CHAPTER-1

INTRODUCTION

1. 1 GENERAL

NTPC Limited, the largest thermal power generating company in India, was incepted in year 1975. It is a public sector company wholly owned by Government of India (GOI). In a span of 30 years, NTPC has emerged as a major power company of international repute and standard. NTPC's core business includes engineering, construction and operation of power generating stations and providing consultancy to power utilities as well. Presently, the total installed capacity of NTPC/JVs stands at more than 27904 MW, which includes 18 coal and 8 gas/naphtha based power stations. NTPC is executing Kol dam Hydro Power Project (800) MW in Himachal Pradesh and Tapoban Vishungad (520 MW) and Loharinag Pala (600 MW) hydro projects in Uttarakhand.

1. 2 PROJECT BACKGROUND

NTPC is planning to set up Rupsiabagar Khasiyabara Hydro-electric Power Project (3x87 MW) in Pithoragarh district of Uttarakhand State. The Memorandum of Understanding (MOU) has been signed in this regard between NTPC and the State Government of Uttarakhand. As per this MOU, NTPC shall carry out detailed investigations and prepare DPR for obtaining clearances from statutory authorities. The approval of draft terms of reference(TOR) for EIA Study which is also site clearance for the project was accorded by Ministry of Environment and Forests (MOEF) vide their

letter dated 23/03/07. NTPC will have the first right to execute the project after obtaining clearances from State Pollution Control Board (SPCB) and Ministry of Environment and Forests (MOEF).

Rupsiabagar-Khasiabara HEPP is proposed to be located on river Goriganga, which is originates from the Milam glacial regions of Himalayas and has tremendous scope for development of hydro-power, which needs to be harnessed to meet the ever-growing demand for power. Goriganga is a tributary of river Sarda, known as Kali river in Uttarakhand. The river Goriganga flows generally in south to south-east direction and experiences a drop of 2530 m in its course of about 95 km till it joins river Sarda (Kali) river. The catchment area of the river Goriganga intercepted at the diversion structure of proposed Rupsiabagar-Khasiyabara hydroelectric project is 1,120 sq.km. The catchment includes 29 glaciers and permanent ice caps measuring an area of 346 sq. km. The seasonal snow covered area in the catchment is about 758 sq. km.

1.3 GORIGANGA BASIN DEVELOPMENT

The toposheets prepared by Survey of India reveal that there is tremendous scope of harnessing the hydro power potential available in this basin by using a drop of about 2280 m available in the river reach between EL. 2960.0 m and 680.00 m which happens to be FRL of the proposed Pancheshwar Multipurpose Project.

The Central Electricity Authority (CEA) has identified various schemes in the Goriganga basin for hydropower development. The list of such schemes is presented in Table-1.1.

TABLE-1.1

Schemes identified in Goriganga basin for hydropower development

Name of Scheme	FRL (m)	TWL (m)	Installed Capacity(MW)
Mapang-Bogudiyar	2920.0	2440.0	200
Bogudiyar-Sirkari Bhyol	2440.0	1960.0	170
Sirkari Bhyol-Rupsiabagar	1960.0	1720.0	210
Rupsiabagar - Khasiyabara	1720.0	1280.0	261
Devi Bagar – Khartoli (Goriganga III-A)	1120.0	1040.0	40
Khartoli Lumti Talli	1040.0	880.0	55

1.4 POLICY, LEGAL AND ADMINISTRATIVE FRAMEWORK

The principal Environmental Regulatory Agency in India is the Ministry of Environment and Forests (MOEF). MOEF formulates environmental policies and accords environmental clearance for the projects. The State Pollution Control Board (SPCB) accords No Objection Certificate (NOC) and Consent for Establishment and Operation for the projects.

As per the EIA notification of MOEF issued on September 14, 2006 a river valley project with a capacity of more than 100 MW requires Environmental Clearance from Ministry of Environment and Forests (MOEF), for which an EIA/EMP study is a pre-requisite requirement.

The assignment of preparing the Comprehensive EIA study has been awarded to M/s. WAPCOS, a Government of India Undertaking in the Ministry of Water Resources. This document presents the Comprehensive EIA report based on the data generated over a period from April 2006 to March 2007.

1.5 OBJECTIVES OF THE STUDY

The purpose of Environmental Impact Assessment (EIA) Report is to assist in the decision making process and to ensure that the project options under consideration are environmentally sound and sustainable. EIA identifies ways of improving project environmentally by preventing, minimizing, mitigating or compensating for adverse impacts.

1.6 OBJECTIVES OF THE PROJECT

In the present developing state of country's economy, there is a great requirement of electrical power for both industrial and agricultural use. As per current power position, requirement during March-April 2003, in the state of Uttarakhand and whole Northern Region was 3,774 MU and 156,610 MU against the availability of 3,670 MU and 144,218 MU, respectively. Thus there were deficit of 2.8% and 7.9%, respectively. This deficit will increase in future in spite of upcoming power projects in the northern region as indicated in the anticipated power supply position in 2006-07. As per this report, in the year 2006-07, total energy requirement and availability in the northern region shall

be 105 BU and 93.4 BU respectively. **Thus, there shall be deficit of 17.80% and 16.5% for total energy and peak energy respectively, in the northern region**. These deficit figures for all India are 12.9% and 12.3%, respectively. Further, the Report of the Working Group on Power for 10th Plan estimated the need based capacity addition of 62213 MW during 11th Plan.

Necessity of Hydro-Power Development in Uttarakhand

The main resources for generating electricity are by utilizing the hydro potential available along the river drops besides the use of fossil fuel. With the limited coal resources and difficult oil position all over the world, it is necessary that electric generation be aimed to achieve the economic balance of 40:60 between the hydro and thermal generation of power, as against the existing 25:65 ratio.

There is a tremendous thrust for establishing hydro-power projects in the country in addition to thermal power projects by the Government of India so that peak deficit is also met apart from overall deficit and there is an improvement in hydro-thermal mix as well.

To improve the share of hydro-power generation, it is essential to harness the hydro power potential. Uttarakhand is one state which has good scope for development of hydro power projects. The hydro power potential of the state is assessed at about 18,175 MW, of which

so far only 6% has been developed.

The existing installed generating capacity in the State is about 1,109 MW, which is entirely contributed by hydro-power. There is no thermal power generation in the state. Another 4,134 MW is further likely to be developed, once the projects under construction are commissioned. The details of major hydro power projects under construction in the state of Uttarakhand are listed in Table-1.2.

TABLE-1.2
Major Hydro-Power Projects under construction in Uttarakhand

Project	**Capacity (MW)**
Maneri Bhali	304
Lakhawar Vyasi Stage-I	300
Lakhawar Vyasi Stage-II	120
Srinagar H.E.Project	330
Tapovan Vishnugad H.E project	520
Loharinagpala H.E Project	600
Lata Topovan H.E Project	120
Vishnugad Pipalkoti H.E Project	444
Tehri Dam Project, Stage-I	1,000
Tehri Dam Project, Stage-II	1,000
Koteshwar Dam Project	400
Dhauliganga H.E. Project, Stage-I	280
Total	**4,134**

With rising hydro power generation and improving efficiencies in distribution of electricity,

Uttarakhand hopes to offer energy at stable prices for eco-friendly industrial development. Though the state is more or less sufficient in its energy generation to meet its own requirement, there is an urgent need to develop its huge untapped hydro power potential capacity with the purpose of harnessing hydro-power resources in the state for economic well being and growth of the people in the whole region.

To bridge the gap between the demand and availability of the power, it is necessary to construct hydro power projects in the country. The proposed Rupsiabagar Kharsiyabara hydroelectric project is one such project, which, on commissioning would play an important role in meeting the hydropower requirements.

1.7 LOCATION AND DESCRIPTION OF SITE

The Rupsiabagar Kharsiyabara hydroelectric project envisages construction of a concrete gravity dam over river Goriganga for hydropower generation. The dam site is located near village Paton, district Pithoragarh, Uttarakhand. The nearest town from the project site is Munsiyari . The project location map is shown in Figure1.1.

The study area (Refer Figure-1.2) can be divided into three parts:

- Submergence area
- Area within 10 km of periphery of water spread area and other appurtenances of the project.
- Catchment area

The salient features of the study area are given in Table-1.3.

TABLE-1.3

Salient environmental features in the study area

Particulars	Details
Coordinates, Dam sites	30°9'56" N, 80°15'06"E
Coordinates, Power house	30°5'23.37"N, 80°16'14.55"E
Nearest railway station	Tanakpur\Kathgodam
Nearest airstrip	Lucknow
Nearest village	Paton
Nearest town	Munsiyari
Hills/valleys	Project area is located in the mountain ranges of western Himalayas
Monuments	Nil
Archaeologically important places	Nil
National Parks	Nil
List of Industries	Nil
Siesmicity	Seismic Zone-V

1.8 SCOPE OF THE EIA STUDY

The brief scope of EIA study includes:

- Assessment of the existing status of physio-chemical, ecological and socio-economic aspects of environment
- Identification of potential impacts on various environmental components due to activities envisaged during construction and operational phases of the proposed hydro-electric project.
- Prediction of significant impacts on major environmental components using appropriate mathematical models.
- Delineation of Environmental Management Plan (EMP) outlining measures to minimize adverse impacts during construction and operation phases of the proposed project.
- Formulation of environmental quality monitoring programmes for construction and operational phases.

- Formulation of Catchment Area Treatment (CAT) Plan, Afforestation, Greenbelt Plan, etc.
- Delineation of a Disaster Management Plan (DMP).

1.9 OUTLINE OF THE REPORT

The contents of the study are arranged as follows:

Chapter 1 gives an overview of the need for the project. The policy, legal and administrative framework for environmental clearance have been summarized. The objectives and need for EIA study too have been covered.

Chapter 2 gives a brief description of the proposed project. The Chapter includs write-up on various project appurtenances, construction schedule and construction material requirement, etc.

Chapter 3 Pre-project environmental baseline conditions including physical, biological and socio-economic parameters, resource base and infrastructure are covered in this Chapter. Before the start of the project, it is essential to ascertain the baseline conditions of appropriate environmental parameters which could be significantly affected by the implementation of the project. The planning of baseline survey emanated from shortlisting of impacts using identification matrix. The baseline study involves both field work and review of existing data documents, which may already have been collected for other purposes.

Chapter 4 presents the anticipated positive and negative impacts likely to accrue as a result of the construction and operation of the proposed hydro-power project. Prediction is

essentially a process to forecast the future environmental conditions of the project area that might be expected to occur as a result of the construction and operation of the proposed project. An attempt has been made to forecast future environmental conditions quantitatively to the extent possible. But for certain parameters, which cannot be quantified, general approach has been to discuss such intangible impacts in qualitative terms so that planners and decision-makers are aware of their existence as well as their possible implications.

Chapter 5 outlines the socio-economic aspects including demographic profile, occupational pattern, infrastructure details, etc. for the project area as well as study area have been covered. The finding of the survey of the project affected families (PAFs) have been presented. A Resettlement and Rehabilitation Plan for Project Affected Families as per the norms outlined in Resettlement and Rehabilitation (R&R) policy of NTPC and National policy for Resettlement and Rehabilitation (2007) has also been presented in this Chapter.

Chapter 6 Environmental Management Plan (EMP) for amelioration of anticipated adverse impacts likely to accrue as a result of the proposed project. The approach for formulation of an Environmental Management Plan (EMP) is to maximize the positive environmental impacts and minimize the negative ones. After selection of suitable environmental mitigation measures, the cost required for implementation of various management measures is also estimated, to have an idea of their cost-effectiveness.

Chapter 7 Catchment Area Treatment (CAT) Plan for the catchment area has been suggested. The cost required for implementation of CAT Plan too has been estimated. The chapter also outlines a schedule for implementation of the CAT Plan.

Chapter 8 Environmental Monitoring Programme for implementation during project construction and operation phases is outlined in the Chapter. The environmental monitoring programme has been suggested to assess the adequacy of various environmental safeguards, and to compare the predicted and actual scenario during construction and operation phases to suggest remedial measures for the impacts not foreseen during the planning stage but arising during these phases and to generate data for further use.

Chapter 9 outlines the Disaster Management Plan.

Chapter 10 Costs required for implementation of the Environmental Management Plan (EMP) and the Environmental Monitoring Programme and summarized in this Chapter.

CHAPTER-2

PROJECT DESCRIPTION

2.1 INTRODUCTION

The project envisages to harness hydropower potential of river Goriganga, by constructing a 62 m high dam with a submergence area of about 4.50 ha. The project comprises of dam, desilting chamber, water conveyance system, Surge shaft, power house and tailrace channel. The installed capacity of the project will be 261 MW. The design discharge is 69.13 cumec. The project site is located near Paton village of Munsiyari Tehsil in district Pithoragarh, Uttarakhand.

2.2 RIVER SYSTEM

The Goriganga river is a tributary of river Sarda, known as river Kali in the state of Uttarakhand. The river originates in the Himalayan ranges from Milam glacier and flows

generally in south to south-east direction. The river experiences a drop of 2,530 m in its course of about 95 km till it joins river Sarda (Kali). The catchment of the river at the diversion structure of proposed Rupsiabagar-Khasiyabara hydroelectric project is 1120 sq.km. The catchment includes 29 glaciers and permanent ice caps measuring 346 sq. km. The seasonal snow covered area in the catchment is about 640 sq. km.

2.3 ANALYSIS OF ALTERNATIVES

The various alternative dam sites covered as a part of the DPR study are briefly described in Table-2.1.

TABLE-2.1

Brief description of various alternative dam sites

Axis No.	Riverbed level and height above riverbed	Geological conditions		Limitations	Live storage (Mm^3)
		Right abutment	Left Abutment		
1	EL 1598 (125 m)	Sound rocky cliff upto 125 m	Sound rocky cliff upto 80 m	Dam of 125 m height is not feasible as Pehal gad Nala is very close to left abutement	2.97
2 (PFR Location)	EL 1602 (121 m)	Glacier debris above 80 m	Sound rocky cliff upto 80 m	Aggravation of landslides just upstream in the reservoir area	1.68

3A	EL 1686 m (37 m)	Sound rock upto 150 m height	Sound rock upto 70 m height and above slided debris of shallow depth	Slope treatment is required on the left abutment	0.27
3B	EL 1674 (49 m)	Sound rock upto 150 m height	Sound rock upto 60-70 height above slided debris of shallow depth	Slope treatment is required on the left abutment	0.38

Dam site 3 B has been selected over sites account of topography, geology and live storage considerations.

2.4 PROJECT DETAILS

The project comprises of the following main components:

- River diversion works
- Dam and Appurtenant works
- Power intakes
- Underground desilting chambers
- Headrace Tunnel
- Surge shaft
- Pressure Shaft and pen stock
- Surface Power house and Switchyard
- Tail Race Channel
- Approach roads

DAM AND SPILLWAY

The dam axis has been selected to take optimum advantage of the topographical and geological conditions of the site.

The size of the three spillway openings of 8.0 m width x 9.5 m height has been selected to allow a discharge of Standard Project Flood (SPF) of 2,930 m^3/s while one of the gates is closed, or the Probable Maximum Flood (PMF) 4,500 m^3/s with sufficient freeboard to avoid overtopping of the dam crest.

POWER INTAKE

The intake structure of the Rupsiabagar Khasiyabara Hydro Power structure will be located on the left bank of the Goriganga river upstream to the dam axis.

A coarse trash rack will be provided in front of the bell mouth shaped to prevent boulders and floating debris entering the head race tunnel. Trash removal will be done with a mechanically operated trash rack cleaning machine located on the top of the intake structure.

Gate will allow isolation of the head race tunnel from the reservoir. The fixed wheel gates will be in a raised, locked position above FRL during normal operating conditions.

INTAKE TUNNELS

The water will enter two D-shaped intake tunnels of 4.0 m dia each at an invert level of EL.1690.75 m near the tunnel intake. The flow into intake tunnels is controlled by Vertical Lift Gates of 4m x 4.5 m size with the help of Gantry Crane hoist.

DESILTING CHAMBER

Considering the topographic conditions at the dam site, an underground desilting arrangement has been recommended. A twin desilting chamber layout has been selected which will enable continuous operation during sediment flushing and 50% capacity when one of the chambers is out of service for maintenance. Sediments with particle size of >0.2 mm will be allowed to settle at the bottom of the desilting basin and will be removed under the pressure of the reservoir head and discharged into the riverbed downstream of the dam site.

HEAD RACE TUNNEL

The Head Race Tunnel (HRT), after desilting basin, would be 4.75 m in diameter and about 7.47 km in length. This tunnel would be provided with a suitable gradient to ensure gravity flow of any seepage water and sufficient water seal at the junction with surge shaft below minimum surge level. The Head Race Tunnel (HRT) would have four (4) faces for its excavation with the provision of two construction Adits.

As a part of DPR, modified horseshoe section with a finished diameter of 4.75 m was derived as the most economical section and the same was adopted for design.

The tunnel will be concrete lined over its entire length to prevent abrasion and rock falls, which could damage the penstocks and the turbine. A lining thickness of 300 mm thick PCC lining has been adopted.

SURGE SHAFT

A restricted Orifice Type Surge Shaft with an inside diameter of 12.5 m is proposed at the end of HRT. This shaft has been proposed to take care of transient flow conditions during sudden shutdown or starting of Power house.

The height of Surge Shaft has been so designed that it contains the maximum upsurge level to prevent overflowing and keeps the maximum down surge level reasonable above the overt to HRT to prevent any air entrainment in the water conductor system.

PRESSURE SHAFTS/PENSTOCKS

From the surge shaft, the horizontal pressure shaft of 4.1 m diameter will daylight after about 190 m distance. The pressure shafts will be steel lined encased in concrete. The surrounding rock is grouted to seal the void between the steel liner, concrete and the rock excavation.

The penstock will follow the natural slope. The pipe will be partly embedded in trenches, wherever possible, to avoid sharp and small streams bends. The trench shall be filled with selected fill before it is backfilled to the level of surrounding ground surface. The pipe will be supported on concrete saddle support at 12.5 m interval and concrete anchor blocks founded and anchored on sound rock.

POWER HOUSE

Surface power house has been recommended for Rupsiabagar Khasiyabara Hydroelectric Power Project, which will be constructed on the left bank of river Goriganga. The power house will consist of a watertight substructure founded on

bedrock and a free-standing superstructure. The power house layout is governed by the requirements of the generating equipment which consists of three Pelton turbines, three generators and various associated equipment.

TAILRACE CHANNEL

Water exiting from turbines will be discharged into the Goriganga river by tailrace channel in front of power house, which extends from the substructure in downstream of the powerhouse with proper slope to minimize water heading up below the runner.

An open weir with crest level EL. 1258.0, sufficient to pass discharge of single machine below normal water level of river is provided at the out fall structure.

APPROACH ROAD

Since the project is not directly approachable by a motorable road fresh roads needs to be built up for access to dam site, power house site, quarry sites workshops etc. 25 km new roads to be constructed in the project area. The road details are given in Table-2.2.

TABLE-2.2

Project Road Details

S. No.	Description	Length
I	**Power House Complex**	
A	Construction of the access road to the power house	1.5 km

S. No.	Description	Length
	from the state highway (Jauljibi to Munsiyari)	
B	Construction of roads from power house road to the top of the surge shaft and to the adit leading to the bottom of the surge shaft, and HRT Adit 3	9.0 km
C	Construction of approach road to HRT Adit-2	1.0 km
II	**Dam Complex**	
D	Construction of approach road to the Dam top connecting enroute quarry and aggregate processing plant area near Jimyghat on right bank	9.0 km
E	Construction of approach roads to the portals of the silt flushing tunnel, access adit to gate chamber and the portals of the construction adits leading to the underground desilting chambers & HRT Adit-1, from approach road to dam site.	2.5 km
F	Road from Dam top to connecting the works area and plant area near village Lilam on right bank	1.5 km
G	Road from top of dam to bottom of dam and to portals of diversion tunnels including intake works and u/s Coffer dam (Right Bank)	0.5 km

The project layout map is shown in Figure-2.1. The salient features of the project are given in Table-2.3.

TABLE-2.3

SALIENT FEATURES OF THE PROPOSED RUPSIABAGAR

KHARSIABARA HYDROELECTRIC PROJECT

Features	Unit	Description
Project Location		
State		Uttarakhand
District		Pithoragarh
River		Goriganga (Sarda Basin)
Sub-Division		Munsiyari

Features	Unit	Description
Vicinity		Munsiyari
Nearest Railhead		Tanakpur/Kathgodam
Nearest Airport		Lucknow
Dam location	Latitude Longitude	$30^{o}09'56.45"$-$30^{o}09'56.34"$ $80^{o}50'06"$ - $80^{o}15'11.2"$
Power house Location	Latitude Longitude	$30^{o}5'23.37"$ N $80^{o}16'14.55"$ E
Hydrology		
Catchment area Dam site	Km^2	1120
Average Annual Rainfall	mm	2595
Average Annual Runoff	Mm^3	1656
90% Dependable Year Runoff	Mm^3	1360
Diversion (Dry Season)	M^3/s	400
Standard Project Flood Discharge (SPF)	M^3/s	2930
Probable Maximum Flood (PMF)	M^3/s	4500
Reservoir		
Full Reservoir Level (FRL)	M	1720.0
Minimum Draw Down Level (MDDL)	M	1700.0
Maximum Reservoir Level (MRL)	M	1721.5
Total Storage Volume	Mm^3	0.5156
Pondage above MDDL (Diurnal storage)	Mm^3	0.3836
Dead Storage Volume	Mm^3	0.132
Reservoir Area at FRL	Ha	4.50
Stretch of Reservoir	M	500
Dam		
Site		Near Paton village
Type		Concrete Gravity
Length of Dam between abutments	M	143.03
Auxiliary spillway bay	No.	1
Under Sluice Bays	No.	3
Top of Dam Elevation	M	1723.0
Minimum Dam Foundation Level	M	1661.0
Maximum Dam Height	M	62.0
River Bed Level (Deepest)	M	1674.0
Diversion		
Upstream Cofferdam		
Crest Elevation	M	1694.0

Features	Unit	Description
Length	M	45.0
Height	M	8.0
Downstream Cofferdam		
Crest Elevation	M	1646.0
Length	M	30.0
Height	M	6.0
Diversion Tunnel		
Diameter, Shape	M	6.0, Horse shoe
Length	M	400.0
Gate Type		Vertical lift gate
Discharge Capacity	M^3/sec	400
Gate Opening, (H x W)	M	6.0 x 6.0
Number of gates	No.	1
Under Sluice Spillway		
Type		Submerged ogee with Breast Wall
Crest Elevation	M	1685.35
Gate Type		Radial
Gate Opening (Wx H)	M	8.0 x 9.5
Number of gates	No.	3.0
Auxiliary Spillway		
Type		Ogee
Crest Elevation	M	1717.0
Gate Type		Vertical slide gate
Gate Opening, (H x W)	M	3.0 x 3.0
Number of gates	No.	1
Intake Structure		
Location		On left abutment
Number of openings		2
Inlet Elevation (Center Line)	M	1692.75
Nominal Discharge through each unit	M^3/s	41.478
Dimension of Trash Rack Opening (W X H)	M	16.8 x 20.8
Number of Gates	No.	2
Intake Tunnel		
Shape/Size	M	4, D-shaped
Invert Level of Tunnels	M	1690.75
Length	M	690/665
Gate Type		Vertical Lift

Features	Unit	Description
Silt Elevation	M	1690.75
Dimensions (W X H)	M	4.0 x 4.5
Desilting Chambers		
Chambers		
Type		Underground, Continuous Sediment Removal
Number of Chambers		2
Size (L x W x H)	M	250 x 10 x 16.0
Nominal Discharge through Each Chamber	M^3	41.478
Size of Particles to be removed	mm	>0.2
D/S Gate Shaft		
Size/Shape	M	6/D-Shaped
Length	M	350
Gates		
Crest Elevation	M	1688.05
Gate Type		Vertical lift slide gate
Gate Opening, (W x H)	M	4 x 4.5
Number of gates	M	2
Maximum Head	M	33
Silt Flushing Tunnel		
Type		Pressurised Tunnel
Size/Shape	M	2.5 m/D-shaped
No.		1
Discharge through Each Tunnel	M^3	6.913
Crest Elevation	M	1675.0
Gate Type		Vertical lift slide gate
Gate Opening, (W x H)	m	3.0 x 3.0
Number of gates	m	2
Maximum Head	m	45.0
Head Race Tunnel		
Tunnel		
Shape		Horse Shoe
Length	m	7470
Finished Diameter	m	4.75
Velocity for Nominal Discharge	m/sec	3.70
Slope		1:233
Nominal Discharge	m^3/s	69.13
Lining Type and Thickness	mm	Concrete, 300

Features	Unit	Description
Number of Adits		3 Nos.
Adit-1		
Location from desilting chamber junction	m	50
Size	m	6.0, D-shaped
Slope		1:200
Length	m	300
Adit-2		
Location from desilting chamber junction	m	5500
Size	m	6.0, D-shaped
Slope		1:200
Length	m	240
Adit-3		
Location from desilting chamber junction	m	7400
Size/shape	m	6.0/ D-shaped
Slope		1:200
Length	m	155
Surge Shaft		
Type		Vertical with Restricted Orifice
Top Elevation	m	1780.0
Total Height	m	120.3
Max. Water Level in Surge Shaft		1760.0
Normal Water Level		1692.0
Min. Surge Level		1667.0
Internal Diameter	m	12.5
Lining	mm	Concrete, 1600 (Max)
Orifice diameter	m	1.92 m
Gate Type		Vertical Shaft
Gate Opening, (H x W)	m	4.75 x 5.88
Number of gates	No.	1
Maximum Head	m	106.0
Length of Adit to Bottom to Shaft	m	215.0
Pressure Shaft		
Horizontal Shaft length	m	Near surge shaft : 180 Near power house : 200
Type		Steel Lined
Internal Diameter	m	4.1
Penstock		

Features	Unit	Description
Type		Surface/Buried
Number	nos.	1
Internal Diameter	m	4.1
Length	m	581
Thickness of Lining	mm	20 – 38
Nominal Discharge	m^3/s	69.13
Velocity for Nominal Discharge	m/sec	5.25
Power House		
Structure		
Type		Surface
Gross Head	m	449.83
Head Losses	m	22.124
Net Head	m	427.71
Installed Capacity	MW	3 x 87 (261)
Plant Load Factor (90% dependable year)	%	52.85
Turbine		
Type		Pelton, Six Jet
Number of Units	Nos.	3
Turbine Setting Elevation	m	1263.5
Rated Discharge per Unit	m^3/sec	23.04
Inlet Valve		
Type		Spherical
Number	nos.	3
Generator		
Type		Vertical Shaft, Synchronous
Number	Nos.	3
Transformer Platform		
Location		D/S to PH
Dimensions (L x W)	m	72 x 11.5
Transformer Type		Single Phase, OFWF
Number		13
Unit Capacity	MVA	30
Voltage Ratio	kV	11/400√3
Tail Race Channel		
Size (W x H)	m	
Length	m	110

Features	Unit	Description
Slope		1:200
Nominal Discharge	m^3/s	69.13
River Bed Elevation	m	1255.0
Minimum Tail Water Level	m	1258.0
Maximum tail water level for full discharge in tail pool	m	1260.0
Switchyard		
Type		Conventional
Location of Switchyard		Open
Cost of Project		
Civil & Hydro-Mechanical	Crores	1193.62
Electro-Mechanical	Crores	361.20
Total Cost without IDC	Crores	1554.82
IDC	Crores	252.24
Power Benefits		
Design Energy Generation *50% Dependable Year*	GWh	1342.73
Design Energy Generation *90% Dependable Year with 95% m/c availability*	GWh	1191.63
Financial Aspects		
Avg. of 1st Five Year Tariff	Rs./kWh	3.08
Levellized Tariff	Rs./kWh	2.35
Construction Period		
Construction Period	months	64

2.5 LAND REQUIREMENT

The total land required for the project is 264 ha. The details are given in Table-2.4.

