43.5% respectively. About 50.6% areas is covered by very deep slope, steep slope 27.7%, extremely slope 7.5% and moderately sloping 1.9% only.

The examination report reveal that the majority of the soils in the catchment area and project area moderately deep and shallow covering the area of 25.8% of the land, 24.3% and 16.6% of the area are very deep and deep respectively. The maximum slope distribution steep slope 48.2%, extremely steep slope 42.8% and very steep slope 7.2% respectively.

SOIL CLASSIFICATION:

The soils are classified according to comprehensive system of soil classification of the USDA now referred as Soil Taxonomy. The soil profiles representing the soil series have been

classified under orders, sub-orders, great groups, sub-groups, and soil families in the field. As per stipulation of soil taxonomy, the soils the Hydroelectric Power Project- Teesta Stage VI qualify for Udic moisture regime and mesic or hyperthermic temperature regime depending upon the elevation and other factors.

Order	**Sub order**	**Great group**	**Sub-group**	**Families**
Entisols	Orthants	Underthents	Aquic Underthents	Coarse loamy Skeletal mixed Hyperthermic Aquic Udorthents
	Aquic	Haplaquents	Aeric fine Haplaquents Aquic Underthents	Loamy mixed Mollic Haplaquents. In loamy mixed.

CLASSIFICATION OF SOIL:

	Aquic	Haplaquents	Aeric fine Haplaquents Aquic Underthents	Loamy mixed Mollic Haplaquents. In loamy mixed.
			Lithic Uderthents	Coarse loamy mixed hyperthermic lithic Udorthents.
Inceptisols	Ochrapts	Dystrochrepts	Umbric Dystrochrepts	Coarse loamy mixed hyperthermic Umbric dystrochrepts
Inceptisols	Umbric	Haplumbrepts	Entic Haplumbrepts	Coarse loamy mixed mesic entric Haplumbrepts.
Alfisols	Udalfs	Hapludalfs	Typic Hapludalfs	Fine loamy mixed mesic typic Hapludalfs.
		Paleudalfs	Typic Hapludalfs	Loamy mixed meric typic Halsudalfs

SOIL TAXONOMY:

As found in other parts of the state soils of both submerged and the catchment area fall under three different order namely – Inceptisols, Entisols and Mollisols. Soils of these types are comparatively new in the process of soil formation. Majority of the area is under Inceptisol in groups Dystrochrepts and Haplumbreps (see the table for details).

Sl. No	Location	Soil Texture	Soil Depth	Soil Family	Group	Soil Order
1	Submergence site-I	Coarse to Fine Loam/Stoniness	Moderately Shallow	Typic Haplumbrepts	Haplumbrepts	Inceptisols
2.	Submergence Site-II	Fine Loam	Moderate to Deep	Typic Udorthents	Udorthents	Enthisols
3.	L.Khamdong	Coarse to fine Loam	Moderately Shallow	Typic Dystrochrepts	Dystrochrepts	Inceptisols
4.	U.Khamdong Dhanbari	Fine Loam	Moderate to Deep	Umbric Dystrochrepts	Dystrochrepts	Inceptisols
5	U.Samdong	Fine Loam	Moderate to Deep	Umbric Dystrochrepts	Dystrochrepts	Inceptisols
6	Makha	Coarse Loam Stoniness	Moderately Shallow	Typic Haplumbrepts	Dystrochrepts	Inceptisols
7	M.Lingi	Coarse to Fine Loam	Moderately Deep	Typic Haplumbrepts	Haplumbrepts	Inceptisols
8	U.Lingmoo	Coarse Loam Stoniness	Moderately Shallow	Typic Haplumbrepts	Haplumbrepts	Inceptisols
9	M.Yangang	Coarse to Fine Loam	Moderately Deep	Typic Haplumbrepts	Haplumbrepts	Inceptisols
10	Near Rabongla	Fine Loam	Moderately Deep	Typic Haplumbrepts	Haplumbrepts	Inceptisols
11	U.Sangmoo	Coarse to Fine Loam	Moderately Shallow	Typic Haplumbrepts	Haplumbrepts	Inceptisols
12	Tarku	Coarse to Fine Loam	Moderately Shallow	Umbric Dystrochrepts	Dystrochrepts	Inceptisols
13		Fine Loam	Moderate to Deep	Typic Argiudolls	Argiudolls	Mollisols

Note: U= Upper, M = Middle and L=Lower

INTERPRETATION OF REPORT:

The land use capability classification is an interpretation grouping of soils mainly based on inherent soil characteristics, internal land features and environmental factors that limit the use of land for sustained production of common cultivated crops, permanent vegetation and the risk of soil damage. Hence, the morphological characteristics and physio-chemical properties such as effective depth, texture, structure, soil reaction plant nutrients status, associated with other land factors with physiographic positions, slope, erosion, stoniness and rockiness etc. are considered in such grouping.

LAND CAPABILITY SUB-CLASSES:

The kind of limitations recognized at sub-class level is as follows.

1. Risk of erosion (c), the erosion susceptibility and erosion hazards are the major limiting factors for use.
2. Wetness, poor drainage or overflow (w). Here the excess water is the dominant factor to limit their use. Poor drainage, wetness, high water table and over-flow are the criteria for determing the soil.
3. Root-zone limitations (S).
   It belongs to sub-class having low moisture holding capacity, low fertility and salinity or alkadity.
4. Climate limitations (C). These are abiotic limitations due to climatic hazards like snowfall, hailstorm, dust storm,
   fog, prolonged dryness etc.

HYDROLOGIC SOIL GROUPING:

Four hydrological soil groups are used for estimating the run off potential of soil groups are based on soil properties that influence the run off. The potentiality is calculated on water in take of a particular soil series during the dry period making it properly wet. The soils of the area fall under the following groups.

Group-A Soils that have high infiltration.

Group-B (Moderately low run off): This group comprises of soils of Assam, Kadamtam, and Gompa. These are deep to very deep, loam, Sandy loam and silty loam soil having moderate infiltration.

Group-C (Moderately high run off): This group comprises of soils of Bushuk, Lingze and Pakyong and Namgechanga. These are moderately deep to very deep soils and have loamy texture with moderate rapid permeability.

Group-D (High run off): This group comprises of the soils of Naitam. These are very shallow to shallow soils at steep slopes.

CHEMICAL PROPERTIES OF SOIL

The chemical property of soil is of utmost importance in the proper understanding of soil-pant relationship. Its composition is largely dependent on the original mineral composition of the parent rock materials, the weathering processes and the nature and amount of organic matter added to it by the vegetation growing therein. To analyze the chemical property samples were taken from both submergence and catchment area (See the table).

Table: Chemical Composition of soil

Sl. No	Location	pH Range	Mean	OM in %-age	Nitrogen(ppm)	Phosphate (ppm)	Potash (ppm)	Fertility Status
1	Submergence site-I	4.2-6.5	5.7	2.01	142	18.42	75	3
2.	Submergence Site-II	4.2-6.4	5.8	4.25	201	21.83	101	2
3.	L.Khamdong	4.4-5.6	5.2	3.10	195	20.10	82	2
4.	U.Khamdong	4.5-5.8	5.3	3.85	110	25.46	108	2
5	Dhanbari	4.2-5.6	4.9	5.92	135	18.90	97	2
6	U.Samdong	4.8-6.7	5.3	3.54	70	13.20	70	3
7	Makha	4.2-6.6	5.1	3.96	165	24.55	140	2
8	M.Lingi	4.5-5.7	5.5	2.95	69	18.62	69	3
9	U.Lingmoo	4.5-5.7	5.6	3.15	92	25.80	92	2
10	M.Yangang	4.5-5.6	5.5	4.68	176	26.35	176	1
11	Near Rabongla	4.2-6.5	4.9	6.45	88	17.49	105	2
	U.Sangmoo	5.0-6.6	5.2	3.74	83	16.97	83	2
	Tarku	4.2-6.5	5.4	6.65	205	25.74	180	1

Note: 1 = Best soil, 2 = Fertile and 3 = Less Fertile: OM = Organic Matter

LAND CAPABILITY CLASS:

According to the study report and references drawn from various sources the following land classification has been grouped. There are four classes I-IV are cultivable and crops can be grown under proper and specific management. Although the quality of the land has been classified from I-IV, but they overlap and interspersed over each class as exact line cannot be drawn.

The next land capacity class compresses from V to VIII which are not suitable for common cultivated crops, but are generally suitable for vegetation Land class VIII is not suitable for any type of agricultural crops or pasture land and are regarded as wildlife habitat, eco-tourism and recreational purposes.

RESULTS

It is predicted that the general condition of the catchment area will improve due to the operation of catchment area treatment based on the deficiencies generated from the comparative studies and appropriate measures has to be incorporated in the EMP. As far as the project site findings are concerned there is a chance of generation of voluminous muck, debris and sludge which may cause erosion and landslide and fill the natural drain and the plains of the agriculture fields.

The physio-chemical and chemical characteristics of the soil pertaining to the area displayed increase of clay content of the cases except the pendons representing the series KD where its distribution is some what irregular. The salt content is generally high. This is normally expected with the biotite rich parent materials. The sand content is distributed in a pattern reverse to the distribution of inorganic colloidal fraction. The surface fraction is ranging from loam to sandy clay loam. Organic carbon value recorded is 3.19% at the surface soil. The water holding capacity and moisture equivalent values are well correlated with the organic and in organic colloidal fraction. These values are observed to be high at the surface but have not increased considerably. Organic matter possessing high, water holding capacity and moisture equivalent values as compared to clay might possibly be responsible for this type of distribution. Soils are all in acidic. pH values at the surface are ranging from 4.10-5.20 in the year 1988 and recent pH values indicated slight change 4.07-6.14. This value is increasing with depth in every case. The trend is indicative of downwards leaching of bases. Cation

exchance capacity value is well comparable with the organic and inorganic colloidal fraction. Base saturation values are all less than 60%. Dispersion ratio values are ranging from 11.4 to 86.4.

The entisol group has been observed at some place where soil forming priestesses towards the formation of genetic horizon have not been started except ochric epipedon. A variety of factors are considered that hinder the soil forming processed, soils of these places being situated on escarpment areas subjected to erosion as a result of which surface materials are losing as fast as or even faster than pedogenic development of the soils.

As per the irritability class of soil of the area indicated five different classes of 'A' very suitable 'B' with slight modification, 'C' expensive management for improvement, 'D' very poor for irrigation purpose and 'E' not at suitable for the purpose.

As indicated in the report that the portion of area falling from opposite Singtam to the Powerhouse and around the barrage site till the Dikchu chu is very delicate and fragile and it is possible that the existing landslide and soil erosion prone area may be aggravated due to the intensive blasting and cutting and other field as well as under ground maneuvering activities of the project. The studies also revealed that the area is under the process of degradation due to other biotic interferences received from development activities. Therefore, it is suggested that the appropriate technologies on long term sustainable safeguards should be planned in the environment management plan.

CONCLUSION:

The modern techniques of soil science, reports of soil expert, institutes and other organizations, geological inputs, toposheet maps, landsat imagery and many other information were used as a means to generate scientific report on soils of the Hydroelectric Power Project being launched at Teesta Stage VI falling part of East, North and South districts of Sikkim. These inputs have been considered to support and refine the report on the conventional system. It is assumed that on the basis of the report that there would be conspicuous change in the soil profile and composition in a gregarious manner due to the construction of the project and its different units scattered along the tunnel till the power house site. However, the earth work being planned to execute on the acquired land the runoff rate would increase to a great extent

and to compensate the adverse impact process on soil and water distribution and to minimize the excess rate of runoff a proper soil and water conservation technologies should be adopted. The Environment Management Plan for the Hydroelectric Power Project Teesta Stage VI should incorporate adequate such activities in it to contend the problems. The implementation of the same should be handled by an expert supervision under the principal guidance of the Forest, Environment & Wildlife Management Department.

CHAPTER XI
SOCIO-ECONOMIC IMPACTS

SIKKIM'S ECONOMY

People of Sikkim engage in different economic activities, prominent among which is Tourism, Industries, Horticulture & Agriculture etc. giving rise to a definite occupational structure. The economy of Sikkim is mainly based on agriculture and animal husbandry. Approx. 11% of the total geographical area is under agriculture. Agriculture is of the mixed type and still at the subsistence level rather than commercial level. The work force participation rate as per 1991 census is 40.44%. The female participation rate in Sikkim is also much higher than the national average. This is an important aspect for the hill economy, as productivity is low and hence all the able-bodied people are employed in agriculture and other activities. Cultivators account for the greater majority of the people in the state. Their percentage is 57.84%. Agricultural laborers as a whole constitute only 7.81% of the workers in the state. House holds and other industries are negligible, but other workers at the state level represent a good percentage of population. The decreasing ratio of workers at the state level indicates the low level of economic diversification. The importance of agriculture can be judged by the high percentage of population approx. 65% engaged in it. Animal husbandry is an integral part of the house hold economy of the region. There are certain house hold industries also which substantially add to house hold incomes. The past one and half decade has witnessed a tremendous upward swing in various development programme giving a new thrust to the Sikkim economy. This process has increased wage employment opportunities. Though most of the inhabitants are basically on agriculture, they have diversified into tertiary jobs such as Government services.

The human population density, demographic profile, cultural practices and the associated activities play the most crucial role in shaping the nature of environment resources of land, air and water of a region. In highlands particularly there are even more profound results on these resources arising out of human activity. The Teesta basin in Sikkim exhibits varied demographic profiles and patterns in various districts and along the altitudinal gradients.

The state is also rich in cultural and ethnic diversity besides being rich in water and biological resources. For any planning and development process to be successful and meaningful it is essential to understand the existing socio economic resource base and levels of its exploitation by the human population. Linked to it is the quality and quantum of services and amenities provided by the state for providing better quality of life to the human population. Since human ecosystems are heavily loaded towards producing higher quantities of waste as a result of various activities it is important to assess the consumption and waste production levels and suggest measures to reduce pollution loads in land, air and water resources. To evaluate the socio-economic environment in this study following parameters have been considered relevant.

- Assessment of human population density and population growth
- Economic profile of human population living in various districts and sector wise employment and employment potential
- Man land ratio across the population profile
- Evaluation of agricultural practices, food production *vis-a-vis* land capability and agricultural productivity
- Distribution pattern of input resources in agriculture *vis-a-vis* socio-economic profile of the population
- Agricultural productivity and carrying capacity
- Evaluation of amenities and services provided by the state in terms of education, health, communication and other facilities
- Assessment of quality of life in terms of existing scenario, perceived scenario and preferred scenario

HUMAN POPULATION AND TRENDS

Sikkim has registered a steady growth of population over the last three decades. The population of Sikkim has grown from 2,09,843 in 1971 to 5,40,851 in 2001. The trend of population growth in successive census years since Sikkim's merger with India is shown in

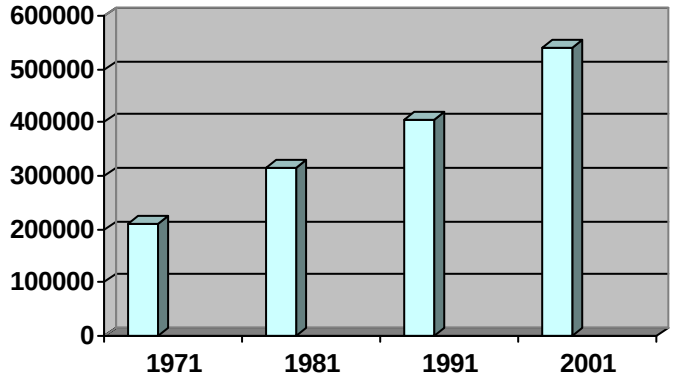


Fig. Population growth in Sikkim

Source: Sikkim: A statistical Profile 2002, Department of Economics, Statistics, Evaluation & Monitoring (DESME), Govt. of Sikkim.

The total population of Sikkim as per the Census of Sikkim (2001) is 540,851 comprising 288,484 male and 252,367 female. The sex ratio in Sikkim is quite low. There are only 875 female per 1000 male. About 480,981 people of Sikkim live in rural areas while only 59,870 persons reside in urban areas. The total number of households in the state as of 2001 is 114,223. The average size of household is 4.7, i.e. approximately five persons reside in each household. The overall density of population in the state is 76 persons per sq km, which is one of the lowest in India. The total number of literates (7 years and above) in the state is 234,135 of whom 137,745 are male and 96,390 are female. The number of illiterates (7 years and above) in the state is 142,430 out of which 63,413 are male and 79,017 are female. The overall literacy rate in Sikkim is 50.6%. There is a notable disparity in the rates of literacy between male and female and between rural and urban population. The literacy rate among the male is 55.4% while among the female it is only 45.0%. The gender gap in the rate of literacy is 10.4%. The rural areas of Sikkim have registered only 46.7% literacy while the same is 80% in the urban areas. The male literacy rates in rural and urban areas are 51.6% and 83.4% as compared to 41.1% and 75.9% for those of the female. The gender gap in literacy in the rural and urban areas is 10 and 7.5% respectively.

Distribution of Rural urban population –2001

District (No. of R. Block)	*POPULATION*				
	Area (Km^2)	**Total**	**Rural**	**Urban**	**% of Urban**
North (45)	4226	41030	9782	1248	3.04
East (119)	954	245040	192188	52852	21.65
South (135)	750	131525	127579	3946	3.00
West (111)	1116	124356	121432	1824	1.48
Sikkim (410)	7096	541956	480981	59870	11.10

Source : Population Census Sikkim – 2001

Comparative figures of sex ratio during 1961-2001

District	Sex ratio (Females per 1000 of males)				
	1961	**1971**	**1981**	**1991**	**2001**
North	888	853	789	828	752
East	884	791	797	859	844
South	917	909	854	892	927
West	NA	937	906	915	930
Sikkim	904	863	835	878	875

Source : Population Census Sikkim 1961-2001

Decadal variation of population (1951-91) in percentage

District	1971-81	1981-91	1991-2001
North District	103.28	18.09	31.32
East District	62.07	28.60	31.32
South District	42.85	29.78	33.37
West District	29.59	30.55	25.48
Sikkim	**50.77**	**28.47**	**32.98**

Source: Population Census – 2001. Sikkim Statistical Profile- 2001.

Distribution of S.C & S.T Population

District	Scheduled Caste population (in %)		Scheduled Tribe population (in %)	
	1991	2001	1991	2001
North	3.56	21.14	55.38	53.06
East	6.99	5.82	21.09	18.49
South	5.64	4.76	16.91	15.57
West	5.02	4.66	19.66	19.33
Sikkim	5.93	5.03	22.36	20.62

Source: Population Census Sikkim- 1991. Population Census Sikkim –2001.

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INDICATION OF THE ECONOMY

ECONOMIC PROFILE

The economic profile of Sikkim is presented under three broad heads, namely, i) Agriculture and allied activities, ii) Industries, and iii) Services. The economic profile of the state shows an overwhelming dependence on agriculture and allied activities. While the industrial sector is slowly picking up, there is not much increase in the tertiary sector. Although there are eight towns in the state, the urban population is very small. Barring Gangtok, all other towns in Sikkim are too small for towns and many, viz. Mangan in North Sikkim, Gyalshing and Naya Bazar in West Sikkim and Namchi and Jorethang in South Sikkim are smaller than some of the villages. If the size of towns is an indication, then it can be said that the state has very limited scope of growth in the urban service sector.

Particulars	**Unit**	**1980-81**	**1993-94**	**1994-95**
Net State Domestic Product at current Prices	Rs.in Lakhs	4898	33547{P}	42138{Q}
Indices of growth	%	-	584.91	760.31
Net State Dometic Product at constant price	Rs. in Lakhs			
Per Capita Income At curent price	Rs. in Lakhs	1571	7679{P}	9239{Q}
Indices of growth	%		388.80	488.09
Per Capita income At constant price		1571		
(P) – Provisional (Q) - Quick estimate				
Source : B. E. S.				

The total number of workers in Sikkim according to 2001 census is 2,22,500. The total number of main workers in the state are 1,86,222, of which 86,314 are cultivators, 10,837 are agricultural laborers, 2,791 are workers in household industries and 86, 280 are other workers. There are 36,278 marginal workers, while 1,90,343 persons in the state are non-workers.

The economic classification of workers in Sikkim shows that about a quarter of the total work force in Sikkim is of primary workers and less than a quarter are tertiary workers. The number of secondary workers is negligible. Almost half (46%) of the total population of Sikkim are non-workers.

The demographic, economic and employment profiles of Sikkim indicate that the state, though disadvantaged due to geographical isolation, has many positive aspects in regard to human and economic resources. No doubt the state has many limitations as far as utilization of resources is concerned. Yet, the profiles make it clear that the state's socio-economic environment is conducive to growth and development of both human as well as economic resources.

The demographic profile of Sikkim shows that in every decade Sikkim is getting about a lakh of additional population. The density of population in Sikkim is still very low. Though migration factor plays a big role as far as growth of population is concerned, there is hardly any mechanism either to check or even to record the entry of immigrants. Another demographic problem of the state is its low sex ratio. The low male-female ratio in the state hints at gender bias. Yet another intriguing feature is the small size of towns. The miniscule size of towns indicates very slow urbanization process. The literacy figures, though improving, are not very impressive as far as rural and female education is concerned.

The economic profile of the state shows growth in the sector of agriculture and allied activities. In spite of limited cultivable land, the state recorded growth in this sector. There was progress both in terms of quality and quantity. Sikkim has scope to expand horticulture, animal husbandry and to some extent sericulture sectors. However, as far as industries are concerned, the state has very little space, except in tourism industry.

The occupational structure of the state is more or less balanced. Though the number of non-workers in the state is pretty large, high work participation of both the sexes in primary, secondary and tertiary activities indicate healthy work environment. Unemployment is still not

acute in Sikkim. There are scopes to expand self-employment opportunities and trade with the diversification of tourism sector and opening of Nathu-la pass in near future.

DISTRIBUTION OF LAND HOLDING SIZE –1997

Operational Holdings	No.	51.24	20271	12854	14448	52697
Area operated	Hect.	15444	34450	29336	32072	111302
Average area For holdings	"	3.01	1.70	2.22	2.28	2.11

Source : Agriculture Department

CLASSIFICATION OF LAND

Item	**Unit**	**Period**	
		1980 - 81	**1990-91**
Net area shown	Hec.	78321	63254
Area under current Follow	"	4428	3906
Other uncultivated Land (Excluding other lands)	"	4560	10830
Follow land other than current fallow	"	9474	9204
Cultivatable waste Land	"	681	9807
Land not available For cultivation	"	11604	14301

Source : Agriculture Census 1990 – 91

District wise per capita food crops production (Tonnes) in 1999-2000

District	Maize	Rice	Wheat	Barley	Pulses
North	0.01	0.050	0.040	0.005	0.00001
East	0.055	0.040	0.176	0.000002	0.006
South	0.130	0.0260	0.020	0.0022	0.016
West	0.150	0.065	0.035	0.005	0.02
Sikkim	**0.099**	**0.043**	**0.024**	**0.003**	**0.011**

Source : Statistical profile 2001-02 (Sikkim.)

District wise per capita main crops land area (hector) 1999-2000- *Statistical profile –2001*

District	**Maize**	**Rice**	**Wheat**	**Barley**	**Pulses**
North	0.075	0.034	0.025	0.004	0.00002
East	0.040	0.021	0.10	0.0014	0.0071
South	0.100	0.020	0.015	0.002	0.180
West	0.11	0.040	0.020	0.004	0.20
Sikkim	**0.073**	**0.030**	**0.15**	**0.002**	**0.012**

THE AMENITIES AVAILABLE IN SIKKIM

FORESTS

Forest is one of the richest natural resources of Sikkim. The total land area managed by and under administrative control of Forest Department is above 80% of the total geographical area of the state. Sikkim has a unique Bio-Diversity. The composition ranges from tropical Dry Deciduous Forests with Sal and its associates in the valleys of Teesta and Rangit to the Alpine Scrub and Grasslands in high altitudes. During the last two decades Forest Department has laid emphasis on development of fodder and fuelwood in the agriculture fallow lands of the villagers giving priority to plantation of broom grass for fodder and for economic upliftment of the villagers. This year, the target for afforestation under 20-Point program is 11,000 hectares of which Forest Department has achieved over 8,000ha.by plantation. The state is listed among the worlds ten most critical centers for biodiversity and endemism. Even though the state has

only 0.2% of the countries geographical area it houses over 4500 species of flowering plants,550 species of Orchids, 362 species of Ferns and its allies, 11 species of oaks, 9 species of Tree Ferns, 30 species of Primulas and 20 species of Bamboos. The faunal wealth of Sikkim comprises of 144 species of mammals, 600 species of Birds, 400 species of Butterflies and Moths and 33 species of Reptiles. Several species of medicinal plants and herbs are found throughout the state.

SOIL AND WATER CONSERVATION

Soil and Water Conservation works through afforestation, Silvipasture, Agro-Forestry and Engineering works were taken up in 30 (thirty) identified watersheds through State Plan and in 3 (three) watersheds under Centrally Sponsored Schemes. In addition, watersheds are also being treated under Catchment Area Treatment of Rangit Hydro-Electric Project in South and West Districts. 1,00,000 cubic meters of engineering work was carried out during the year 1997-98 under Natural Calamity, Catchment Area Treatment, River Valley Project and State Watershed Scheme.

FOREST PROTECTION

Illegal activities in the forest, illegal transportation of Timber and other forest produce is being taken care of by the Mobile Squad of the Department headed by a Deputy Conservator of Forests. The Territorial Division in all four districts are vigilant and are putting substantial effort to prevent illicit felling and illegal movement of forest produce, grazing in reserve forest has been banned in South and West Districts.

WILDLIFE

The initial 850 square Kilometer area of Kanchendzonga National park (High Altitude) has been extended and expanded to 1784 square Kilometers. The Wildlife wing conducted a high altitude expedition in West District covering Dzongri, Gochala, Lampokhari, Ledo Khola and Dhupidara to study the habitat in the highlands. 28% i.e. 2049 square kilometers of total geographical area of Sikkim is under Wildlife protected areas. There are altogether 6 (six) numbers of Wildlife Reserves in the form of National Park and Sanctuaries. Forest Department has also won the encroachment case of Fambong Lho Wildlife Sanctuary and the encroachers

have been evacuated. 54 birds belonging to 20 species have been successfully signed and released in Sanctuaries. Research work is also being carried out on Wildlife.

UTILIZATION

To meet the Timber, fuel wood and charcoal requirement of the state, the Utilization Circle of the Forest Department extracted 1047 cubic feet of timber, 457 bags of charcoal and 786 piles of fuel wood during the year 1997-98, out of wind fallen, dead trees and from leftover coupes. The Department also distributed smokeless chullahs in North and South Districts to reduce pressure on forests.

Distribution of households availability of fuel used for cooking

State /District	Fire wood%	Kerosene %	LPG%	Cowdung cake %
Sikkim	65	14.51	18.83	0.06
North	75	14.19	7.58	0.53
Chungthang	72	17.44	3.98	2.33
Mangan	76	13.26	8.60	0.02
West	85	5.52	7.64	0.01
Gyalshing	83	6.39	8.92	0.01
Sorang	88	4.59	6.28	0.02
South	73	10.14	13.69	0.02
Namchi	69	12.81	16.25	0.02
Ravong	80	4.73	8.50	0.04
East	48	21.34	28.98	0.03
Gangtok	39	24.97	34.62	0.03
Pakyong	83	5.06	10.36	0.00
Rongali	76	13.56	8.27	0.06

Source: Census –2001.

SERICULTURE

Forest Department has two Sericulture Farms, one at Rorathang (East Sikkim) and other at Mamring and Namthang (South District). Extension of Mulberry Plantation in West District has been carried out at Chakung in an area of 10 hectares.

Following are carried out every year

- Rearing of improved variety of silkworms.
- Propagation of Mulberry seedlings.
- Distribution of seedlings to villagers.
- Training to beneficiaries and awareness programmes.

Sericulture has picked up its pace since 1996. Training is being imparted to beneficiaries from East, South and West Districts for mulberry cultivation and silkworm rearing. There was overwhelming response but the Department could take up with 19 beneficiaries during the year 1997-98 due to financial constraints. The beneficiaries have already started producing cocoon in their own silk farms. All the trained beneficiaries are provided with all inputs free of cost and a financial assistance of Rs. 7000/- each.

NURSERIES

Forest Department is maintaining about 180 hectares of nurseries all over the State and the annual production of seedlings is around 150 lakhs to cater afforestation schemes and for distribution to villagers for planting in their private holdings.

CONCLUSION

Plants, animals and man are interdependent from time immemorial. Destruction of one has direct bearing on the survival of the others. Among them, man is the most intellect and has great responsibility to create conditions to maintain balance to posterity. Environment degradation of late is a global issue and its protection is the foremost responsibility of the citizens of this earth. Emission of excessive amount of chloroflorocarbon by developed countries and methane by developing countries has led to punctures in the ozone layer thereby giving way to ultra-violet rays of the sun to the earth. Increase in the amount of carbon-dioxide in the atmosphere has resulted in global warming, excessive melting of snow and glaciers,

increase in sea level and submergence of many smaller islands in the oceans. Pollution of the environment has increased to such an extent that the days are not far away that we may get acid rains. To check further degradation of the environment, it is high time that each of us join hands to make our earth clean and green because we have only one planet to sustain life in the entire solar system.

MINING

The state of Sikkim is endowed with rich geological resources. The department of mines and geology has been responsible for exploration and establishment of mineral resources, with the object of developing commercially exploitable mineral resources. Moderate to fair amount of success has been achieved during the investigation carried out by different agencies in certain sectors namely dolomite, coal, quartzite, graphite, lime stone, silliminite, talc, mineral water, thermal springs, building stone and materials for porcelain.

MINES & GEOLOGY

The achievement in 1992-93 was production of 12,230 metric tones of ore (production of concentrates of Copper 349.50 MT, Lead- 73.00 MT and Zinc - 355.35 MT), micro-biological studies of 200 samples of drinking water from various sources, geo-engineering survey of Kumre Sitey slide near Jorthang and mineral exploitatiion study of coal, silica, limestone etc. The department completed 15 hazard zonation mapping, one traverse mapping and 150 drillings for carbonate rock investigation.

POWER

The various sources of energy in use in the state are electricity, kerosene, LPG, firewood, cow-dung and solar power. Till date, firewood and electricity are considered as the chief sources of energy in Sikkim. Since use of wood as fuel is highly restricted in Sikkim, people are encouraged to use electricity and other renewable sources of energy like biogas and solar power. Though the state authorities provide training to use biogas and solar power at village level, these are not yet popular in the state. Rural people still prefer firewood for cooking and heating purpose, while they use electricity only for lighting. In urban and semi-urban areas, people use LPG for cooking commonly and for heating and lighting people

depend on electricity. Kerosene has limited use, mainly for cooking and also for lighting purpose in areas where supply of electricity is erratic.

The innumerable streams and rivers flowing down the Himalayas have provided Sikkim with an immense potential for development of Hydro Electric Power. The demand for Power increased with the increase in the population. The number of urban centers and the pace of industrialization is picking up in the State and finally taking up to rural electrification. The power generation capacity of the state is as under :

Particulars Unit		**North**	**East**	**South**	**West**	**State**
Installed Capacity	MW	4.30	27.70	3.60	-	35.60
Power Generated	MKWH	10.99	57.53	3.98	-	72.50
Town Electrified	%	100	100	100	100	100
Revenue block Electrified	%	100	100	100	100	100

Source : Power Department

In the VII Plan the two Hydel Projects namely Rimbi Stage II and Rongnichu Stage II have been completed along with the Lachen Micro Hydel Project. Above all, Sikkim Government, extended a total number of 3000 free connections under the scheme of extending two point free domestic connections to the poor masses and provided electrification to all the district headquarters, towns and 90% of the total revenue blocks. Sikkim stood first in rank along with 12 States in the cent percent village electrification.

The achievement during 1993-94 was generation of 41.38.38 MKWH through 10 Hydro Power Projects viz. Lowre Lagyap Hydel Project, Jali Power House, Rothak Micro Hydel Project, Rimbi Micro Hydel Project-I, Rimbi State -II, Lachen Micro Hydel Project, Rongnichu Hydel Project, Lachung Micro Hydel Project, Upper Rongnichu Hydel Project, Mieongnichu Hydel Project which have a total installed capacity of 33.80 MW. The College Khola Hydel Project is in the final stage of completion. The total power generation during 1993-94 was 50.80 MKWH where the total consumption during the same year was 73.70 MKWH. The shortfall was met through import of 22.90 MKWH from Chuka. The total

transmission line by 1992-93 was 197 km of 66 kv, 1520 km of 11 Kv and 3200 Km of 440 volt lines.

The survey and investigation of new hydel schemes like Rongpu, Hee, Tarang, Bakcha, Rongli were in progress and the expenditure of Rs. 6.84 lakhs was made during 1993-94. A number of residential and non-residential buildings were under construction for which the sum of Rs. 50.00 lakhs was spent. One system improvement scheme funded by REC was under progress during 1993-94.

The Mieongnichu Hydel Project was commissioned in 1993-94 and work on other Hydel Project is in progress. The work on transmission and distribution were also in progress of which 13 tower erection and 18 stringing were completed.

Distribution of house holds by source of lighting with percentage

State /District	House holds in Percentage				
	Electricity %	Kerosene %	Solar energy	Other oil %	No lighting %
Sikkim	77.76	21.59	0.14	0.05	0.35
North	64.85	32.97	0.58	0.08	1.08
Chunthang	58.24	38.69	1.99	0.06	0.00
Mangan	66.73	31.34	0.18	0.08	1.39
West	74.68	24.83	0.11	0.11	0.16
Gyalshing	83.03	16.29	0.17	011	0.26
Soreng	65.77	33.95	0.05	0.11	0.04
South	71.13	27.93	0.11	0.04	0.75
Namchi	75.58	24.03	0.08	0.00	0.30
Navong	62.11	35.83	0.18	0.12	0.66
East	84.98	14.70	0.10	0.03	0.12

Source: Census –2001

The per capita consumption of power during 1990-91 for Sikkim was 82.5 KWH. as against the All India average 241.5 KWH. Sikkim was placed on 20th position when ranked based on per capita consumption. The highest consumption of 631.3 KWH was for Punjab. Sikkim also stood first in rank along with 12 states in the cent percent village electrified. The transmission loss in Sikkim in 1991-92 was estimated at 22.8% as compared to National average of 22.9%.

The All India average cost of realisation for 1988-89 was 53.95 paise per KWH for domestic consumption (89.33 p in Orissa and 43.50 p for Maharastra), 15.7 paise for Agriculture consumtion (30 p for Assam and 4.5 p for Andhra Pradesh) and Bihar and 48.47 p for Kerala). The average rate for the state of Sikkim for 1988-89 was 50 paise per unit for domestic supply upto 25 units, 60 paise upto 50 units and 70 paise above 50 units. The rate for commercial, industrial and mixed supply was 70 paise per unit.

The All India average cost of generation and supply was 91.04 paise per KWH. (224.76 p per KWH. for Assam and 61.29 p for Kerala). The figure for the state Sikkim worked out to Rs. 1.54 for 1993-94.

LIVESTOCK

In a predominantly rural economy such as Sikkim, animal husbandry activities form an extremely important element in the effort to bring about substantial improvements in living standards. The overall area available for agriculture operations is limited to about 15% of the geographical area of the state and with the increasing population, per capita land availability has been consistently declining, it is therefore, essential, that supplementary sources of income should be developed in order to provide not only the much needed support to the rural families but also to make available in increasing quantity, protein rich food items such as milk, egg, and meat. Adequate number of livestock like cattle, buffaloes, pigs, sheep, goats, yaks and few other are reared in Sikkim. Yaks are reared in north eastern ranges bordering Tibet, Bhutan and western region bordering Nepal.

Livestock population in Sikkim is widely distributed. In the high altitude areas yaks, sheep and local goats known as "Chengra" predominate whereas in the mid hill and low lying

areas the important breeds are Siri cows, Jersy and H.F. crossbred, goats, poultry and pigs are reared. In almost all these livestock the exotic blood inheritance level is increasing due to continuous introduction of genetically superior germ-plasm. In Sikkim the first official livestock census was conducted in 1977 and the population of important livestock census was taken. The population of important livestock species has increased considerably except for buffaloes and horse population as may be seen from the following table:

Livestock population as on 31st March ,2001

Species	**East**	**(%)**	**West**	**(%)**	**North**	**(%)**	**South**	**(%)**	**Total**
Cattle	50431	35.27	42502	29.71	12841	8.98	37250	26.04	143024
Buffalo	323	16.39	1311	66.55	66	3.36	270	13.70	1970
Sheep	316	6.29	1777	35.38	2325	46.29	605	12.04	5023
Goat	24375	29.39	24719	29.80	8375	10.09	25469	30.72	82938
Yak	953	30.35	638	20.31	1549	49.33	-	-	3140
Horse & Poney	1087	19.99	2272	41.80	1322	24.32	755	13.89	5436
Donkey & Mule	98	80.99	-	-	21	17.36	2	1.65	121
Poultry	66066	29.84	75316	34.02	22023	9.94	58001	26.20	221406
Pig	8784	32.56	8366	31.01	3135	11.62	6690	24.80	26975
Rabbit	117	32.77	131	36.69	54	15.12	55	15.40	357
Dog	11856	50.32	4750	20.00	1142	4.84	5810	24.66	23558
Total livestock pop.	164404	31.99	161782	31.48	52853	10.28	134907	26.25	513948
Density of livestock (km)	172		145		13		180		72

Source: Statistical profile Sikkim- 2001.