TABLE-2.4

Land requirement for Rupsiabagar Khasiyabara hydroelectric project

(Unit : ha)

Project Appurtenance	Govt. Land	Private Land	Total

Project area including reservoir	19.2	12.8	32.0
Infrastructure/township colony	109.2	72.8	182.0
Quarry and muck disposal	30.0	20.0	50.0
Total	**158.4**	**105.6**	**264.0**

2.6 CONSTRUCTION EQUIPMENT

The list of major equipment to be used during construction phase is given as below:

- Batching plant
- Aggregate processing plant
- Dumpers
- Transit Mixer
- Excavator
- Shovel
- Loader
- Dozer
- DG Sets
- Compressors
- Concrete pump
- Scoop tippets
- Boomers with 2 boom
- Ventilation Blower
- Tunnel Loading Machine
- Crushers

2.7 CONSTRUCTION MATERIAL

The construction material requirement is given in Table-2.5.

TABLE-2.5

Construction material requirement for Rupsiabagar Khasiabara H.E. project

Material	Unit	Quantity
Cement	MT	160,000
Structural steel	MT	10,000
Fine aggregate	m^3	130,000
Coarse aggregate	m^3	50,000

Sand	m^3	115,000

The construction material, e.g. coarse and fine aggregates is to be acquired from Bhadeli and Jimiya Ghat quarries. About 80% of requirement is to be met from the quarry at Bhadeli and balance shall be met from Jimiyaghat quarry.

2.8 CONSTRUCTION PERIOD

The project is proposed to be completed within a time period of 64 months.

CHAPTER-3

ENVIRONMENTAL BASELINE STATUS

3.1 GENERAL

Before the start of any Environmental Impact Assessment study, it is necessary to identify the baseline levels of relevant environmental parameters which are likely to be affected as a result of the construction and operation of the planned project. A similar approach has been adopted for conducting the EIA study for the proposed Rupsiabagar Khasiabara hydroelectric Project. A Scoping Matrix was formulated to identify various issues likely to be affected as a result of the proposed project. Based on the specific inputs likely to accrue in the proposed project, aspects to be covered in the EIA study were identified. The other issues as outlined in the Scoping Matrix were then discarded. Thus, planning of baseline survey commenced with the shortlisting of impacts and identification of parameters for which the data needs to be collected. The scoping matrix adopted for the EIA study for the proposed Rupsiabagar Khasiabara hydro electric project is given in Table-3.1

TABLE-3.1

Scoping Matrix for EIA study for the proposed Rupsiabagar Khasiabara hydroelectric Project, Uttarakhand

Aspect of Environment	Likely Impacts
A. Land Environment	
Construction phase	- Increase in soil erosion - Pollution by construction spoils - Use of land for labour colonies - Problems due to muck disposal - Solid waste from labour colonies - Acquisition of land for various project appurtenances
B. Water resources and water quality	
Construction phase	- Increase in turbidity of nearby receiving water bodies - Degradation of water quality due to disposal of wastes from labour colony and construction sites
Operation phase	- Disruption of hydrologic regime - Impacts on D.O. due to increased residence time in reservoir - Eutrophication risks
C. Aquatic Ecology	
Construction phase	- Increased pressure on aquatic ecology as a result of indiscriminate fishing. - Reduced productivity due to increase in turbidity
Operation phase	- Impacts on migratory fish species - Impacts on spawning and breeding grounds - Degradation of riverine ecology
D. Terrestrial Ecology	
Construction phase	- Increased pressure on nearby forests to meet the fuel wood and timber requirements of labour population migrating in the area during

Aspect of Environment	Likely Impacts
	construction phase - Adverse impacts due to migration of labour population
Operation phase	- Impacts on terrestrial flora and fauna - Impacts on wildlife - Impacts on economically/ genetically/ biologically important plant species
E. Socio-Economics	
Construction phase	- Acquisition of land and private properties - Impacts on archaeological and cultural monuments - Impacts on mineral reserves - Improved employment potential during project construction phase - Development of allied sectors leading to greater employment - Pressure on existing infrastructure facilities - Friction between guest and host community
Operation phase	- Increased revenue from power generation
F. Air Pollution	
Construction Phase	- Impacts due to emissions generated by crushers and other equipment. - Impacts due to increased vehicular movement - Fugitive emissions from various sources
Operation phase	- Impacts due to urbanization and increased vehicular traffic
G. Noise Pollution	
Construction Phase	- Noise due to operation of various equipment - Noise due to increased vehicular movement - Noise due to blasting activities
Operation phase	- No Impact
H. Public Health	
Construction Phase	- Increased incidence of water related diseases - Transmission of diseases by immigrant labour population
Operation phase	- Increased incidence of vector borne diseases

The relevant environmental impacts out of the entire gamut of issues outlined in the Scoping Matrix were identified. For these impacts or aspects, environmental baseline data has been collected from secondary as well as primary data sources. As a part of the study, detailed field studies on various aspects were conducted. The baseline status has been ascertained for the following aspects:

Water Environment	-	Water resources
	-	Water use
	-	Water quality
	-	Hydrology
	-	Sediments
Climate and Weather	-	Meteorology
	-	Ambient air quality
	-	Noise
Land Environment	-	Land use
	-	Geology
	-	Seismology
	-	Soils
Biological Environment	-	Terrestrial Ecology
	-	Aquatic Ecology
Socio-Economic, health and Cultural Environment	-	Demography and Socio-economics
		Public health

The socio-economic aspects have been covered separately in Chapter-5. The other aspects as outlined above are covered in the present Chapter.

The information presented in this Chapter has been collected through field studies, interaction with various government departments and collation of available literature with various institutions and organizations. The summary of data collected from various sources as a part of the EIA study is outlined in Table-3.2.

TABLE-3.2

Summary of data collection from various sources

Aspect	Mode of Data collection	Parameters monitored	Frequency	Source(s)
Meteorology	Secondary	Temperature, humidity, rainfall	-	India Meteorological Department (IMD)
Water	Secondary	Flow, Design	-	Detailed Project

Aspect	Mode of Data collection	Parameters monitored	Frequency	Source(s)
Resources		hydrograph and design flood hydrograph		Report
Water Quality	Primary	Physico-chemical and bacteriological parameters	Three seasons (summer, monsoon, and winter)	Field studies
Ambient air quality	Primary	RPM, SPM, SO_2, NOx	Three seasons (summer, post-monsoon, and winter)	Field studies
Noise	Primary	Hourly noise level	Three seasons (summer, post-monsoon, and winter)	Field studies
Landuse	Primary and secondary	Landuse pattern	-	National Remote Sensing Agency (NRSA) and Ground truth Studies
Geology	Secondary Geological characteristics of study area		-	Geological survey being conducted for the project as a part of DPR preparation
Soils	Primary	Physico-chemical parameters	Three seasons (summer, monsoon, and winter)	Field studies
Terrestrial Ecology	Primary and secondary field survey	Floral and faunal diversity	Three seasons (summer, monsoon, and winter)	Field studies, Forest Department and literature
Aquatic Ecology	Primary and Secondary	Presence and	Three seasons (summer,	Field studies, Forest Department

Aspect	Mode of Data collection	Parameters monitored	Frequency	Source(s)
		abundance of various species	monsoon, and winter)	and literature review
Socio-economic aspects	Primary and secondary	Demographic & socio-economic, Public health cultural	-	Revenue Department and literature review. Census Data

3.2 WATER ENVIRONMENT

3.2.1 Water resources

Catchment Area and River

The proposed Rupsiabagar-Khasiyabara dam site is located on the river Goriganga which is a sub system of Sarda Basin. The river Goriganga originates in Himalayan ranges from Milan glacier at an EL 3600 m and flows generally in the S-SE direction for about 90 km after which it joins river Kali about 1km downstream of Jauljibi. The river Kali (also known as river Sarda in downstream stretches) finally joins river Ganga. The Goriganga catchment contains 29 glaciers and permanent ice caps measuring 346 sq. km. The seasonal snow cover area in the catchment is about 758 sq. km. The total

catchment area of river Goriganga intercepted upto Rupsiabagar Khasiabara dam site is about 1120 sq. km. The length of river Goriganga upto the proposed dam site is 48.96 km. The elevation in the catchment ranges from 6000 m in the upper reaches to around 900 m near the dam site.

Design Storm

The 1-day probable maximum precipitation (PMP) value of Goriganga sub-basin is adopted as 33.41 cm. A Probable Maximum Flood (PMF) value of 4313 cumec has been adopted for proposed project. The flood for return period for various years is given in Table-3.3.

TABLE-3.3

Floods for various return periods

S. No.	Return Period	Design flood Peak (cumecs)	Remarks
1.	25 years	2030.12	-
2.	50 years	2525.75	-
3.	100 years	3021.39	-
4.	1000 years	4800	Projected from 25, 50 and 100 years flood peaks using Gumbel probability papers.
5.	PMF	4312.70	-

Flood Frequency Analysis

As a part of the DPR, flood frequency analysis has been carried out using Annual Maximum method and Peak over Threshold (POT) method. The final results of various return period floods estimated at Pancheswar were transposed to Rupsiabagar Khasiyabara Dam site using Dicken's formula. The 10,000 year flood value for Pancheswar is 15041.36 cumecs. Using this relation, the 10000 year flood at Rupsiabagar Khasiyabara project site has been estimated as 3685.15 cumec.

3.2.2 Water use

The major sources of water in the project area are rivers and nallahs, which flow adjacent to the habitations. These are used to meet the major water requirements in the project as well as the study area. The water is conveyed to the point of consumption, i.e. habitations, through open channels, which is then utilized for meeting domestic requirements.

The study area in general, depends on rainfall for irrigation. Rainwater and snow are absorbed within the soil, which then percolate through pores and crevices and reappear in the form of springs. During monsoons, number and discharge of the springs increases. The supply of water in the perennial springs gets reduced in winter and summer seasons. Spring water is generally collected in tanks and stored for meeting irrigation and other requirements during the periods of scarcity. The spring water is also used for meeting domestic requirements in many areas. The water is carried through surface channels called `gools' into the fields located at lower levels.

3.2.3 Water quality

The project area has low population density and no major water polluting industries are observed in the area. The cropping intensity of the catchment area is low. Most of the farmers do not use agro-chemicals, i.e. pesticides, chemical fertilizers, etc. Thus, the only source of pollution in the area is sewage generated by the human and livestock population. Since the population density is low, the quantum of sewage generated is much lower than the carrying capacity at minimum flow. Thus, even for minimum flow, there is sufficient water available in river Goriganga, for dilution of untreated sewage generated from domestic sources. Thus, water quality in such settings is expected to be excellent in the project area.

As a part of the field studies, water samples from river Goriganga and other tributaries from various locations within the study area were collected and analysed for various physico-chemical parameters. The various sampling locations are shown in Figure-3.1 and are listed as below:

W1 - River Goriganga 0.6 km downstream of dam site
W2 - River Goriganga 2 km downstream of dam site
W3 - Tributary 4 km downstream of dam site
W4 - Kwiri gad 5 km downstream of dam site
W5 - Tributary 7 km downstream of dam site
W6 - River Goriganga, 0.5 km downstream of powerhouse

The water quality has been monitored for three seasons listed as below:

- Summer season : April 2006.
- Monsoon season : July 2006
- Winter season : December 2006

The results of water quality analysis conducted for various seasons are given in Tables-3.4 to 3.6. The drinking water standards are given Annexure-I.

TABLE-3.4

Water quality analysis in the study area for summer season

Parameter	Unit	W1	W2	W3	W4	W5	W6
pH	-	7.8	7.7	7.6	7.5	7.4	7.8
Temperature	^{o}C	9.7	9.1	9.2	9.1	9.1	9.7
Dissolved Oxygen (DO)	mg/l	8.2	8.5	8.4	8.2	8.4	8.5
Electrical Conductivity (EC)	µS/cm	60	60	57	58	68	59
Total Dissolved Solids (TDS)	mg/l	44	43	42	42	51	43
Alkalinity	mg/l	7.6	7,8	7.2	8.0	8.4	8.0
Hardness as $CaCO_3$	mg/l	40	38	40	38	38	44
Caclium as Ca	mg/l	9.2	9.0	8.;8	7.9	8.4	9.0
Magnesium as Mg	mg/l	4.4	3.8	4.4	4.8	4.3	5.1
Fluorides	mg/l	0.5	0.5	0.5	0.5	0.5	0.5
Carbonates	mg/l	5	8	6	8	5	8
BOD	mg/l	1.8	1.4	1.5	1.5	1.5	1.5
COD	mg/l	3.7	3.0	3.1	3.0	3.1	3.2
Nitrates	mg/l	4.8	5.1	5.0	5.0	4.7	4.8

Parameter	Unit	W1	W2	W3	W4	W5	W6
Chlorides	mg/l	11.2	10.9	10.8	12.1	14.4	11.2
Phenolic compounds	mg/l	Nil	Nil	Nil	Nil	Nil	Nil
Lead	mg/l	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL
Mercury	mg/l	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL
Cadmium	mg/l	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL
Chromium	mg/l	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL
Cyanides	mg/l	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL
Faecal Coliform	MPN/ 100 ml	Absent	Absent	Absent	Absent	Absent	Absent
Total Coliform	MPN/ 100 ml	28	20	25	20	24	22

TABLE-3.5

Water quality analysis in the study area for monsoon season

Parameter	Unit	W1	W2	W3	W4	W5	W6
pH	-	7.8	7.8	7.8	7.6	7.6	7.9
Temperature	^{o}C	8.9	8.4	8.3	8.3	8.6	9.1
Dissolved Oxygen (DO)	mg/l	8.4	8.6	8.6	8.5	8.7	8.7
Electrical Conductivity (EC)	µS/cm	67	72	69	69	78	71
Total Dissolved Solids (TDS)	mg/l	44	43	42	42	51	43
Alkalinity	mg/l	7.6	7.8	7.2	8.0	8.4	8.0
Hardness as $CaCO_3$	mg/l	40	38	40	38	38	44
Caclium as Ca	mg/l	9.2	9.0	8.8	7.9	8.4	9.0
Magnesium as Mg	mg/l	4.4	3.8	4.4	4.8	4.3	5.1
Fluorides	mg/l	0.5	0.5	0.5	0.5	0.5	0.5
Carbonates	mg/l	5	8	6	8	5	8
BOD	mg/l	1.8	1.4	1.5	1.5	1.5	1.5
COD	mg/l	3.7	3.0	3.1	3.0	3.1	3.2
Nitrates	mg/l	4.8	5.1	5.0	5.0	4.7	4.8
Chlorides	mg/l	11.2	10.9	10.8	12.1	14.4	11.2
Phenolic compounds	mg/l	Nil	Nil	Nil	Nil	Nil	Nil
Lead	mg/l	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL
Mercury	mg/l	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL
Cadmium	mg/l	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL
Chromium	mg/l	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL
Cyanides	mg/l	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL
Faecal Coliform	MPN/ 100 ml	Absent	Absent	Absent	Absent	Absent	Absent
Total Coliform	MPN/ 100 ml	28	20	25	20	24	22

TABLE-3.6

Water quality analysis in the study area for winter season

Parameter	Unit	W1	W2	W3	W4	W5	W6
pH	-	7.6	7.6	7.6	7.5	7.4	7.6
Temperature	^oC	9.6	9.2	9.12	9.1	9.1	9.4
Dissolved Oxygen (DO)	mg/l	8.4	8.6	8.4	8.3	8.3	8.6
Electrical Conductivity (EC)	µS/cm	56	57	53	55	60	56
Total Dissolved Solids (TDS)	mg/l	42	44	39	41	46	42
Alkalinity	mg/l	7.8	7.9	7.5	7.9	8.5	8.2
Hardness as $CaCO_3$	mg/l	43	38	46	41	42	48
Caclium as Ca	mg/l	9.8	9.8	8.6	7.8	8.8	9.0
Magnesium as Mg	mg/l	4.2	3.7	4.3	4.7	4.3	5.2
Fluorides	mg/l	0.5	0.5	0.7	0.6	0.5	0.5
Carbonates	mg/l	5.1	7.6	6.5	7.5	5.7	7.2
BOD	mg/l	1.8	1.6	1.7	1.7	1.8	1.8
COD	mg/l	3.8	3.6	3.7	3.8	3.9	4.0
Nitrates	mg/l	4.9	5.4	5.4	5.1	5.2	5.3
Chlorides	mg/l	11.7	11.3	11.2	12.3	13.1	11.0
Phenolic compounds	mg/l	Nil	Nil	Nil	Nil	Nil	Nil
Lead	mg/l	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL
Mercury	mg/l	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL
Cadmium	mg/l	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL
Chromium	mg/l	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL
Cyanides	mg/l	<BDL	<BDL	<BDL	<BDL	<BDL	<BDL
Faecal Coliform	MPN/ 100 ml	Absent	Absent	Absent	Absent	Absent	Absent
Total Coliform	MPN/ 100 ml	32	21	24	28	29	24

The EC and TDS values were observed to be too at various sampling stations covered as a part of the study. The concentration of TDS level ranged from 42 to 51 mg/l, which is much lower than the permissible limit of 500 mg/l specified for domestic use. The EC level as observed in various seasons 58 to 78 µs/cm. The concentration of various cations and anions, e.g. calcium, magnesium, chlorides, nitrates are also well below the permissible specified for meeting drinking water requirements.

The total hardness in various water samples ranged from 38-48 mg/l. The low calcium and magnesium levels are responsible for soft nature of water. The carbonate hardness (for water with alkalinity level as observed in the study area) is equal to the alkalinity level, i.e. ranging from 7.2 to 8.5 mg/l. The non-carbonate hardness accounts for the balance hardness. However, hardness level in the area do not warrant any treatment, as the total hardness in the water samples collected from different sampling locations in various seasons was observed to be well below the permissible limit of 200 mg/l.

The fluorides level was lower than the permissible limit (1 mg/l) for drinking requirements. Use of water with such fluorides level could lead to dental caries.

The BOD values are well within the permissible limits, which indicates the absence of organic pollution loading. This is mainly due to the low population density and absence of industries in the area. The low COD values also indicates the absence of chemical pollution loading in the area. The marginal quantity of pollution

load which enters river Goriganga, gets diluted.
The concentration of various toxic compounds e.g., cyanides and phenolic compounds were observed to be well within the permissible limits. Likewise, concentration of heavy metals too was observed to be well below the permissible limits. This indicates the absence of pollution sources. The Total Coliform is higher than permissible limits. However, in past, no major water-borne epidemic has been reported in the area.
Another significant aspect to be noted was that there was not much variation in water quality in various seasons. Although there was significant variation in flow or discharge in river Goriganga, but only marginal variation in various water quality parameters was observed. This can be attributed to the fact that pollution loading in low in the area and sufficient flows are available for dilution even in the lean season.

3.3 METEOROLOGY AND AIR ENVIRONMENT

3.3.1 Meteorology

The altitudinal and slope variation have given rise to varying climates in different parts of the catchment area. The climate is hot and moist (tropical) in the sub-mountain zone and in the river valley below 600 m in elevation. At higher elevations, the climate becomes sub-tropical upto altitudes 1,200 m, co-temperate upto 1,800 m and cold temperate between 1,800 and 2,400 m. At still higher altitudes, the climate is almost polar. As a part of the study, information of the IMD station at Munsiyari was collected.

Rainfall: The annual average precipitation over the basin is 778.3 mm. The rainfall occurs throughout the year. The rainfall is received in two spells, i.e. under the influence of south-west monsoons in the months from July to September and the winter rainfall in the months of January and February. The number of rainy days (i.e. days with more than 2.5 mm rainfall) in a year is 55.3. The monthwise rainfall received in the area is enclosed as Figure-3.2.

Temperature: January is the coolest month with average monthly average temperature of the order of 8.3^{o}C. Generally, August is the hottest molnth of the year with mean

monthly maximum temperature of about around 25.3 ^{o}C. The monthwise temperature variation are shown in Figure-3.3.

Humidity : The humidity is higher in monsoon month (84 to 90%). In other months of the year it is comparatively low. Winter months have the lowest humidity. The monthwise humidity variation are shown in Figure-3.4.

The average meteorological conditions reported at the IMD station at Munsiyari are given in Table-3.7.

TABLE-3.7

Average Meteorological conditions in the Project Area

S. No.	Month	Mean Temp. (^{o}C)	Rainfall (mm)	No. of rainy days	Relative humidity (%)	Cloud cover (Oktas of sky)
1.	January	8.3	189.5	9.4	60	3.6
2.	February	13.0	117.8	7.1	58	3.1
3.	March	18.1	63.6	4.7	54	2.4
4.	April	19.0	47.8	3.0	54	2.0
5.	May	22.5	22.8	2.4	56	2.4
6.	June	23.8	18.2	2.5	73	5.0
7.	July	24.4	75.4	6.6	89	6.5
8.	August	25.3	73.4	7.4	90	6.6
9.	September	24.4	124.7	6.4	84	4.4
10.	October	19.4	11.9	1.1	72	2.1
11.	November	15.6	7.8	1.0	62	1.4
12.	December	10.6	25.4	1.7	50	2.2
	Total		**778.3**	**53.3**		

Source : IMD

3.3.2 Ambient air quality

The baseline status of the ambient air quality has been established through a scientifically designed ambient air quality monitoring network. The sampling locations were selected considering the topography of the area, proximity of the sampling location to major construction site and sources of pollution in the present scenario. Four Ambient Air Quality Monitoring (AAQM) locations were selected taking care of above mentioned points. Ambient air quality monitoring at each station has been carried out with a frequency of two samples per week for four weeks locations for three seasons.

The seasons covered as a part of ambient air quality monitoring are given as below:

- Summer season : April-May 2006.
- Post-Monsoon season : October-November 2006
- Winter season : December 2006-January 2007

The frequency of monitoring was twice a week for four consecutive weeks. The baseline data of ambient air enviornment is generated for the mentioned parameters as given below:

- Suspended Particulate Matter (SPM)
- Respirable Particulate Matter (RPM)
- Sulphur dioxide (SO_2)
- Oxides of Nitrogen (NOx).

Instruments used for sampling

Respirable Dust Samplers APM-451 of Envirotech Instruments are being used for monitoring Suspended Particulate Matter (SPM), Respirable fraction (<10 microns) and

gaseous pollutants like SO_2 and NOx.

Sampling and Analysis Techniques

SPM and RPM present in ambient air is sucked through the cyclone. Coarse and non-respirable dust is separated from the air stream by centrifugal forces acting on the solid particles. The separated particulates fall through the cyclone's conical hopper and are collected in the sampling cap placed at the bottom. The fine dust (<10 microns) forming the respirable fraction of the SPM passes the cyclone and is retained by the filter paper. A tapping is provided on the suction side of the blower to provide a suction for air sampling through a set of impingers.

SPM and RPM have been estimated by gravimetric method. Modified West and Gaeke Method (IS-5182 Part-II, 1962) have been adopted for estimation of SO_2. Jacobs Hochheiser method (IS 5182 Part-II, 1975) has been adopted for estimation of NOx.

The Ambient Air Quality Monitoring stations covered as a part of EIA study are shown in Figure-3.1. The relative direction and distance with respect to dam site are given in Table-3.8. The results of survey conducted in three seasons covered as a part of the study are given in Annexure-II. The summary of results of ambient air quality monitoring are given in Table-3.9. The ambient air quality standards are given in Annexure-III.

TABLE-3.8

Ambient Air Quality Monitoring Stations

SNO	Station	Aerial Distance* (km)	REMARKS
1.	Dam Site	-	Located close to the dam site. The proposed site will be a major construction site, with associated pollution from fugitive as well as point sources. The site is located close to Joshimath-Malari State Highway
2.	Paton	1.12	Located upstream of the dam site. Sampling was done within the village area to assess the impacts of human activities on ambient air quality.
3.	Bhikarpani	6.00	Located within the village area. Sampling was done close to habitation site. The proposed site was related to assess the present level of ait pollution.
4.	Power house site	8.50	Located near powr house site. The station was selected as major construction activities are anticipated in the surrounding area.

Note : * with respect to dam site.

TABLE-3.9

Summary of ambient air quality monitoring in the study area (Unit: μg/m^3)

1.1.1.1.1 Parameter/Location	Average	Maximum	Minimum
Summer season			
RPM			
1.1.1.1.2 Dam Site	45.5	51.2	38.2
Paton	47.7	54.2	40.4
Bhikarpani	43.3	48.4	38.0

1.1.1.1.1 Parameter/Location	Average	Maximum	Minimum
Power house site	42.3	48.6	38.7
SPM			
1.1.1.1.3 Dam Site	123	139	105
Paton	126.1	142	109
Bhikarpani	114.5	129	98
Power house site	112.5	127	104
SO_2			
1.1.1.1.4 Dam Site	7.5	8.2	6.4
Paton	7.6	9.0	6.9
Bhikarpani	7.8	8.6	7.1
Power house site	7.5	8.6	7.1
NOx			
1.1.1.1.5 Dam Site	14.3	18.4	11.2
Paton	15.2	18.2	12.8
Bhikarpani	17.2	18.7	15.4
Power house site	11.8	13.4	10.2
Post-monsoon season			
RPM			
1.1.1.1.6 Dam Site	44.5	50.3	40.2
Paton	49.8	55.8	45.5
Bhikarpani	46.9	52.0	40.8
Power house site	48.5	55.6	44.1
SPM			
1.1.1.1.7 Dam Site	120.9	131	107
Paton	127.0	137	112
Bhikarpani	115.8	129	102
Power house site	124.6	138	114
SO_2			
1.1.1.1.8 Dam Site	8.1	9.5	6.9
Paton	8.9	9.5	7.6

1.1.1.1.1 Parameter/Location	Average	Maximum	Minimum
Bhikarpani	8.7	11.6	7.0
Power house site	7.6	7.8	6.9
NOx			
1.1.1.1.9 Dam Site	16.6	21.9	11.3
Paton	19.7	22.7	15.9
Bhikarpani	19.6	21.9	17.9
Power house site	17.1	21.0	12.6
Winter season			
RPM			
1.1.1.1.10 Dam Site	49.4	55.9	45.6
Paton	51.4	56.6	44.0
Bhikarpani	46.6	50.6	42.8
Power house site	48.2	51.5	45.7
SPM			
1.1.1.1.11 Dam Site	124.1	139	112
Paton	128.0	140	110
Bhikarpani	124.5	135	113
Power house site	119.8	126	114
SO_2			
1.1.1.1.12 Dam Site	8.7	9.6	7.0
Paton	9.2	9.9	7.7
Bhikarpani	8.1	9.0	7.0
Power house site	7.6	9.0	7.0
NOx			
1.1.1.1.13 Dam Site	18.3	22.0	11.0
Paton	19.8	22.7	17.9
Bhikarpani	16.8	18.0	13.6
Power house site	18.6	22.6	15.9

Observations on ambient RPM levels

The average RPM level as observed at various monitoring stations in the study area ranged from 42.3 to 51.4 µg/m^3 in various seasons. The average RPM level observed at various sampling stations in various seasons covered as a part of the CEIA study are given in Figure-3.5. The highest RPM value of 55.9 µg/m^3 was recorded near Dam Site in winter season. All the values of RPM monitored during the field survey were well within the permissible limit of 100 µg/m^3 for residential, rural and other areas (Refer Annexure-III).

Observations on ambient SPM levels

The maximum SPM level observed in survey conducted during various seasons was observed to be 140 µg/m^3 in winter season. The average SPM level at various monitoring stations ranged from 112.5 to 128.0 µg/m^3. The SPM level at various stations was observed to be well much below the permissible limit of 200 µg/m^3, specified for residential, rural and other areas at various stations covered during the survey. (Refer Annexure-III). The average SPM level observed at various sampling monitored for various seasons as a part of the study area are shown in Figure-3.6.

Observation on ambient SO_2 levels

The maximum SO_2 level of 11.6 µg/m^3 was observed at station located at village Bhikarpani in the post-monsoon season. The SO_2 level observed at various stations

during various seasons covered as a part of the study was much lower than the permissible limit of 80 $\mu g/m^3$ specified for residential, rural and other areas (Refer Annexure-III). The average SO_2 level observed in ambient air at various stations for different seasons covered as a part of the EIA study are shown in Figure-3.7.

Observations on NOx levels

The highest average NOx values of 22.7 $\mu g/m^3$ was observed at station located at Paton in post-monsoon and winter seasons. The NOx level observed at various sampling stations monitored under various seaons was much lower than the permissible limit of 80 $\mu g/m^3$ for residential, rural and other areas (Refer Annexure-III). The average NOx levels observed at various sampling locations in different seasons covered as a part of the EIA study are shown in Figure-3.8.

Conclusions

Based on the findings of the ambient air quality survey, conducted for the three seasons, it can be concluded that the ambient air quality is quite good in the area. Values of various parameters, e.g. SPM, RPM, SO_2 and NOx were well within the permissible limits specified for residential, rural and other areas. The absence of pollution sources and low population density in the area are the attributable factors for excellent quality of ambient air in the area.

3.3.3 Ambient Noise Level

The baseline status of the ambient noise level was monitored for three seasons. The details are given as below:

- Summer season : April 2006.
- Post-Monsoon season : October 2006
- Winter season : December 2006

The noise levels were monitored continuously from 6 AM to 9 PM at each location and hourly equivalent noise level was measured. Sound Pressure Level (SPL) measurement in the ambient environment was made using sound level meter. The sampling locations are listed in Table-3.10. The location of noise monitoring stations is given in Figure - 3.1. The ambient noise level monitoring results, which were observed during the field survey various seasons, is given in Tables 3.11 to 3.13. The noise standards for various categories is given in Annexure-IV. The day time equivalent noise level observed at various sampling stations in different seasons covered as a part of the EIA study are given in Table-3.14 are depicted in Figure-3.9.

TABLE-3.10

Noise monitoring locations

Sample No.	Location	Aerial Distance (km)*	Direction
N1	1.1.1.1.14 Dam Site	-	-
N2	Paton	1	North
N3	Bhikarpani	6	South
N4	Power house site	8.5	South

Note : * with respect to dam site

TABLE-3.11

Hourly equivalent noise levels in the study area-Summer season (Unit:dB(A))

Time	Dam site	Paton	Bhikarpani	Power house site
6 – 7 A.M.	33	34	34	33
7 – 8 A.M.	34	34	35	33
8 -9 A.M.	35	34	36	36
9-10 A.M.	38	34	38	36
10-11 A.M.	37	33	40	38
11 am - 12 Noon	37	40	38	36
12 noon – 1 P.M.	38	41	41	37

Time	**Dam site**	**Paton**	**Bhikarpani**	**Power house site**
1 –2 PM	36	40	42	37
2 – 3 PM	34	38	39	37
3 – 4 PM	38	38	40	38
4 – 5 PM	38	37	40	37
5 – 6 PM	37	40	38	36
6 – 7 PM	34	33	35	35
7 – 8 PM	32	39	34	34
8 – 9PM	32	34	34	33

TABLE-3.12

Hourly equivalent noise levels in the study area-Post-monsoon season (Unit:dB(A))

Time	**Dam site**	**Paton**	**Bhikarpani**	**Power house site**
6 – 7 A.M.	32	32	32	33
7 – 8 A.M.	34	35	35	34
8 -9 A.M.	36	36	35	35
9-10 A.M.	39	38	37	37
10-11 A.M.	38	38	40	38
11 am - 12 Noon	37	38	38	37
12 noon – 1 P.M.	39	38	39	37
1 –2 PM	37	37	39	37
2 – 3 PM	36	36	38	36
3 – 4 PM	36	36	38	36
4 – 5 PM	39	39	40	38
5 – 6 PM	38	38	39	35
6 – 7 PM	37	38	38	35
7 – 8 PM	35	36	37	34
8 – 9PM	34	35	36	33

TABLE-3.13

Hourly equivalent noise levels in the study area-Winetter season (Unit:dB(A))

Time	**Dam site**	**Paton**	**Bhikarpani**	**Power house site**
6 – 7 A.M.	32	33	33	32
7 – 8 A.M.	33	34	34	33
8 -9 A.M.	34	35	34	33
9-10 A.M.	34	36	37	34
10-11 A.M.	35	36	37	35
11 am - 12 Noon	36	36	36	36
12 noon – 1 P.M.	37	38	38	36
1 –2 PM	38	39	39	37
2 – 3 PM	38	39	40	36
3 – 4 PM	38	39	40	36
4 – 5 PM	38	39	39	36
5 – 6 PM	37	38	38	36
6 – 7 PM	36	35	36	35
7 – 8 PM	34	33	35	34
8 – 9PM	33	32	33	33

TABLE-3.14

Day time equivalent noise level observed in various seasons (Unit: dB(A))

Location	**Zone**	**Summer**	**Post-monsoon**	**Winter**

Location	Zone	Summer	Post-monsoon	Winter
Dam Site	Residential	34.5	36.9	36.0
Paton	Residential	36.9	37.0	36.7
Bhikarpani	Residential	37.9	37.8	37.2
Power house site	Residential	35.7	36.0	35.0

The day time equivalent noise level at various sampling stations ranged from 34.5 to 37.9 dB(A) in summer season. In post-monsoon season, day time equivalent noise level ranged from 36.0 to 37.8 dB(A) at various sations. Similarly in winter season, day time equivalent noise level at various stations ranged from 35.0 to 37.2 dB(A). The noise levels were observed to be well within permissible limits specified for residential area (Refer Annexure-III).

3.4 LAND USE

3.4.1 LAND USE PATTERN

Landuse describes how a patch of land is used (e.g. for agriculture, settlement, forest), whereas land cover describes the materials (such as vegetation, rocks or buildings) that are present on the surface. Accurate land use and land cover identification is the key to most of the planning processes.
The land use pattern of the study area has been studied through digital satellite imagery data. Digital IRC-1C/1D and Panchromatic remote sensing satellite data was procured from National Remote Sensing Agency (NRSA), Hyderabad. The data was processed through ERDAS software package available with WAPCOS. Ground truth studies were conducted in the area to validate various signals in the satellite images and correlate them with different land use domains. Vegetation index was estimated and the image enhancement was done converting it into a single band data, which is called grey set. The grey set was merged with the coloured FCC. This image was then classified using the prominent signatures extracted based on the past experience. The FCC and classified images of the study area are shown in Figures-3.10 and 3.11 respectively. The land use pattern of the study area is outlined in Table-3.15.

TABLE-3.15

Land use pattern of the study area

Landuse Cover	Area in ha (% of Study area)
Open vegetation	**5681 (13.13)**
Medium Vegetation	**19629 (45.35)**
Scrubs	**768 (1.77)**
Barren rocky outcrop	**14112 (32.61)**
Snow cover	**2891 (5.52)**
Water	**689 (1.59)**
Settlements	**10 (0.02)**
Total	48280 (100)

Note : **Figure in brackets indicate percentage.**

The major land use category in the study area is Medium vegetation and barren land and which account for 45.35% and 32.61% of the study area respectively. The other dominant landuse categories are open vegetation (13.13%). The area under snow cover and scrubs is 5.52% and 1.77% of the study area respectively.

3.4.2 GEOLOGY

Regional Geology

The Uttarakhand Himalayas form central part of the Himalaya folded belt exposes four major tectonic belts designed as foothill Shivalik belt, lesser Himalayan belt, and central Crystallines and Tethyan belt.

The project area falls in the Main Central Crystalline belt, which consists of Mylonite gneisses, phylltes, garnetiferous schist, calc, silicate rock and quartzites with associated migmatite syntectnonic granite gneisses and late to post tectonic tourmaline granite.

The main structural discontinuities running through the entire length of Uttarakhand is on the Main Central Thrust (MCT) which is locally referred as the Munisiari Thrust. This

thrust has brought the Central Crystallines in juxtaposition with rocks of low-grade complexes (lesser Himalaya belt of rock), which in a sense marks southern boundary of lesser Himalayas. Apart from the regional thrust following the Himalaya trends, a number of faults of transverse disposition dissects and displace the rock gneiss.

Geology of project area

The project area is located in Goriganga river section, of the main Sharda Basin in Uttarakhand Himalayas. The river Goriganga flows in a general north-south direction at the project site. The hill range on either side form high craggy smooth surfaces due to snow action and rise up to EL. 3000 m and above, the valley is marked by a number of glacial deposits indicating evidences of past glacial erosion and a number of glacial and fluvio-glacial debris zone is a feature along the course of the river.

The rocks of the lesser Himalayas group mostly consisting of quartzites with phyllites and basic rocks are exposed in the river section and power house slopes of the project area. These rocks types form prominent hill slope on either side of the river and well exposed in the river section and a tributary stream. These are followed towards north by Central Crystalline which consist of Quartz felspathic, gneisses, migmaticic gneisses. Biotite gneisses, calc, silicate gneisses, Mica schists, porphyritic gneisses, schistose quartzite, chlorite schists, phyllites etc.

All the above types of crystalline rock are exposed in the project area. The dam site, tunnel, surge shaft will be located in the crystalline rocks and lower quartzite's of lesser

Himalaya may be encountered in the powerhouse area.

The groups of rocks generally strike east-west to ENE-WSW with dip of 20^0 - 45^0 and sometimes steeper towards the river i.e. upstream. The rock groups are well jointed with four prominent systems.

The lesser Himalayas rocks are marked by the MCT (Main Central Thrust) termed Munsiyari Thrust at the powerhouse area. This MCT is supposed to be a ductile shear zone. A number of faults trending N.S. is evidenced from displacement of lithounits. A number of springs (hot and cold) have been noted in the project area.

Geology of dam site

The rock type exposed at the dam site is porphyoblastic quartz felspathic mica gneisses with layers of packeved schist, varying in thickness form, few cms to a metre or so and quartz veins. Fine-grained quartz mica gneisses are also exposed in the area. The joints are fairly long persistent and mostly clean. The southerly dipping joints are low dipping also and are smooth and plain.

On the right bank from the river bed level up to few meters heights there are fairly continuous exposures of rock along the course of the river and after a distance, it forms steep scrap up to track level and beyond. On the left bank, rock exposure continues as a continuous steep scarp face up to ±80 m height beyond which it is covered by overburden.

Head Race Tunnel

The proposed head race tunnel alignment passes through a rough and rugged terrain as the left bank of river Goriganga aligned generally in a N-S direction with higher peak rising up to ± 2500 m. The tunnel rock is marked by three major slides, on the hill slope, which makes it obligatory to choose a tunnel alignment mostly along the peaks of ridges.

The tunnel will encounter the Central crystalline groups of rocks comprising quartz felsparic gneisses, coarse is perphyllite fine grained quartz mica gneisses. With layers of mica schists, calc. silicate rocks, garnetiferous mica schists, quantitative and phyllites.

Power House Site

The power house is proposed to be constructed on a flat terrace on the left bank of River Goriganga. The terrace measure a length of more than 80 m with a maximum width of 74 m. The river section close to the power house site is occupied by fluvio-glacial deposits comprising boulders of gneisses, quartzite, schist and phyllites of varied types with sand in between. The terrace in the river section is occupied by ill-assorted boulders of gneissic schist quartzites and few granite pieces with sand.

The hill face rising from the flat terrace is occupied at lower levels by jointed sugary white quartzites overlain by sericite phyllites and quartz mica schist, gneisses. The structure MCT is expected to pass through terrace area of power house. The foliation strikes east-west and dip at 20^0 to 45^0 towards north i.e. upstream. These rocks are

exposed on the slopes of 30^0 to 45^0 and form prominent exposures. No visible signs of instability are noted on the hill slopes warranting special care for layout of engineering structures.

3.4.3 Seismology

Earthquake activity in Uttarakhand has been prolific in the last two hundred years. The state comes under Seismic Zones IV and V of Seismic Zoning Map of India, which correspond to Zone Factors of 0.36 and 0.24 (effective peak ground acceleration in terms of 'g') (IS 1893 part 2002).

Uttarakhand, including western part of Nepal Himalayas has been classified in to four hazard classes as very high (VHH), High (HH), moderate (MH) and (LH). (P.Pande 1996)The HH zone lying between energy contours 10^{15} and 10^{17} ergs km^{-2} yr^{-1} occupies 36% area of Uttarakhand and encompasses major parts of districts Uttarkashi, Chamoli, Bageshwar, Almora, Pithoragarh and Champawat. In these districts, there is a possibility of occurrence of earthquake of $6<M<7$ once in every 100 years. The MH zone, where there is possibility of $5<M<6$ in every 100 years, covers 41% of the area covered by the above referred district. The major towns falling under this zone include Purola, Tehri, Rudraprayag and Haridwar.

GSI and BRGM France carried out an exercise on seismic hazard assessment of Northwest India in 1994-95 (P. Pandey 1996). It evaluated the Peak Ground Acceleration (PGA) values using a probabilistic approach. In Uttarakhand – West Nepal, the PGA varied from 130 cm/sec^2 in the Foot Hill region to 340 cm/sec^2 in the Indo-Nepal border, respectively, corresponding to a return period of 475 years. These values were of the order of 290-320 cm/sec^2 in the Uttarkashi- Chamoli region.

The project area lies in a high seismic zone and falls within Zone-IV of the seismic zoning map of India. Seismologically, the area is active. Many earthquakes of high magnitude have occurred in this region viz., at Dharchula (magnitude 7.5 on Richter scale; 1916), Kapkot (magnitude 6.6 on Richter Scale; 1958), and near West Nepal-India Border (magnitude 6.1 on Richter Scale; 1965 and 1980). The area is known to have frequent occurrences of low level micro-seismicity. The area is known to have one or two earthquakes per month of small magnitude. The maximum earthquake intensity map prepared by Kaila and Sarkar (1978) indicates that the project area falls in the intensity zones of VIII and IX on the Modified Mercalli Scale. The maximum destruction observed in this intensity zone has mainly been breaking of pipelines, collapse and damage of buildings and initiation of ground cracking.

The seismicity in Himalayas is mainly influenced by the Tectonic planes of regional dimensions viz, Main Central Thrust (MCT), Main Boundary Fault (MBF) and Himalayan Frontal Thrust (HFT), which is a tectonic feature arising further south of Shivaliks. The MCT passes through the catchment area in Goriganga basin near Lilam. The other regional lineaments located in the study area are the Chhiplakot and Munsiyari Thrust. Geologists at present reckon MCT as seismo-tectonically less active as compared to MBF and HFT, as the dissipation of strain energy is more uniform in MCT. On the other hand, the dissipation of energy has been mainly through high magnitude earthquakes along MBF. Gupta (1983) plotted epicentres of major earthquakes and found that none of the major earthquakes were located in the vicinity of MCT, Munsiyari and Chhiplakot Thrusts. However, such conclusions must be treated with caution. It needs to be mentioned that the record of epicentres of earthquakes in India is available for a shorter period of time. Recent experience suggests that many thrust planes which were considered tectonically inactive are actually not so and earthquakes can occur.

It needs to be specifically indicated that most of the Himalayan earthquakes occur due to the subduction of Indian plate in the Chinese plate and therefore the source of most of the earthquakes is generally at shallower depth. Shallow sources can generate devastating ground waves.

The Dharchula-Kapkot belt in India and the Bajang areas of Nepal are frequently rocked by earthquakes of magnitudes between 5 and 6 on Richter scale. Kalia and Narayan (1976) have assessed that this part of the Himalayas has the highest seismicity any where in the Himalayas. Their findings also show a conspicuous transversal north-easterly trend spawning the high seismicity belt of Delhi with that of the north-eastern Kumaun. The linear distribution in a northerly direction of the epicentres in the Dharchula area is suggestive of tear movement along the transverse faults concommitant with the strike-slip movements along the thrust planes. The tightly compressed synclinal Chhiplakot crystalline in the Bajang-Dharchula area and the wedging up of the autochthronous base in the Sirdang belt is responsible for not only the higher number of earthquakes but also for the greater depth of the foci of the earthquakes.

3.4.4 Soils

Soil is the product of geological, chemical and biological interactions. The soil in a region vary according to altitude and climate. The soil in the project and the study areas, like any other region of Himalayas are young. The vegetal cover is one of the most important influencing factor characterizing the soil types in a region. Soil on the slope above 30^{o}, due to erosion and mass wasting processes, are generally shallow and usually have very thin surface horizons. Such soils have medium to coarse texture. Residual soils are well developed on level summits of lesser Himalayas, sub-soils are

deep and heavily textured. High contents of organic matter are found in its `A' horizon and are acidic in nature.

Valley soils are developed from colluvium and alluvium brought down from the upper slopes and thus, are deposited in the valleys and low-lying tracts or river terraces as a process of aggradation. In general north facing slopes support deep, moist and fertile soils. The south facing slopes on the other hand, are too precipituous and well exposed to denudation.

Based on various samples, a negative correlation has been found between the soil, pH and altitude. The decrease in pH with increase in elevation is possibly because of leaching out of calcium and magnesium from surface soils. The soils are invariably rich in potash, medium in phosphorus and por in nitrogen content. Only a few cultivated soils are rich in organic matter.

The soil quality has been mnitored for three seasons as a part of the EIA study. The seasons covered as a part of the study are listed as below:

- Summer season : April 2006.
- Monsoon season : July 2006
- Winter season : December 2006

The results of soil quality analysis for conducted for various seasons are given in Tables-3.16 to 3.18.

TABLE-3.16

Results of soil sampling analysis (Summer season)

Sample No.	1.1.1.1.15 Parameters				
	PH	AVAILABLE POTASSIUM AS K_2O_5 (KG/HA)	Available Nitrogen (kg/ha)	Available Phosphorus (kg/ha)	Organic Matter (%)
S1	6.82	130	380	2.8	1.87
S2	6.4	105	364	2.7	1.42
S3	6.84	126	321	2.4	1.60
S4	6.68	140	284	1.8	1.24
S5	7.02	220	292	1.2	1.19
S6	7.11	180	316	1.6	1.62
S7	6.92	172	484	1.8	0.84
S8	6.88	166	584	1.2	2.24
S9	7.08	152	261	1.8	1.78
S10	6.74	126	273	1.2	1.29

TABLE-3.17

Results of soil sampling analysis (Post-monsoon season)

Sample No.	1.1.1.1.16 Parameters				
	PH	AVAILABLE POTASSIUM AS K_2O_5 (KG/HA)	Available Nitrogen (kg/ha)	Available Phosphorus (kg/ha)	Organic Matter (%)
S1	6.8	132	384	2.7	1.82
S2	6.3	115	355	2.7	1.45
S3	6.8	120	326	2.5	1.65

Sample No.	1.1.1.1.16 Parameters				
	PH	AVAILABLE POTASSIUM AS K_2O_5 (KG/HA)	Available Nitrogen (kg/ha)	Available Phosphorus (kg/ha)	Organic Matter (%)
S4	6.7	127	286	1.9	1.39
S5	7.0	222	305	1.0	1.23
S6	7.0	167	309	1.5	1.60
S7	7.0	167	480	1.5	0.87
S8	6.9	160	565	1.2	2.28
S9	7.03	158	260	1.6	1.70
S10	6.72	129	276	1.3	1.27

TABLE-3.18

Results of soil sampling analysis (Winter season)

Sample No.	1.1.1.1.17 Parameters				
	PH	AVAILABLE POTASSIUM AS K_2O_5 (KG/HA)	Available Nitrogen (kg/ha)	Available Phosphorus (kg/ha)	Organic Matter (%)
S1	6.8	143	378	2.6	1.90
S2	6.4	115	367	2.6	1.48
S3	6.8	129	328	2.8	1.68
S4	6.6	140	280	1.7	1.27
S5	7.1	220	298	1.4	1.29
S6	7.3	180	310	1.8	1.65
S7	6.8	175	478	1.8	0.89
S8	6.8	165	567	1.4	2.20
S9	6.94	154	268	1.8	1.77
S10	6.70	125	270	1.3	1.34

In a hydro-electric project, no significant impact on soil quality is expected barring, soil

pollution at local level due to disposal of construction waste. For amelioration of such impacts appropriate management measures are recommended. The pH of soil at vairous sites lies within neutral range. The levels of various nutrients indicates low to moderate soil productivity.

3.4.5 Agriculture

Agriculture is the major occupation in the project area. Cereals are the major crops grown in the area as they account for almost 97% of the cropped area. Rice and wheat are the major cereals as they together account for more than 64% of the cropped area. The other crops grown include barley, masoor, etc.

The study area in general, depends on rainfall for meeting its water requirement. Rainwater and snow are absorbed within the soil, which then percolates through pores and crevices and reappears in the form of springs. During monsoons, the number and discharge of the springs increases. The supply of water in the perennial springs reduces in winter and summer seasons. Spring water is generally, collected in a tank and stored for irrigation during the periods of scarcity. The spring water is also used for domestic use in many areas. The water is carried through surface channels called `gools' into the fields located at lower levels.

The major sources of irrigation are canals and `gools' and tanks and pump sets installed on level sources. The carriage of water through `gools' requires a lot of labour and

patience, though, capital requirement is less. For this purpose, large rivers are not useful, and it is only the smaller streams and rivulets forming tributaries to the larger rivers and springs are utilized for taking out `gools' to carry water to various places. At the source, a small dam/bund like structure is built to ensure regular flow, earthen channels, lined with stones offtakes from the dams. The intensity of irrigation is poor in the catchment area which is generally the case in hilly region.

The fertilizer consumption in Munsiyari development block is given in Table-3.19.