EDUCATIONAL INSTITUTIONS

Sikkim has a wide range of educational institutions ranging from pre primary to graduate levels and varying from government to private. The types of government educational institutions in Sikkim and their district-wise break up are given in the Table .

Educational Institutions in Sikkim, 2000

Educational Institutions	North	East	South	West	State
Pre-primary school	76	235	212	216	739
Lower Primary School	21	35	48	75	179
Primary School	33	114	94	81	322
Junior High School	9	44	43	33	129
Secondary School	10	24	22	20	76
Senior Sec. School	2	14	7	6	29
Monastic School	14	16	12	8	50
Sanskrit Pathshala	-	8	2	2	12
Madrasa	-	1	-	-	1
Degree College	-	1	1	-	2
Law College	-	1	-	-	1
Sheda (Monastic College)	-	1	-	-	1
Sanskrit Mahavidyalaya	-	1	-	-	1
TTI	-	1	-	-	1
SIE	-	1	-		1
ITI	-	1	-	-	1

Percentage of literates in different subdivision and districts of Sikkim –2001

	Total	Male	Female	Rural	Urban
Sikkim	**69.68**	**76.73**	**61.46**	**67.67**	**84.82**
North	69.11	77.32	57.65	68.78	79.41
Chengthag	75.89	84.87	55.01	75.89	-
Mangan	66.67	73.79	58.27	66.11	79.41
East	75.57	82.05	67.74	72.89	84.86
Gangtok	77.42	83.55	69.82	74.38	84.86
Pakyong	68.98	76.45	60.91	68.98	-
Rongli	69.78	77.13	61.44	69.78	-
South	68.12	74.57	61.02	67.43	88.92
Namchi	71.51	77.87	64.53	70.63	88.92
Ravong	61.33	67.98	53.97	61.32	-
West	59.31	67.21	50.75	59.02	77.98
Gyalshing	56.05	63.92	47.31	55.72	79.15
Soreng	62.83	70.84	54.36	62.58	76.93

Source: Provisional population census of Sikkim- 2001.

Percentage of population +7 years by Educational Level (1981-1991)

Source : Ram R.K – Demography and development of human population in Sikkim,

Education Level	1981			1991		
	Total(%)	**Male(%)**	**Female(%)**	**Total(%)**	**Male(%)**	**Female (%)**
Illiterate	58.41	47.00	72.42	43.06	34.30	53.24
Literate	41.59	53.00	27.38	56.94	65.70	46.76
Literate without-education level	16.86	20.78	11.98	20.58	23.21	17.51
Primary	14.73	19.07	9.32	13.87	15.86	11.57
Middle	4.21	5.38	2.77	11.28	12.93	9.36
Metric/Secondary	3.12	4.05	1.95	6.98	8.14	5.63
Higher Secondary	1.39	1.91	0.74	2.20	2.83	1.48
Technical diploma	0.11	0.19	0.01	0.05	0.08	0.02
Equivalent to degree Graduate and above	1.17	1.62	0.61	1.96	2.62	1.18

Enrolment in Govt. Schools and Colleges- 31st March 2000

Particulars	**North**	**East**	**South**	**West**	**State**
Preprimary	2088	8290	6564	6220	23162
Primary (I-V)	7566	31325	21721	20058	80670
J.H.S stage (VI-VIII)	1560	11349	6063	6045	25017
Secondary stage (IX-X)	480	3557	1938	1612	7587
Senior secondary stage	202	1690	734	687	3313
Degree College	-	1663	245	-	1908
Eng College	-	-	-	-	-

Source- Education Department – Sikkim

HEALTH AND MEDICAL FACILITIES

Sikkim claims to have achieved the national norms of 1 Primary Health Centre per 20,000 people and 1 Primary Health Sub Centre for every 3000 people. Considering the small size of population, it was not very difficult for Sikkim to achieve the national norms, but the ratio is in no way satisfactory. In a mountainous area, only 1 health centre for 3000 persons is much less than sufficient. The health facilities in Sikkim include hospitals, health centers, family welfare centers, maternity and child welfare centers, blood bank services, drug de-addiction centers, etc.

Although Sikkim is located in one of the most humid regions in the country it faces shortage of drinking water at many places. The capital town Gangtok itself faces water scarcity during the monsoons when disruptions occur in the water distribution system due to damage of pipelines. At Gangtok, water is brought from reservoirs at Selep, located at a distance of 16.5 km from the town. The capacity of Selep reservoir has recently been increased to 6 million gallon (MGD) of water per day, still it is not sufficient to meet the growing demand. The water distribution system needs to be improved to ensure equitable water supply.

Distribution of households by source of drinking water

State/District	Tap %	Hand pump	Tube well	River canal	Spring	Any other
Sikkim	**70.31**	**0.24**	**0.18**	**1.16**	**25.32**	**1.73**
North	42.15	0.75	2.25	3.27	51.69	2.25
Chungthang	41.76	0.00	0.00	8.13	48.98	0.85
Mangan	42.26	0.19	0.32	1.89	52.47	2.65
West	75.37	0.15	0.15	0.59	22.50	0.57
Gyalshing	83.22	0.22	0.26	1.09	12.96	1.03
Soreng	66.98	0.07	0.03	0.06	32.69	0.09
South	73.55	0.47	0.34	1.17	16.18	5.28
Namchi	74.69	0.50	0.43	0.96	15.65	5.00
Ravong	71.22	0.41	0.18	1.57	17.26	5.83
East	70.77	0.18	0.10	1.08	27.22	0.31
Gangtok	72.84	0.19	0.06	1.23	24.93	0.39
Pakyong	65.29	0.17	0.37	0.73	33.19	0.03
Rongli	61.51	0.17	0.04	0.32	37.56	0.00

Sources : Census – 2001.

Sikkim has 174 registered government doctors and 160 staff nurses. East Sikkim alone accounts for 107 doctors and 125 nurses. The North, South and West districts have 16, 31 and 20 doctors and 10, 15 and 10 nurses, respectively. The total number of hospitals in Sikkim is 5, out of which 2 are in the East district and the North, South and West districts have 1 each. Besides, there are 24 Primary Health Centres (PHC) and 147 Primary Health Sub Centres (PHSC) in the state (Table 16).

Distribution of PHCs and PHSCs in the districts of Sikkim (2001-02)

Health Centres	North	East	South	West
PHC	3	8	6	7
PHSC	19	48	39	41

Source: Sikkim: A Statistical Profile, 2002. DESME, Govt. of Sikkim

TOURISM

Tourism is considered as the backbone of Sikkim's economy. It has brought economic prosperity in Sikkim. With the salubrious climate, the natural beauty and the fine cultural heritage of Sikkim, the growth of tourism has immense possibilities. There are large number of places of tourist attraction particularly the snow clad mountains, the lakes and unspoiled forest areas and valleys of flowers. The advantage of having very fine monasteries in Sikkim can also be taken to attract Buddhist tourists from countries like Japan and the South Eastern countries.

AGRICULTURE

Agriculture is the major economic activity and is practiced on terraced field that has been laboriously created from steep hillsides. There are in all 689 enterprises that have been identified, which are mostly concentrated in rural areas. Sikkim is the largest producer of cardamom and also boasts to utilize largest area for its cultivation. Tea is exported to USSR & Germany. A coffee plantation has also been started at Majitar. Sikkimese economy broadly depends on the agriculture which provides livelihood to the majority of population in the state. However, its progress remains limited due to difficult topography and other natural barriers. As

a result all head sectors related to agriculture emerged, government is doing it's best to improve the situation.

HORTICULTURE

Horticulture is one of the major economic activities of the people of Sikkim. Large Cardamom, ginger and turmeric are the principal crops while Mandarin orange, guava, mango, banana and so on are the principal fruits grown in the state. The department of Horticulture is deeply involved in motivating and providing technical guidance to local farmers. Sikkim is also a paradise for flowers. Gladioli, anthuriums, lilliums, primulas, rhododendrons, orchids as well as many other floral species thrive here. The state is home to an amazing 450 species of exotic orchids alone. There is immense potential for developing floriculture on a commercial basis here, and the department of Horticulture is making concerted efforts to turn this sector into an export-oriented industry.

INDUSTRIES

Sikkim is industrially backward due to its isolated location and difficult terrain. Exploitation of mineral resources in the state is a challenging task. The known reserves are small and their extraction process is un-economical. Therefore, the state has hardly any mineral-based industry except copper, the production of which too is dwindling. Though Sikkim is rich in forest resources, forest-based industries are not encouraged since there is always a risk factor associated with exploitation of forest resources. The existing industries in Sikkim are medium, small-scale and cottage enterprises, based chiefly on agriculture and animal resources. Most of the medium-scale industries of the state are beverage industries (tea, beer and other alcoholic drinks) while the small-scale and cottage units are chiefly related to food products and handicrafts. The policy of framework in regard to industrialization in Sikkim has to be formulated keeping in mind the particular factors endowments that the state has the limitations in regard to resources, particularly, minerals and industrial raw materials as well as man power. The state is not so rich in mineral resources and apart from the deposits of copper, lead and zinc, no other viable and exploitable mineral deposits have so far been discovered. While on the other hand the state enjoys a salubrious climate, a dust free atmosphere and

peaceful industrial entrepreneurial talent, has also to be taken note of. In regard to industrial development, a number of small and medium units have been promoted in the state.

MARKETS

Sikkim has developed a number of Rural Marketing Centres (RMCs) and Bazars spread over all four districts. All in total there are 108 RMCs and 46 Bazar areas in Sikkim. The Bazar areas are classified as Class I, II and III according to their size and volume of transaction.

Number of Markets and their percentages to the total revenue blocks

State/District	Number of Markets	Command area in Km2 per market	Command population per market	Percentage of market to total revenue blocks	Number of market days
North	1	423	30.340	2.0	1
East	4	239	36.332	3.2	4
South	6	125	16.150	4.2	7
West	6	194	16.159	5.0	6
Sikkim	**17**	**417**	**21.678**	**3.9**	**18**

Source : (Role of Markets Centers in Jana M.M the development in Sikkim)

AQUA CULTURE

Pisiculture is an important area of economic activity particularly in the context of enabling the rural people. The states natural resources endowments with an extensive network of freshwater rivers, lakes and streams offers conditions which are conducive for development of inland fisheries where a variety of carps and trout's can thrive. The land, their scope for utilization for large production and agencies to be involved are abstracted below

Type of Land	Scope of utilization for fodder production	Agencies to be involved
Alpine and sub alpine grass lands and other cultivable waste lands in higher altitudes.	Temperate forage production and seedling for grass land improvement	Animal Husbandry and Forest Department of State Government.
Forest lands	Various fodder based forestry systems like fodder forestry and silvi pasture	Forest Department of the State Government
Community waste lands and uncultivable lands	Perennial grass production	Respective local self-government such as municipalities and panchayats.
Lands under operational holdings	Intensive fodder production in a portion of the cultivable area perennial grasses and silvi pastural land use in uncultivable area.	Operational landholders farmers.

Source: Balaraman N. Indigenous farming system for livestock production in Sikkim.

Area under gaucharan, khasmal and alpine pasture in Sikkim

Categories	Area (Km^2)	Percent
Alpine pasture	1070.48	65.92
Khasmal land	570.73	31.45
Gaucharan land	42.71	2.63
Total	**1623.92**	**100.00**

Source: Paljor S. feed and fodder Resource of Sikkim.

District wise details area of alpine pasture khasmal and gaucharan land in Sikkim (Area in Km^2)

District	Alpine pasture	Khasmal	Gaucharan	Total	Percentage
North	908.61	216.07	12.00	1136.68	73
South	30.32	97.78	10.82	138.92	9
West	64.87	91.89	10.86	167.62	11
East	.06	104.99	9.02	114.07	7
Total	**1003.86**	**510.73**	**42.70**	**1557.29**	**100**

Source: Paljar S., feed and fodder situation in Sikkim

Assessment of fodder requirement and sources of fodder production in Sikkim

S.No	*Source*	Annual production in million tons per annum	Percentage
1	Permanent pasture and grazing lands including cultivable waste land 102490 hector and 4 tones per hector.	0.41	31.00
2	Fodder production from agricultural land 79060 hector and 2.5 tones per hector.	0.20	15.00
3	Estimated fodder production from forest area 2 tones per hector from 265210 hector	0.53	40.00
4	Fodder production from private forest	0.10	8.00
5	Fodder available from agricultural waste land	0.08	6.00
6	Total fodder production in the state	1.32	100.00
7	Total fodder requirements in the state	2.08	-
8	Fodder deficit	0.76	36.54

Source : State Forest Department (1957). Sikkim perspectives for planning and development 1998.

Requirements of fodders (tones) 1977-2001

Livestock	Livestock population		Livestock population	
	1977	**2001**	**1977**	**2001**
Cattle	157546	143024	221201.70	200812.00
Baffalow	5438	1970	15879.07	5752.44
Yak	3995	3140	5991.60	4709.29
Sheep	16104	5023	95882.94	80274.70
Goat	88386	82938	-	-

Source: Paljor Sonam's Thesis paper on livestock of North Sikkim.

Distribution of Surveyed revenue blocks and households

Sl. No	**District**	**Total Rev. Block**	**%**	**Surveyed Rev Block**	**%**	**Total House Hold**	**%**	**Surveyed House hold**	**%**
1	North	45	10.95	33	73.33	10921	9.56	3756	34.39
2	South	135	32.85	95	70.37	25477	22.30	12438	48.82
3	East	120	29.20	4	3.33	54581	47.78	270	0.50
4	West	111	27.00	70	63.06	23244	20.35	6000	25.81
	Sikkim	**411**	**-**	**202**	**49.15**	**114223**	**-**	**22464**	**19.67**

Not yet surveyed. Source: Field Survey.

Distribution of surveyed population

Sl. No	Dist/State	Total Population	%	Surveyed Population	%	Total Male	%	Total Female	%
1	North	41030	7.59	3446	8.40	1771	51.39	1677	48.67
2	South	131525	24.32	3632	2.76	1884	51.87	1748	48.13
3	East	245040	45.31	315	0.13	162	51.43	153	48.57
4	West	123256	22.79	2078	1.69	1070	51.49	1008	48.51
	Sikkim	**540851**	**-**	**9471**	**1.75**	**4887**	**51.69**	**4586**	**48.42**

* ***Not yet surveyed***

Source: Field Survey.

ENVIRONMENTAL IMPACT ASSESSEMENT ON THE SOCIO ECONOMIC IMPACT OF THE PROPOSED TEESTA STAGE VI H.E. PROJECT

An introductory note on the ethnic structure of Sikkim as such is useful for appreciating the socio economic profile of the Sikkim populace living around, and affected because of, the proposed Project.

Nepali Hindus constitute by far the largest portion of the population of Sikkim, estimated at more than 70%. Nepalese mass immigration in Sikkim was initiated by the British, reportedly to counterbalance the power of the Kazis. Nepali castes include Chettri, Brahmin, Sharma, Kami, Tamang, Gurung, Thami, and Rai, with Chettris among the most numerous. There are cultural and dietary differences between the Nepali castes , and most villages have at least two or three different castes represented. As minorities, Bhutias, Lepchas, Limbus and Tsongs have been declared scheduled tribes by the Government, and are therefore eligible for special subsidies, as noted in the RRA and mission reports.

Historically, the Kazis were strategically placed persons from privileged families of Bhutia (Bhutanese) households, who occupied an aristocratic place in the feudal system (Sinha 1983). The former Chogyal (king) of Sikkim, who was deposed during the Indian annexation of Sikkim, was the head of the Bhutia aristocracy. Today Bhutia families represent a minority

of the population (about 15%), but tend to be better educated and wealthier than other groups in Sikkim. Bhutias also control many former and highly productive Kazi agricultural holdings, as well as the profitable cardamon crop. Bhutias are Lamaist Buddhists aligned with the traditional Tibetan and Bhutanese aristocratic houses (Sinha 1983).

Lepcha families represent the original inhabitants of Sikkim, and are also primarily Buddhist. Lepchas have intermarried with both Bhutia and Nepali families, and their numbers are said to be in decline. Lepchas represent approximately 10-15% of the total population, and are concentrated in the southern and central portions of the state. Limbus and Tsongs are indigenous groups of small populations.

The rural appraisals carried out by FAO team in four villages in the East and Southern districts of Sikkim indicated that there is considerable variation in the sexual division of labor among villages by ethnicity (e.g. Nepali vis-a-vis Lepcha vis-a-vis Bhutia) and by caste or clan within an ethnic group (e.g. Nepali Chettri vis-a-vis Rai). Although it was observed that there is considerable variations on gender roles even within a single village (e.g. between Lepchas and Rais), it is not advisable to extrapolate our findings to Sikkim overall. In addition, the gender roles prevailing in other Indian states cannot be assumed to exist in Sikkim, which has a very different socio-cultural history and composition. However, it is clear that all household members are heavily involved in agriculture and subsistence tasks, and that all family members contribute long hours each day to the household economy.

Few generalizations can be safely made about gender roles in rural households, and that each village should be viewed separately, with distinct labor patterns. Livestock management has a distinct place in the rural economy of the area chosen for our study. In the above mentioned four villages, however, we found that the following overall patterns tend to prevail, although with variations:

- men tend to care for livestock that are of larger size (goats, cattle, oxen), although women and children are also involved in livestock management;
- women are primarily responsible for tending poultry;
- men and women are involved in agricultural production on a relatively equal basis, but the involvement of children in agriculture varies by village and by ethnic group;

- women are primarily responsible for hauling water;
- women cook, do childcare, and other household tasks, although men also cook for large groups, and all household members may share domestic tasks;
- all household members are involved in cleaning and washing.