TABLE-3.19

Fertilizer consumption in Munsiyari Development Block

Fertilizer	Consumption (tones/year)
Nitrogen	23
Phosphatic	29
Potash	4
Total	**56**

The total cropped area in Munsiyari Development Block is 17683 ha. Thus, fertilizer dosing works out 3.2 kg/ha, which is less than 10% of the national average of 35 kg/ha. Most of the land holders are marginal farmers, thus, do not have sufficient resources to use fertilizers in a large way.

3.5 BIOLOGICAL ENVIRONMENT

3.5.1 Vegetation

The altitude in the study area ranges from 1200 m to 4000 m. Forests or vegetation in an area varies with altitude and topography. The major forest type observed in the study area including the project area is dense mixed Banj (Oak) forest. At higher elevations within the study area, scrubs are observed.

The following forest categories are observed in the study area:

- Oak forests
- Deodar forests
- Himalayan pastures

The above referred forest categories are briefly described in the following paragraphs:

Oak forests

These forests are observed upto an altitude of 1800 m to 2750 m and mainly include broad leaved forests. The main species of this type of forest observed in the catchment area include Banj (*Quercus leactricophora*), Faliant (*Quercus glauca*), Rigia (*Quercus lanuginosa*), Utis (*Alnus nepalensis*), Burans (*Rhododendron arboreum*) and Kajal (*Myrica sapida*), etc.

Deodar forest

Deodar (*Cedrus deodar*) forests are observed from an elevation of 1350 m to 2050 m. However, good quality Deodar forests are observed at elevation between 1800 m to 2050 m. The main associates of Deodar in this region are Chir (*Pinus roxburghii*), Kilnosa (*Berbesis asiatica*), Himsalu (*Rubus ellepticus*), Kunja (*Rosa musckala*) and Guru (*Sarcocca saligna*), etc.

Himalayan Pastures

Pastures are also observed in the catchment area between the 1000m to 3000 m elevation. These pastures can be further divided into the temperate pasture, Alder pasture and Alpine pastures, etc. In the lower portion of the catchment, Utis (*Alnus nepalensis*), Baupipal (*Populus ciliata*), and Panger (*Aesculus indica*) are common. In the middle portion of the catchment, Kumeria (*Hetropogon contortus*) and Salam (*Chrysopogon gryllus*) are observed. In the upper reaches Hipophy scrub, Himalayan pastures and Alpine pastures are found at an altitude of more than 2400 m. The main species includes Chuk (*Hippophae salicifolia*), Bamboo (*Dendrocalamus strictus*), Banpipal (*Populus ciliata*), Bhojpatra (*Betula utilis*), Chimula (*Rhododendron campanulatum*) and Kala Hinsalu (*Rubus lasiocarpus*).

3.5.1.1 Field studies

The terrestrial ecological survey has been conducted for three season. The details are given as below:

- Summer season : April 2006.
- Monsoon season : July 2006
- Winter season : December 2006

The objectives of the ecological survey were to:

- prepare a checklist of flora in the study area.
- list the rare/endangered, economically important and medicinal plant species.
- determine frequency, abundance and density of different vegetation components.

(i) Sampling Sites

The sampling sites covered under Terrestrial Ecological survey are listed as below and are shown in Figure-3.1.

- In submergence area, close to village Paton
- Near Village Lilam
- Near Power house site.

(ii) Ecological survey

Considering the difficult terrain, quadrate method was used for sampling of the vegetation. Taking into consideration the size of the vegetation patches, twenty five random quadrates of 10 x 10 m size were laid to study the trees and shrubs, and twenty five random 1x 1 m quadrates were laid to study the herbaceous component at each sampling site. During the survey, number of plants of different species in each quadrate was identified and counted. The height of individual tree was estimated using an Abney level/Binocular and the DBH of all trees having height more than 8 m was measured.

Based on the qudrate data, frequency, density and cover (basal area) of each species were calculated. The IVI values for different tree species were determined by summing up the Relative Density, Relative Frequency and Relative Cover values. The Relative Density and Relative Frequency values were used to calculate the IVI of shrubs and herbs. The volume of wood for trees was estimated using the data on DBH (measured at 1.5 m above the ground level) and height. The volume was estimated using the formula: $\pi r^2 h$, where r is the radius and h is the estimated height of the bole of the tree. The data on density and volume were presented in per ha basis.

Species diversity indices viz., Shannon index of general diversity (H) and Evenness index (e) were computed using the following formula:

Shannon index of general diversity (H): $- \Sigma(ni/N)\log_2(ni/N)$

where n_i = number of individuals of the species

N = total importance of individuals of all species

Evenness index (e): H/ log S

where H = Shannon index of general diversity

and S = number of species

IVI values were used for computation of both the diversity indices.

During the vegetation survey, herbaria were prepared for the plants which had flowers. The Red Data Book of India and other available literature, flora and herbarium pertaining to the rare/endangered species of Western Himalayas were referred to identify the endemic, rare and other threatened categories of plants.

3.5.1.2 Floristic composition

A total number of 73,71 and 66 plant species were recorded during floristic survey in the various sampling locations in summer, monsoon and winter season, respectively. The number of plant species belonging to different groups is summarised in Table-3.20. No rare and endangered species was reported from the project area and its surroundings. The list of various floral species observed in the study area is given in Table-3.21.

TABLE-3.20

Summary table of plants belonging to different groups listed during the vegetation survey

Plant Group	No. of species		
	Summer	Monsoon	Winter
Tree	26	26	26
Shrub	20	15	18
Herb	27	30	22
Total	**73**	**71**	**66**

TABLE - 3.21

List of floral species observed in the study area

S.No.	Botanical Name	Local Name
	TREES	
1.	*Aesandra butyracea* **Roxb**.	Chiura
2.	*Aesculus indica* **Colebr.**	Pangar
3.	*Alnus nepalensis* **D. Don**	Utees
4.	*Betula alnoides* **Buch-Ham**	Saur Bhojapatra
5.	*Betula utilis* **D. Don**	Bhojpatra
6.	*Carpinus viminea* **Lindley**	Putli
7.	*Cedrella toona* **Hiern**	Tun
8.	*Celtis australis* **Hook.**	Kharik
9.	*Cinnamon tamala* **Buch-Ham**	Dalchini, Tejpat
10.	*Dalbergia sissoo* **Roxb.**	Sisham
11.	*Dandroclamus strictus* **Nees**	Bans
12.	*Ehretia laevis* **Roxb.**	Chamror
13.	*Erythriana arborescens* **Roxb.**	Dhauldhak
14.	*Ficus glomerata* **Roxb.**	Gular
15.	*Ficus hispida* **L.**	Totmila

S.No.	Botanical Name	Local Name
16.	*Ficus palmate* **Forsk**	Bedu / Anjir
17.	*Ilex excelsa* **Hook.**	Gauloo
18.	*Juglans regia* **L.**	Akhrot
19.	*Litsea glutinosa* **Robinson**	Singrau/Maida lakri
20.	*Myrica esculenta* **Buch-Ham**	Kaphal
21.	*Phoenix sylvestris* **L.**	Khajoor
22.	*Pinus wallichiana* **AB Jeckson**	Kail
23.	*Pterocarpus marsupium* **Roxb**.	Bija Sal
24.	*Quercus leucotrichophora* **Camus**	Banj
25.	*Rhamnus persica* **Boissier**	Chirla
26.	*Rhododendron arboreum* **Smith**	Burans
27.	*Rhus japonica* **L.**	Beshmeel
28.	*Salix acutifolia* **Hook.**	Bhains
29.	*Sapindus mukorossi* **Gaertner**	Reetha
30.	*Sapium insigne* **Royle**	Khinna
31.	*Sorbus aucuparia* **L.**	Mohli
32.	*Spondias pinnata* **Kurz**	Amra
33.	*Trewia nudiflora* **L**.	Gutel
	SHRUBS	
1.	*Ageratum conizoides* **L**.	Gundrya
2.	*Artemisia vulgaris* **Clarke**	Kunja
3.	*Artemisia nilagirica* **Clarke**	Kunja
4.	*Arundo donax* **L.**	Tinta
5.	*Berberis aristata* **DC**	Kingor
6.	*Berberis lycium* **Royle**	Kingor
7.	*Bistorta amplexicaulis* **D. Don**	Kutrya
8.	*Boehmeria platzphylla* **D. Don**.	Khagsa
9.	*Cannabis sativa* **L.**	Bhang
10.	*Cissus rependa* **Vahl**	Pani-bel
11.	*Colebrookia oppositifolia* **Smith**	Binda
12.	*Cotoneaster microphyllus* **Wall**	Bugarchilla
13.	*Callicarp arboria* **Roxb**.	Kumahr
14.	*Duchesnea indica* **Andrews**	Bhiun-Kaphal
15.	*Girardinia diversifolia* **Link**	Bhainsya Kandali,
16.	*Indigofera heterantha* **Wall**	Sakina
17.	*Indigofera pulchella* **Roxbr.**	Saknya
18.	*Lecanthus peduncularis* **Royle**	-

S.No.	Botanical Name	Local Name
19.	*Pyracantha crenulata* **D. Don**	Ghingaru
20.	*Reinwardtia indica* **Dumortier**	Phunli
21.	*Rubus paniculatus* **Smith**	Kala Hinsar
22.	*Salix elogans* **Wall**	Bhotiana
23.	*Smilax aspera* **L.**	Kukurdara
24.	*Spermadictyon sauveolens* **Roxb.**	Padera
25.	*Urtica dioica* **L.**	Kandali
26.	*Zenthoxylum armetus* **DC**	Timroo
	HERBS	
1.	*Acorus calamus* **L.**	Bauj, Bach
2	*Agrostis nervosa* **Nees**	
3.	*Anaphalis adnata* **Wall**	Bugla
4.	*Anemone vitifolia* **Buch-Ham**	Mudeela
5	*Apium leptophyllum* **Persoon**	-
6.	*Arabidopsis thaliana* **L**.	-
7.	*Artemisia japonica* **Thunb.**	Patee, Pamsi
8.	*Bergenia ciliata* **Haworth**	Silpara,
9.	*Bistorta amplexicaulis* **D. Don**	Kutrya
10	*Centella asiatica* **L.**	Brahmibuti
11.	*Clematis tibatiana*	
12.	*Curcuma aromatica* **Salisbury**	Ban Haldi
13.	*Cymbopogon flexuosus* **Watson**	-
14	*Cymbopogon msrtinii* **Watson**	Priya-ghas
15.	*Cynodon dactylon* **L.**	Dubla,
16.	*Deyeuxia scabescens*	-
17.	*Echinops cornigerus* **DC.**	Kantela
18.	*Eragostis poaeoides* **P. Beaue**	-
19	*Eulaliopsis bineta* **Hubbard**	Babula
20.	*Impatiens balsamina* **L**	
21.	*Iris kumaonensis* **D. Don**	Phyaktuli
22.	*Polygonum glabrum* **Willd**	-
23.	*Polygonum recumbens* **Willd**	-
24.	*Reinwardtia indica* **Dumortier**	Phiunli
25.	*Rumes nepalensis* **Sprengel**	Khatura
26.	*Solanum nigrum* **L.**	Makoi
27.	*Stephania glabra* **Roxb.**	Gindadu
28.	*Themeda anathera* **Hackel**	Golda
29.	*Thespesia lampas* **Cav**	Jangli Bhindi

S.No.	Botanical Name	Local Name
30.	*Torilis leptophylla* **DC**	-
31.	*Vilo biflora* **L**	Vanafsa

3.5.1.3 Dominance of various floral speies

The dominance characteristics, i.e. frequency, density, basal cover and IVI value of trees, shrubs, herbs at various sampling sites are observed during the survey are given in Tables-3.22 to 3.24.

TABLE – 3.22

Frequency, density, abundance, basal area and importance value index (IVI) of trees at sampling station in submergence area

Plants	Frequency (%)	Density (ind.ha^{-1})	Abundance	Diversity index (Shannon Weiner	Basal area (ha)	IVI
Summer season						
Trees						
Aesandra butyracia	24	40	1.67	0.247	15.015	5.714
Aesculus indica	44	64	1.45	0.329	26.997	10.476
Alnus nepalensis	56	80	1.43	0.371	21.386	13.333
Betula alnoides	28	40	1.43	0.247	16.890	6.667
Erythriana arborescens	52	80	1.54	0.371	6.845	12.381
Ficus glomerata	20	40	2.00	0.247	12.701	4.762
Ilex excelsa	36	40	1.11	0.247	16.245	8.571
Juglans regia	32	48	1.50	0.277	21.386	7.619
Myrica esculenta	16	52	3.25	0.291	14.537	3.810
Pinus wallichiana	24	32	1.33	0.213	57.760	5.714
Quercus leucotrichophora	40	56	1.40	0.304	13.834	9.524
Rhamnus persica	20	40	2.00	0.247	6.771	4.762
Rhododendron arboretum	28	40	1.43	0.247	16.359	6.667
Total		**652**		**3.639**		

Plants	Frequency (%)	Density (ind.ha^{-1})	Abundance	Diversity index (Shannon Weiner	Basal area (ha)	IVI
Shrubs						
Artemisia vulgaris	48	64	1.33	0.275	0.0253	18.168
Arundo donax	52	72	1.38	0.295	0.0344	20.918
Berberis lyceum	40	40	1.00	0.203	0.0308	14.921
Bistorta amplexicaulis	32	40	1.25	0.203	0.0578	17.299
Cannabis sativa	64	96	1.50	0.349	0.0308	25.034
Cissus repanda	20	40	2.00	0.203	0.0415	13.234
Colebrookia oppositifolia	32	48	1.50	0.229	0.0578	18.208
Cotoneaster microphyllus	40	52	1.30	0.241	0.0308	16.284
Girardinia diversifolia	100	140	1.40	0.422	0.0288	35.397
Indigofera heterantha	40	48	1.20	0.229	0.0162	13.878
Indigofera pulchella	28	40	1.43	0.203	0.2738	45.649
Pyracantha crenulata	32	40	1.25	0.203	0.0392	14.804
Rubus paniculatus	48	60	1.25	0.264	0.0415	19.881
Urtica dioica	64	100	1.56	0.357	0.0370	26.326
Total		**880**		**3.674**		
Herbs						
Acorus calamus	48	72	1.50	0.271	0.0039	6.452
Anaphalis adnata	56	56	1.00	0.230	0.0035	7.527
Anemone vitifolia	64	68	1.06	0.261	0.0037	8.602
Apium leptophyllum	40	52	1.30	0.219	0.0016	5.376
Arabidopsis thaliana	48	48	1.00	0.208	0.0026	6.452
Artemisia japonica	60	104	1.73	0.337	0.0061	8.065
Bergenia ciliata	8	8	1.00	0.055	0.0097	1.075
Bistorta amplexicaulis	40	40	1.00	0.184	0.0022	5.376
Clematis tibetana	40	48	1.20	0.208	0.0005	5.376

Plants	Frequency (%)	Density (ind.ha^{-1})	Abundance	Diversity index (Shannon Weiner	Basal area (ha)	IVI
Curcuma aromatica	40	40	1.00	0.184	0.0010	5.376
Cynodon dactylon	80	160	2.00	0.420	0.0020	10.753
Deyeuxia scabescens	28	36	1.29	0.171	0.0051	3.763
Iris kumaonensis	24	32	1.33	0.157	0.0065	3.226
Polygonum recumbens	40	56	1.40	0.230	0.0058	5.376
Reinwardtia indica	60	96	1.60	0.322	0.0071	8.065
Thespesia lampas	68	100	1.47	0.329	0.0072	9.140
Total		**1016**		**3.786**		
Monsoon season						
Trees						
Aesandra butyracia	24	40	1.67	0.247	15.015	5.714
Aesculus indica	44	64	1.45	0.329	26.997	10.476
Alnus nepalensis	56	80	1.43	0.371	21.386	13.333
Betula alnoides	28	40	1.43	0.247	16.890	6.667
Erythriana arborescens	52	80	1.54	0.371	6.845	12.381
Ficus glomerata	20	40	2.00	0.247	12.701	4.762
Ilex excelsa	36	40	1.11	0.247	16.245	8.571
Juglans regia	32	48	1.50	0.277	21.386	7.619
Myrica esculenta	16	52	3.25	0.291	14.537	3.810
Pinus wallichiana	24	32	1.33	0.213	57.760	5.714
Quercus leucotrichophora	40	56	1.40	0.304	13.834	9.524
Rhamnus persica	20	40	2.00	0.247	6.771	4.762
Rhododendron arboretum	28	40	1.43	0.247	16.359	6.667
Total		**652**		**3.639**		
Shrubs						

Plants	Frequency (%)	Density (ind.ha^{-1})	Abundance	Diversity index (Shannon Weiner	Basal area (ha)	IVI
Artemisia vulgaris	48	72	1.50	0.275	0.0253	18.346
Arundo donax	56	80	1.43	0.293	0.0344	21.650
Berberis lycium	40	84	2.10	0.302	0.0308	19.003
Bistorta amplexicaulis	32	48	1.50	0.211	0.0578	17.720
Cannabis sativa	64	104	1.63	0.341	0.0308	24.865
Cissus repanda	20	48	2.40	0.211	0.0415	13.607
Colebrookia oppositifolia	28	48	1.71	0.211	0.0578	17.079
Cotoneaster microphyllus	40	56	1.40	0.234	0.0308	16.181
Girardinia diversifolia	88	140	1.59	0.399	0.0288	32.079
Indigofera heterantha	24	48	2.00	0.211	0.0162	10.858
Indigofera pulchella	28	48	1.71	0.211	0.2738	46.054
Pyracantha crenulata	32	44	1.38	0.199	0.0392	14.822
Rubus paniculatus	56	64	1.14	0.255	0.0415	20.989
Urtica dioica	68	108	1.59	0.348	0.0370	26.747
Total		**992**		**3.703**		
Herbs						
Acorus calamus	56	64	1.14	0.240	0.0039	18.873
Anaphalis adnata	60	108	1.80	0.331	0.0035	27.188
Anemone vitifolia	44	56	1.27	0.220	0.0037	15.145
Apium leptophyllum	64	72	1.13	0.259	0.0016	20.945
Arabidopsis thaliana	40	56	1.40	0.220	0.0026	13.094
Artemisia japonica	48	80	1.67	0.277	0.0061	19.767
Bergenia ciliata	40	40	1.00	0.175	0.0097	12.414
Bistorta amplexicaulis	12	12	1.00	0.072	0.0022	16.880

Plants	Frequency (%)	Density (ind.ha^{-1})	Abundance	Diversity index (Shannon Weiner	Basal area (ha)	IVI
Clematis tibetana	80	152	1.90	0.397	0.0005	28.057
Curcuma aromatica	40	60	1.50	0.231	0.0010	11.830
Cynodon dactylon	36	48	1.33	0.199	0.0020	10.950
Deyeuxia scabescens	28	48	1.71	0.199	0.0051	15.781
Iris kumaonensis	24	36	1.50	0.163	0.0065	16.100
Polygonum recumbens	36	60	1.67	0.231	0.0058	19.062
Reinwardtia indica	48	96	2.00	0.309	0.0071	25.825
Thespesia lampas	60	100	1.67	0.317	0.0072	28.089
Total		**1,088**		**3.838**		
Winter season						
Trees						
Aesandra butyracia	24	40	1.67	0.247	15.015	5.714
Aesculus indica	44	64	1.45	0.329	26.997	10.476
Alnus nepalensis	56	80	1.43	0.371	21.386	13.333
Betula alnoides	28	40	1.43	0.247	16.890	6.667
Erythriana arborescens	52	80	1.54	0.371	6.845	12.381
Ficus glomerata	20	40	2.00	0.247	12.701	4.762
Ilex excelsa	36	40	1.11	0.247	16.245	8.571
Juglans regia	32	48	1.50	0.277	21.386	7.619
Myrica esculenta	16	52	3.25	0.291	14.537	3.810
Pinus wallichiana	24	32	1.33	0.213	57.760	5.714
Quercus leucotrichophora	40	56	1.40	0.304	13.834	9.524
Rhamnus persica	20	40	2.00	0.247	6.771	4.762
Rhododendron arboretum	28	40	1.43	0.247	16.359	6.667
Total		**652**		**3.639**		
Shrubs						

Plants	Frequency (%)	Density (ind.ha^{-1})	Abundance	Diversity index (Shannon Weiner	Basal area (ha)	IVI
Artemisia vulgaris	48	64	1.33	0.302	0.0253	21.151
Arundo donax	52	72	1.38	0.323	0.0344	24.279
Berberis lycium	20	20	1.00	0.139	0.0150	8.6345
Bistorta amplexicaulis	32	40	1.25	0.224	0.0578	19.674
Cannabis sativa	40	60	1.50	0.290	0.0190	18.242
Cissus repanda	20	40	2.00	0.224	0.0415	15.059
Colebrookia oppositifolia	32	48	1.50	0.253	0.0578	20.733
Cotoneaster microphyllus	40	52	1.30	0.266	0.0308	18.856
Girardinia diversifolia	80	120	1.40	0.421	0.025	34.485
Indigofera heterantha	28	40	1.20	0.224	0.0140	12.509
Indigofera pulchella	28	40	1.43	0.224	0.0140	50.195
Pyracantha crenulata	32	40	1.25	0.224	0.0392	16.981
Rubus paniculatus	28	40	1.25	0.224	0.0280	14.56
Urtica dioica	52	80	1.56	0.343	0.0300	24.642
Total		**880**		**3.682**		
Herbs						
Acorus calamus	48	72	1.50	0.348	0.0039	30.437
Anemone vitifolia	64	68	1.06	0.337	0.0037	33.064
Apium leptophyllum	40	52	1.30	0.288	0.0016	20.538
Artemisia japonica	40	84	1.73	0.378	0.0049	32.666
Bergenia ciliata	8	8	1.00	0.077	0.0097	24.312
Curcuma aromatica	40	40	1.00	0.245	0.0010	17.409
Cynodon dactylon	80	160	2.00	0.495	0.0020	46.903
Iris kumaonensis	24	32	1.33	0.211	0.0065	24.591
Polygonum recumbens	40	56	1.40	0.301	0.0058	30.351
Thespesia lampas	52	90	1.47	0.391	0.00648	39.730

Plants	Frequency (%)	Density (ind.ha^{-1})	Abundance	Diversity index (Shannon Weiner	Basal area (ha)	IVI
Total		**1016**		**3.072**		

TABLE – 3.23
Frequency, density, abundance, basal area and importance value index (IVI) of trees at sampling station near village Lilam

Plants	Frequency (%)	Density (ind.ha^{-1})	Abundance	Diversity index (Shannon Weiner	Basal area (ha)	IVI
Summer season						
Trees						
Aesculus indica	32	60	1.88	0.349	5.279	7.207
Alnus nepalensis	44	104	2.36	0.455	12.721	9.+910
Celtis australis	72	64	0.89	0.362	18.000	16.216
Dendrocalamus strictus	40	56	1.40	0.336	0.677	9.009
Ficus palmata	48	4	0.08	0.052	11.520	10.811
Juglans regia	36	8	0.22	0.089	16.820	8.108
Litsea glutinosa	32	40	1.25	0.276	10.125	7.207
Pterocarpus marsupium	36	48	1.33	0.308	6.480	8.108
Quercus leucotrichophora	28	44	1.57	0.292	14.580	6.306
Rhododendron	24	40	1.67	0.276	6.771	5.405

Plants	Frequency (%)	Density (ind.ha^{-1})	Abundance	Diversity index (Shannon Weiner	Basal area (ha)	IVI
arboreum						
Sapium insigne	24	40	1.67	0.276	7.683	5.405
Spondias pinnata	28	40	1.43	0.276	7.220	6.306
Total		**548**		**3.346**		
Shrubs						
Arundo donax	48	76	1.58	0.308	0.033	20.935
Berberis aristata	40	80	2.00	0.317	1.280	88.041
Cannabis sativa	64	160	2.50	0.450	0.029	39.962
Cotoneaster microphyllus	48	88	1.83	0.335	0.045	26.290
Girardinia diversifolia	40	140	3.50	0.425	0.025	31.492
Pyracantha crenulata	40	60	1.50	0.266	0.324	34.891
Rubus paniculatus	40	56	1.40	0.255	0.041	19.458
Smilax aspera	24	48	2.00	0.231	0.072	16.363
Spermadictyon sauveolens	44	72	1.64	0.298	0.024	21.876
Urtica dioica	72	88	1.22	0.335	0.034	30.920
Total		**868**		**3.219**		
Herbs						
Anaphalis adnata	48	172	3.58	0.356	0.002	10.256
Centella asiatica	24	68	2.83	0.201	0.000	5.128
Cynadon dactylon	52	204	3.92	0.389	0.001	11.111
Echinops cornigerus	24	92	3.83	0.245	0.001	5.128
Eragrotis poaeoides	44	124	2.82	0.295	0.002	9.402
Impatiens balsamina	32	144	4.50	0.323	0.007	6.838
Leucas lanata	20	56	2.80	0.176	0.001	4.274
Oxalis corniculata	28	60	2.14	0.184	0.000	5.983
Polygonum glabrum	28	128	4.57	0.301	0.001	5.983
Reinwardtia indica	32	104	3.25	0.265	0.002	6.838
Rumex nepalensis	24	52	2.17	0.167	0.003	5.128