Again, these responsibilities vary by village and by ethnic group. There are several factors that appear to affect the allocation of labor of different household members to goat keeping:

- Stage in family cycle
    - sex and age of children
    - availability of old men to tend grazing goats
    - school attendance/non-attendance
    - ethnicity/caste
- Natural resource endowment
    - altitude, slope and aspect (which determine cropping systems/potentials)
    - distance to water source (location of home)
    - availability and access to forest resources (location of home)
    - holding size
- Season
    - (competition with crops)
    - crops in fields
    - school holidays
- Flock size
    - feeding system (stall-feeding, tethering or grazing)
    - water requirements

Labor constraints differ by village, and probably depend upon household size and composition, holding size, the basic natural resource endowment of the village (e.g. proximity of water sources, households with RDD-installed water taps, availability and distance of fodder sources, etc.). It was found that in some cases the size of the goat flock is limited by feed/fodder availability, which in turn is affected by labor availability.

Labor is a serious constraint for most rural households. Collection of water and of fodder for livestock occupies considerable time for most households, and is done by men, women and children depending on the village. It is not possible to say that any one household member assumes primary responsibility for goat rearing in any of the villages surveyed. This activity appears to be very much of a household endeavor, with all family members contributing at least some labor to the well being of the flock. There is a clearer pattern with regard to chicken rearing, with women having the primary responsibility for management, although other family members may do some tasks (such as housing construction, decision making, marketing, etc.).

Labor constraints may affect marriage arrangements and family composition. One household was identified where two sisters in their thirties had never married (i.e. marriage had never been arranged for them) because they were required to look after the family's herd of 28 goats. However, this was the only example discovered of such a practice, and the family herd was larger than any other in the village.

Lama (1994) notes that among Lepcha and Bhutia households "there is no hard and fast division of labour between the sexes, although the heavier works are done mostly by men. There is practically no such distinction as men's work and women's work. Both men and women run small business and shops. Women also work as porters."

Children, and particularly girls, have a high labor contribution to the household economy. Girls are sometimes withdrawn from school after three years (when they have learned to write their names) to work, with preference for education given to boys. We were unable to determine how widespread the practice is of "draw-out" of girls, although it appears to exist in all four villages surveyed. This was felt by the team to be a major gender disparity, in terms of more limited educational opportunities available for rural girls.

PROPERTY RELATIONS

Property relations differ among Sikkimese ethnic groups. Bhutias and Lepcha households follow a patriarchal family system, with the adult male (father) as the head of the household. Bhutias are generally polyandrous (one common wife shared by all brothers), a practice still in widespread existence today (Lama 1994). Marriages are not arranged.

Lepchas are polygamous, and marriages are not arranged -- Lepchas are free to choose their partners. There was apparently a tradition of polyandry among the Lepchas at one time (Kotturan 1983). Among both Lepchas and Bhutias, all property, either moveable or immovable, belongs to the father, or male head of household. Women have no legal right to family property. However, women and girls are given gifts and assets including livestock, utensils, ornaments, land (if the household is wealthy) and other goods, which may be taken with them after marriage. This practice is described in the RRA report, and is known as pewa.

As both Bhutias and Lepchas are scheduled tribes they are not subject to the Hindu Marriage Act of 1955, which was extended to Sikkim in 1989. Custody of children and of household property is determined by customary law, which relies on elders to resolve custody issues. Child marriage and the dowry system are unknown in Bhutia and Lepcha households (Lama 1994). Bhutia and Lepcha daughters have no rights of inheritance to their fathers' properties, even when there are no sons. Bhutia and Lepcha women who marry outside of their ethnic group forfeit their rights to any personal and pewa property.

Among Nepalis, marriages are commonly arranged. At the time of marriage a non-compulsory gift or dowry known as daijo is given, which may include household goods or livestock. As Hindus, Nepalis are subject to the Hindu Marriage Act of 1955, which governs property relations in marriage among Sikkimese Hindu households.

Land tenure is always registered in the name of the male head of household in Sikkim, regardless of ethnicity. Panchayat land records only note the name of the male head of household. Upon the death of the male head of household, women retain usufruct rights to the family holding, and continue to live there until their death. Landlessness is not a widespread problem, affecting probably less than 10% of rural households. Precise data was not available on landlessness. Landless families cultivate land on a sharecropper arrangement known as kut.

EDUCATION

There has been a tremendous increase in the number of girls and women obtaining an education since the turn of the century, although this increase does not appear to be uniform across all regions of the state and across all income and ethnic groups.

Bhutia women probably have benefited most from increased access to educational facilities. Women in aristocratic Bhutia households have had access to higher education, as well as education abroad, since the beginning of the 20th century (Lama 1994).

As noted, withdrawal of girl children during the primary school years was observed in all the villages assessed. Although the information is qualitative, the practice is apparently fairly common in rural areas. Data on literacy rates, graduation rates, or access to higher education by gender were not immediately available in Gangtok, although there are apparently data available from the Central Statistical Service that were compiled from the most recent census.

RURAL INSTITUTIONS AND SUPPORT SYSTEMS AND WOMEN'S ACCESS TO THEM

Government institutions in general have a very limited presence in rural areas. Perhaps the most omnipresent government institution found is the Indian Army and Border Roads Organization, followed by the Public Works Department (responsible for the upkeep of the road network). The later is a major source of employment for rural households, and particularly for women and children, who perform unskilled daily labor as porters, fire tenders for tar, and manual breaking of stones into gravel.

The Rural Development Department (RDD) and SRDA (Sikkim Rural Development Agency) both have a strong rural presence in the form of subsidies and maternal and child welfare programmes, respectively. The RDD has put into place an impressive infrastructure of rural electrification and rural water supply, although both systems lack maintenance and upkeep, and suffer from intermittent service. The water system in particular affects women in rural villages by its intermittent nature, by creating considerable work for women to obtain water from distant sources. In addition, as noted in the RRA report, aspects of the RDD programs are regarded as a disincentive to effective, sustainable rural development by creating a "hand-out" mentality. It was noted that there is a complete absence of extension services to most rural households. This cuts across several departments and sectors, including public health, animal husbandry and veterinary services, forestry, and agriculture. As a result there is a widespread lack of knowledge about basic human and animal health practices, livestock management, and soil conservation. Although all rural people are affected by this problem,

women seem to be particularly ignored by the extension system, and are uninvited by the local panchayats when an extension activity does occur. In addition, none of the government departments encountered are familiar with participatory approaches and methods, and rely on hierarchical top-down approaches to rural development that are based primarily on subsidies.

In terms of employment, it was noted by the mission that most households in Sikkim have at least one family member employed as a Government civil servant, even in rural areas. Overall, 20.74% of government employees are women, of which 35 % are of Lepcha or Bhutia ethnicity (Lama 1994).

The organizational structure of rural villages is based upon the Indian panchayat model, with panchayat members voted in by popular election. However, generally panchayats are comprised primarily of men. Presence of women in Panchayat organizations is increasingly getting prominent.

In Lepcha villages, chieftaincy remains a male preserve, but men and women are otherwise regarded as social equals. Lepchas have evolved a surprising sense of cohesion, with villages mostly self-sufficient and to a large extent self-governing (Kotturan 1983).

With regard to local institutions, weekly markets are perhaps the most important feature of rural life. Women probably make up the bulk of small-scale vendors at weekly markets, particularly those without stalls or shops, which are primarily run by Hindu men. Women were observed as vendors of most items with the exception of footwear and clothing. A number of Bhutia and Lepcha women selling livestock reported that they had travelled unaccompanied on foot for four or five days to reach the local market.

With regard to religious institutions, both Lepcha and Bhutia women are admitted to Buddhist monasteries in Sikkim, although their numbers are very small (Lama 1994).

POLITICAL PARTICIPATION/PUBLIC ROLE

At present there is little participation by women in the political sphere or in party politics, which appears to be dominated by men. Compared to other Indian states, women in Sikkim are more active in politics. No professional associations of women were discovered. However, association like ‘Cheli Morcha’ is making its presence felt.

No national organizations of women were identified, and there is no official representation to India (national level) on behalf of Sikkimese women. There is no delegation representing Sikkim attending the 1995 Beijing conference, and no Sikkimese women attended the 1985 Nairobi conference.

Not only is there an absence of state-level and local women's organizations, there is also an absence of international and national (Indian) women's organizations (e.g. YWCA, SEWA, or other Indian NGOs addressing gender concerns) in Sikkim. The geographic, cultural and economic isolation of Sikkim from India probably is a major factor, as there are few associations in general that exist in the country. However, this isolation may be changing, as many Bhutia families have begun to send their children abroad for higher education and due to the recent acquisition of numerous satellite dishes by urban and many rural households.

There appears to be few social or professional organizations of any kind in Sikkim, for either men or women. It should be noted that Sikkim is a very small state, and that a good deal of economic and political relations occur on a social and private basis, particularly among the Bhutias and Lepchas, as most public and civil servants know each other personally.

SUMMING UP: GENDER GAPS AND DISPARITIES

While it can be concurred that women in Sikkim do not suffer from the onerous and inequitable positions of their counterparts in other parts of the world, but that nevertheless a number of gender disparities exist, summarized below:

- the considerable isolation of Sikkimese women from national (Indian) and international gender networks, activities, and conferences, resulting in a lack of sensitization and understanding of gender issues;
- there is a notable gap between urban educated women and their rural counterparts, and the relative opportunities available to each;
- traditions and customs governing marriage (e.g. arranged marriages and dowries) and property relations (patriarchal/patrilineal) restrict the assets available to women;
- the withdrawal of girl children from school to address labor constraints and shortages in rural households;

- women and girls are generally overlooked by extension services, and their role in agricultural and natural resources management is generally unknown and unappreciated by government staff.

The socio economic profile of the populace living in the vicinity of the proposed hydel project is as follows

The population is predominantly tribal. The economy is primarily pastoral with seasonal work. The males work in the paddy fields. The other main crop is maize. Further, in the non cultivation season, many of the people work as domestic help. In the social milieu, the importance of the 'Haat' can not be undermined. On Sundays the male members of the households proceed to Gangtok for selling of vegetables etc.

The proposed airport has kindled all types of hopes in the people of the area. Alongwith a general euphoria there exists certain caveats in the form of increased drunkenness among the males/ playing of flush and other games involving money transactions. Drugs may be easily available after the completion of the project. Thus the compensation package received by the locals may go waste if proper planning and the system support is lacking.

The locals perceive the coming up project as a boon and panacea for their ills. Simultaneously there are many apprehensions also. General perception is that with the opening up of the area to the outside influence the local gullible 'Seedha Lata' populace may easily be duped. Further, they also perceive the project as a stimulator for their socio-economic developments. Also they think that they will be merged with the mainstream of development by availing the sophisticated technologies. In this sense, 'Universalization' can be taking shape. Further, Rangpo will be developed as an alternate township. At present Singtam is the major town in the vicinity

Concomitant with the development, there are dangers of environmental degradation, water sources getting dried up, large scale deforestation, looming landslides and other dangers are also envisaged. The people have time tested knowledge of preservation of environment and biodiversity i.e. biodiversity centered traditional ecological knowledge (TEK)

The present population of Sikkim is primarily composed of different races or ethnic groups. They are the Lepchas, the Bhutia, the Nepali and the plainsmen. These different ethnic

groups have their distinct languages and cultural pattern. This cultural diversity of the ethnic groups who have no common racial backgrounds has become the central point of socio-economic and political problems in Sikkim. Over centuries, the narrow fertile valleys of the inner Himalayas and the rugged hill tracts of the greater Himalayas have been settled by the Tibeto-Burmese, Tibeto-Mongoloid and Indo-Aryan races who have adjusted themselves to the rigorous climate of this state. Thus Sikkim has become a state of multi-racial inhabitants. The oldest inhabitants are the Rongs or Lepchas who migrated via Assam to this mountain state. Next came the Khampas from the Tibetan province of Kham, they are now commonly known as Bhutias. The Limbus who are considered by some as belonging to Lhasa gotra are believed to have migrated from Shigatse, Penam, Norpu, Giangtse etc of the Tsong province of Tibet. These Limbus and other Magar, Rai, Gurung, Murmi etc are allied races and in fact belong to the Kirati sub-cultural stock of the Nepali race who migrated to Sikkim from Nepal in the west English is the official language of Sikkim. The Lingua-franca is however Nepalese. It closely resembles Hindi. The Lepcha language belongs to the Tibeto-Burman family. The languages of the Bhutias, Limbu, Murmi, Magar, Khamba and Mewar also belong to it.

High priority has been given to education. Education is free upto the primary school level. While in the higher classes the fee is nominal, for girls education is free up to class XI.

THE LEPCHAS

The central zone, the lands of the Lepchas, roughly covers the area from the junction of the river Teesta and the Lachung river to the junction of the Teesta and the Dikchu rivers. The Rong-pas, who are known as the Lepchas are the original inhabitants of Sikkim. Earlier it was believed that, the tribe was a very ancient colony from southern Tibet. Their physical characteristics showed them to be a member of the Mongolian race. But later, it was supposed that they had come from the east, from the direction of Assam and Burma. The Lepchas are markedly Mongolian in features and differ from the Tibetans. It is also said that the Lepchas have similarity with the tribes of Hangarang in the North West Frontier Province and with the mountain tribes of the Laree area in Ladakh. Others content that the Lepchas and the Khasias of Khasi -Jaintai area are two different branches of the same ethnic group. Though, at one time, the Lepchas had blood relation only with the Limbus at present no restriction is maintained in establishing matrimonial relations with other tribes. The Lepchas have no caste distinction, but

they believe that they belong to any of the five classes of Syang-Den, Mu, Ling-SingMu, Himu, Karthak Mu and Thikung Syalang. There are certain other classes based on the places of residence.

Marriage of wards is normally negotiated by the parents and after fulfilling certain condition, the marriage is publicly celebrated with much feasting. The Lepchas are primarily animists. They acknowledge the existence of God and the bad spirits and do a lot to appease the bad one. Every class has a priest doctor, who is in fact an exorcist. The priest doctors may be either male or female. The male one is called bon and the female one is called generally monn. The Lepchas have their own language which according to Mainwaring is the oldest of all the hill dialects. It is contended that the language they speak is of the Tibeto-Burmese family.

The Lepchas are very intelligent, amiable and always cheerful. They are very modest, extremely hospitable people. They love sports and games and are sociable. They are innocent and good humored. They are peace-loving people who avoid quarrels.

BHUTIAS

The Bhutias, who are all Buddhists, are quite distinct from the Lepchas. The Tibetan Bhutias entered Sikkim by way of Bhutan and settled in higher altitudes after driving the original inhabitants, the Lepchas into forests and lower valleys. They converted the indigenous Lepcha people to their religious faith, established matrimonial relations with them and thereby paved the way for cultural and social assimilation of the two races. This gave rise to a new race.

The matrimonial relation between the Tibetan nobles and Lepcha chiefs or Jongpons gave rise to a new affluent class of Kazis. The Bhutias are mostly traders and Herdsman. But many of them are accustomed to cultivation now-a-days. The Bhutias are more assertive and industrious than the Lepchas. They are not fond of isolation as the Lecphas.

The Bhutia social structure is patriarchal. Normally, the Bhutias live in a joint family. There is no caste distinction among the Bhutias. Bhutia women generally enjoy a great deal of independence and they are treated as equal; to men. Marriage is normally arranged and settled

by the parents. In the affairs of marriage, maternal uncle and astrologer play an important role. Both man and woman can seek a divorce. If the matrimonial relation has to be served, the man or the wife would refer the case to the village elders. At present the aggrieved parties go to the court of law also. Traditionally, the parties who apply for separation has to pay a penalty and the actual expense incurred during marriage.

THE NEPALI

The Nepali immigration in Sikkim started long after the Bhutia settlement. The Nepali community is composed of different sub-cultural stocks with considerable differences in physical characteristic and customs. Each tribe is sub-divided into many classes. The most important of these tribes are: Limta, Gurung, Magar, Rai, Tamang, Mewar etc. Of the caste Hindus, there are the Brahmins, Thakurs, Chettris etc. Among the low caste tradesman there are the Sarki, Kami,Damai etc. The Nepalese are spread throughout the east, south and west of Sikkim. They are mostly Hindus but some of them are Buddhists. They have terraced fields and also work on building roads. They are also good at trade and own many shops in the main Bazaar at Gangtok. They also work as Silversmiths.

The immigration of the Nepalese and their rapid expansion has created a serious problem for the original inhabitants - the Lepchas and the Bhutias. The Nepalese are not only multiplying more rapidly in numbers but are also ahead in education which enables them to get jobs in government. While the Lepchas and Bhutias still prefer the traditional education in the monasteries, the Nepalese send their children to schools. The Lepchas and Bhutias are averse to cultivate waste lands. Nepalese plant maize which grows in abundance and is their staple food. The Nepalese children work from the age of five and when they are ten years of age are able to earn more than they consume. Their style of living is comparatively much economical. Their dress and diet are simple. They do not spend much money on marriage and festival. On the other hand, the Lepchas and Bhutias take rice with meat, if possible. Their dress is expensive. Above all, they have to support the monks, according to the religious custom, make occasional offerings, either in kind or cash to the 'gompa' and then pay a high fee to the priests for the various services rendered by them.

THE TAMANG

The Tamangs claim their origin from four families, viz. Bal, Yonjon, Moktan, Ghising. Their two main divisions are Bara Tamang and Atharajat. Bara Tamang is socially superior. Tamangs have a similarity with the Gurangs. Their language is similar to Gurang Kura. By religion the Tamangs are Lamaist Buddhists.

THE NEWAR

The Mewar are originally agriculturists and masons. But in Sikkim many of them have taken to trade. The Mewars of Sikkim are mostly Hindus.

GURKHAS

Of the Gurkhas who settled in Sikkim, the Brahmins have the highest social standing. They are mainly agriculturists and are mostly orthodox Hindus and would not normally have any matrimonial relations with other lower castes. But with the passage of time, rigidity of social attitude and behaviour is fast disappearing. In the urban areas Brahmins are found marrying non-Brahmins, taking up a variety of professions other than priest hood and mixing freely with others.

THAKURS

Next in social rank are the Thakurs. A Thakur is also entitled to wear sacred thread. Inter-marriage among certain class of Thakurs is permissible while marriage with members of other classes is restricted.

CHETTRIS

The Chettris are next in rank. They also wear sacred thread and have Brahmanical prejudices. Though inter-marriage is common, they prefer marriage only among their own class.