Plants	Frequency (%)	Density (ind.ha^{-1})	Abundance	Diversity index (Shannon Weiner	Basal area (ha)	IVI
Solanum nigrum	28	60	2.14	0.184	0.001	5.983
Stephania glabra	20	56	2.80	0.176	0.003	4.274
Thespesia lampas	28	96	3.43	0.252	0.007	5.983
Viola biflora	36	100	2.78	0.259	0.000	7.692
Total		**1516**		**3.774**		
Monsoon season						
Trees						
Aesculus indica	32	60	1.88	0.349	5.279	7.207
Alnus nepalensis	44	104	2.36	0.455	12.721	9.910
Celtis australis	72	64	0.89	0.362	18.000	16.216
Dendrocalamus strictus	40	56	1.40	0.336	0.677	9.009
Ficus palmata	48	4	0.08	0.052	11.520	10.811
Juglans regia	36	8	0.22	0.089	16.820	8.108
Litsea glutinosa	32	40	1.25	0.276	10.125	7.207
Pterocarpus marsupium	36	48	1.33	0.308	6.480	8.108
Quercus leucotrichophora	28	44	1.57	0.292	14.580	6.306
Rhododendron arboreum	24	40	1.67	0.276	6.771	5.405
Sapium insigne	24	40	1.67	0.276	7.683	5.405
Spondias pinnata	28	40	1.43	0.276	7.220	6.306
Total		**548**		**3.346**		
Shrubs						
Arundo donax	48	80	1.67	0.311	0.033	21.107
Berberis aristata	48	88	1.83	0.329	1.280	91.007
Cannabis sativa	64	152	2.38	0.434	0.029	38.735
Cotoneaster microphyllus	44	96	2.18	0.345	0.045	26.647
Girardinia	44	128	2.91	0.401	0.025	30.521

Plants	Frequency (%)	Density (ind.ha^{-1})	Abundance	Diversity index (Shannon Weiner	Basal area (ha)	IVI
diversifolia						
Pyracantha crenulata	40	68	1.70	0.282	0.324	36.118
Rubus paniculatus	24	56	2.33	0.250	0.041	17.590
Smilax aspera	40	72	1.80	0.292	0.072	21.007
Spermadictyon sauveolens	72	92	1.28	0.337	0.024	31.534
Urtica dioica	36	64	1.78	0.272	0.034	19.815
Total		**896**		**3.254**		
Herbs						
Ageratum conyzoides	36	76	2.11	0.320	0.003	23.115
Agrostis nervosa	24	56	2.33	0.266	0.022	17.279
Echinops cornigerus	40	60	1.50	0.278	0.003	45.382
Impatiens balsamina	36	100	2.78	0.372	0.007	31.720
Oxalis corniculata	24	68	2.83	0.300	0.001	16.384
Polygonum glabrum	32	56	1.75	0.266	0.012	30.286
Reinwardtia indica	32	72	2.25	0.310	0.024	46.877
Rumex nepalensis	20	52	2.60	0.254	0.008	21.604
Stephania glabra	20	48	2.40	0.241	0.000	11.960
Torilis leptophylla	36	128	3.56	0.420	0.002	29.391
Viola biflora	36	96	2.67	0.364	0.003	26.003
Total		**812**		**3.391**		
Shrubs						
Arundo donax	48	80	1.67	0.311	0.033	21.107
Berberis aristata	48	88	1.83	0.329	1.280	91.007
Cannabis sativa	64	152	2.38	0.434	0.029	38.735
Cotoneaster microphyllus	44	96	2.18	0.345	0.045	26.647
Girardinia	44	128	2.91	0.401	0.025	30.521

Plants	Frequency (%)	Density (ind.ha^{-1})	Abundance	Diversity index (Shannon Weiner	Basal area (ha)	IVI
diversifolia						
Pyracantha crenulata	40	68	1.70	0.282	0.324	36.118
Rubus paniculatus	24	56	2.33	0.250	0.041	17.590
Smilax aspera	40	72	1.80	0.292	0.072	21.007
Spermadictyon sauveolens	72	92	1.28	0.337	0.024	31.534
Urtica dioica	36	64	1.78	0.272	0.034	19.815
Total		**896**		**3.254**		
Herbs						
Ageratum conyzoides	36	76	2.11	0.320	0.003	23.115
Agrostis nervosa	24	56	2.33	0.266	0.022	17.279
Echinops cornigerus	40	60	1.50	0.278	0.003	45.382
Impatiens balsamina	36	100	2.78	0.372	0.007	31.720
Oxalis corniculata	24	68	2.83	0.300	0.001	16.384
Polygonum glabrum	32	56	1.75	0.266	0.012	30.286
Reinwardtia indica	32	72	2.25	0.310	0.024	46.877
Rumex nepalensis	20	52	2.60	0.254	0.008	21.604
Stephania glabra	20	48	2.40	0.241	0.000	11.960
Torilis leptophylla	36	128	3.56	0.420	0.002	29.391
Viola biflora	36	96	2.67	0.364	0.003	26.003
Total		**812**		**3.391**		
Winter season						
Trees						
Aesculus indica	32	60	1.88	0.349	5.279	7.207
Alnus nepalensis	44	104	2.36	0.455	12.721	9.910
Celtis australis	72	64	0.89	0.362	18.000	16.216
Dendrocalamus strictus	40	56	1.40	0.336	0.677	9.009

Plants	Frequency (%)	Density (ind.ha^{-1})	Abundance	Diversity index (Shannon Weiner	Basal area (ha)	IVI
Ficus palmate	48	4	0.08	0.052	11.520	10.811
Juglans regia	36	8	0.22	0.089	16.820	8.108
Litsea glutinosa	32	40	1.25	0.276	10.125	7.207
Pterocarpus marsupium	36	48	1.33	0.308	6.480	8.108
Quercus leucotrichophora	28	44	1.57	0.292	14.580	6.306
Rhododendron arboretum	24	40	1.67	0.276	6.771	5.405
Sapium insigne	24	40	1.67	0.276	7.683	5.405
Spondias pinnata	28	40	1.43	0.276	7.220	6.306
Total		**548**		**3.346**		
Shrubs						
Arundo donax	48	76	1.58	0.345	0.033	24.93877
Berberis aristata	40	80	2.00	0.354	1.280	90.09816
Cannabis sativa	32	80	2.50	0.354	0.0145	20.34465
Cotoneaster microphyllus	48	88	1.83	0.373	0.045	27.26584
Girardinia diversifolia	28	96	3.50	0.390	0.0171	21.69149
Pyracantha crenulata	40	60	1.50	0.301	0.324	36.16891
Rubus paniculatus	32	48	1.40	0.262	0.0351	16.9541
Smilax aspera	24	48	2.00	0.262	0.072	16.84163
Spermadictyon sauveolens	28	60	1.64	0.301	0.020	16.78809
Urtica dioica	64	76	1.22	0.345	0.0294	28.91099
Total		**868**		**3.286**		
Herrbs						
Ageratum conyzoides	36	64	1.78	0.4081	0.003	37.078
Agrostis nervosa	40	48	1.20	0.3522	0.022	70.674

Plants	Frequency (%)	Density (ind.ha^{-1})	Abundance	Diversity index (Shannon Weiner	Basal area (ha)	IVI
Impatiens balsamina	28	80	2.86	0.4505	0.007	44.541
Polygonum glabrum	36	56	1.56	0.3821	0.012	52.018
Rumex nepalensis	24	52	2.17	0.3677	0.008	38.074
Stephania glabra	20	40	2.00	0.3179	0.000	18.519
Torilis leptophylla	32	92	3.11	0.4752	0.0016	39.176
Total		**704**		**2.7537**		

TABLE - 3.24
Frequency, density, abundance, basal area and importance value index (IVI) of trees at sampling station near power house site

Plants	Frequency (%)	Density (ind.ha^{-1})	Abundance	Diversity index (Shannon Weiner	Basal area (ha)	IVI
Summer						
Trees						
Aesandra butyracea	16	40	2.50	0.282	16.382	5.405
Alnus nepalensis	52	148	2.85	0.514	11.888	17.568
Cedrella toona	28	40	1.43	0.282	14.797	9.459
Celtis australis	24	56	2.33	0.343	9.875	8.108
Dalbergia sissoo	20	40	2.00	0.282	9.645	6.757
Ficus hispida	20	40	2.00	0.282	7.296	6.757
Litsea glutinosa	52	20	0.38	0.179	11.064	17.568
Phoenix sylvestris	4	4	1.00	0.053	25.920	1.351

Plants	Frequency (%)	Density (ind.ha^{-1})	Abundance	Diversity index (Shannon Weiner	Basal area (ha)	IVI
Pterocarpus marsupium	28	60	2.14	0.357	7.159	9.459
Sapium insigne	28	48	1.71	0.314	6.567	9.459
Salix acutifolia	8	8	1.00	0.092	6.238	2.703
Trewia nudiflora	16	24	1.50	0.203	12.600	5.405
Total		**528**		**3.183**		
Shrubs						
Artemisia nilagirica	36	72	2.00	0.309	0.006	9.783
Berberis aristata	12	20	1.67	0.131	0.002	3.261
Cannabis sativa	48	120	2.50	0.407	0.010	13.043
Colebrookia oppositifolia	24	40	1.67	0.213	0.002	6.522
Cotoneaster microphyllus	32	60	1.88	0.277	0.011	8.696
Girardinia diversifolia	52	124	2.38	0.413	0.017	14.130
Pyracantha crenulata	20	44	2.20	0.227	0.006	5.435
Rubus paniculatus	20	40	2.00	0.213	0.002	5.435
Salix elongans	20	32	1.60	0.183	0.008	5.435
Smilax aspera	20	24	1.20	0.150	0.003	5.435
Spermadictyon sauveolens	48	180	3.75	0.481	0.004	13.043
Urtica dioica	8	12	1.50	0.090	0.002	2.174
Zanthoxylum sp.	28	48	1.71	0.240	0.016	7.609
Total		**816**		**3.334**		
Herbs						
Anaphalis adnata	48	172	3.58	0.356	0.002	10.256
Centella asiatica	24	68	2.83	0.201	0.000	5.128
Cynadon dactylon	52	204	3.92	0.389	0.001	11.111
Echinops cornigerus	24	92	3.83	0.245	0.001	5.128
Eragrotis poaeoides	44	124	2.82	0.295	0.002	9.402
Impatiens balsamina	32	144	4.50	0.323	0.007	6.838

Plants	Frequency (%)	Density (ind.ha^{-1})	Abundance	Diversity index (Shannon Weiner	Basal area (ha)	IVI
Leucas lanata	20	56	2.80	0.176	0.001	4.274
Oxalis corniculata	28	60	2.14	0.184	0.000	5.983
Polygonum glabrum	28	128	4.57	0.301	0.001	5.983
Reinwardtia indica	32	104	3.25	0.265	0.002	6.838
Rumex nepalensis	24	52	2.17	0.167	0.003	5.128
Solanum nigrum	28	60	2.14	0.184	0.001	5.983
Stephania glabra	20	56	2.80	0.176	0.003	4.274
Thespesia lampas	28	96	3.43	0.252	0.007	5.983
Viola biflora	36	100	2.78	0.259	0.000	7.692
Total		**1516**		**3.774**		
Monsoon season						
Trees						
Aesandra butyracea	16	40	2.50	0.282	16.382	5.405
Alnus nepalensis	52	148	2.85	0.514	11.888	17.568
Cedrella toona	28	40	1.43	0.282	14.797	9.459
Celtis australis	24	56	2.33	0.343	9.875	8.108
Dalbergia sissoo	20	40	2.00	0.282	9.645	6.757
Ficus hispida	20	40	2.00	0.282	7.296	6.757
Litsea glutinosa	52	20	0.38	0.179	11.064	17.568
Phoenix sylvestris	4	4	1.00	0.053	25.920	1.351
Pterocarpus marsupium	28	60	2.14	0.357	7.159	9.459
Sapium insigne	28	48	1.71	0.314	6.567	9.459
Salix acutifolia	8	8	1.00	0.092	6.238	2.703
Trewia nudiflora	16	24	1.50	0.203	12.600	5.405
Total		**528**		**3.183**		
Shrubs						
Artemisia nilagirica	36	80	2.22	0.328	0.006	25.771
Berberis aristata	12	28	1.75	0.167	0.002	8.163

Plants	Frequency (%)	Density (ind.ha^{-1})	Abundance	Diversity index (Shannon Weiner	Basal area (ha)	IVI
Cannabis sativa	48	128	2.67	0.419	0.010	38.993
Colebrookia oppositifolia	24	44	1.83	0.227	0.002	13.765
Cotoneaster microphyllus	32	64	1.78	0.288	0.011	28.381
Girardinia diversifolia	52	132	2.54	0.425	0.017	48.199
Pyracantha crenulata	20	56	2.33	0.265	0.006	18.463
Rubus paniculatus	20	44	2.20	0.227	0.002	13.092
Salix elongans	20	36	1.80	0.199	0.008	18.570
Smilax aspera	20	28	1.17	0.167	0.003	11.865
Spermadictyon sauveolens	48	168	3.82	0.469	0.004	36.177
Urtica dioica	8	20	2.50	0.131	0.002	6.535
Zanthoxylum sp.	28	56	2.33	0.265	0.016	32.025
Total		**884**		**3.579**		
Herbs						
Anaphalis adnata	24	180	3.58	0.356	0.002	23.613
Centella asiatica	24	80	2.83	0.217	0.000	11.666
Cynadon dactylon	52	188	3.92	0.364	0.001	25.116
Echinops cornigerus	24	100	3.83	0.251	0.001	14.300
Eragrotis poaeoides	44	128	2.82	0.292	0.002	23.119
Impatiens balsamina	32	152	4.50	0.324	0.007	38.358
Leucas lanata	20	64	2.80	0.186	0.001	13.027
Oxalis corniculata	28	60	2.14	0.178	0.000	10.649
Polygonum glabrum	28	128	4.57	0.292	0.001	17.473
Reinwardtia indica	32	112	3.25	0.269	0.002	21.144
Rumex nepalensis	24	60	2.17	0.178	0.003	18.671
Solanum nigrum	28	68	2.14	0.194	0.001	13.704

Plants	Frequency (%)	Density (ind.ha^{-1})	Abundance	Diversity index (Shannon Weiner	Basal area (ha)	IVI
Stephania glabra	20	64	2.80	0.186	0.003	19.308
Thespesia lampas	28	100	3.43	0.251	0.007	33.723
Viola biflora	36	108	2.78	0.263	0.000	16.127
Total		**1,592**		**3.803**		
Winter season						
Trees						
Aesandra butyracea	16	40	2.50	0.282	16.382	5.405
Alnus nepalensis	52	148	2.85	0.514	11.888	17.568
Cedrella toona	28	40	1.43	0.282	14.797	9.459
Celtis australis	24	56	2.33	0.343	9.875	8.108
Dalbergia sissoo	20	40	2.00	0.282	9.645	6.757
Ficus hispida	20	40	2.00	0.282	7.296	6.757
Litsea glutinosa	52	20	0.38	0.179	11.064	17.568
Phoenix sylvestris	4	4	1.00	0.053	25.920	1.351
Pterocarpus marsupium	28	60	2.14	0.357	7.159	9.459
Sapium insigne	28	48	1.71	0.314	6.567	9.459
Salix acutifolia	8	8	1.00	0.092	6.238	2.703
Trewia nudiflora	16	24	1.50	0.203	12.600	5.405
Total		**528**		**3.183**		
Shrubs						
Artemisia nilagirica	36	72	2.00	0.3528	0.006	31.296
Berberis aristata	12	20	1.67	0.1552	0.002	9.813
Cannabis sativa	32	80	2.50	0.3732	0.0067	32.176
Colebrookia oppositifolia	20	30	1.67	0.2057	0.0015	13.253
Cotoneaster microphyllus	32	60	1.88	0.3184	0.011	35.192
Girardinia diversifolia	36	88	2.38	0.3918	0.0121	42.327

Plants	Frequency (%)	Density (ind.ha^{-1})	Abundance	Diversity index (Shannon Weiner	Basal area (ha)	IVI
Pyracantha crenulata	20	44	2.20	0.264	0.006	21.767
Rubus paniculatus	20	40	2.00	0.2485	0.002	15.506
Salix elongans	20	32	1.60	0.2148	0.008	22.731
Smilax aspera	20	24	1.20	0.1765	0.003	14.44
Spermadictyon sauveolens	32	120	3.75	0.4511	0.0027	32.727
Urtica dioica	8	12	1.50	0.1068	0.002	7.2759
Zanthoxylum sp.	20	24	1.71	0.1765	0.008	21.492
Total		**816**		**3.4352**		
Herbs						
Centella asiatica	24	68	2.83	0.2886	0.000	16.566
Cynadon dactylon	44	180	3.92	0.4715	0.001	40.661
Eragrotis poaeoides	44	124	2.82	0.402	0.002	39.104
Impatiens balsamina	28	88	4.50	0.3356	0.0043	39.176
Leucas lanata	20	56	2.80	0.2559	0.001	18.133
Polygonum glabrum	24	96	4.57	0.3522	0.0008	23.111
Rumex nepalensis	24	52	2.17	0.244	0.003	27.93
Solanum nigrum	20	48	2.14	0.2317	0.001	16.326
Stephania glabra	20	56	2.80	0.2559	0.003	26.944
Thespesia lampas	28	96	3.43	0.3522	0.007	52.093
Total		**1516**		**3.1895**		

Species diversity indices can be considered as measure of environmental quality and it indicates the ecosystem wellbeings.The Shannon diversity index at various sampling sites covered during the survey ranged from 3.183 to 3.639 for trees, 3.219 to 3.703 for shrubs and 2.753 to 3.838 for herbs.

The dominance characteristics as observed at various sampling sites is described in the following paragraphs:

Submergence area : The dominant tree species in the submergence area are Utis (*Alnus nepalensis*) and Dhuladhak (E*rythriana arborescens)*. The dominant shrubs are Bhainsya Kendai (*Girardinia diversifolia).* Amongst the herbs, the dominant species are Dubla (*Cynodon dactlylon),* and Patee (*Artemisia japonica)*.

Village Lilam : The dominant tree species at this site was Utis (*Alnus nepalensis*). Amongst the Shrubs Bhang (*Cannabis satira),* Bhainsya Kandali (*Girardinia diversifolia)* were dominant. The dominant herbs observed at this site were *Torilis leptophylla* and *Impatiens balsamina*.

Near Power House Site: Utis (*Alnus nepalensis)* was the dominant tree species at this site. Amongst the shrubs, Padera (*spermdictyon sauveolens)* was dominant. The dominant herbs were *Impatiens balsamanica, Polygonum glabarum and Eragrostis poeoides.*

The tree density observed at various sampling stations is given in Table-3.25.

TABLE-3.25

Tree density at various sampling sites

Sampling Station	Tree density (No./ha)
Submergence area	652
Village Lilam	868
Power house site	528

The major land acquisition is envisaged at dam site, power house area where tree density ranges from 528 to 652 trees/ha. This indicates medium density of tree cover in the area.

3.5.1.4 Ethnobotanical Aspects

The recent rediscovery of remarkable plant species have given a new life to the inter-disciplinary science of ethnobotany, which deals with the direct relationship of plant with man, and comprises of the following aspects:

- Medicinal plants
- Wild edibles
- Fibre yielding plants
- Timber yielding plants
- Plants of religious and cultural importance

The ethnobotanical utility of various trees, shrubs, herbs, climbers and grass species observed in the study area and its surroundings are given in Table-3.26.

TABLE-3.26

Economic use of various floral species observed in the study area

S.No.	Botanical Name	Local Name	Economic Importance

S.No.	Botanical Name	Local Name	Economic Importance
	Trees		
1.	*Aesandra butyracea* **Roxb**.	Chiura	Vegetable, butter from seeds, social forestry
2.	*Aesculus indica* **Colebr.**	Pangar	Social forestry, wood for making pots & vessels
3.	*Alnus nepalensis* **D. Don**	Utees	Soil binder
4.	*Betula alnoides* **Buch-Ham**	Saur Bhojapatra	Sacred, medicinal, bark used as paper for writing
5.	*Betula utilis* **D. Don**	Bhojpatra	Sacred, medicinal, bark used as paper for writing
6.	*Carpinus viminea* **Lindley**	Putli	Fodder, furniture
7.	*Cedrella toona* **Hiern**	Tun	Furniture
8.	*Celtis australis* **Hook.**	Kharik	Fodder
9.	*Cinnamon tamala* **Buch-Ham**	Dalchini, Tejpat	Spices, medicinal
10.	*Dalbergia sissoo* **Roxb.**	Sisham	Furniture
11.	*Dandroclamus strictus* **Nees**	Bans	Furniture, sticks
12.	*Ehretia laevis* **Roxb.**	Chamror	Fodder
13.	*Erythriana arborescens* **Roxb.**	Dhauldhak	Social Forestry, medicinal
14.	*Ficus glomerata* **Roxb.**	Gular	Fruits edible, fodder
15.	*Ficus hispida* **L.**	Totmila	Fruits edible, fodder
16.	*Ficus palmata* **Forsk**	Bedu / Anjir	Fruits edible, fodder
17.	*Ilex excelsa* **Hook.**	Gauloo	Fodder
18.	*Juglans regia* **L.**	Akhrot	Dry fruits, edible, oil
19.	*Litsea glutinosa* **Robinson**	Singrau/Maida lakri	Elastic wood
20.	*Myrica esculenta* **Buch-Ham**	Kaphal	Fruits edible
21.	*Phoenix sylvestris* **L.**	Khajoor	Broom, mats
22.	*Pinus wallichiana* **AB Jeckson**	Kail	Furniture
23.	*Pterocarpus marsupium* **Roxb**.	Bija Sal	Timber, medicinal
24.	*Quercus leucotrichophora* **Camus**	Banj	Furniture
25.	*Rhamnus persica* **Boissier**	Chirla	Fruits edible, fodder
26.	*Rhododendron arboreum* **Smith**	Burans	Flowers for refreshing drink, medicinal
27.	*Rhus japonica* **L.**	Beshmeel	Medicinal
28.	*Salix acutifolia* **Hook.**	Bhains	Basket, vessels

S.No.	Botanical Name	Local Name	Economic Importance
29.	*Sapindus mukorossi* **Gaertner**	Reetha	Fruits as soap
30.	*Sapium insigne* **Royle**	Khinna	Ichthyotoxic
31.	*Sorbus aucuparia* **L.**	Mohli	Fruits edible, medicinal
32.	*Spondias pinnata* **Kurz**	Amra	Fruits edible, pickle
33.	*Trewia nudiflora* **L**.	Gutel	Used for making drums
	Shrubs		
1.	*Ageratum conizoides* **L**.	Gundrya	Medicinal
2.	*Artemisia vulgaris* **Clarke**	Kunja	Medicinal
3.	*Artemisia nilagirica* **Clarke**	Kunja	Medicinal
4.	*Arundo donax* **L.**	Tinta	Fodder, for making brooms & baskets
5.	*Berberis aristata* **DC**	Kingor	Fruits edible, medicinal
6.	*Berberis lycium* **Royle**	Kingor	Fruits edible, medicinal
7.	*Bistorta amplexicaulis* **D. Don**	Kutrya	Medicinal
8.	*Boehmeria platzphylla* **D. Don**.	Khagsa	Fodder
9.	*Cannabis sativa* **L.**	Bhang	Medicinal
10.	*Cissus rependa* **Vahl**	Pani-bel	Fruits edible, medicinal
11.	*Colebrookia oppositifolia* **Smith**	Binda	Medicinal
12.	*Cotoneaster microphyllus* **Wall**	Bugarchilla	Medicinal
13.	*Callicarp arboria* **Roxb**.	Kumahr	Fuel, small handicrafts
14.	*Duchesnea indica* **Andrews**	Bhiun-Kaphal	Fruits edible, medicinal
15.	*Girardinia diversifolia* **Link**	Bhainsya Kandali,	Medicinal, Stem fibers for ropes
16.	*Indigofera heterantha* **Wall**	Sakina	Vegetable, fodder, medicinal
17.	*Indigofera pulchella* **Roxbr.**	Saknya	Vegetable, medicinal
18.	*Lecanthus peduncularis* **Royle**	-	-
19.	*Pyracantha crenulata* **D. Don**	Ghingaru	Fruits edible
20.	*Reinwardtia indica* **Dumortier**	Phunli	Sacred
21.	*Rubus paniculatus* **Smith**	Kala Hinsar	Fruits edible, medicinal
22.	*Salix elogans* **Wall**	Bhotiana	Fuel and fodder
23.	*Smilax aspera* **L.**	Kukurdara	Vegetable, medicinal
24.	*Spermadictyon sauveolens*	Padera	Medicinal

S.No.	Botanical Name	Local Name	Economic Importance
	Roxb.		
25.	*Urtica dioica* **L.**	Kandali	Vegetable, medicinal
26.	*Zenthoxylum armetus* **DC**	Timroo	Mouth freshener
	Herbs		
1.	*Acorus calamus* **L.**	Bauj, Bach	Medicinal, softdriks made from rhizome
2	*Agrostis nervosa* **Nees**		Fodder
3.	*Anaphalis adnata* **Wall**	Bugla	Medicinal
4.	*Anemone vitifolia* **Buch-Ham**	Mudeela	Medicinal, fodder
5	*Apium leptophyllum* **Persoon**	-	Medicinal
6.	*Arabidopsis thaliana* **L**.	-	Medicinal
7.	*Artemisia japonica* **Thunb.**	Patee, Pamsi	Leaves & flowers edible
8.	*Bergenia ciliata* **Haworth**	Silpara,	Medicinal
9.	*Bistorta amplexicaulis* **D. Don**	Kutrya	Medicinal
10	*Centella asiatica* **L.**	Brahmibuti	Medicinal
11.	*Clematis tibatiana*		Medicinal
12.	*Curcuma aromatica* **Salisbury**	Ban Haldi	Dye obtained from rhizome, edible
13.	*Cymbopogon flexuosus* **Watson**	-	Fodder
14	*Cymbopogon msrtinii* **Watson**	Priya-ghas	Medicinal
15.	*Cynodon dactylon* **L.**	Dubla,	Medicinal, sacred
16.	*Deyeuxia scabescens*	-	Fodder
17.	*Echinops cornigerus* **DC.**	Kantela	Medicinal, Roots edible
18.	*Eragostis poaeoides* **P. Beaue**	-	Fodder
19	*Eulaliopsis bineta* **Hubbard**	Babula	Fodder
20.	*Impatiens balsamina* **L**		Seeds edible
21.	*Iris kumaonensis* **D. Don**	Phyaktuli	-
22.	*Polygonum glabrum* **Willd**	-	-
23.	*Polygonum recumbens* **Willd**	-	Medicinal
24.	*Reinwardtia indica* **Dumortier**	Phiunli	Tongue cleaner, sacred
25.	*Rumes nepalensis* **Sprengel**	Khatura	Vegetable, Medicinal
26.	*Solanum nigrum* **L.**	Makoi	Fruits edible
27.	*Stephania glabra* **Roxb.**	Gindadu	Medicinal
28.	*Themeda anathera* **Hackel**	Golda	Fodder

S.No.	Botanical Name	Local Name	Economic Importance
29.	*Thespesia lampas* **Cav**	Jangli Bhindi	Medicinal
30.	*Torilis leptophylla* **DC**	-	Medicinal
31.	*Vilo biflora* **L**	Vanafsa	Medicinal

3.5.2 WILDLIFE

Ranging from area under permanent snow cover to the hot sub-tropical jungles of the foothills, the catchment area presents diverse habitats with significant levels of variation. This area is the home of a wide variety of mammals, reptiles and birds. The major part of the catchment area lies in the central Himalayas which has a relatively less rainfall as compared to that of eastern part of the Himalayas and the climate is temperate to sub-temperate with fairly heavy snowfall above 2500 meters. It has restricted the wildlife habitat significantly.

Zoo-geographically the study area adjoining the project can be divided into two regions:

- Himalayan Foothills
- Temperate region

Himalayan Foot Hills

This area has elevation upto 2000 meters. The fauna of this region is more or less similar to that of the Indo-Gangetic plain. This is characterised by grassy meadows and savannah vegetation. This region is reported to harbour various Mammalian fauna i.e. sambhar, barking deer, wild boar, jackal etc. This area was frequented by the famous tiger enthusiast Jim Corbett. However, growth of human settlement have

narrowed the wildlife habitat in this area to a significant extent. Due to terrain characteristics, the sighting of wildlife is poor.

Temperate region of Western Himalayas

This region comprises the temperate areas above an elevation of 2000 meters. The climate is moist temperate with snowfall in the winter months. The faunal species include jackal, sambhar, cats, brown bear and black bear. Amongst the avi-fauna, the common species include the Himalayan Golden Eagle, Himalayan woodpecker, Indian Mayna ,and Hill Patridges. The important faunal species reported in the project area and its surroundings are documented in Table-3.27. These informations are based on secondary sources as well as field observations during the ecological survey.

TABLE-3.27
Major faunal species reported in the project area and its surroundings

S. No.	Zoological Name	English Name	Local Name	Schedule as per wild life protection Act
MAMMALS				
1.	*Felis bengalensis*	Leopard cat	Ban Biralu	I
2.	*Felis chaus*	Jungle cat	Ban Biralu	II
3.	*Hystrix indica*	Indian Porcupine	Solu	IV
4.	*Lepus nigricollis*	Indian hare	Khargosh	IV
5.	*Macaca mulatto*	Rhesus Monkey	Banar	II
6.	*Muntiacus muntjak*	Barking deer	Kakar	III
7.	*Nemarhaedus ghural*	Goral	Gural	III
8.	*Panthera pardus*	Leopard	Bagh	I
9.	*Selenarctos thibetanus*	Himalayan Black Bear	Rikh	II
10.	*Sus scrofacristatus*	Wild Boar	Jungli suwar	III
BIRDS				
1.	*Acridotheres tristis*	Indian Myana	Myana	IV
2.	*Alectoris Chukar*	Chukor Patridge	Chakor	
3.	*Aquila crysaetos*	Himalayan Golden Eagle	Garud	
4.	*Arborophila torqueola*	Hill Patridge	Titar	IV
5.	*Bubo bubo bengalensis*	Eagle Owl	Ghughu	IV
6.	*Corvus macrorhynchos*	Jungle Crow	Kawwa	V
7.	*Corvus splendens*	House crow	Kawwa	V
8.	*Dendrocopos himalayensis*	Himalayan Woodpecker	Kathphorwa	IV
REPTILES				
1.	*Agama tuberculata*	Common lizard	Chhipkali	
2.	*Argyrogena ventromaculatus*	Gray's rat snake	Saanp	IV
3.	*Varanus bengalensis*	Indian monitor lizard	Goh	I
4.	*Xenochrophis piscator*	Checkered	Saanp	II

S. No.	Zoological Name	English Name	Local Name	Schedule as per wild life protection Act
		keel-back		
5.	*Ptyas mucosus*	Rat snake	Saanp	II

3.5.3 Aquatic ecology

Biological parameters are very important in the aquatic ecosystem, since they determine the productivity of a water body. Primary productivity is an important indicator of pollution level in any aquatic ecosystem. Fish production is dependent on production of zooplankton which in turn is dependent on the phytoplankton production or primary productivity. All these are related to the physio-chemical characteristics of the water. The aquatic ecology describe in this section based on published work and field observation made by the consultant during the course of study.

The aquatic ecological survey has been conducted for three seasons. The details are given as below:

- Summer season : April 2006.
- Monsoon season : July 2006
- Winter season : December 2006

3.5.3.1 Plankton

The data on planktonic community of the river Goriganga are very meagre. A few information are available on this subject for Dhauliganga but study restricted to a particular stretch which may not be relevent to the project area. The occurrence of Planktonic population in river Goriganga depends on season flow and temperature. The density and diversity for plankton in the river water was studied by collecting the water samples from various sites in the project area.

(AQ 1) – Submergence area
(AQ 2) – Goriganga downstream of village Lilam
(AQ 3) – Near the proposed tailrace confluence

For enumeration of plankton population, bulk water samples were collected in polythene jars. For obtaining net plankton from the water sample, 150 ml of bulk water was filtered through a 50 µm net and was centrifuged at 1500 rpm for 10 minutes. The sediment of the centrifuge tubes was made to volume of 5 ml. An aliquot of 0.5 ml of this concentrate was used for enumeration of zooplankton population. A plankton chamber of 0.5 capacity was used for counting of plankton under a light microscope. The total number of plankters present in a litre of water sample was calculated using the following formula:

$$\text{Number of plankton per litre} = \frac{\text{Number of plankters in 0.5 ml aliquot} \times 0.5 \times 1000}{\text{Volume of sediment concentrate} \times \text{Volume of water centrifuged}}$$

However the density of periphyton was estimated following the standard method outline in Wetzel (1979).

Species diversity indices (Shannon Weiner Indices) of general diversity (H) was computed using the following formula.

Shanon Weiner Diversity Index (H) = $-\Sigma(ni/N) * Log_2 (ni/N)$
Where H, Shannon Index of diversity
ni, total number of individual of a species and
N, total number of individual of each species

Periphyton and Phytoplankton

The river Goriganga is a high altitude tributary of the river Sarda. Periphyton and phytoplankton were represented by 16 genera of the families of Bacillariophyceae (12), Chlorophyceae(2), and Myxophyceae(1). However, maximum 15 genera of periphyton were represented by the families of Bacillariophyceae, Cholorophyceae and Myxophyceae in winter season. The data on frequency, density, abundance and diversity indices of periphyton in Goriganga have been presented in Tables-3.28 to 3.30. The total density of periphyton ranged from 1,056 individual/m^{-2} to 3076 individual/m^{-2}, which was dominated by the members of Bacillariophyceae. Diversity indices (Shannon-Weiner) of the periphyton ranged from 2.2 to 2.9, which is the indication that the periphytonic diversity and quality of aquatic ecosystem were moderately good in river Goriganga at the project site or area coming under reservoir and the river stretch coming within the project area.

TABLE–3.28

Frequency, density, abundance and diversity index of periphytons in Goriganga river at sampling site on river Goriganga in submergence area

Periphyton	Frequency (%)	Density (individual/ m^{-2})	Abundance	Diversity index (Shannon Weiner)
Summer season				
Bacillariophyceae				
Tabellaria fenestris	88	308	3.500	0.494
Diatoma vulgaris	72	284	3.944	0.481
Fragilaria inflata	80	304	3.800	0.492
Nitzschia	16	20	1.250	0.094
Navicula radiosa	76	272	3.579	0.474
Cymbella cistula	12	16	1.333	0.079
Coconeis placetula	12	16	1.333	0.079
Synedra ulna	12	20	1.667	0.094
Cyclotella	8	8	1.000	0.046
Stauroneis	8	12	1.500	0.063
Ceratoneis	8	8	1.000	0.046
Denticula	4	4	1.000	0.026
Chlorophyceae				
Ulothrix zonata	4	8	2.000	0.046
Myxophyceae				
Oscillatoria tenuis	4	4	1.000	0.026
Total		**1,284**		**2.538**
Monsoon season				
Bacillariophyceae				

Periphyton	Frequency (%)	Density (individual/ m^{-2})	Abundance	Diversity index (Shannon Weiner)
Tabellaria fenestris	48	31.2	3.250	0.523
Diatoma vulgaris	44	29.6	3.364	0.518
Synedra ulna	4	1.6	2.000	0.094
Fragilaria inflata	44	33.6	3.818	0.528
Nitzschia	8	1.6	1.000	0.094
Navicula radiosa	20	5.6	1.400	0.230
Cymbella cistula	4	0.8	1.000	0.055
Gomphonema	4	0.8	1.000	0.055
Chlorophyceae		0		
Ulothrix zonata	4	0.8	1.000	0.055
Myxophyceae		0		
Oscillatoria tenuis	4	0.8	1.000	0.055
Total		**1064**		**2.209**
Winter season				
Bacillariophyceae				
Tabellaria fenestris	100	476	4.760	0.417
Diatoma vulgaris	100	340	3.400	0.351
Fragilaria inflata	100	544	5.440	0.442
Nitzschia	84	496	5.905	0.425
Navicula radiosa	100	536	5.360	0.439
Gomphoneis	12	16	1.383	0.039
Cymbella cistula	100	488	4.880	0.421
Coconeis placetula	12	16	1.333	0.039
Synedra ulna	12	20	1.667	0.047
Stauroneis	8	12	1.500	0.031
Ceratoneis areus	8	8	1.000	0.022
Chlorophyceae				
Ulothrix zonata	4	8	2.000	0.022
Chlorella	28	40	1.428	0.081
Myxophyceae				
Oscillatoria tenuis	32	48	1.500	0.094
Rivularia	20	28	1.400	0.062
Total		**3076**		**2.934**

TABLE-3.29

Frequency, density, abundance and diversity index (Shannon and Weiner) of periphyton in Goriganga river at sampling downstream of village Lilam

Periphyton	Frequency (%)	Density (individual/ m^{-2})	Abundance	Diversity index (Shannon Weiner)
Summer season				
Bacillariophyceae				
Tabellaria fenestris	76	328	4.316	0.493
Diatoma vulgaris	80	300	3.750	0.479
Fragilaria inflata	86	292	4.056	0.475
Nitzschia	16	24	1.500	0.102
Navicula radiosa	80	276	3.450	0.465
Cymbella cistula	28	36	1.286	0.138
Coconeis placentula	12	16	1.333	0.075
Synedra ulna	16	20	1.250	0.089
Cyclotella	12	16	1.333	0.075
Stauroneis	16	20	1.250	0.089
Ceratoneis	12	16	1.333	0.075
Denicula	8	12	1.500	0.060
Gomphonema	8	8	1.000	0.043
Chlorophyceae				
Ulothrix zonata	4	4	1.000	0.024
Myxophyceae				
Oscillatoria tenuis	4	8	2.000	0.043
Total		**1,376**		**2.723**

Periphyton	Frequency (%)	Density (individual/ m^{-2})	Abundance	Diversity index (Shannon Weiner)
Monsoon season				
Bacillariophyceae				
Tabellaria fenestris	96	296	3.083	0.461
Diatoma vulgaris	80	304	3.800	0.466
Fragilaria inflata	88	276	3.136	0.448
Nitzschia	36	72	2.000	0.210
Navicula radiosa	84	280	3.333	0.451
Cymbella cistula	44	76	1.727	0.217
Coconeis placentula	28	36	1.286	0.129
Synedra ulna	32	40	1.250	0.139
Cyclotella	12	36	3.000	0.129
Stauroneis	24	24	1.000	0.095
Ceratoneis	12	12	1.000	0.055
Denticula	8	8	1.000	0.040
Gomphonema	12	16	1.333	0.070
Chlorophyceae				
Ulothrix zonata	12	20	1.667	0.083
Spirogyra	16	20	1.250	0.083
Myxophyceae				
Oscillatoria tenuis	8	12	1.500	0.055
Total		**1,528**		**3.130**
Winter season				
Bacillariophyceae				
Tabellaria fenestris	100	568	5.680	0.477
Diatoma vulgaris	100	432	4.320	0.428
Fragilaria inflata	100	512	5.120	0.459
Nitzschia	100	400	4.000	0.413
Navicula radiosa	96	388	4.042	0.407
Cymbella cistula	28	36	1.286	0.085
Coconeis placentula	40	44	1.100	0.099
Synedra ulna	16	20	1.250	0.053
Cyclotella	64	104	1.625	0.184
Stauroneis	16	20	1.250	0.053
Ceratoneis	12	16	1.333	0.045
Gomphonema	8	8	1.000	0.025

Periphyton	Frequency (%)	Density (individual/ m^{-2})	Abundance	Diversity index (Shannon Weiner)
Chlorophyceae				
Ulothrix zonata	8	12	1.500	0.035
Chlorella	20	20	1.00	0.053
Myxophyceae				
Oscillatoria tenuis	28	36	1.280	0.085
Rivularia	16	20	1.250	0.053
Total		**2,636**		**2.955**

TABLE-3.30

Frequency, density, abundance and diversity index (Shannon and Weiner) of periphyton in Goriganga river at sampling site near Power house site

Periphyton	Frequency (%)	Density (individual/ m^{-2})	Abundance	Diversity index (Shannon Weiner)
Summer season				
Bacillariophyceae				
Tabellaria fenestris	96	296	3.083	0.461
Diatoma vulgaris	76	300	3.947	0.463
Fragilaria inflata	88	268	3.045	0.443
Nitzschia	36	72	2.000	0.210
Navicula radiosa	84	280	3.333	0.451
Cymbella cistula	44	76	1.727	0.217
Coconeis placentula	28	36	1.286	0.129
Synedra ulna	41	40	1.429	0.139
Cyclotella	12	20	1.667	0.083
Stauroneis	24	28	1.167	0.107
Ceratoneis	12	16	1.333	0.070
Denticula	8	12	1.500	0.055
Gomphonema	12	16	1.333	0.070
Chlorophyceae				

Periphyton	**Frequency (%)**	**Density (individual/ m^{-2})**	**Abundance**	**Diversity index (Shannon Weiner)**
Ulothrix zonata	12	16	1.333	0.070
Spirogyra	16	20	1.250	0.083
Myxophyceae				
Oscillatoria tenuis	8	12	1.500	0.055
Monsoon season				
Tabellaria fenestris	60	39.2	3.267	0.526
Diatoma vulgaris	56	35.2	3.143	0.516
Synedra	8	3.2	2.000	0.137
Fragilaria inflata	56	36	3.214	0.519
Nitzschia	4	0.8	1.000	0.047
Navicula radiosa	8	2.4	1.500	0.111
Cymbella cistula	12	2.4	1.000	0.111
Cocconeis placentula	8	1.6	1.000	0.081
Gomphonema	4	0.8	1.000	0.047
Denticula	4	0.8	1.000	0.047
Chlorophyceae		0		
Ulothrix zonata	8	1.6	1.000	0.081
Spirogyra	4	0.8	1.000	0.047
Myxophyceae		0		
Oscillatoria tenuis	4	0.8	1.000	0.047
Total		**125.6**		**2.318**
Winter season				
Bacillariophyceae				
Tabellaria fenestris	100	600	6.000	0.450
Diatoma vulgaris	100	540	5.400	0.430
Fragilaria inflata	100	408	4.080	0.375
Nitzschia	100	400	4.000	0.372
Navicula radiosa	100	536	5.360	0.428
Cymbella cistula	100	470	4.702	0.403
Coconeis placentula	40	44	1.100	0.084
Synedra ulna	52	76	1.462	0.126
Cyclotella	44	56	1.273	0.101
Stauroneis	24	28	1.167	0.059
Ceratoneis	12	16	1.333	0.038
Gomphonema	12	16	1.333	0.038

Periphyton	Frequency (%)	Density (individual/ m^{-2})	Abundance	Diversity index (Shannon Weiner)
Chlorophyceae				
Ulothrix zonata	12	16	1.333	0.038
Chlorella	20	20	1.00	0.045
Myxophyceae				
Oscillatoria tenuis	8	12	1.500	0.030
Rivularia	16	20	1.220	0.045
Total		**3258**		**3.061**

The data on frequency, density, abundance and diversity index (Shannon-Weiner) of phytoplankton of Goriganga river have been presented in Tables 3.31 to 3.33. The population of phytoplankton were sparse (101.6-250.8 individual/l^{-1}) at all the sampling sites. The highest desity 250.8 individual/l^{-1} were recored at Lilam during winter season. The diversity indices of phytoplankton ranged from 2.064-2.852. The highest diversity of 2.85 was also observed at Lilam during winter, which shows the water quality is good in Goriganga.

TABLE-3.31

Frequency, density, abundance and diversity index (Shannon and Weiner) of phytoplankton in Goriganga river at sampling site in submergence area

Phytoplankton	Frequency (%)	Density (individual/l^{-2})	Abundance	Diversity index (Shannon Weiner)
Summer season				
Bacillariophyceae				
Tabellaria fenestris	48	30.4	3.167	0.521
Diatoma vulgaris	44	28.8	3.273	0.516
Synedra ulna	4	0.8	1.000	0.055
Fragilaria inflate	44	31.2	3.545	0.523
Nitzschia	8	1.6	1.000	0.094
Navicula radiosa	20	5.6	1.400	0.230
Cymbella cistula	4	0.8	1.000	0.055
Gomphonema	4	0.8	1.000	0.055
Chlorophyceae				
Ulothrix zonata	4	0.8	1.000	0.055
Myxophyceae				
Oscillatoria tenuis	4	0.8	1.000	0.055
Total		**101.6**		**2.159**
Monsoon season				
Bacillariophyceae				
Tabellaria fenestris	48	31.2	3.250	0.523
Diatoma vulgaris	44	29.6	3.364	0.518
Synedra ulna	4	1.6	2.000	0.094
Fragilaria inflata	44	33.6	3.818	0.528
Nitzschia	8	1.6	1.000	0.094
Navicula radiosa	20	5.6	1.400	0.230
Cymbella cistula	4	0.8	1.000	0.055
Gomphonema	4	0.8	1.000	0.055
Chlorophyceae		0		
Ulothrix zonata	4	0.8	1.000	0.055
Myxophyceae		0		
Oscillatoria tenuis	4	0.8	1.000	0.055
Total		**106.4**		**2.209**
Winter season				
Bacillariophyceae				

Phytoplankton	Frequency (%)	Density (individual/l^{-2})	Abundance	Diversity index (Shannon Weiner)
Tabellaria fenestris	80	35.2	2.200	0.466
Diatoma vulgaris	20	4.0	1.000	0.125
Gomphoneiss	8	1.6	1.000	0.062
Synedra ulna	4	0.8	1.000	0.036
Fragilaria inflata	44	31.2	3.545	0.445
Nitzschia	8	1.6	1.000	0.062
Navicula radiosa	20	5.6	1.400	0.160
Cymbella cistula	4	0.8	1.000	0.036
Gomphonema	4	0.8	1.000	0.036
Gyrosigma	4	0.8	1.000	0.036
Chlorophyceae				
Ulothrix zonata	4	0.8	1.000	0.036
Spirogyra	4	0.8	1.000	0.036
Myxophyceae				
Oscillatoria tenuis	4	0.8	1.000	0.036
Rivularia	20	89.2	1.400	0.494
Total		**174**		**2.064**

TABLE-3.32

Frequency, density, abundance and diversity index (Shannon and Weiner) of phytoplankton in Goriganga river at sampling site near village Lilam

Phytoplankton	Frequency (%)	Density (individual/l^{-2})	Abundance	Diversity index (Shannon Weiner)
Summer season				
Bacillariophyceae				
Tabellaria fenestris	48	31.2	3.250	0.522
Diatoma vulgaris	64	29.6	2.313	0.517
Synedra ulna	8	1.6	1.000	0.093
Fragilaria inflata	56	32.0	2.857	0.524
Nitzschia	4	0.8	1.000	0.054

Phytoplankton	**Frequency (%)**	**Density (individual/l^{-2})**	**Abundance**	**Diversity index (Shannon Weiner)**
Navicula radiosa	12	3.2	1.333	0.155
Cymbella cistula	4	1.6	2.000	0.093
Cocconeis	4	0.8	1.000	0.054
Gomphonema	4	0.8	1.000	0.054
Chlorophyceae				
Ulothrix zonata	4	0.8	1.000	0.054
Myxophyceae				
Oscillatoria tenuis	4	0.8	1.000	0.054
Total		**103.2**		**2.176**
Monsoon season				
Bacillariophyceae				
Tabellaria fenestris	48	35.2	3.667	0.529
Diatoma vulgaris	64	31.2	2.438	0.522
Synedra ulna	8	3.2	2.000	0.155
Fragilaria inflata	56	32	2.857	0.524
Nitzschia	4	0.8	1.000	0.054
Navicula radiosa	12	4	1.667	0.182
Cymbella cistula	4	1.6	2.000	0.093
Cocconeis	4	0.8	1.000	0.054
Gomphonema	4	0.8	1.000	0.054
Chlorophyceae		0		
Ulothrix zonata	4	0.8	1.000	0.054
Myxophyceae		0		
Oscillatoria tenuis				
Total		**111.2**		**2.277**
Winter season				
Bacillariophyceae				
Tabellaria fenestris	92	40.8	2.217	0.426
Diatoma vulgaris	28	6.4	1.143	0.135
Synedra ulna	8	1.6	1.000	0.047
Fragilaria inflate	84	36	2.238	0.402
Nitzschia	36	8.8	1.222	0.170
Navicula radiosa	52	16	1.538	0.253

Phytoplankton	Frequency (%)	Density (individual/l^{-2})	Abundance	Diversity index (Shannon Weiner)
Cymbella cistula	96	54	2.875	0.477
Cocconeis	4	0.8	1.000	0.026
Gomphonema	4	0.8	1.000	0.026
Chlorophyceae				
Spirogyra	36	56	1.556	0.483
Ulothrix zonata	4	0.8	1.000	0.026
Myxophyceae				
Rivularia	20	28	1.400	0.353
Oscillatoria tenuis	4	0.8	1.000	0.026
Total		**250.8**		**2.852**

TABLE 3.33
Frequency, density, abundance and diversity index (Shannon and Weiner) of phytoplankton in Goriganga river at sampling site near power house site

Phytoplankton	Frequency (%)	Density (individual/l^{-2})	Abundance	Diversity index (Shannon Weiner)
Summer season				
Bacillariophyceae				
Tabellaria fenestris	60	38.4	3.200	0.524
Diatoma vulgaris	56	35.2	3.143	0.516
Synedra	4	1.6	2.000	0.081

Phytoplankton	Frequency (%)	Density (individual/l^{-2})	Abundance	Diversity index (Shannon Weiner)
Fragilaria inflata	56	36.0	3.214	0.519
Nitzschia	4	0.8	1.000	0.047
Navicula radiosa	8	2.4	1.500	0.111
Cymbella cistula	12	2.4	1.000	0.111
Cocconeis placentula	8	1.6	1.000	0.081
Gomphonema	4	0.8	1.000	0.047
Denticula	4	0.8	1.000	0.047
Chlorophyceae				
Ulothrix zonata	8	1.6	1.000	0.081
Spirogyra	4	0.8	1.000	0.047
Myxophyceae				
Oscillatoria tenuis	4	0.8	1.000	0.047
Total		**123.2**		**2.261**
Monsoon season				
Bacillariophyceae				
Tabellaria fenestris	60	39.2	3.267	0.526
Diatoma vulgaris	56	35.2	3.143	0.516
Synedra	8	3.2	2.000	0.137
Fragilaria inflata	56	36	3.214	0.519
Nitzschia	4	0.8	1.000	0.047
Navicula radiosa	8	2.4	1.500	0.111
Cymbella cistula	12	2.4	1.000	0.111
Cocconeis placentula	8	1.6	1.000	0.081
Gomphonema	4	0.8	1.000	0.047
Denticula	4	0.8	1.000	0.047
Chlorophyceae		0		
Ulothrix zonata	8	1.6	1.000	0.081
Spirogyra	4	0.8	1.000	0.047
Myxophyceae		0		
Oscillatoria tenuis	4	0.8	1.000	0.047
Total		**125.6**		**2.318**
Winter season				
Bacillariophyceae				

Phytoplankton	Frequency (%)	Density (individual/l^{-2})	Abundance	Diversity index (Shannon Weiner)
Tabellaria fenestris	92	40	2.174	0.529
Diatoma vulgaris	16	4	1.250	0.165
Synedra	12	20	1.660	0.433
Fragilaria inflata	56	36.0	3.214	0.522
Nitzschia	4	0.8	1.000	0.049
Navicula radiosa	8	2.4	1.500	0.114
Cymbella cistula	12	2.4	1.000	0.114
Cocconeis placentula	8	1.6	1.000	0.084
Gomphonema	4	0.8	1.000	0.049
Chlorophyceae				
Ulothrix zonata	8	1.6	1.000	0.084
Spirogyra	36	5.6	1.566	0.208
Myxophyceae				
Oscillatoria tenuis	4	0.8	1.000	0.049
Rivularia	20	2.8	1.400	0.127
Total		**118.8**		**2.524**

Zooplanktons

The density and diversity of zooplankton species observed during the survey conducted in summer, monsoon and winter season at various sampling sites are given in Tables-3.34 to 3.36. Zooplankton population in the Goriganga under the stretch of Rupsiyabagar-Kharsiabara hydroelectric project area was very low (Refer Tables-3.34 to 3.36). The total species of Zooplanktons were observed during summer, monsoon and winter season represented by the taxa of cladocerans (01) and rotifers (03). Density of zooplankton ranged from 19.2-58.8 individual/l^{-1}. The diversity indices (Shannon-Weiner) of zooplankton ranged from 1.126 to 1.824 at all the sites. The highest diversity observed 1.824 at station at power house site suring winter season. It indicates the poor diversity of zooplanktons in river Goriganga.