In Sikkim, inter-marriage among these higher castes is not uncommon. Traditionally a Gurkha can possess any number of wives. A wife taken through formal ceremonial marriage is

called a 'Behaite 'while others are called 'Lihaites'. But this practice is now on the wane. Divorce is permissible. Both man and wife can refer any plea for divorce to the village elders who decide it.

THE LIMBU

Limbu is a branch of the Kirati tribe. They have a tradition of inter marriage with other tribes particularly with the Lepchas and in certain respects their habits are similar to those of the Lepchas. They have also matrimonial relation with the Rai or Khambas. The Limbus call themselves Yakthamba. One of the branches came via Lhasa and is called the Lhasa gotra, while the other branch which came from Benaras is called the Kashi gotra. The Limbu have their own priests, they are known as 'Phedangba'. They conduct the religious ceremonies, and also deals in omen and forecasts. They have their own language, called the Limbu Kura. Limbu marriage is often conducted without the consent of the parents.

THE RAI

The Rai or Khambas have much in common with the Limbus. By religion they are Hindu. Men of their own, tribe called the 'home' serve as their priest. But now-a-days, Brahmins are engaged to conduct rituals. They also engage Bijuwas or occasionally a Phedangba or a Jhankri to ward off evil spirits. Their marriage customs do not differ much from those of other Kirati tribes. The Rai people have a dialect of their own. They have artistic talents. They are mainly agriculturists.

THE MANGAR

The Mangars are another important tribe whose customs and religious ceremonies closely conform to those of the Hindus. They have a language of their own, known as Mangar Kura which is of Tibeto-Burmese group. There are seven classes of Mangar who are all socially equal. They are Ale, Burathoki, Gharti, Pun, Rana, Roka and Thapa. Thapa is the largest class of the Magar. Inter marriage is permissible among the classes.

THE GURUNG

The Gurung are basically agriculturists. They are of Mongolian origin and they profess Hinduism. But in the early period they were, in fact, fond of using the services of the Lama instead of Brahmins for all priestly function. Now-a-days, they have a different tendency and engage Brahmins also. This tribe is divided into two branches, the Char Jat and Sora Jat. But the distinction is now disappearing. Marriage between the two branches is now common. The Gurungs have their own languages which is called the Gurung Kura. The Gurungs in the urban areas now generally follow Hindu rituals.

FESTIVALS AND ENVIRONMENTAL RESOURCES

The festivals of Sikkim are of two types — religious and social. Again, the religious festivals are of different categories depending upon the religion involved. Social festivals too are varied due to the presence of various ethnic groups. The religious festivals according to the dominant religions may be grouped as follows:

Buddhist Festivals	Hindu Festivals	Tribal Festivals
Losar	Maghey Sankranti	Losoong
Bum Chu	Kusey Aunsi	Pang Lhabsol
Lhabab Duchen	Dasain	
Saga Dawa	Drukpa-tseshi	
	Bhimsen Puja	
	Tihar	
	BhaiTika	

QUALITY OF LIFE SIKKIM

For the present work, an interview schedule was structured on the basis of the wants and needs of the people at three levels, viz. individual, family and society. Three sets of indicators — economic, social and environmental- were used. The economic indicators included the, a) quality of housing in terms of construction, number of rooms, separate cooking

area, toilet facility, sources of energy, water, etc. and b) ownership of assets in terms of household goods, livestock and agricultural land. The social indicators, due to their objective nature, were based on a set of open-ended questions on people's perception of QL and aspiration for a better QL at the levels of individual, family and society. The environmental indicators were inclusive of both natural and man-made environments. Particular emphasis was laid on the availability of natural resources like clean air, water, vegetation and human endeavour for the upkeep of natural resources.

The present study is based entirely on case studies and sample survey. Fifty villages were selected for sample survey and 150 persons were interviewed. On an average three key informants were selected from each of the villages. The selection of informants was purposive but a non-probability approach was maintained in selecting sample villages. The questionnaire design took into account a) facts, b) opinions, and c) attitudes of the respondents. For each of the respondents, a score sheet for ten variables (economic indicators), namely i) Type of House, ii) Number of rooms, iii) Separate room for cooking, iv) Fuel used for cooking, v) Source of light, vi) Source of drinking water, vii) Toilet facility, viii) Livestock owned, ix) Ownership of household goods and x) Ownership of land was prepared. The Quality of Life Index (QLI) for Sikkim was prepared on the basis of scores obtained by the households. The minimum possible score on the basis of economic indicators was 9 while maximum was 75. In Sikkim none of the houses surveyed scored as low as 9 or as high as75. Four class groups were made on the basis of scores obtained by the households. The households that score below 20 are poor but stay above the poverty line. The households with scores below 30 fall in the category of lower middle class, and those scoring below 40 belong to the middle class. The few households scoring above 40 belong to the upper middle class. None of the families interviewed were found to be rich (minimum score required: above50).

Ethnic aspirations apart, all the communities of the area aspire for economic security. The communities living in this part are aware of their natural resources. They are still fortunate to have un-spoilt, pollution-free environment over most of their habitat. They have taken lessons from the errors committed by their neighbouring states and have become cautious in dealing with environment and ecology They have taken ideas from the west and are keen to preserve and protect their resources. The communities have varying levels of ambition, and they do aspire for development, but they do not want to go the way some of the mountain

communities in some other parts of the Eastern Himalaya have gone. All the communities want to have improved infrastructure, especially in terms of roads and communication. They are in favor of exploiting the local energy resources - water in particular, so that they get enough supply of electricity However, the local people are not in favor of bringing factory- oriented industrial development, rather they would welcome industries like tourism.

Field observation in the area starting from Rangpo to Lachen confirmed that the indigenous people of Sikkim are no longer in favor of isolation. There was a time when the ethnic Bhutias looked up to the Tibetan aristocrats and religious leaders for their worldly as well as spiritual developments. There were regular exchanges across the border and every Bhutia family of the region aspired to adopt the life style and standards set by the northern neighbours. The merger of Sikkim with India took some time to settle in the psyche of the remote villagers. With the closure of borders, the focus gradually shifted to the south. Reservation and inhibition in adopting Indian ways of development is still not uncommon. But after almost three decades of association, the trends are changing and there is a conscious effort to learn and adopt the best of methods suited to their well-being. The villagers are getting used to electricity instead of oil lamp, concrete building instead of wooden one, flush toilet instead of pit toilet, cooking gas (LPG) instead of fire wood, packaged stuff in stead of home made ones and so on and so forth. The instances of sending children to study in a metropolitan city or to join the Indian army are no longer rare

There has been a massive change in the social and economic scenario of some of the remote villages after the introduction of tourism business. For instance, Lachung in North Sikkim, Pelling in West Sikkim and Ravongla in South Sikkim have become tourism hotspots. To accommodate seasonal crowds, small cottage owners of Lachung, Pelling and Ravongla have converted portions of their households into tourist lodges while the affluents constructed villas and resorts. Lodges have come up even in remote Yoksum and Thangu. Once rare automobiles are now considered as objects of necessity and many villagers own four wheelers. The village shops sell all kinds of manufactured consumer goods ranging from packed instant food to synthetic garments to machine-finished footwear.

Under such circumstances, it is but natural that the local people no longer remain isolated from rest of the world. There are limitations due to attitudinal differences but the people of Sikkim exhibit a rather high level of aspiration. Usually they have good control over

all the developmental activities, especially in regard to infra-structural development. The things they cannot do themselves are leased out to others but the reign of control remains in the hands of the villagers.

The ethnic communities living in Sikkim are well aware of the carrying capacity of their native area. The man-land ratio that they maintained for centuries in far-flung pastures and villages is based on calculative experience. They are aware of the wealth of their forest, water and animal resources.

On the whole, the people of Sikkim, though conservative, are not averse to the introduction of improved techniques that help them raise their quality of life. During field visit and investigation it was observed that the local communities were desirous to have, i) Life that is free of diseases, ii) Quality education for children, iii) All weather roads for better communication, and iv) Uninterrupted supply of fuel and power. In other words, the things that they considered most important to bring improvement in the existing quality of life were i) Better healthcare facilities, ii) Education for all, iii) Improved communication network, and iv) Energy resources. The life of the villagers being secure otherwise, they were not necessarily keen to bring in alien techniques, but aspired for an easy and comfortable living by improving upon the existing resources.

IMPACTS ON SOCIO-ECONOMIC ENVIRONMENT

IMMIGRATION OF LABOUR POPULATION.

The construction phase will last for about 5 years. The peak labour force and technical staff required is estimated at about 1500. The labour population involved in construction activities would immigrate into the project area from various parts of the country mainly having different cultural, ethnic and social backgrounds. Such a mixture of population has its own advantages and disadvantages. The advantages include exchange of ideas and cultures between various groups of people, a new culture, having a distinct socio-economic similarity would develop which will have its own entity. Job opportunities will drastically improve in this area. At present most of the population sustains on agriculture and allied activities. There are no major industries or other avenues of occupation in the area. In other hand the availability of infrastructure could be a problem during the construction phase. Thus, it is necessary to

develop infrastructure in health and education sectors, Public Health Engineering. The district administration and Forest Department has to play a prominent role along with the project authority.

INCREASED INCIDENCE OF WATER-RELATED DISEASES.

The construction of a barrage converts riverine ecosystem into a lacustrine ecosystem. The vectors of various diseases may breed in shallow parts of the impounded water. The magnitude of breeding sites for mosquitoes and other vectors in the impounded water is in direct proportion to the length of the shoreline. In the proposed project, increase in water spread area is more, i.e. 22 ha. The marginal increase in shore line could to some extent increase the incidence of mosquitoes mostly in Singtam bazaar and Manpari areas. Labour camps could be vulnerable to increased incidence of water-borne diseases, if adequate measure for distribution of potable water and sewage treatment and disposal are not undertaken.

IMPACTS ON CULTURAL/ RELIGIOUS / HISTORICAL MONUMENTS.

No monuments of cultural / religious / historical / archaeological importance are reported in the project construction and submergence areas. But in the catchment area these structures are involved, since there are no damages anticipated except the surrounding area development for good green cover hence no impact on such structure is envisaged.

IMPACTS DUE TO ACQUISITION OF PRIVATE LANDS.

Total land required for project is 105 Ha, which includes both government and private land. A total of 111 Families are likely to loose only their lands partially. No family is going to loose their house or part of that. The details are given in Table below:-

Village wise break up of PAPs

Sl.No	Block	No. of Project Affected Families	Population
1	Sirwani	7	29
2	Namphing -I	1	5
3	Namphing – II	4	13
4	Tokal	1	5
5	Chalamthang – I	8	37
6	Chalamthang – II	8	34
7	Karek	31	112
8	Mamring	5	18
9	Maney Dara	14	53
10	Pamphok	28	97
11	Kabrey	4	14
TOTAL		**111**	**417**

The socio-economic survey for project Affected Families (PAFs) was conducted in the month of January 2006. In the present report, findings of the social survey conducted for families getting affected as a result of land to be acquired for various project appurtenances have been covered.

Primary data was collected with the help of survey schedules. For this purpose two levels of survey schedules were prepared viz. village – level and house-hold level. Initially, these survey schedules were pre-tested in the field, and necessary modifications were made before they were finalized. The village, questionnaire was used to gather information for the whole village including population and availability of amenities and facilities. The household survey schedule was used to gather information on family profiles, education and occupational levels, assets holding pattern and other socio-economic parameters at the household level.

At site a survey team was formed, which visited the project affected families in the four project affected villages to conduct the socio-economic survey. All the families were covered as a part of the survey. The data was analyzed using Statistical Package of Social Science (SPSS). The results are summarized in the following sections.

FINDINGS OF SOCIO-ECONOMIC SURVEY.

As a part of the survey, all the 111 PAFs were covered. The population of surveyed PAPs is 417 the average family size is 3-4 members. The population residing in the affected village is primarily rural. The details are given in the Table below :

Caste details of PAFs

Caste Category	**Number**
Scheduled Tribe (ST)	41
Scheduled Caste (SC)	6
Most Backward Class (MBC)	8
Other Backward Class (OBC)	55
Others	1
Total	**111**

Source : Primary Survey.

MARITAL STATUS

The information on marital status of the Project Affected Persons (PAPs) was also collected as part of the survey. Among the PAPs married population accounts for about 40.7 % of the total surveyed population. The single, widow and widower population constitutes about 54.9 %, 2.3% and 1.8% of the total surveyed population respectively.

Details of marital status of PAPs

Marital Status	**Number in %**
Married	40.7 %
Single	54.9 %
Widower	1.8 %
Widow	2.3 %
Divorced	0.3 %
Total	**100 %**

Source : Primary Survey

EDUCATIONAL PROFILE.

As a part of the socio-economic survey, information on the educational status of the Project Affected Persons (PAPs) was also collected. The educational profile of the survey population is depicted in the Table below :

Details of Educational Profile

Educational Level	**Number**
Not going to School / Illiterate	11.3 %
Primary School	37.3 %
Middle School	23.6 %
High School	13.2 %
Senior Secondary School	7.7%
Graduation	4.3 %
MBBS / Engg.	0.3 %
Lama / Monk	2.3 %
Total	**100 %**

Source : Primary Survey.

The percentage of population literate or presently undergoing education at primary, middle, high and senior secondary school level was 37.3 %, 23.6 %, 13.2 % and 7.7 % respectively. About 4.3 % of the PAPs had studied up to graduate levels. However, some of the PAPs (0.3 %) have professional degrees such as MBBS / Engineering.

OCCUPATIONAL PROFILE.

Out of the total population it is found that 11.1 % are not working, 37.3 % are students at different levels, 17.4 % are doing the household jobs. There is considerable number of farmers in the project area which is about 26.6 %. The percentage of employees in Government and Private institutions is about 9.9 %. Small section of the population work as Monk also which is about 0.7 %.

Distribution of PAPs on the basis of the Main Occupation

Occupational Categories	Number
Not Working	11.1 %
Student	37.3 %
Household	17.4 %
Farmer	26.6 %
Government Job	5.4 %
Private Job	1.6 %
Teacher	2.9 %
Monk	0.7 %
Total	**100 %**

Source: Primary Survey

Amongst the working population, about 26.6 % are engaged in cultivation. While about 5.4 % and 1.6 % are engaged in Government service and private sector jobs respectively.

LIVESTOCK

Apart from the agriculture land, livestock is the major asset of the PAPs. Every house in the rural area invariably keeps a few cows, bullock, goats, pig and poultry. The total livestock (excluding poultry) owned by the PAPs is 37, which works out to almost 33.3 % animals per PAFs. The details are given in the Table below :

Livestock Holding pattern among the PAPs

Sl.No	Livestock	Numbers
1	Cow	6
2	Bullock	4
3	Calves	3
4	Pigs	12
5	Goat	12
6	Poultry	-
	TOTAL	**37**

Source: Primary Survey

In the land being acquired for the construction of the project there is no household. The land owners, in most of the cases, have houses outside the land being acquired. That is the reason why the number of livestock is very less.

MATERIAL ASSETS

As a part of the socio-economic survey, the information on material assets owned by PAPs was also collected. The findings are summarized in Table

MATERIAL ASSETS OWNED BY PAPS

Material Assets owned by PAPs	Numbers
Television	90 %
Tape recorder	60 %
Radio	15 %
CD player	10 %
LPG	70 %
Refrigerator	10 %
Bicycle	-
Motor Cycle	20 %
Car	15 %

Source: Primary Survey

It can be observed from Table that amongst the various modes of entertainment, such as television sets are owned by almost 90 % of the PAPs. Amongst the vehicles owned by various PAPs, cycles are not common among the PAPs.

LABOUR FORCE TO BE EMPLOYED

1. Peak and average labor force to be employed has to be worked out after consulting the developers i.e Lanco energy private ltd. However as per the version of the concerned officials the average labour force may reach up to 1000 no's and at the peak it may reach to 1600 no's per-day during peak construction phase.
2. The proper sanitation for the construction workers will be made by the executing and supervising department or authority as per the strength and position of the workers.

3. The fuelwood provision for the workers to be consulted with FCSD with alternatives to using wood and coal (such as LPG connection). The quantum of which also will be known only after knowing the number of the workers.
4. Measures for protection of endemic diseases during the work shall be taken up by the developer itself by establishing the PHSC and appointing the doctors and subordinate staff to look after the health facilities under the guidance of Health Department.
5. Employment of local people is stated in the MOU i.e. to appoint the technical and non technical section of the workers from the local people only after the completion of construction, whereas unskilled workers can be engaged during construction in progress with the agreeing of the project developers.

The details have been prepared by consulting and compiling the records available in DM office, Gangtok and Namchi.

CHAPTER XII
WATER, AIR AND NOISE ENVIRONMENT

INTRODUCTION

The Teesta stage – VI Hydroelectric Project is located in the South District of Sikkim. The project proposes to utilize the water of Teesta River by constructing a barrage at Sirwani near Singtam and the water will be diverted through a tunnel and taken to power house located at Subinkhore.

Any project which is aimed at generation of power through water impoundment is likely to have impacts on the local environment and at the project site during pre-construction, construction and operational stage. Based on the nature and size of the project, impacts on different environmental components vary in type and magnitude. The impact also depends on the geographical conditions of the project site. The overall impact on different environmental components viz. water, land, biological, socio-economical, weather and climate can be assessed and quantified only through a comprehensive study on environment impact assessment within the impact zone of the proposed project prior to its implementation.

The present study assesses impact only on the air, water and noise level of the project area. Taking into consideration the magnitude of the proposed hydro-electric project area, the location of the barrage, power house and tailrace discharge water, the study was under taken at the barrage site location and downstream of proposed power house location.

WATER ENVIRONMENT

The study on the water quality of Teesta River was carried out during 2006. The purpose of the study was to assess the likely changes that may take place due to the coming up of the Project. The water samples were collected from the upstream and downstream of barrage site and the powerhouse site, for the physico-chemical analysis and simultaneously for biological water quality criteria (BWQC) water assessment was carried out at all the sampling points.

Biological characteristics involve the status of total coliforms, zooplankton, phytoplankton, phytobenthos and macro-invertebrates. A presumptive test (presence/absence test) was performed for the estimation of total coliforms as per the methods described by Central Pollution Control Board (CPCB), New Delhi. For the quantification of zooplankton and phytoplankton 50 liters of water for each community was filtered at each site by using plankton net made up of fine silk cloths (mesh size 25 µm). The study was repeated three times at each site and samples were pooled. The filtrate collected for phytoplankton was brought to the laboratory. Epilithic phytobenthos were obtained by scrapping the surface of rocks and boulders (3 X 3 cm^3) with the help of a hard brush. Three replicates, obtained from each site were pooled and preserved in Lugol's solution for further analysis. Before going further for other analysis of the plankton and benthic samples the density was estimated by using Sedgwick Rafter cell (Sr. cell). The density of phytoplankton and phytobenthos and their permanent mounts were estimated as per the methods of APHA (1992). The phytoplanktons and phytobenthos were identified with the help of Sarod and Kamat (1984). Hustedt and Jensen (1985) and Edmondson (1959). The zooplanktons were identified with the help of Edmondson (1959) and Battish (1992).

The macro-invertebrates were obtained with the help of a square feet Surber's sampler. 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 100 µm 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).

SAMPLING SITE FOR SURFACE WATER QUALITY.

Sampling Site Designation	Sampling Site Description
S1	Upstream barrage site (Sirwani)
S_2	Downstream barrage (Sirwani)
S_3	Downstream of powershouse (Subinkhor)

SURFACE WATER QUALITY-PHYSICAL PARAMETERS

Sampling Site	PH	Ambient Temp. (^{0}C)	Water Temp. (^{0}C)	Colour	Taste	TSS	TDS	TS	Odour
S_1	6.0	17	07	Colourless	Tasteless	350	155	505	Odourless
S_2	6.0	17	07	-do-	-do-	350	155	505	-do-
S_3	6.5	21	08	-do-	-do-	215	170	385	-do-

SURFACE WATER QUALITY-INORGANIC PARAMETERS & COLIFORMS (mg/l).

Parameters	S1	S2	S3
D.O.	9.4	9.4	8.5
Alkalinity	15	14.8	16.
Free CO_2	9.5	9.5	9.8
B.O.D.	4	4.1	4.5
Total coliforms	**Absent**	**Absent**	**Absent**

INFERENCE

TOTAL SOLID:

The total solid content is highest in sampling site – S_1 & S_2 with Total Solid value of 395 mg/l, the lowest Total Solids at site – S_2 with TS value of 371 mg/l.

pH:

The pH was found to be within the range of 6.0 to 6.5, with pH 6.0 at sampling site –S_1 and S_2 and pH 6.5 at site – S_3.

COLOUR, ODOUR & TASTE:

The colour, odour and taste of water at all the sampling sites were unobjectionable.

DISSOLVE OXYGEN:

The D.O. is lowest at sampling site – S_3 with D.O. value of 8.5 mg/l and highest at sampling site – S_1 with D.O. value of 9.4 mg/l.

ALKALINITY:

The alkalinity is highest at sampling site – S_3 with the value of 16 mg/l and lowest at site –S_2 with the value of 14.8 mg/l.

FREE CO_2:

Free CO_2 is highest in sampling site – S_3 with the value 9.8 mg/l and the lowest at site S_1 & S_2 with the value 9.5 mg/l.

BIOCHEMICAL OXYGEN DEMAND:

B.O.D. was found to be highest at sampling site –S_3 with the value of 4.5 mg/l and the lowest was found at sampling site – S_1 with the value of 4.0 mg/l.

BIO-MONITORING:

To assess the actual health of water bodies, Central Pollution Control Board (CPCB) has derived a Biological Water Quality Criteria (BWQC) for water quality evaluation. This system is based on the range of saprobic values and diversity of the benthic macro-invertebrate families with respect to water quality. The system has been developed after extensive field trials and calibration on the saprobity and diversity information of different taxonomic groups of benthic animals collected from artificial substratum and natural sub stream of various water bodies. To indicate changes in water quality to different grades of pollution level, the entire

taxonomic groups, with their range of saprobic score from 1 to 10, in combination with the range of diversity score from 0 to 1 has been classified into five different classes of water quality (Table A). The abnormal combination of saprobic score and diversity score indicates sudden change in environmental condition.

TABLE – 4

Range of Saprobic Score	**Range of Diversity Score**	**Water Quality**	**Water Quality Class**	**Indicator colour**
7 and more	0.2-1.0	Clean	A	Blue
6.0-7.0	0.5-1.0	Slight pollution	B	Light Blue
3.0-6.0	0.3-0.9	Moderate Pollution	C	Green
2.0-5.0	0.4-less	Heavy Pollution	D	Orange
0-2.0	0.0-2	Severe Pollution	E	Red

For this parameter (BWQC) benthic micro-invertebrates specimens were collected from all the sampling sites, and the result is shown in the following tables.

BIOLOGICAL WATER QUALITY EVALUATION OF THE SAMPLING SITES.

Sampling Site	**Range of Score Saprobic (0-10)**	**Range of Diversity Score (0-10)**	**Water Quality**	**Water Qty. Class**	**Indicator Color**
S_1	8.85	0.2-1.0	Clean	A	Blue
S_2	7.27	0.2-1.0	Clean	A	Blue
S_3	8	0.2-1.0	Clean	A	Blue

The result of BWQC shows that the water of all the sampling sites fall under class A, under the Water Quality class.

AIR ENVIRONMENT

The study on the air environment was carried out using the AMP 460 NL Respirable Dust Sampler at the barrage and power house sites. The following parameters for air environment assessment were taken Viz. NO_x, SO_2, SPM & RSPM.

SAMPLING SITE FOR AIR QUALITY MONITORING:

Sampling Site Designation	**Sampling Site Description**
A_1	Barrage site
A_2	Powerhouse site

AMBIENT AIR QUALITY:

Pollutant ug/m^3	**Time Weighed Average**	**Sampling Site A_1**	**Sampling SiteA_2**
SO_2	**24 hours**	**4.5 µg/m^3**	**5.0 µg/m^3**
NO_x	**24 hours**	**5.0 µg/m^3**	**5.5 µg/m^3**
SPM	**24 hours**	**55 µg/m^3**	**60 µg/m^3**
RSPM	**24 hours**	**11 µg/m^3**	**20 µg/m^3**

All the parameters are within the national standards.

NOISE ENVIRONMENT

The assessments of noise level was carried out by using Cygnet Sound Level Meter, Model – 2031 A. The assessment was carried out at barrage site and powerhouse site.

SAMPLING SITE FOR NOISE MONITORING.

Sampling site Designation	**Sampling Site Description**
BN	**Barrage site (Sirwani)**
PH	**Powerhouse site (Subinkhor)**

THE AMBIENT NOISE LEVEL OF THE MONITORING SITE IS SHOWN BELOW.

Sampling Site	Period	Noise Level L_{min} dB	Noise Level L_{mix} dB	Noise Level Lea dB
BN	Day time	39	75	57
PH	Day time	60	50	55

EVALUATION OF ENVIRONMENT IMPACTS:

The environmental inventory is a complete description of the environment as it exists in an area where a particular proposed action is being considered. It serves as a basis for evaluating the potential impact on the environment.

Environmental quality assessment for Teesta Stage-VI Hydro-electric power project has been undertaken by evaluation of environmental parameters covering air, water & noise.

ENVIRONMENT POLLUTION

1) WATER ENVIRONMENT

The assessment of water quality of the Tessta river shows that the water is of pristine quality. The different construction activities during the implementation of the project may contribute to marginal negative impacts on the water quality parameters.

Water quality parameters like taste, colour, turbidity, sediment content, dissolved oxygen, BOD may change besides with an increase in toxic substances, faecal coliforms, oil & grease etc. the BWQC may change due to human interferences.

It is anticipated that once the construction activities are over it is likely that the quality of water will return to its present level, however during the construction period necessary steps must be taken to prevent any possible contamination of river water.

2) AIR ENVIRONMENT

Rapid growth, population explosion and unplanned development will lead to a number of environmental problems like lowering of air quality and basic human needs. It is very well known that good air quality is essential for the human as well as for the biological environment of any region. The presence of good forest cover and absence of heavy industries has ensured good air quality in Sikkim, especially in Gangtok and National Highway and State Highway connecting the main tourist towns/places. As the state has proposed a number of hydro-electric projects, the construction activities are likely to lead to increase in suspended particulate matter and SO_x, NO_x owing to increase in traffic in these project areas. Therefore, different air quality parameters were measured in the proposed project area to generate baseline information on these aspects.

The increase in the vehicular traffic, installation of stone crusher machines, drilling activities, construction of dams & infrastructure facilities is likely to increase the level of suspended particulate matter, NO_x, SO_2, CO, which may cause slight deterioration of the ambient air quality.

It is anticipated that once the construction activities are over the quality will improve, however during construction period all environmental regulations should be followed to minimize air pollution.

3) NOISE ENVIRONMENT

The noise levels at different project locations were recorded by sound level meter **(2031: CYGNET)**. The observed noise levels at the barrage site and powerhouse site of the proposed hydroelectric project are within the prescribed range. At the barrage site the noise level was around 57 dB. At powerhouse site also the noise level was around 55 dB.

The noise level values recorded during the night time at powerhouse site and barrage site of Teesta H.E. Project Stage VI area were much below the values recorded during the day as described earlier. The values range between 40 dB - 45 dB at these times.

The increase in the vehicular traffic and also the use of dynamites, drilling machines, stone crusher, and community noise during the construction stages will result in the increase in noise level thereby posing adverse effect on the noise environment.

With the completion of project it is expected that the level of noise shall come down, however during the construction period care should be taken to reduce noise pollution.

CONCLUSION

The present pre-impoundment study of the river Teesta indicated that the water quality of the river is good and free of any organic pollution. The chemical profile of water especially pH and Dissolved Oxygen, absence of total coliforms and presence of pollution sensitive species of different biotic communities in all the sampling sites indicates that river water is healthy, potable and free of organic pollution. But monsoon phenomenon triggers surface run-off and leads to an increase in the water discharge and turbidity. The suspended silt, however, leads to slight deterioration in the water quality during monsoon season.

After the impoundment of Teesta, most of the water would be diverted through a head race tunnel to the proposed power house. The downstream stretch would have to depend on the mandatory release of water from the barrage during lean season and discharge of two major tributaries like Rani Khola and Rangpo Khola. The post-impoundment profile of water quality is expected to change. The holding back of water by any structure generally results in loss of its capability of self - purification (Mason, 2003). However, the stretch that is likely to be severely affected is small because River Rani joins the main river channel downstream of the barrage site below Singtam town. Besides these two rivers, many other small streams also join the main channel. The water discharge from all these streams may not be sufficient to sustain aquatic organisms downstream of the barrage site. Therefore, appropriate measures should be adopted to ensure the biological health of the river in this stretch.

CHAPTER XIII

EXECUTIVE SUMMARY OF ENVIRONMENTAL IMPACTS

INTRODUCTION

This summary of environmental impact assessment has been prepared after an evaluation and condensation of a full environmental impact assessment (EIA) of the new Hydel project proposed to be constructed at Subin Khore in South district of Sikkim state. The Sikkim state is mountainous one with hills and mountains scaling 800 ft to 28168 ft (Kanchendzonga). It shares its International border with Nepal in the west and Bhutan in the east. The northern border is in touch with Tibet and the southern border is with West Bengal. The state of Sikkim has an area of 7096 Sq.Km and is scarcely populated with population of about 5,40,000 as per last census.

This summary of EIA is based on (i) the detailed EIA containing various reports on, survey of flora and fauna, surface runoff, soil erosion studies using GIS and remote sensing technology environmental impact studies on noise, air quality, water quality, socio economic, Seismotectonics, Geological impacts and other studies (ii) the Project feasibility study prepared by Lanco Energy private Ltd (iii) discussions with principal authors (CWC) of the original DPR, (iv) field visits to the Project site by a number of experts from various fields (v) discussions with local people inhabiting the area (iv) discussions with government officials and members of various non-Government organizations with environmental responsibilities.

This Summary EIA presents a synopsis of baseline data and field methods used in the EIA, and incorporates the results and conclusions of the EIA.

I. DESCRIPTION OF THE PROJECT

The project with an installed capacity of 500 MW consisting of 4 units of 125 MW each has been planned with the following components:

(i) Barrage area comprising of Barrage having 6 (Six) waterways and 105 m length, 4 nos. intakes, 4 nos. desilting chambers, gate operation chamber, 2 nos . silt flushing tunnels.

(ii) Power house comprising of Head Race Tunnels, Surge shaft, Pressure shafts, Power house cavern, Transformer cavern, Tail race surge chamber, tunnels and pot head yard.

Barrage

Diversion barrage has been prepared to be across river Teesta about 500m downstream of L.D. Kazi bridge at Sirwani. The adequate pondage downstream of Teesta Stage – V is available and it also avoids the submergence of houses, roads and other facilities. The river profile is considerably straight therefore the suitable location for intake structure and desilting chambers is available.

The barrage structure with 6 (Six) nos. spillway of 12.5 m each along with 5 (Five) nos of 6 m thick piers have been provided making total width as 105 m of the barrage. The average bed level of river is 338 m, to facilitate the flushing of river load. The crust level of the spillway bays is proposed at 338 m, the top level of barrage has been kept as 361.5 m. The barrage is designed to cater a flood of 7103 cumecs. The high flood level for design flood works out to be EL 345.20 m. The FRL and MDDL proposed as EL 360 m and EL 354 m respectively.

For energy disipitation, stilling basin has been provided at the glacier. Upstream and downstream cut off have also been provided at the end of impervious flow. The suitable protection works for upstream and downstream flood protection have been provided and launching approach has also been provided. 6 (Six) nos. top seal radial gates each of size 12.5 m (Width) X 14 m (Height) have been provided and designed for full head of water to seal level (EL 338 m) to FRL (EL 360 m). The gate will be updated with the help of hydraulic hoist. Provision for 1 (One) set of stop lock gate has been kept for inspection / maintenance of radial gates and is designed for corresponding FRL which shall be operated with the help of gantry crane. The crane will move on rails

Diversion Arrangement During Construction

The construction of barrage has been considered during non-monsoon season only and the diversion of 700 cumecs non-monsoon flow has been considered for seasonal diversion to construct the barrage. The 700 cumecs discharge is 25% higher than the maximum recruited non-monsoon discharge. The diversion channel and earth/rockfill coffer dams shall be constructed to divert the water during non-monsoon period.

Water Conductor System

The water conductor system located on the right bank of river Teesta has been designed to carry a discharge of 531 cumecs. The layout of water conductor system and power house complex has been finalized on the basis of available topographical conditions. All the structures are underground.

Intake Structure

4 (Four) nos of intake structures shall be located at the right of barrage with an inclination of 15^0 from barrage axis. Each intake straight type intake has been designed to pass a discharge of about 159.3 cumecs and shall have centre to centre distance of 24 m. The intake structure invert shall be at EL 341m which is 3 m above the crest level. The bell mouth entry on upper hall of the intake has been proposed. The size of the intake is 3.5m (W) X 8.85m (H) having top EL 349.85m to avoid any vortex formation.

Desilting Chambers

4 (Four) nos of desilting chambers with a clear distance of 31.5m between the chambers have been proposed to remove the silt particles of size 0.2mm and above. The length of the desilting chamber has been proposed as 550m and 18.5m width X 28.5 m deep (including hopper) to provide an average flow velocity of 0.324 m/sec.

The silt settled in the desilting chamber shall be collected by silt flushing tunnels through 4 (Four) nos silt flushing conduits further through 2 (Two) nos desilting tunnels.

The desilting chambers shall be lined with M 20 grade concrete. The size of the silt flushing tunnels shall be varying from 0 .9m X 1.5m to 1.4m X 1.5m along the length of

chamber. Ultimately merging with D shaped tunnel of size 5.5m X 6.0m. The outfall of silt flushing tunnel is about 1.4 Km distance of barrage near the adit I area. The river slope in conduits has been limited to 1 in 30. The vertical lift gate of 5.3m X 6.5m has been proposed at downstream of each desilting chambers operated by hydraulic hoist placed in gate operation chamber.

Head Race Tunnel

2 (Two) nos of head race tunnel to cater the discharge of 531 cumecs having modified horse shoe dia of 9.5m in a select of 1 in 350 m has been proposed. The maximum velocity in the HRT has been limited to 3.76 m/sec. The average lining thickness of 400 mm has been proposed in both the head race tunnels. In the weak zones or poor rock conditions steel support has been provided otherwise the tunnel as proposed to be supported with rock bolts and shotcrete. For construction of HRT 4 (Four) no. adits have been provided at Singtam, Kalej Khola , Mamring and Subin Khore near the power house. The tunnels have been kept 50m apart from each other.

Surge Shaft

2 (Two) nos underground restricted orifice type surge shaft of 28m (D) X 115m (H). The orifice area of 15.39 Sq.m including area of gate grooves has been provided.

Pressure Shaft

4 (Four) nos steel lined pressure shafts of 5.4m dia each with length varying from 150 to 226m has been provided. The centre distance between surge shaft is 18m. The maximum velocity through pressure shaft works out to be 5.83 m/sec. The penstock liner has been designed to withstand internal and external water pressure.

Power House Complex

The power house is proposed to be located underground within the rocky hill slope comprising of:

- Power house Cavern;
- Transformer Cavern;
- Down Stream Surge Cavern;
- Draft Tube Tunnels, one for each unit;
- Main Access Tunnels;
- Ventilation / Cable Tunnel;
- Interconnecting Gallery;
- Drainage Cum Escape Tunnel

4 (Four) generating units of 125 MW capacity each have been proposed to be installed in the power house. Vertical Francis Type Turbine has been chosen. The crown of the cavern is at EL 271m and the minimum cover available is of the order of 190m. The overall size of the cavern is 140m (L), 22m (W) and 50m (H). At one end service bay is provided at floor level of EL 249m. The power house roof is supposed to be an arch. 4 (Four) nos of draft tube tunnels carry the discharge from 4 (Four) turbine units having size of 7m X 8m D shaped each. Surge chamber of 160m (L) 18m (W) and 49m (H) have been proposed to cater the downstream surge of tail race tunnel. 2 (Two) nos of tail race tunnel of 1.7 Km each with 9.5m dia have been proposed to discharge the tail water at the outlet near Seti Khola. 2 (Two) nos 225/30 tonnes EOT cranes have been proposed.

The transformer cavern is 110m (L), 15m (W) and 25m (H) with floor level at EL 252m to accommodate the transformer have been proposed. The transformer are to be brought via services bay through inter connecting tunnel between power house and transformer cavern. 400 KV GIS in double bus switching arrangements shall be provided in the transformer cavern. A D- shaped access tunnel of 8m (W) is provided for access to power house service bay and transformer cavern during construction and operation. The 7.5m D- shaped construction adit at crown level shall be provided for construction.

4m (W) and 5m (H) cable tunnel have been provided to evacuate the power through cables from transformer cavern to pot head yard. The same tunnel shall also function as ventilation tunnel.