TABLE -3.34

Frequency, density, abundance and diversity index (Shannon and Weiner) of zooplankton in Goriganga river at sampling site in submergence area

Zooplankton	Frequency (%)	Density (individual/l^{-2})	Abundance	Diversity index (Shannon Weiner)
Summer season				
Cladocerans				
Daphnia	4	0.8	1.000	0.118

Rotifers				
Trichocera	44	19.2	2.182	0.495
Keratella	40	17.6	2.200	0.513
Total		**36.7**		**1.126**
Monsoon season				
Cladocerans				
Daphnia	4	0.8	1.000	0.120
Rotifers				
Trichocera	44	19.2	2.182	0.495
Keratella	48	16.8	1.750	0.519
Total		**36.8**		**1.135**
Winter season				
Cladocerans				
Daphnia	4	0.8	1.000	0.191
Rotifers				
Trichocera	4	0.8	1.000	0.191
Keratella	24	4.8	1.000	0.500
Branceionus	40	12.8	1.600	0.390
Total		**19.2**		**1.272**

TABLE 3.35

Frequency, density, abundance and diversity index (Shannon and Weiner) of zooplankton in Goriganga river at sampling site downstream of village Lilam

Zooplankton	Frequency (%)	Density (individual/ l^{-2})	Abundance	Diversity index (Shannon Weiner)
Summer season				
Cladocerans				
Daphnia	4	0.8	1.000	0.126
Rotifers				
Trichocera	40	18.4	2.300	0.483
Keratella	36	14.4	2.000	0.526
Asplanchna	4	0.8	1.000	0.126
Total		**34.4**		**1.261**
Monsoon season				
Cladocerans				
Daphnia	4	0.8	1.000	0.126

Rotifers				
Trichocera	36	18.4	2.556	0.483
Keratella	36	16.8	1.909	0.505
Asplanchna	4	1.6	2.000	0.206
Total		**37.6**		**1.320**
Winter season				
Cladocerans				
Daphnia	4	0.8	1.000	0.115
Rotifers				
Trichocera	0.8	18.4	2.300	0.512
Keratella	52	16	1.538	0.528
Asplanchna	4	0.8	1.000	0.115
Brancionus	12	3.2	1.333	0.295
Total		**39.2**		**1.564**

TABLE-3.36

Frequency, density, abundance and diversity index (Shannon and Weiner) of zooplankton in Goriganga river at sampling site near power house site

Zooplankton	Frequency (%)	Density (individual/ l^{-2})	Abundance	Diversity index (Shannon Weiner)
Summer season				
Cladocerans				
Daphnia	4	1.6	2.000	0.170
Rotifers				
Trichocera	40	20.0	2.500	0.522
Keratella	48	22.4	2.333	0.504
Asplanchna	8	1.6	1.000	0.170
Total		**45.6**		**1.364**
Monsoon season				
Cladocerans				

Daphnia	4	2.4	3.000	0.224
Rotifers				
Trichocera	40	18.4	2.300	0.528
Keratella	52	24	2.308	0.487
Asplanchna	8	1.6	1.000	0.170
Total		**46.4**		**1.409**
Winter season				
Cladocerans				
Daphnia	4	1.6	2.000	0.142
Rotifers				
Trichocera	40	20.0	2.500	0.529
Keratella	48	22.4	2.333	0.530
Asplanchna	8	1.6	1.000	0.142
Brancionus	48	12.8	1.600	0.480
Total		**58.4**		**1.824**

3.5.3.2 Macrozoobenthos

Macrozoobenthos of Goriganga were represented by the members of Ephemeroptera (7), Trichoptera (3), Odonata (2) and Plecoptera (2). Contribution of Ephemeropterans was highest to the total macro-zoobenthos. The density of macrozoobenthos was present in the range of 376-672 individual/m^{-2}. The maximum density was observed at sampling station near powerhouse. At this site open area with substantial bottom substrates in the form of boulders, pabbels and stones is observed. The diversity indices (Shannon-Weiner) of macrozoobenthos ranged from 2.885 to 3.752 in the Rupsiyabagar-Kharsiabara Project area. The details are given in Table-3.37 to 3.39.

TABLE -3.37

Frequency, density, abundance and diversity index (Shannon and Weiner) of benthos in Goriganga at sampling site in submergence area

Benthos	Frequency (%)	Density (individual/m^{-2})	Abundance	Diversity index (Shannon Weiner)
Summer season				
EPHEMEROPTERA				
Baetis rhodani	36	48	1.330	0.379
Baetis niger	52	72	1.380	0.456
B. muticus	24	36	1.500	0.324
Rithrogena	32	44	1.360	0.362
Heptagenia sulphurea	48	84	1.750	0.483
H. lateratis	48	64	1.330	0.434
TRICHOPTERA				
Glossosoma	4	8	2.000	0.118
Hydropsychae	8	8	1.000	0.118
Leptocela	4	4	1.000	0.069
ODONATA				
Amphizoa	4	8	2.000	0.118
Antocha	8	8	1.000	0.118
PLECOPTERA				
Isoperla	4	4	1.000	0.069
Total		**376**		**2.885**
Monsoon season				
EPHEMEROPTERA				
Baetis rhodani	36	84	2.333	0.453
Baetis niger	52	80	1.538	0.444
B. muticus	24	36	1.500	0.292
Rithrogena	28	40	1.429	0.311
Heptagenia sulphurea	48	100	2.083	0.483
H. lateratis	44	64	1.455	0.401
TRICHOPTERA				
Glossosoma	4	12	2.000	0.140
Hydropsychae	4	12	3.000	0.140

Benthos	Frequency (%)	Density (individual/m^{-2})	Abundance	Diversity index (Shannon Weiner)
Leptocela	4	4	1.000	0.061
ODONATA				
Amphizoa	4	8	2.000	0.104
Antocha	4	12	3.000	0.140
PLECOPTERA				
Isoperla	4	4	1.000	0.061
Total		**456**		**3.029**
Winter season				
EPHEMEROPTERA				
Baetis rhodani	56	108	1.929	0.459
Baetis niger	52	72	1.380	0.382
B. muticus	24	36	1.500	0.256
Rithrogena	44	88	2.000	0.421
Heptagenia sulphurea	48	84	1.750	0.412
H. lateratis	48	64	1.330	0.359
TRICHOPTERA				
Glossosoma	24	32	1.333	0.237
Hydroptella	16	40	2.500	0.273
Leptocela	4	4	1.000	0.051
ODONATA				
Amphizoa	4	8	2.000	0.088
Antocha	8	8	1.000	0.088
PLECOPTERA				
Isoperla	4	4	1.000	0.051
Pirla	8	8	1.000	0.088
Total		**556**		**3.165**

TABLE-3.38

Frequency, density, abundance and diversity index (Shannon and Weiner) of benthos in Goriganga at sampling site downstream of village Lilam

Benthos	Frequency (%)	Density (individual/ m^{-2})	Abundance	Diversity index (Shannon Weiner)
Summer season				
EPHEMEROPTERA				
Baetis rhodani	36	60	1.670	0.393
Baetis niger	20	24	1.200	0.230
B. muticus	40	64	1.600	0.406
Rithrogena	52	72	1.380	0.429
Heptagenia sulphurea	48	88	1.830	0.466
H. lateratis	32	64	2.000	0.406
Ecdynurus	16	24	1.500	0.230
TRICHOPTERA				
Glossosoma	4	8	2.000	0.105
Hydropsychae	8	8	1.000	0.105
ODONATA				
Amphizoa	8	12	1.500	0.142
Antocha	4	4	1.000	0.062
PLECOPTERA				
Isoperla	8	12	1.500	0.142
Total		**436**		**3.084**
Monsoon season				
EPHEMEROPTERA				
Baetis rhodani	40	60	1.500	0.394
Baetis niger	16	32	2.000	0.277
B. muticus	40	68	1.700	0.418
Rithrogena	52	76	1.462	0.439
Heptagenia sulphurea	48	92	1.917	0.474
H. lateratis	32	72	2.250	0.429
Ecdynurus	16	32	2.000	0.277
TRICHOPTERA				
Glossosoma	4	12	3.000	0.143
Hydropsychae	8	8	1.000	0.106
ODONATA				
Amphizoa	12	8	0.667	0.106
Antocha	4	4	1.000	0.062

Benthos	Frequency (%)	Density (individual/ m^{-2})	Abundance	Diversity index (Shannon Weiner)
PLECOPTERA				
Isoperla	12	8	0.667	0.106
Total		**472**		**3.229**
Winter season				
EPHEMEROPTERA				
Baetis rhodani	36	60	1.670	0.345
Baetis niger	20	24	1.200	0.195
B. muticus	40	64	1.600	0.358
Ephemerlignita	64	108	1.688	0.458
Rithrogena	52	72	1.380	0.380
Heptagenia sulphurea	48	88	1.830	0.420
H. lateratis	32	64	2.000	0.358
Ecdynurus	16	24	1.500	0.195
TRICHOPTERA				
Glossosoma	4	8	2.000	0.088
Hydroptila	8	8	1.000	0.088
Leptocella	4	4	1.000	0.051
ODONATA				
Amphizoa	8	12	1.500	0.119
Antocha	4	4	1.000	0.051
PLECOPTERA				
Isoperla	8	12	1.500	0.119
Pirla	8	8	1.000	0.088
Total		**560**		**3.310**

TABLE-3.39

Frequency, density, abundance and diversity index (Shannon and Weiner) of benthos in Goriganga at sampling site near power house site

Benthos	Frequency (%)	Density (individual/ m^{-2})	Abundance	Diversity index (Shannon Weiner)

Benthos	Frequency (%)	Density (individual/ m^{-2})	Abundance	Diversity index (Shannon Weiner)
EPHEMEROPTERA				
Baetis rhodani	40	52	1.300	0.321
Baetis niger	24	40	1.667	0.274
B. muticus	36	44	1.222	0.290
Rithrogena	44	72	1.636	0.383
Heptagenia sulphurea	40	64	1.600	0.360
H. lateratis	36	60	1.667	0.348
Ecdynurus	28	32	1.143	0.238
TRICHOPTERA				
Glossosoma	40	44	1.100	0.290
Hydropsychae	28	36	1.286	0.256
Leptocela	24	32	1.333	0.238
ODONATA				
Amphizoa	32	40	1.250	0.274
Antocha	16	20	1.250	0.173
PLECOPTERA				
Isoperla	16	16	1.000	0.148
Total		**552**		**3.598**
Monsoon season				
EPHEMEROPTERA				
Baetis rhodani	40	56	1.400	0.335
Baetis niger	24	40	1.667	0.274
B. muticus	36	48	1.333	0.306
Rithrogena	44	80	1.818	0.404
Heptagenia sulphurea	40	64	1.600	0.360
H. lateratis	36	60	1.667	0.348
Ecdynurus	32	32	1.000	0.238
TRICHOPTERA				
Glossosoma	40	48	1.200	0.306
Hydropsychae	28	36	1.286	0.257
Leptocela	20	36	1.800	0.257
ODONATA				
Amphizoa	36	40	1.111	0.274

Benthos	Frequency (%)	Density (individual/ m^{-2})	Abundance	Diversity index (Shannon Weiner)
Antocha	16	28	1.750	0.218
PLECOPTERA				
Isoperla	16	20	1.250	0.173
Total		**588**		**3.752**
Winter season				
EPHEMEROPTERA				
Baetis rhodani	40	52	1.300	0.286
Baetis niger	24	40	1.667	0.242
B. muticus	36	44	1.222	0.258
Ephemerlaignitta	64	108	1.688	0.424
Rithrogena	44	72	1.636	0.345
Heptagenia sulphurea	40	64	1.600	0.323
H. lateratis	36	60	1.667	0.311
Ecdynurus	28	32	1.143	0.209
TRICHOPTERA				
Glossosoma	40	44	1.100	0.258
Hydroptilla	16	40	1.500	0.242
Leptocela	24	32	1.333	0.209
ODONATA				
Amphizoa	32	40	1.250	0.242
Antocha	16	20	1.250	0.151
PLECOPTERA				
Isoperla	16	16	1.000	0.128
Pirla	8	8	1.000	0.076
Total		**672**		**3.705**

Primary Productivity

The phytoplankton primary productivity was determined by light and dark bottle method. The water samples for determination of the productivity were collected in light and dark BOD bottles. Three replicates were maintained for each sample. The experimental bottles were kept for 4 hours in the river from where the water samples were collected. Winkler's method was used for determination of oxygen in the light and dark bottles. Following formula was used for calculation of phytoplankton primary productivity.

Gross Primary Productivity (GPP)= $\frac{O_2 \text{ content of light bottle} - O_2 \text{ content of dark bottle} \times 1000 \times 0.375 \text{ (mgC/m}^3\text{/hour)}}{1.2 \times \text{Incubation hour}}$

$$\text{Net Primary Productivity (NPP)} = \frac{O_2 \text{ content of light bottle} - O_2 \text{ content of initial bottle} \times 1000 \times 0.375}{1.2 \times \text{Incubation hour}} \ (\text{mgC/m}^3\text{/hour})$$

The productivity measure of during all the three seasons (summer, monsoon and winter) at various sampling locations is given in Tables-3.40 to 3.42.

TABLE-3.40

Gross primary productivity (P_g), respiration (R), net Primary productivity (P_n) per hour and P/R ratio of aquatic periphyton and phytoplankton in river Goriganga in summer season

Sites	Gross primary productivity (P_g)			Respiration (R)			Net Primary Productivity (P_n)			P/R ratio
	Biomass (dry) g m^{-3} hr^{-1}	Carbon value g C m^{-3} hr^{-1}	Calories of energy K Cal m^{-3} hr^{-1}	Biomass (dry) g m^{-3} hr^{-1}	Carbon value g C m^{-3} hr^{-1}	Calories of energy K Cal m^{-3} hr^{-1}	Biomass (dry) g m^{-3} hr^{-1}	Carbon value g C m^{-3} hr^{-1}	Calories of energy K Cal m^{-3} hr^{-1}	
S_1	0.940	0.470	5.172	0.888	0.444	4.882	0.053	0.026	0.289	1.059
S_2	1.147	0.573	6.307	1.057	0.528	5.812	0.090	0.045	0.495	1.085
S_3	1.361	0.680	7.484	1.190	0.595	6.544	0.171	0.085	0.939	1.144

TABLE-3.41

Gross primary productivity (P_g), respiration (R), net Primary productivity (P_n) per hour and P/R ratio of aquatic periphyton and phytoplankton in river Goriganga in monsoon season

Sites	Gross primary productivity (P_g)			Respiration (R)			Net Primary Productivity (P_n)			P/R ratio
	Biomass (dry) g m^{-3} hr^{-1}	Carbon value g C m^{-3} hr^{-1}	Calories of energy K Cal m^{-3} hr^{-1}	Biomass (dry) g m^{-3} hr^{-1}	Carbon value g C m^{-3} hr^{-1}	Calories of energy K Cal m^{-3} hr^{-1}	Biomass (dry) g m^{-3} hr^{-1}	Carbon value g C m^{-3} hr^{-1}	Calories of energy K Cal m^{-3} hr^{-1}	
S_1	1.366	0.683	7.515	1.276	0.638	7.019	0.09	0.045	0.495	1.071
S_2	1.314	0.657	7.226	1.201	0.601	6.606	0.113	0.056	0.619	1.094
S_3	1.426	0.713	7.845	1.22	0.61	6.71	0.206	0.103	1.135	1.169

TABLE-3.42

Gross primary productivity (P_g), respiration (R), net Primary productivity (P_n) per hour and P/R ratio of aquatic periphyton and phytoplankton in river Goriganga in winter season

Sites	Gross primary productivity (P_g)			Respiration (R)			Net Primary Productivity (P_n)			P/R ratio
	Biomass (dry) g m^{-3} hr^{-1}	Carbon value g C m^{-3} hr^{-1}	Calories of energy K Cal m^{-3} hr^{-1}	Biomass (dry) g m^{-3} hr^{-1}	Carbon value g C m^{-3} hr^{-1}	Calories of energy K Cal m^{-3} hr^{-1}	Biomass (dry) g m^{-3} hr^{-1}	Carbon value g C m^{-3} hr^{-1}	Calories of energy K Cal m^{-3} hr^{-1}	
S_1	0.980	0.460	5.372	0.908	0.444	4.986	0.072	0.016	0.386	1.077
S_2	1.037	0.603	6.507	0.957	0.508	5.912	0.080	0.095	0.595	1.100
S_3	1.406	0.580	6.880	1.210	0.405	6.040	0.196	0.175	0.84	1.14

It was found from the analysis that Gross Primary Productivity (GPP) and Net Primary Productivity (NPP) of the river ranged between 0.460 to 0.713 mgC/m^3/hour and 0.016 to 0.175 mgC/m^3/hour respectively during all three seasons. The gross primaary productivity level indicates low to moderate biological productivity, which can be attributed temporal variations in the flow of the river.

3.5.4 Fisheries

The fisheries in the project area are poorly developed since the potential has remained unexploited owing to difficult terrain, unfavourable climate and poor infrastructural facilities. The elevation, temperature, current, velocity and natural biota are the factors governing the growth of fish in the rivers and water bodies in the area. Most of the streams, rivers, village ponds and other aquatic body in the upper reaches maintain fairly low temperature which results into low primary productivity. Hence, generally small sized fish are available in upper streams. However, slightly bigger fish were observed in the lower region where water temperature is slightly higher.

To ascertain the existing status of fisheries in the project area survey has been conducted using eastnet in the upstream of dam, between dam and power house and downstream of the power house in different section of the river during April 2006, July 2006 and December 2006.

The list of major species observed during survey are given in Table-3.43.

TABLE-3.43

Inventory of fish dwelling in Goriganga in the Rukpsiyabagar-Kharsiabara HEP area, Uttarakhnad

Name of the Fish	Local Name
Family Cyprinidae	
Schizothorax richardsonii	Asala
Schizothorax sinuatus	Asala
Schizothorax kumaonensis	Asala

Name of the Fish	Local Name
Tor tor	Dansulu
Tor putitora	Dansula
Garra lamta	Gondal
Garra gotyla gotyla	Gondal
Crossocheilus latius	Sunhera
Barilius bendelisis	Fulra
Barilius barna	Fulra
Barilius vagra	Fulra
Labeo dyocheilus	Kharont
Family Cobitidae	
Noemacheilus montanus	Gadiyal
Noemacheilus botia	Gadiyal
Noemacheilus rupicola	Gadiyal
Family Sisoridae	
Glyptothorax pectinopterus	Nau
Pseudoecheneis sulcatus	Mungria Nau

The Fish catch composition is given in Table-3.44.

TABLE-3.44

Fish catch composition in project area

Species	Composition (%)		
	April 2006	**July 2006**	**December 2006**
Schizothorax sp.	50	40	65
Tor sp.	5	10	-
Barillus sp.	5	-	-
Labeo sp.	10	10	5

Nemacheilus sp.	-	5	-
Miscellaneous	30	35	40

It is observed from the Table-3.44 that fish catch was dominated by Schizothorax sp. in all the season and constitute 40% to 60% the next dominant sp. were *Labeo* sp. and *Tor* sp. The catch per man hour has been worked out as 150 gm – 350 gm. It is worthwhile to mentioned that all these species observed in the downstream of power house. In the upstream, only *Schizothorax* species was observed. The occurrence of varying sizes (100-150 mm) of *Schizothorax* sp. in the castnet indicates the possibility of spawing of this species.

Snow trout, a migratory fish species represented by *Schizothorax* sp. are endemic to Himalayas. In winter months, when the water in upper reaches of these rivers touches almost $0^{o}C$, snow trouts migrate downstream for a considerable distance and constitute the major fisheries, particularly in the middle and lower stretches i.e. below an altitude of 800 m. Mahaseer in the area is represented by Tor species, which is one of the finest group of game fish of lower Himalayas (altitude <500 m). During months of May and June, they migrate upward and ascend to the smaller tributaries for breeding.

Minor carps and loaches are the other common groups of fish species found in this area. The minor carps are represented by *Labeo* sp., *Barilius* sp. and *Glyptothorax* sp. However, these fishes do not grow bigger in size and have less commercial value but they contribute significantly in meeting the food requirements of locals.

3.5.5 Micro-flora

1.1.1.1 The Himalayas constitute one of the three geo-morphological divisions of Indian subcontinent. They are abode of large variety of species belonging to micro-flora. Based on the comments of Appraisal Committee of Ministry of Environment & Forests, Government of India, the information on micro-flora was collected through primary and secondary sources. The findings of the same are given in the following paragraphs.

Ferns and fern allies are distributed throughout the length and breadth of Himalayas. It is reported that *Selanginella adunca*, *Selaginella pallissima*, *Selaginella pallida*, *Selaginalla chrysocaulos*, *Equisetum diffusum* distributed throughout the Himalayas between elevations 1500 to 2400 m are endemic to the region. Based on primary as well as secondary data sources, the presence of following species can be confirmed:

- *Athyrium* sp.
- *Driopteris* sp.
- *Adiantum* spp.
- *Pteris* spp.
- *Pteridium ecquilinum*
- *Selaginella spp.*
- *Osmunda regalis*
- *Gymnopteris* sp.

The major fungi species reported in the project area are given as below:

- *Erysiphe polygoni*
- *Uncinula odinea*
- *Aecidium* sp.
- *Rhizopus* sp.
- *Agaricus sp.*

The major bryophytes observed in the project area :

- *Anthoceros sp.*
- *Funaria* sp.
- *Notothylus* sp.
- *Riccia* sp.
- *Pellia* sp.
- *Marchantia* sp.

The major lichens observed in the project area :

- *Graphis sp.*
- *Parmelia sp.*
- *Usnea sp.*

CHAPTER-4
PREDICTION OF IMPACTS

4.1 GENERAL

Based on the project details and the baseline environmental status, potential impacts due to the construction and operation of the proposed Rupsiabagar Khasiabara hydroelectric project have been identified. This Chapter presents the potential impacts likely to accrue as a result of the proposed project. The Environmental Impact Assessment (EIA) for quite a few disciplines are subjective in nature and cannot be quantified. Wherever possible, impacts have been quantified and otherwise, qualitative assessment has been undertaken. This Chapter deals with the anticipated positive as well as negative impacts due to construction and operation of the proposed project.

The impacts which have been covered in the present Chapter are categorized as below:

- Water Environment
- Climate and Weather Environment
- Land Environment
- Ecological Environment

The impacts as referred above are described in the following sections. However, impacts on Demographic and socio-economic environment have been described in Chapter-5. The guidelines for formulation of Resettlement and Rehabilitation (R&R) Plan for Project Affected Families as per the R&R policy of NTPC is also delineated in Chapter-5.

4.2 WATER ENVIRONMENT

The various aspects covered under water environment are :

- Water resources
- Water quality
- Sediments

4.2.1 Water Resources

The construction of the dam leads to the formation of water spread area. The passage of flood through a water spread area leads to the reduction in peak flow. The dry season flow in the river too is regulated. Since, the storage capacity is small in the proposed project, moderation in flow is not expected to be significant.

The river stretch downstream of the dam site up to the confluence point of tail race discharge will have reduced flow due to diversion of water for hydro-power generation for a distance of about 9.4 km. There are significant number of streams out-falling in the river stretch between the dam and the tailrace discharge outfall site.

The reduction in flow is expected upto a distance of 3.5 km downstream of dam site, where River Kwirigad outfalls into river Goriganga on the left bank.

Just downstream of this point of confluence, another perennial stream flowing adjacent to Lainga village outfalls into river Goriganga on the right bank side at a distance of 3.9 km downstream of the dam site.

At a distance of 6.2 km downstream of the dam site, Suringarh Nadi confluence with river Goriganga and Just 0.6 km upstream of the tail race disposal site, another perennial stream outfalls into river Goriganga. Thus, there are four perennial streams outfalling in river Goriganga in the stretch from dam site to tail race disposal site.

Thus, river Goriganga will not be completely dry, in the intervening stretch. However, as mentioned earlier, there will be reduced flow upto confluence of Kwiri gad, at a distance of about 3. 5 km downstream of dam site. The reduction in flow or drying of the river in the intervening stretch is not likely to have any adverse impact on the downstream users. This is mainly because of the fact that settlements/villages within this stretch are not dependent on the water of river Goriganga, as the villagers use water of small streams or nallahs flowing adjacent to their habitation for meeting irrigation or domestic water requirements. Based on the interaction with locals and field observations, there are no schemes in the area, which lift water from river Goriganga for meeting water requirements for various uses. However, the reduction in flow can adversely affect the riverine ecology, especially fisheries as a result of reduction in flow. This aspect is covered in greater detail in Section 4.5.4 of this chapter.

4.2.2 Water quality

a) **Construction phase**

The major sources of surface water pollution during project construction phase are as follows:

- Sewage from labour camps/colonies.
- Effluent from crushers.
- Effluent from construction areas
- Effluent from truck parking area, workshop, etc.