A drainage cum escape tunnel of 2.5m X 3.5m is also provided around the power house to arrest seepage of water and to act as escape tunnel. An inter connecting gallery 8m (W) X 8m (H) connecting the machine hall cavern to the transformer cavern has been provided.

INSTRUMENTATION

An instrumentation system comprising of thermometer, power pressure cells, stress meters, no stress-strain meters, seismograph etc. have been provided in the body of barrage as well as in power house and transformer caverns to monitor the behavior of completed structure.

LOCATION

The proposed project site is located at a distance of five Kilometer from Rangpoo Bazar which is located at a distance of about 40 kilometers (km) from Gangtok.

BASIC STRUCTURES

The project includes the following basic structures:

The Project is a Run off the river Hydro Electric Project, having Installed capacity of (125 X 4) 500 MW with Firm power generation of 77.69 MW with **ANNUAL GENERATION OF** 2441 Gwh (90% Dependable Year).

A. Access to the ProjectT

(a)	By road	Through NH – 31 A from Tarkhola to Singtam
(b)	By air	Bagdogra – 95 Km from Project site.
(c)	By rail	New Jalpaiguri – 85 Km from Project site Siliguri – 80 Km

B. Hydrology

(a)	Catchment Area	4500 Sq. Km
(b)	Maximum Design Flood	7103 Cumecs
(c)	Diversion Design Discharge	700 Cumecs

C. Reservoir

(a)	Full Reservoir Level (FRL)	EL. 360 m
(b)	Minimum Draw Down Level (MDDL)	EL. 354 m
(c)	Gross Storage at FRL	3.18 Million Cumecs
(d)	Live Storage	1.83 Million Cumecs
(e)	Area of submergence at FRL	36 Ha

D. Barrage & Appurtenant Works

(a)	Top Elevation	361.5 m
(b)	Length at Top	105 m
(c)	Crest Elevation	338 m
(d)	Downstream Floor Elevation	330.5 m
(e)	Maximum Height from Bed	23.5 m
(f)	Type of Gates	Radial
(g)	No. of Spans	6 Nos.
(h)	Size of Gate	12.5 m X 14 m (W) (H)
(i)	Thickness of Pier	6 m

E. Water Conductor System

Intake

(a)	Type	Bell Mouth Rectangular
(b)	Size	6.5 m X 8.85 m (W) (H)
(c)	Number of Units	4 (Four)
(d)	Intake Tunnel	4 Nos of 6.5 m Diameter

Desilting Chamber

(a)	Type	Underground
(b)	Number	4 (Four)
(c)	Shape	Hopper shaped with arched roof
(d)	Size	550 m X 18.5 m X 8.5 m (L) (W) (H)
(e)	Average Velocity	0.324 m/ second

Head Race Tunnel

(a)	Design Discharge	531 Cumecs
(b)	Number	2 (Two)
(c)	Shape	Circular
(d)	Size	11.8 Km X 9.5 m (L) (D)

Surge Shaft

(a)Type		Underground; Restricted Orifice
(b)	Number	2 (Two)
(c)	Size	28 m X 115 m (D) (L)

Pressure Shaft

(a)	Type	Vertical
(b)	Numbers	4 (Four)
(c)	Size	5.40 m X 150 m to 226 m (D) (H)
(d)	Shape	Circular
(e)	Steel Lining Thickness	24 mm with Stiffeners

Tail Race Tunnel

(a)	Number	2 (Two)
(b)	Type	Circular
(c)	Size	9.5 m X 1.7 Km (D) (L)
(d)	Maximum Tail Water Level	242 m
(e)	Minimum Tail Water Level	240 m

F. Power House Complex

(a)	Type	Underground
(b)	Type of Turbine	Francis (Vertical Shaft)
(c)	Type of Generator	13.8 KV, 50 Hz Vertical Shaft Synchronous Generator.
(d)	Size of Cavern	140 m X 22 m X 50 m (L) (W) (H)
(e)	Gross head (Average)	116 m
(f)	Net Head (Average)	103.2 m

G. Transformer Cavern

(a)	Type	Underground
(b)	Size of Transformer Cavern	110 m X 15 m X 25 m (L) (W) (H)
(c)	Generator Transformer	13.8/400 KV, 3 x 51 MVA, Oil Directed Water Forced Type.
(d)	GIS	Accommodated in this Cavern

H. Down Stream Surge Chamber

(a)	Type	Underground
(b)	Size of Cavern	160 m X 18 m X 45.5 m (L) (W) (H)

I. Pothead Yard

(a)	Type	Surface
(b)	Size	30 m X 100 m (W) (L)

J. Evacuation System — 400 KV, D/C Transmission Line from Power House Pothead Yard to Pooling Station

ROADS AND BUILDINGS

The project shall provide the approach roads to various structures and thereby the left bank approach road from Shirwani to Mamamring bridge and from NH 31-A to Subin khore area shall be constructed. The project colony comprising of permanent residential and non residential buildings such as Office building, Hospital building, Clubs and recreation buildings, Parks and play grounds, Bank and Post office etc. shall be constructed at Subin Khore, power house area. The facilities shall be extended to local villagers as well by the project.

DESCRIPTION OF THE ENVIRONMENT

A. Physical Resources and Natural Environment

i. The proposed project proposal is located along Teesta river, which is typical of the topography of the Sikkim hills. Elevations on the site range between 800 mt to 900 meters above mean sea level. The underlying geology of the area in the South and East districts two prominent groups of rocks are found namely Gneissose series and Daling series. Stratigraphical units are superimposed due to various geological processes. In the region of higher elevations, the Daling series have been gradually changed into Mica schist. The boundaries between the Daling and Gneissose series are irregular and often cannot be traced out. The Gneissose series in the tract is highly micaceous. The rocks are well foliated and the crystalline complex consists both of igneous and sedimentary rocks. Bands of quartzite are also common. Soils varies in texture from sandy loam to clayey loam. Humus is from shallow to deep in about two – third of the

area while in about one-third of the area, the humus is absent. Soil is slightly compact in the tract. All these factors contribute to a good growth of crop.

ii. Records for the past 20 years indicate that the site lies within an earthquake zone IV however, no major earthquake is reported in last 30 years although low intensity and frequency earthquakes are reported.

iii. The climate of the area is typical of Sikkim with heavy to moderate rainfall in the monsoon months from June to September. The average weekly rainfall is 81 millimeters. Total rainfall in a month has been recorded up to 1082 mm and the heaviest rainfall in 24 hours has been recorded up to 180 mm. There are small variations in the daily mean, maximum, and minimum temperatures during the year. Maximum mean temperature during last 10 years varied from 13.7 ^{o}C to 28.2 ^{o}C whereas highest mean temperature varied from 19.2 to 31.3 ^{o}C. The mean minimum temperature varied from 5.9 to 20.5 ^{o}C.

iv. .Baseline monitoring of air quality and noise was performed at two locations, one at barrage and one at Power house. The results are shown in Table 1. At each location the level of air quality was better than the national standards.

Table 1 Baseline air quality

Name of the location	**Sulphur dioxide(µg/m^3)**	**Nitrogen dioxide(µg/m^3)**	**Suspended Particulate Matter(µg/m^3)**
Barrage	5.0	5.5	60
Power house	4.5	5.0	55

v. Baseline monitoring of surface water quality was conducted above the proposed reservoir and below the Power house area locations on the site. Sampling and testing showed some existing pollution described to the humic soil content of the area and to

its use for the disposal of human waste by the sparse population that lives on or near it upstream from the site.

vi Baseline monitoring of noise data was conducted at Barrage and Power house. The results are as hereunder

Table 2 Ambient Noise Level:

Sl.no	Station name	Noise level(dB)	
		Day	Night
1	Barrage	75	39
2	Power house	60	50

B. Ecological Resources

i. There are no rare or endangered species of flora and fauna in the general area of the specific site where the construction of power project is proposed as most of the private holdings are under cultivation. While on site fauna are limited to flocking birds like Russet Sparrows *Passer rutilans,* and common urban birds like House Crows, Blue Rock Pigeons and Common Myna (nesting in the bazaar area in trees or buildings). A huge flock of about 50+ Russet Sparrows were noticed in a dry fields at the time of inspection. There are also many forest birds like Grey-headed Flycatchers, Laughing thrushes, Warblers and Magpies. With in 20 km radius of the site fall two major wildlife protection areas one is Meemam wildlife sanctuary in South district and th other is Fambong Lho Wild life sanctuary in East district. The major ecological functions of these sanctuaries are to serve as habitat of many species including mammalians like Himalayan black bear (*Selenarctus thebetanus*), Himalayan langur (*Presbytis entellus),* Himalayan yellow throated marten (*Martes falvigula),* Monkey (*Macaca assemensis),* Musk deer (*Maschus muschiferus)* Red panda (*Ailurus fulgens),* Serow (*Capricornis sumatraensis),* Takin (*Bodrocus taxicolor),* Tibetan fox (*Vulpes ferrilatus),* Wild dog (*Lucox alpinus),* Wolf (*Canis lupus chanko*) Bharal (*Ovis nahura),* Goral (*Nemorhaedus goral,* Bison (*Bos gaurus) and avifauna like* Blood pheasant (*Ihaginis cruentus)* Hill partridge, Kalij pheasant (*Lophora leucomelana),* Monal pheasant (*Lophophorus impejanus),* Tragopan (*Satyra tragopan) etc.* The Meenam Sanctuary serves as water reservoir of Ravangla town as water which is

tapped in this area serves as water sources of the town. Fambong-lho Wildlife Sanctuary serves as water supply source of Ranka, Rakdong Tintek, Tumin, Martam, Sang Khamdong, Luing Pabrong, Rumtek Lingdong, Pangthang blocks. These Sancturies are breeding ground for Goral, Musk deer, Yellow throated Martens and weasel, Himalayan Marmot.

ii. Out of the 233 bird species from the Important Bird Area (IBA) list for Sikkim, 105 species important bird species could occur in and around theproject area. This does not include the migratory waterbirds which overfly the proposed project area during annual return migration in spring and could pose a potential hazard. Number of species enlisted as rare and endangered are not only in the project area but throughout the state. Any displacement and disturbances by human interference may accelerate the rate of mortality of wildlife and pose threat to the valuable wildlife population.

iii. The aquatic ecology and water quality studies of the Teesta river, which involves physical, chemical and biological characteristics of Rangpo Chu below the project site were conducted. The results indicate that the temperature and other geo-physical characteristic provided a fair ecological nich for the Mahaseer. In addition to this few more species viz. Barilius bendelisis, B vagra Clupisoma Montana, Puntius spp. Labeo dero, inhabit in this region. The cultural fishery was found to be completely absent from this area, whereas very little practice of capture fishery was seen in the vicinity of Rani khola and Teesta and Rangpoo chu.

iv. Soil erosion is a naturally occurring process on all land and both rainfall and runoff factors need to be considered in assessing a soil erosion problem in the project area. The amount of runoff is likely to be increased if infiltration is reduced due to soil compaction, crusting or construction of roads. During construction of the project several structures like barrage, HRT, Power house, residential colonies etc are likely to increase the runoff due to soil compaction and contribute to increased soil erodibility. An accurate understanding of the hydrological behaviour of a watershed is important for effective management. In the present study Remote Sensing and GIS technique

have been used effectively to generate the land use/land cover map for treating the catchment areas.

v. The tree species like Alnus nepalensis, Albizia procera, Rhus javanica, Melia dubia ,Gynocardia Odorata, Ficus hitra, Toona ciliata, Macaranga denticulata. Large patches of the site have been used for subsistence agriculture in the past. In comparison of vegetation existing within the proposed area, is much similar to the remaining watershed. According to the existing rules of the Forest Department Compensatory afforestation will be taken up in the surrounding areas and the near by Forest blanks to compensate the Environmental losses. Since the Forest land involvement is more in the project it is proposed to take up the plantation of ten no's of seedlings in place of each tree felling in the proposed project area (Private an non-Forest land tree felling rules). User agency has to transfer the required fund for plantation and its protection to the State Forest department according to the scheme prepared by the Forest department. Creation of habitat improvement schemes have to be taken up with the project cost as mentioned in the EIA report.

C. Human and Economic Development

i. People of Sikkim engage in different economic activities, prominent among which are Tourism, Industries, Horticulture & Agriculture etc. giving rise to a definite occupational structure. The economy of Sikkim is mainly based on agricultural and animal husbandry. Approx. 11% of the total geographical area is under agriculture. Agriculture is of the mixed type and still at the subsistence level rather than commercial level. The work force participation rate as per 1991 census is 40.44%. The female participation rate in the State is also much higher than the national average. This is an important aspect if the hill economy, as productivity is low and hence all the able-bodied people are employed in agriculture and other activities. Cultivators account for the greater majority of the people in the state. their percentage is 57.84%. Agricultural labourers as a whole constitute only 7.81% of the workers in the state. There are certain house hold industries also which substantially adds to house hold incomes.

ii. The proposed project is located in an area of low population density. There are Bhutia, Lepcha, Limbu and Tamang tribal communities whose land is being diverted for the project. Besides land of other Sikkimese communities like Rais, Newars, Bhramins, Chettries and Gurung communities whose land is being acquired. Population of about 400 to500 belongs to 111 families will be affected due to acquisition of some portion of land. These families are being removed by giving compensation package after following due procedure by the Government.

iii. The main source of income of the residents of the area is subsistence farming supplemented by small-scale commercial activities along the main highway. The income level is quite low. The predominant land use around the project site is Forestry and agricultural. The construction activities will promote economic development through enhanced commercial activities.

D. Quality of Life Values

i. There are no cultural, historical, archeological, wilderness, or protected resources or areas on or near the proposed project. There is an Hospital at Rangpoo and also a public health Center at Melli with a resident doctor. There is a power line along the highway, which provides electricity to all the houses. There is telephone service available for the inhabitants of the area. Sources of drinking water is from Suntaley and Pampok reserve Forest areas. Facilities of wastewater treatment are not available.

ii. A minor increase in land values, particularly of land closest to the main highway, has already occurred as a result of the purchase of the site for project development. Land values along the main highway can be expected to change as a result of the construction of the projegt; however, any adverse effects will be mitigated by land use planning, zoning, and the issuance of building permits by the local government in a manner that restricts development off the site.

iii. There are no archeological, cultural, or historic resources on site, or within the area that will be adversely affected by the construction of this Teesta stage-VI HE project

E. Environmental Impacts

The environmental impacts of the proposed Teesta stage-VI H.E. project is being forecast in light of the constructional activities of barrage, tunneling for HRT, roads, housing, labour colonies, quarrying, dumping and other related works. The impacts are being considered on ecosystems, both aquatic and terrestrial, as a whole, on individual critical species, if any, on the geophysical environment of the area which may lead to serious negative consequences. An attempt has also, been made to understand the impacts on the human society in terms of socio-cultural and socio-economic structure of the areas directly and/ or indirectly concerned with the proposed project activities. Care has been taken to classify the impacts either as permanent damages or temporary impacts, which are likely to cease after the project work is completed. It is important to mention that in the present studies an ecosystem approach has been followed to project the impacts. It is believed that this is an integrated approach, which takes care of the geophysical environment as the substrate for the biological activities and in turn biological processes controlling the geophysical environment. It is expected that this systems approach would yield some meaningful insights into the likely impacts of the proposed project and suggest .measures to mitigate the negative impacts and aim at achieving the goal of sustainable development.

TERRESTRIAL ECOSYSTEMS

Habitat Disturbance, Degradation, Fragmentation and Destruction

i. The proposed project involves only a small forest area to be submerged near village Sirwani and attempts at minimizing the damages through water augmentation and tunnel network to gain the required discharge and head. Lesser negative impacts are foreseen on the terrestrial ecosystems of the areas of concern. In addition underground power house is proposed, very small area of land is required for building and construction purposes, no significant damages are foreseen for the habitats of flora and fauna. Necessary measures will be taken to minimum destruction to the environment while road construction inside forest areas, therefore, no serious degradation or fragmentation of habitat is expected.

iii. Submergence Area

Area to be submerged by the project is about 36 ha, which is under forest and private lands forms mostly the river bank on right and left, sides and some small agriculture lands are also there. The forest on both the banks has predominantly broad leaf species, like Termilania, Murraya, Alnus,woody climbers that will be submerged. The habitats on the left bank that is proposed to be submerged has extensive human interference in terms of agriculture, lopping and bridle path and are not undisturbed natural Ecosystems. The right bank slopes in the immediate vicinity of the proposed reservoir has natural forest. However, in view of a barrage and reservoir very little vegetation and species of plants will be submerged. Also, most of the species and vegetation which will be inundated are extremely common and widely distributed. Since the submergence area is small, partly disturbed, it is highly unlikely that the area would constitute a critical habitat of any plant or animal species. Also, during our surveys, we did not encounter any endangered species in the proposed submergence area and hence any major negative impact on any species or its habitat is not expected.

iii. Road Construction

In the project area it is proposed to construct 16.65 km of new roads and 5.5 km of roads building activity would be limited to maintenance or their widening at some places. These activities, therefore, are not, expected to lead to any severe habitat losses or habitat degradation and habitat fragmentation. There is an existing road at left bank of barrage site, Right bank Manpari area at barrage, Adit-III Mamring area. The project authorities shall construct and maintain these roads. Therefore, this activity would lead to disturbance and destruction but proper care should be taken by the project authority.

iv. Muck Disposal dumping Sites

In the project DPR it is proposed to utilize 20% of the excavated materials in various construction activities. The remaining fraction of the muck is proposed to be dumped. The dumping sites are mostly located downstream of the proposed reservoir, therefore, no negative impacts on the reservoir are foreseen due to this activity. The muck is proposed to be dumped in an environmentally sound manner in pre-identified dumping

sites which area proposed forrehabilitation subsequently in an environmentally sound manner for which appropriate environmental management plan has been prepared. Even then during the construction phase and also during disposal of muck, there is a possibility of washing away of the muck into the main river which might cause some negative impacts on the aquatic ecosystem of the river. Hence the suitable areas are identified in safe distance from the water bodies and johras. Therefore, project authorities are advised to adhere to strict environmental norms during the excavation and subsequently disposal of the muck.

v. Biotic interference

The threat of habitat disturbance, degradation and fragmentation may not only come from the constructional activities, but from the large labor population that is employed in such developmental projects. The presence of human population in large numbers in small natural ecosystems is known to exert tremendous pressure on the natural ecosystems around the project activity sites. The pressures may be foreseen in terms of fuel-wood collection, rearing of livestock and the grazing pressure on the surrounding natural forest ecosystems, killing and poaching of animals for consumption, adventure sport and commerce, pressure on medicinal plant species and other minor forest produce that are critically endangered, degradation of habitat through tree felling and negative changes in aesthetic quality of landscape by overcrowding beyond its carrying capacity.

Serious impacts outlined above may not result at all the locations of project activity because labor Intensive activities and labor colonies are concentrated in areas away from pristine natural ecosystems. This however does not preclude the possibility of human intervention in the neighboring natural ecosystems by the workers of the project. Areas where indirect negative impacts by human activities are foreseen include natural ecosystems surrounding the forest areas in the vicinity of the proposed project.

Owing to the small nature of the project it is expected that a substantial number of labor force (minimum 800 and maximum 1600 with 75% being skilled and 25% being unskilled) would be employed, therefore, restricting the likely damage that may arise as

a result of presence of human beings. Keeping in view the fact that Manpari village at barrage, Mamring at adit point are in the close proximity of the proposed project, it may be advisable to have these labor colonies located around the existing village thereby avoiding any illegal activity by the workforce. In addition project authorities proposed the construction to be equipment oriented rather than labor oriented. the latest equipment may be used to cut down on labor intensive project work. The use of modern construction equipment would reduce the construction period to four years and minimizing the requirement of labor.

v. Impacts on Wildlife

The creation of a barrage across the Teesta river and formation of a reservoir would result in the change of habitat and would lead to minor fragmentation. This reservoir will function as a physical barrier, which comes in the way of animal migration and dispersal. It has been observed that such physical barrier lead to fragmentation of large populations into several small and isolated populations. However, the present proposed project envisages a barrage which does not inundate large area and also does not store large quantity of water, the existing Sirwani (LD Kazi) bridge will also reduce the problem of fragmentation, therefore serious negative impacts on migration and dispersal of fauna may not occur. However, besides the present developmental activities any future anthropogenic activity could become a serious hazard for terrestrial and avifauna of the region. Attention needs to be paid to restrict and regulate any secondary activity after the construction of proposed H.E. Project. There should not be any fencing or wall construction around the reservoir to avoid obstruction to the wild animals for their drinking water.

vii. Species Population Losses

The threats of loss and disappearance to species and populations may arise from inundation, habitat destruction and fragmentation, direct removal and/or killing. The species populations that face maximum risk includes endemic species to

Sikkim with small population sizes, critically endangered, over- exploitation, and restricted distribution. Our investigations have revealed that in the proposed project no such species have been encountered that may face extinction due to the project activities. However, species populations with small number of individual survivors and highly specialized niches may need special protection and care to avoid population extinctions. The reservoir area, which proposes to inundate about 36 ha (including the present submerged area) of forest land does not contain any critically endangered species, therefore, there is no threat to any species at this site, Since majority of species occurring in the submergence zone are widely distributed in this region as well as other regions and are very common species, no negative impact is envisaged on the biota of this site.

viii. Aquatic Ecosystems

Habitat degradation, Fragmentation and Destruction

The proposed barrage on Teesta river at Sirwani is expected to change the habitat conditions in the immediate downstream of the river. Though some portion of the river may go dry during lean season because of diversion, there is a Rani khola which is going to join Teesta river below Singtam bazaar (300mts from the barrage) and also a number of small streams that meet the main channels downstream of the diversion structure. This Rani khola and the small streams will ensure perennial flow of water in main channel and minimize negative impacts on the processes and structure of these aquatic ecosystems. Also, in view of the fact that there are no migratory fish species in the river, the proposed diversion barrage will not result in any negative impact on the fish fauna of the river. However conservation strategy for Mahaseer fish, alternative source to the fisher man depending upon this disturbed stretch have to be adopted in the EMP.

ix. Impact on Water Quality & Aquatic Ecosystem

The major impact on the water quality may arise in case muck is disposed along the river bank. However, project authorities have identified suitable muck disposal sites which are located away from the river channel. The muck will essentially come from the road-building activity, tunneling and other excavation works. The unasserted waste going into the river channel will greatly enhance the turbidity of water continuously for

long time periods. The high turbidity is known to reduce the photosynthetic efficiency of primary producers in the river and as a result the biological productivity will be greatly reduced. Though the rivers do naturally experience turbidity during monsoon periods, but during post- monsoon months a large diversity of organisms inhabit the ecosystem. In event of no respite from the turbid conditions many species of aquatic flora and fauna may be put to survival risk. The second source of impact will be from the exposed lands in the catchment and other construction areas in the project. Proper biological and mechanical measures should be adopted.

In view of presence of labor and other work force going to be stationed on the river banks and to avoid any deterioration in water quality and subsequent changes in the aquatic biota, project authorities propose to have a proper sewage disposal system in and around various labor colonies to check that waste and refuse is not discharged into the river. In absence of such measures there is bound to be deterioration in water quality and the subsequent changes in the aquatic biota .

a. The degradation in water quality will mainly arise from discharge of waste and refuse into the river channel by the labour colonies and other temporary human habitations.
b. The increased organic content in the river waters may result in eu-trophication and change in the species composition.
c. This will lead to changes in the food chain and tropic structure in the river channel.
d . An important bearing will be on the Mahaseer fish population in the downstream areas, which might be affected by the changed physico-chemical conditions.

If the human waste and refuse is directly drained into the river channel, the coliforms and other disease causing agents may increase leading to water borne diseases. This is one of the serious negative impacts that may arise due to the developmental activity, which will not only lead to human health hazard, but also increase pollution levels in the w*ater* and bringing about changes in the natural biotic diversity of the aquatic ecosystem of the river.

HUMAN ECOSYSTEM

i. Demographic Changes and Related Impacts

If the quantum of human population migrating from other areas is greater than the local human population in the area, it would result in demographic changes and other repercussions that follow. Since the migrant workforce will be from different regions, diverse ethnic and cultural backgrounds and value systems, they are bound to affect the local socio-cultural and value systems. In addition, these migrants may be carriers of various diseases not known sofar in the region resulting in health risk for the indigenous population. Some of the important impacts that can be foreseen on the socio-economic and socio-cultural aspects of human societies in the project area are enumerated below.

a. Changes in demographic profiles are known to bring about cultural invasions in the society. Such invasions will surely be expected here, though it may be a temporary phenomenon.
b. The past experience has shown that projects where migrant population of this magnitude is concentrated various social vices like drinking and trade in human flesh follow. This is an area of concern that the project authorities will have to seriously prepare for with the help of local administration.
c. Migrant workers might act as carriers of new diseases hitherto Unknown/unreported from the project area. Diseases like AIDS, VDS, Malaria, Gastro-enteritis, etc. are some of the potential risks to human health. For these project authorities have proposed proper quarantine procedure for screening and detecting such cases. In addition the existing medical facilities would also be strengthened.
d. With out proper health check and certification from the concerned Medical officer labor should not be engaged in project works. Proper instructions should be given to the Contractors for this check and certification.

ii. Worker Safety and Health

Worker safety will be protected by contractual undertakings to implement safe site practices. Because this is a new airport there are no hazards from operating aircraft at the moment. Sanitary practices in regard to providing potable water and the disposal of human waste will be enforced to safeguard worker health as part of the construction contract in the construction phase.

iii. Slum Creation

Practically all of the work force will be recruited locally or from the more urbanized area nearby. This potential workforce lives within busing or walking distance of the site. Hence there will be little need to construct on-site housing, and in any case all of the contractors' on-site temporary structures will be demolished upon job completion. Little hazard of slum creation exists.

iv. Quality of Life Values

The current deficit of public facilities and services, as well as the lack of employment beyond subsistence activities, which adversely affect the quality of life of the population in the area, are likely to improve during the construction and operational phases of the hydel project. The population around the project is likely to grow, and as it grows, the installation of such services as potable water and sewage treatment for the project area is likely to occur and health facilities are likely to improve as the hospital meant for project staff shall also be required to cater to local population. As a result, the quality of life of the nearby inhabitants is likely to improve

v. Geophysical Impacts

Surface investigations in the Teesta stage-VI H.E. project site indicates that geologically suitable localities have been selected for the barrage site and power house site. Subsurface investigations in the region have revealed that some of the weak zones, earlier suspected through surface investigations and remote sensing studies, do not really exist at depth. This buttresses the conclusion that the region is ideal for such engineering structures. However, presence of some subsurface

weak zones cannot be ruled out in any region in Himalayan terrain and these zones may be encountered during the construction phase. These zones, if encountered would require proper excavation and reinforce through grouting, steel support and concreting. Furthermore, the region being within the milieu of Himalaya, geological phenomena like landslides and valley erosion in the region must be kept under constant vigilance during and after the construction of the project and adequate measures should be taken wherever necessary.

The seismo-tectonic study has the following environmental implications for the Lanco H.E. project site and the adjoining region.

a. The parallelism of the trend of Teesta river with NE-SW trending shear is a feature, which is important from the point of view of seismic activity of the region. Therefore neo- tectonic activity in the region such as landslide along the course of the Teesta river in the project site must be kept under continuous surveillance and monitoring.

b. The micro-seismic study indicates that the project area is surrounded by seismically active zones within 20 km radius towards the E. NE, SW and therefore, it would be worthwhile that a suitable seismic monitoring mechanism should be put in place in the project area.

TABLE : Summary of Impacts, suggested management measures and implementing agency.

S.No	Parameters	Impact	Management measures	Implementing Agency
1	**Land Environment**			
	Construction phase	• Increases in turbidity in the river downstream of barrage and power house	• Proper collection and disposal of construction spoils at identified safe and stable land	• Lanco Energy pvt ltd (LEPL)
		• Increased incidence of water related diseases other health	• Development of Hospital and health centers, health camps, Bleaching and anti mosquito spray	• Lanco & District Medical officer
		• Generation of solid wastes from labour camps/colonies	• Disposal at designated landfill sites. Community lavatory	• LEPL
2	**Water Resources**			
	Operation phase	• River stretch from Barrage site to tailrace outfall will have reduced flow during lean season.	• More than 15% of minimum flow be released to maintain the riverine ecology and dilution of domestic effluent. The Rongni chu and Ranpo chu, the	• LEPL

		• Negligible siltation and sedimentation problems	two main sub streams of Teesta river feed the Teesta at this location. • No impact, CAT, Rim treatment plans are proposed to be done in directly draining catchments	• LEPL Forest Department
3.	**Water Quality**			
	Construction	• Water pollution due to disposal of sewage from labour colonies. • Disposal of effluents with high turbidity from crushers commissioned at various sites and effluents from adits at tunnel.	• Provision of community toilets, and sewage treatment plant • Provision of setting tanks, Conditions stipulated by the SPCB and Forest deptt will be implemented at the time of crusher operation	• LEPL • Project contractor
	Operation Phase	• Deterioration of water quality in the dry stretch of river due to reduce flow during the lean season.	• Minimum flow will be released	• LEPL

		• Disposal of sewage from project colony	• Commissioning of Sewage Treatment Plant (STP), Extension of local UDHD and PHE facilities	• LEPL
4.	**Terrestrial Flora**			
	Construction phase	• Cutting of trees for meeting fuel wood requirement by labour. • Acquisition of forest land.	• Provision of subsidized kerosene, Electricity and LPG to construction labour and staff. • Compensatory a forestation	• Project Contract/LEPL • Forest Deptt and LEPL
5	**Terrestrial Fauna**			
	Construction phase Operation phase	• Disturbance to wildlife due to operation of various construction equipment. • Disturbance to wildlife due to increased accessibility in the area.	• PA's are far from the project area, no major wildlife is found, hence impact is not expected to be significant • Surveillance through check posts is recommended	• Forest deptt shall monitor • Forest deptt
6	**Aquatic Ecology**			
	Construction phase	• Marginal decrease in aquatic productivity due to increase	• Treatment through setting tanks	• Project Contractor

	Operation phase	turbidity and lesser light penetration. • Impact on migration of snow trout • Drying of river stretch downstream of barrage up to tail race outfall.	• Stocking of river Teesta upstream and downstream of dam site. • Release of minimum flow, Avoid destruction to Rani Khola	• Fisheries Deptt. • LEPL and Forest deptt
7	**Noise Environment**			
	Construction phase	• Marginal increase in noise levels due to operation of various construction equipment.	• Maintenance of construction equipment • Provision of ear plug/ ear muff for laborers, Use of sophisticated ones	• Project contractor
8	**Air Environment**			
	Construction phase	• Fugitive emissions due to crusher operation at various sites.	• Commissioning of cyclone, sprinklers in each crusher.	• Project contractor.
9	**Socio-economic Environment**			
	Construction phase	• Acquisition of land and other properties	• Compensation as per the existing rates.	• Land revenue and LEPL
10	**Increased incidence of water –related diseases**			
	Construction phase	• Increase water-borne diseases	• Provision of community toilets and STP.	• Project contractor/ PHE

		• Increase in water-related diseases due to creation of suitable habitats for growth of vectors.	• Medical check-up of labour and development of medical facilities through mobile hospital. • Spray of chemicals to avoid growth of vectors.	• Lanco& Health, Departme nt

vi. Environmental Overview

The project will not involve the use of any scarce or irreplaceable resources in favor of short-term over long-term needs. The project will use common raw materials such as sand and gravel for its construction. These materials are readily available from non sensitive sites. No scarce energy or financial resources will be used for the Project. No loss of biodiversity will occur and the impact on biodiversity is assessed and mitigation measures suggested in detailed EIA and Environment Management Plan (EMP) report.

vii. Non-quantified Environmental Impacts

a. Non-quantified environmental impacts from project development and increased other development off-site, including greenhouse gases and global warming have brought air quality to the forefront in the environmental community and general public concern.

b. These non quantified impacts from noise pollution, air pollution, and surface water pollution, were considered marginal, and therefore such assessment was not undertaken. Since the recommended mitigation measures involve standard design and construction practices for project, it was not considered necessary to analyze their impact.Measures mentioned in the EIA should be taken care by the project authority.

PUBLIC HEARING

Local residents in the area were consulted during the site selection, land acquisition, and site clearing processes by the local government and Public hearing was conducted by the SPCB as it is a mandatory requirement. Extensive consultation will be involved during the site acquisition process, with all landowners being compensated for the sale of their land. During Public hearing the officials of SPCB met with local residents of the area at Mamring and solicited their views on 21/6/2006. These local residents expressed general support for the new Hydel project. The detailed Public hearing report is annexed. It is planned that, during Project implementation, the Project administration, in coordination with the local government, will

keep related agencies and the local population near the project informed about the Project, and will solicit their views as the Project progresses.

MONITORING AND REPORTING

Monitoring will be required during the period of construction and during the operation of the Project. The minor cost of the equipment required for monitoring environmental impacts is also included in the Project cost. The personnel to carry out the monitoring and testing will be provided by the Department responsible for Environment and SPCB and assisted by the Project Administration authority during construction. During operation, project and operating staff of the project shall assist the SPCB and Department of Forests,Environment and Wild life management for monitoring environmental impacts. The necessary staff and budget for monitoring will be allocated in the regular operations and maintenance budget.

Monitoring during the construction phase of the Project will focus primarily on sedimentation and control of erosion and water runoff, water quality, worker safety and health, and traffic interference. Monitoring of construction operations such as the placement and maintenance of constructed siltation barriers and erosion controls will be done on a monthly basis as part of the ongoing supervision and inspection of construction, as will worker safety and public health. Monitoring of water quality in the Teesta river will be done on a quarterly basis. Periodic observations of the water flow in the river will be made after heavy rainfalls to determine the effectiveness of the erosion and runoff controls that have been put in place as part of the construction process. Truck traffic will be monitored during mobilization and the import of materials to the site to determine that the traffic improvements at the entrance to the site are functioning properly. Monitoring during construction will be the joint responsibility of SPCB, State Department of Forests Environmentand Wild life management deptt and Project authority assisted by the supervisory and inspection force of the concerned departments. They will ensure that the construction contractor carries out the necessary control and mitigation measures specified in the EIA/EMP and the contract documents. The representative of MOEF and State Department of Environment and Project authority will review the results of the environmental monitoring process in bi-annual meeting based on the quarterly report of impact assessment during the construction phase.

Monitoring during the operational phase will focus primarily on land use and development around the site, and water quality, and will continue for five years during the operational phase, after construction is finished. Monitoring will be performed on a quarterly basis, supplemented by spot checks as necessary of water flow and quality and ambient noise level. The project operational and administrative staff of the Lanco Energy pvt ltd, will carry out the environmental monitoring work during the operational phase of the Project. Relevant monitoring data concerning noise and water quality will be obtained monthly at locations both off and on the immediate site. Environmental monitoring reports will be submitted quarterly for review during the five year period to a committee which shall be notified by the State Government and shall include representatives of local Non Government Organizations.

INSTITUTIONAL REQUIREMENTS AND ENVIRONMENTAL MONITORING PROGRAM

a. Institutional Capability

There is extensive experience in Forest, Environment And Wildlife Management Department and State Polution control Board (SPCB) in Sikkim in carrying out the EIA planning process and in implementing EIA monitoring programs. Pertinent governmental regulations and guidance concerning environmental protection have been in place since Environment Protection Act (1986) has been implemented. These regulations were updated in 1994 by the issuance of Government Regulation No. 60(e) dated 27.1 1994 regarding Environmental Impact Assessment notification from Ministry of Environment and Forests, Government of India which includes environmental impact monitoring of major projects In view of the long experience of SPCB in environmental monitoring and control, no special training is required.

b. Submission of Reports

As previously noted, construction progress reports, containing the results of regular monitoring, will be submitted monthly throughout the construction period, and monitoring reports during the operational phase will be submitted quarterly. These reports will be submitted to the State Forests Environment and Wild life management Department.

CONCLUSIONS

a. The proposed Teesta stage-VI construction and development will have no significantly adverse impacts on the surrounding environment provided appropriate measures are taken to mitigate the damage caused. The construction, while involving soil improvement and considerable earthwork will, use proven construction techniques and conventional earthwork methods. Potentially minor adverse impacts can readily be avoided by good site management and construction practices, particularly related to excavation, dumping of muck and Labour camps design.

b. The excavation and dumping works for the construction of the project is approximately 54.18 lakh cumt. Out of the excavated earth 20% will be reutilized and the remaining will be dumped in the identified places in the DPR.

c. A simple monitoring program is needed to cover the construction phase and the first five years of operation. This will be prepared during the design phase of the Project by the Environment wing, SPCB and the Project proponents. It will then be implemented during Project construction by the Project administration and by the staff operating the project (Lanco Energy private ltd) during project operation. The monitoring program will be supervised by the state Department of Forests Environment and Wild life management.

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