Sewage from labour camps

The project construction is likely to last for a period of 6 years. The peak labour strength likely to be employed during project construction phase is about 2000 workers and 600 technical staff. The employment opportunities in the area are limited. Thus, during the project construction phase, the employment opportunities for the locals is likely to increase. It has been observed during construction phase of many of the projects, the major works are contracted out, who bring their own skilled labour. However, it is only in the unskilled category, that locals are likely to get employment. The construction phase however, will lead to mushrooming of various allied activities in the area, which will lead to improvement in the employment scenario. This can also lead to migration of people into the area in search of employment.

The following assumptions have been made for assessing the emigrating population in the area:

- 80% of workers and technical staff emigrating into the area are married.
- In 80% of the family of workers both the husband and wife will work.
- In 100% of the family of technical staff, only husband will work.
- 2% of total migrating population has been assumed as service providers.
- 50% of service providers will have families.
- Family size has been assumed as 5.

Based on experience of similar projects, the increase in the population as a result of migration of labour population during construction phase is expected to be of the order of 8,200.

The domestic water requirements has been estimated as 70 lites per capita per day (lpcd). Thus, total water requirements for a labour population of 8200 works out to 0.57 mld. It is assumed that about 80% of the water supplied will be generated as sewage. Thus, total quantum of sewage generated is expected to be of the order of 0.46 mld. The BOD load contributed by domestic sources will be about 369 kg/day. Generally, labour population resides in 2 to 3 colonies. Considering the worst case scenario for the purpose of assessment of impacts on water quality, it is assumed that all the sewage generated from various labour camps/colonies outfall at a common point.

Dissolved Oxygen modelling to assess the impacts on DO level of river Goriganga as a result of discharge of sewage from labour camps has been done using Streeter Phelp's model. The DO level was estimated using the following equation:

$$D_t = \frac{K_1 L_A [10^{-K1t} - 10^{-K2t}]}{K_2 - K_1} + D_A 10^{-K2t}$$

D_t = D.O. deficit downstream at time t.

K_1 = deoxygeration rate

K_2 = reaeration rate

L_A = ultimate upstream BOD

D_A = D.O. deficit upstream

t = time of stream flow upstream to point at which D.O. level is to be estimated

The results of D.O. model are summarized in Table-4.1.

TABLE-4.1

Results of D.O. modelling due to disposal of sewage from labour camps

Distance from outfall (km)	D.O. (mg/l)
0.1	8.00
0.2	8.00
0.3	8.00
0.4	8.00
0.5	8.00
1.0	8.00

In the proposed project, during project construction, one labour camp each is likely to be located near the dam and power house sites. Thus, in the proposed project too, sewage/BOD loading would outfall into the river Goriganga through 2 drains, which means that impacts on DO level of river water quality would be marginal. As a part of the Environmental Management Plan outlined in Chapter-6, appropriate sewage treatment facilities for labour population have been recommended, which will ameliorate even the marginal impacts on river quality due to disposal effluents from labour camps.

Effluent from crushers

During construction phase, at least one crusher each will be commissioned at the dam and the power project sites by the contractor involved in construction activities. The total capacity of the two crushers is likely to be will be of the order of 120-150 tph. Water is required to wash the boulders and to lower the temperature of the crushing edge. About 0.1 m^3 of water is required per tonne of material crushed. The effluent from the crusher would contain high suspended solids, i.e. 3,000 to 4,000 mg/l. About 12-15 m^3/hr of waste water is expected to be generated from each crusher. The effluent, if disposed without treatment can lead to marginal increase in the turbidity levels in the receiving water bodies. The natural slope in the area is such that, the effluent from the crushers will ultimately find its way in river Goriganga. This could lead to marginal increase in the turbidity levels for some stretch downstream of the point of confluence. Based on the experience in similar projects, the increase in turbidity level is generally not very significant. Similar phenomenon is expected in the proposed project as well. As a control measure, it is recommended to treat the effluent in settling tanks before disposal. Thus, with the commissioning of settling tanks, the treated effluent will have a suspended solid load of less than 100 mg/l, which means that effluent generated from crushers is not expected to cause any impact on river water quality.

Effluent from construction areas

Substantial quantities of water would be used in the construction activities. With regard to water quality, waste water from construction activities would mostly contain suspended impurities. Adequate care should be taken so that excess suspended solids in the wastewater are removed before discharge into water body.

Effluent from truck parking area, workshop, etc.

Similarly, the effluents due to washing from truck parking area, workshop, etc. would have high oil and grease values. The effluent quality is too small to cause any adverse impact.

However, it is still recommended to treat the effluent from these units/areas by oil and separator unit, to ameliorate even the marginal adverse impact likely to accrue on this amount.

b) Operation phase

The major sources of water pollution during project operation phase include:

- Effluent from project colony.
- Impacts on water quality due to impoundage
- Eutrophication risks.

Effluent from project colony

During project operation phase, due to absence of any large scale construction activity, the cause and source of water pollution will be much different. Since, only a small number of O&M staff will reside in the area in a well designed colony with sewage treatment plant and other infrastructure facilities, the problems of water pollution due to disposal of sewage are not anticipated. In the operation phase, about 50 families (total population of 250-300) will be residing in the project colony. About 0.038 to 0.045 mld of sewage will be generated. Considering the BOD level in the untreated sewage as 200 mg/l, the total BOD loading will be order of 7.6 to 9 kg/day. It is proposed to construct a project colony for staff and personnel involved in project operation phase. The project colony will have adequate sewage treatment facilities including secondary treatment units for sewage treatment. The BOD level in the treated sewage will reduce to 0.76 to 0.9 kg/day. The BOD loading is too small to cause any adverse impact. Thus, no impacts are anticipated as a result of disposal of sewage by staff involved in project operation phase.

Impacts on water quality due to impoundage

The flooding of previously forest and agricultural land in the submergence area will increase the availability of nutrients resulting from decomposition of vegetative matter. Phytoplankton productivity can supersaturate the euphotic zone with oxygen before contributing to the accommodation of organic matter in the sediments. Enrichment of water with organic and inorganic nutrients will be the main water quality problem immediately on commencement of the operation. However, this phenomenon is likely to last for a short duration of few years from the filling up of the reservoir. In the proposed project, most of the land coming under water spread area is barren, with few patches of trees. The tree density in the submergence area of the proposed dam is about 650 trees/ha. It is recommended to cut the trees before filling up of the reservoir. This will minimize the nutrient loading to a large extent. The reservoir area in the proposed project is of the order of only 4 ha. Normally, in such a small reservoir, there is significant variation in water level. This entails significant natural reaeration. As a result, D.O. level will be maintained and no reduction in D.O. levels are anticipated during project operation phase.

Eutrophication risks

Another significant impact observed in the reservoir/water spreads area is the problem of eutrophication which occurs mainly due to the disposal of nutrient rich effluents from the agricultural fields. However, in the present case, fertilizer use in the project area is almost negligible, i.e. less than 3 kg/ha, which is less than 10% of the national average of 35 kg/ha. Most of the land holdings in the catchment area intercepted upto the dam site is small. The cropping intensity too is quite less. Even in the project operation phase, the scenario is likely to be same. This is mainly because of the fact that the population density is low, and correspondingly the cropping intensity is low. Most of the cropping is done on terraced areas, where use of agro-chemicals is currently minimal and is likely to remain so even during project operation phase as well. Thus, the nutrient loading in project operation phase too is not likely to increase significantly. Hence, eutrophication risks are not anticipated.

4.2.3 Sediments

The catchment area has large number of reserve forests, dense mixed forest, open scrubs, rockfall sites and moraine deposits carried by glaciers. At higher elevations i.e. beyond proposed scheme Mapang Bogudiyar, the forest cover is almost nil. Open mixed jungle is sparsely located. Major catchment area contains a number of glaciers and bare rocks with little or no soil cover. The average annual sediment rate for Khasiyabara Dam as per DPR has been estimated as 0.17 ha.m/m^2/year.

4.3 AIR ENVIRONMENT

The various impacts covered under the above category are:

- Ambient air quality
- Noise

4.3.1 Ambient air quality

In a water resources project, air pollution occurs mainly during project construction phase. The major sources of air pollution during construction phase are:

- Pollution due to fuel combustion in various construction equipment.
- Fugitive emissions from crushers.
- Impacts due to vehicular movement.

Pollution due to fuel combustion in various equipment

The operation of various construction equipment requires combustion of fuel. Normally, diesel is used in such equipment. The major pollutant which gets emitted as a result of diesel combustion is SO_2. The SPM

emissions are minimal due to low ash content. Based on past experience in similar projects, the increase in SPM and SO_2 is not expected to increase significantly due to combustion of fuel in various construction equipment. In the proposed project, no significant impact on ambient air quality is expected as a result of operation of various construction equipment.

Emissions from various crushers

The operation of the crusher during the construction phase is likely to generate fugitive emissions, which can move even upto 1 km in predominant wind direction. During construction phase, one crusher each is likely to be commissioned at the barrage and power house sites. During crushing operations, fugitive emissions comprising of the suspended particulate will be generated. There could be marginal impacts to settlements close to the sites at which crushers are commissioned. However, based on past experience, adverse impacts on this account are not anticipated. However, during finalising the project layout, it should be ensured that the labour camps, colonies, etc. are located on the leeward side and outside the impact zone (about 1.5 to 2 km) of the crushers.

Impacts due to vehicular movement

During construction phase, there will be increased vehicular movement for transportation of various construction materials to the project site. Large quantity of dust is likely to be entrained due to the movement of trucks and other heavy vehicles. However, such ground level emissions do not travel for long distances. Thus, no major adverse impacts are anticipated on this account.

4.3.2 Impacts on noise environment

In a water resource projects, the impacts on ambient noise levels are expected only during the project construction phase, due to earth moving machinery, etc. Likewise, noise due to quarrying, blasting, vehicular movement will have some adverse impact on the ambient noise levels in the area.

Impacts due to operation of construction equipment

The noise level due to operation of various construction equipment is given in Table-4.2.

TABLE-4.2

Noise level due to operation of various construction equipment

Equipment	Noise level (dB(A))
Compressors	75-85
DG Sets	72-82
Concrete placers	70-80
Batching plant	75-85
Crushers	68-70
Concrete Pumps	68-70
Tippers	60-65
Boomers	65-75
Excavator	70-80
Mixers	65-75
Shovel	75-85
Loader	70-80
Dozer	70-80
Tunnel Loading Machine	75-85

As a part of the study, noise modeling was done to assess impacts on ambient noise level due to operation of various construction equipment. Based on the noise modeling results and considering of attenuation due to various factors, no significant increase in ambient noise level was anticipated, beyond a distance of 200 to 300 m from the construction sites.

Impacts due to increased vehicular movement

During construction phase, there will be significant increase in vehicular movement for transportation of construction material. At present, vehicular movement near the barrage site is of the order of 10-15 trucks/hour. During construction phase, the increase in vehicular movement is expected to increase upto a maximum of 45 to 50 trucks/hour.

As a part of EIA study, impact on noise level due to increased vehicular movement was studied using Federal Highway Administration model. Based on the results of modeling studies and attenuation due to various factors, significant increase in ambient noise level was not anticipated as a result of increase vehicular movement, during project construction phase.

Impacts on labour

The effect of high noise levels on the operating personnel, has to be considered as this may be particularly harmful. It is known that continuous exposures to high noise levels above 90 dB(A) affects the hearing acuity of the workers/operators and hence, should be avoided. To prevent these effects, it has been recommended by Occupational Safety and Health Administration (OSHA) that the exposure period of affected persons be limited as in Table-4.3.

TABLE-4.3

Maximum Exposure Periods specified by OSHA

Maximum equivalent continuous Noise level dB(A)	Unprotected exposure period per day for 8 hrs/day and 5 days/week
90	8
95	4
100	2
105	1
110	½
115	¼
120	No exposure permitted at or above this level

Noise generated due to blasting

Noise generated by blasting is instantaneous in nature. Noise generated due to blasting is site specific and depends on type, quantity of explosives, dimension of drill hole, degree of compaction of explosives in the hole and rock. Noise levels generated due to blasting have been monitored at various sites and the results have been summarized in Table-4.4.

TABLE-4.4

Noise generation due to blasting

No. of holes	Total charge (kg)	Maximum charge/delay (kg)	Distance (m)	Noise level dB(A)
15	1500	100	250	76-85
17	1700	100	250	76-86
18	1800	100	250	74-85
19	1900	100	400	70-75
20	2000	100	100	76-80

It can be observed from Table-4.4, that noise level due to blasting operations are expected to be of the order of 75-86 dB(A). Since, the nearest settlement is atleast 1 km away, the incremental noise due to blasting is expected to be 50-60 dB(A). As the blasting is likely to last for 4 to 5 seconds depending on the charge, noise levels over this time would be instantaneous and short in duration. Considering attenuation due to various sources, even the instantaneous increase in noise level is not expected to higher than 60 dB(A). Hence, noise level due to blasting is not expected to cause any significant adverse impact.

Impacts due to ground vibrations

The explosive energy generated during blasting sets up a seismic wave within the surface, which may affect the structures and cause discomfort to human population. When an explosive charge is fired in a hole, stress waves traverse in various directions, causing the rock particles to oscillate. Blasting also generates ground vibrations and instantaneous noise.
Various measures have been recommended to minimize the adverse impacts due to blasting:

- proper design of blast hole to be developed
- Use of noiseless trunk delays to minimize the noise due to air blast.
- Use of non-electric system of blasting for true bottom hole initiation.
- Use of muffling mats to arrest the dust and fly rock.

4.4 IMPACTS ON LAND ENVIRONMENT

The major impacts anticipated on land environment are due to following:

- Quarrying operations.
- Operation of construction equipment.
- Muck disposal.
- Construction of roads.
- Acquisition of land

4.4.1 Quarrying operations

The project would require about 1.3 lakh m^3 of coarse aggregate, 0.5 lakh m^3 of fine aggregate and 115,000 m^3 of sand. A part of the excavated material generated during tunneling operations will be utilized as construction material. Two quarries are proposed to be used for the project. About 80% of the requirement are proposed to be met from Bhadeli quarry and the balance requirement is proposed to be met from Jimmyghat quarry. Sand is proposed to be acquired from river Goriganga close to power house site.
The quarrying operations shall be semi-mechanized in nature. Normally, in a hilly terrain like Uttarakhand, quarrying is done by cutting a face of the hill. A permanent scar is likely to be left, once quarrying activities are over. With the passage of time, rock from the exposed face of the quarry under the action of wind and other erosional forces, get slowly weathered and after some time, they become a potential source of landslide. Thus it is necessary to implement appropriate slope stabilization measures to prevent the possibility of soil erosion and landslides in the quarry sites.
The measures recommended for quarry slope stabilization are given in Chapter-6 of this Report.

Operation of construction equipment

During construction phase, various types of equipment will be brought to the site. These include crushers, batching plant, drillers, earth movers, rock bolters, etc. The siting of these construction equipment would require significant amount of space. Similarly, space will be required for storing of various other construction equipment. In addition, land will also be

temporarily acquired, i.e. for the duration of project construction for storage of quarried material before crushing, crushed material, cement, rubble, etc. Efforts must be made for proper siting of these facilities.

The various criteria for selection of these sites would be:

- Proximity to the site of use.
- Sensitivity of forests in the nearby areas.
- Proximity from habitations.

Efforts must be made to site the contractor's working space in such a way that the adverse impacts on environment are minimal. These should be located on government land at a distance from human population. No major wildlife population is reported in the project area and its surrounding area. Hence, impacts on this account are not expected to be significant.

Muck disposal

About 1.65 Mm^3 of muck is expected to be generated from various sources. The details are given in Table-4.5.

TABLE-4.5

Quantum of muck to be generated in the proposed Rupsiabagar Khasiabara Hydroelectric project

Project Appurtenance	**Quantity (m^3)**
Diversion tunnel	70,000
Dam	435,000
Intake and Intake tunnel	120,000
Desilting chambers	270,000
Head Race Tunnel	513,000
Surge shaft	110,000
Penstock	22,000
Power house	110,000
Total	**1650,000 or 1.65 Mm^3**

A part of the muck is proposed to be used as a construction material and the balance is proposed to be disposed at designated sites, which shall be located in low lying areas or depressions. Trees, if any, shall be cut before muck disposal. However, shrubs, grass or other types of undergrowth in the muck disposal at sites shall perish.

Adequate area shall be earmarked which can cater to the entire quantity of muck to be disposed. A part of the muck can be disposed by landfilling the sites where many of the project appurtenances are likely to come up and require landfiling. Similarly, a part of the muck can be used for restoration of the construction sites. The remedial measures required have been addressed in the Environmental Management Plan (EMP) which is outlined in Chapter-6 of this Report.

Construction of roads

The project construction would entail significant vehicular movement for transportation of large quantities of construction material, heavy construction equipment. New access roads

would have to be constructed. Some of the existing roads in the project area, would require widening. The construction of roads can lead to the following impacts:

- The topography of the project area has steep slopes, which descend rapidly into narrow valleys. The conditions can give rise to erosion hazards due to net downhill movement of soil aggregates. Removal of trees on slopes and re-working of the slopes in the immediate vicinity of roads, can encourage landslides, erosion gullies, etc. With the removal of vegetal cover, erosive action of water gets pronounced and accelerates the process of soil erosion and formation of deep gullies. Consequently, the hill faces are bared of soil vegetative cover and enormous quantities of soil and rock can move down the rivers, and in some cases, the road itself may get washed out.

- Construction of new roads increases the accessibility of an hitherto undisturbed areas resulting in greater human interferences and subsequent adverse impacts on the ecosystem.

- Increased air pollution during construction phase.

Various management measures have been recommended for control of adverse impacts due to construction of roads, and the same have been covered as a part of Environmental Management Plan outlined in Chapter-6 of this Report.

Acquisition of land

The total land proposed to be acquired for the project is 264 ha. The details are given in Table-4.6. About 105.6 ha of private land is proposed to be acquired. The Project Affected Families (PAFs) shall be provided with adequate compensation as per norms specified in National Policy on Resettlement and Rehabilitation (2007) and R&R policy of NTPC (2005).

TABLE-4.6

Land requirement for Rupsiabagar Khasiyabara hydroelectric project

Project appurtenance	Government land ha)	Private land (ha)	Total (ha)
Project area including reservoir	19.2	12.8	32.0
Infrastructure including township	109.2	72.8	182.0
Quarry and Muck disposal area	30.0	20.0	50.0
Total	**158.4**	**105.6**	**264.0**

4.5 IMPACTS ON ECOLOGY

4.5.1 Terrestrial Ecology

Increased human interferences

The direct impact of construction activity of any water resource project in a Himalayan terrain is generally limited in the vicinity of the construction sites only. As mentioned earlier, a large population (8,200) including technical staff, workers and other group of people are likely to congregate in the area during the project construction phase. It can be assumed that the

technical staff will be of higher economic status and will live in a more urbanized habitat, and will not use wood as fuel, if adequate alternate sources of fuel are provided. However, workers and other population groups residing in the area may use fuel wood (if no alternate fuel is provided) for whom firewood/coal depot could be provided. To minimize impacts, community kitchens have been recommended. These community kitchens shall use LPG or diesel as fuel. The details have been covered in Environmental Management Plan outlined in Chapter-6 of this Report.

Acquisition of forest land

During project construction phase, land will also be required for location of construction equipment, storage of construction material, muck disposal, widening of existing roads and construction of new project roads. The total land to be acquired for the project is about 264 ha. The details are given in Table-4.6.

In Uttarakhand, the entire land is considered to be government land under the ownership of Forest Department.

As a part of the EIA study, detailed Ecological survey has been conducted for summer season. Based on the findings of the survey, it can be concluded that the tree density in the project area to be acquired shows that the area has medium density forest. Though the project area is located in an ecologically sensitive area, the forest in and around the project area are quite degraded. No rare or endangered species are observed.

The density of trees in the submergence area is about 652/ha. Likewise at the power house site, the tree density is 528/ha. Normally in a good forest, the tree density is of the order of 1000-1200 per ha. The diversity too is high in such forests. In the proposed project area, 12-15 tree species only were observed at various sampling sites. No rare and endangered floral species are observed. Thus, forests in the project area can be categorized as having medium density, hence, no major adverse impacts due to various activities during project construction and operation phases are envisaged.

Disturbance to wildlife

During construction phase, large number of machinery and construction labour will have to be mobilized. The operation of various construction equipment, and blasting is likely to generate noise. These activities can lead to some disturbance to wildlife population. Likewise, siting of construction equipment, godowns, stores, labour camps, etc. can lead to adverse impacts on fauna, in the area. From the available data, the area does not have significant wildlife population. Likewise, area does not appear to be on the migratory routes of animals and therefore the construction of the project will not affect the animals.

Based on field observations and interactions with locals, etc. it can be said that no major fauna is observed in the project area. Hence, the impacts on terrestrial fauna is not expected to be significant. Stray animals, however, may some times drift to the construction site. It should be ensured through stringent anti-poaching surveillance that the stray animals are not killed. Detailed measures for the same have been suggested in Chapter-6 which outlines the Environmental Management Plan (EMP).

4.5.3 Impacts due to increased accessibility

During the project operation phase, the accessibility to the area will improve due to construction of roads, which in turn may increase human interferences leading to marginal adverse impacts on the terrestrial ecosystem. At present, major wildlife population is not

observed or reported from the project area and its surroundings. Thus, no impact is expected on these sites. However, mitigation measures to improve the terrestrial ecology of the area and also to increase the surveillance in the area are given in Chapter-6 of this Report.

4.5.4 Aquatic ecology

a) Construction phase

The construction of the proposed Rupsiabagar Khasiabara hydroelectric would involve large scale extraction of different types of construction material from the river bed including boulders, stones, gravel, sand, etc. Extraction of gravel and sand causes considerable damage to fish stocks and other aquatic life by destabilizing the sub-stratum, increasing the turbidity of water, silting of the channel bottom and modifying the flow which in turn may result in erosion of the river channel. These alterations upset the composition and balance of aquatic organisms. The material at the river sub-stratum like stones and pebbles often provide anchorage and home to the invertebrates who remain attached in a fast flowing streams. During fish spawning season, fertilized eggs are laid amidst the gravel, where it is made sure, that eggs are not washed away in fast flowing stream. The eggs of almost all species are sticky in nature which provide additional safety. The turbidity in excess of 100 ppm brought by suspended solids chokes the gills of young fish. Fine solids in concentration greater than 25 mg/l, adversely affects the development of fish eggs and fish.

During construction of a river valley project, huge quantity of debris is generated at various construction sites. The debris, if a separate area for dumping of the material is not marked, invariably would flow down the river during heavy precipitation. Such a condition adversely affects the development of aquatic life. Hence, it is very much desirable that a suitable area is earmarked for the disposal of muck generation during the construction phase.

Impacts due to excavation of construction material from river bed

During the construction phase of the proposed Rupsiabagar Khasiabara hydroelectric project, large quantity of building material like stones, pebbles, gravel and sand would be needed for various construction of various project appurtenances. Some of the proposed is to be extracted the construction material, affects the river water quality by increasing the turbidity levels. This is mainly because of the fact that during excavation of marterial from river, the dredged material gets released during:

- excavation of material from the river bed
- loss of material during transport to the surface
- overflow from the dredger while loading
- loss of material from the dredger during transport.

The cumulative impact of the above is increased turbidity levels. Good dredging practice can however, minimize turbidity. It has also been observed that slope collapse is the major factor in increasing the turbidity levels. If the depth of cut is too high, there is slope collapse, which releases a sediment cloud, which goes outside the suction radius of dredged head. In order to ensure that this does not happen, the depth of cut should be restricted such that:

$$\gamma H/C < 5.5$$

where

γ - unit weight of the soil
H - depth of soil
C - cohesive strength of soil

The dredging and deposition of dredged material is likely to affect the survival and propagation of micro benthic organisms. The macro-benthic life which remains attached to the stones, boulders etc. gets dislodged and is carried away downstream by turbulent flow. The areas from where construction material is excavated, benthic fauna gets destroyed. In due course of time, however, the area gets recolonized, with benthic fauna. The density and diversity of benthic fauna, is however, much lesser as compared to the pre-dredging levels.

Impacts due to discharge of sewage from labour camp/colony

The proposed hydro-power project would envisage temporary and permanent residential areas to accommodate labour and staff engaged in the project. This would result in emergence of domestic waste

water which is usually discharged into the river. Due to perennial nature of river Goriganga, it maintains sufficient flow through out the year. The available flow is sufficient to dilute the sewage and as mentioned earlier, no adverse impacts on water quality are anticipated.

Impacts due to increased human activities

The increase of human activities in the project area, results in enhancement in indiscriminate fishing, which can adversely affect the riverine ecology. Indiscriminate fishing will reduce fish stock availability for commercial and sport fishermen. Thus, it is recommended that adequate surveillance measures are implemented during project construction phase to ameliorate such impacts.

b) Operation phase

The completion of Rupsiabagar Kharsiyabara hydroelectric Project would bring about significant changes in the riverine ecology, as the river transforms from a fast-flowing water system to a quiescent lacustrine environment. Such an alteration of the habitat would bring changes in physical, chemical and biotic life. Amongst the biotic communities, certain species can survive the transitional phase and can adapt to the changed riverine habitat. There are other species amongst the biotic communities, which, however, for varied reasons related to feeding and reproductive characteristics cannot acclimatize to the changed environment, and may disappear in the early years of impoundment of water. The micro-biotic organisms especially diatoms, blue-green and green algae before the operation of project, have their habitats beneath boulders, stones, fallen logs along the river, where depth is such that light penetration can take place. But with the damming of river, these organisms may perish as a result of increase in depth.

Amongst the aquatic animals, it is the fish life which would be most affected. The migratory route of fish

species, like snow trout is likely to be affected due to the construction of the proposed barrage.

With the completion of dam, and diversion of flow for hydropower generation, following changes are expected

- reduced flow rate
- increase in water temperature
- reduction in availability of stano-thermal aquatic animals
- increase in population of euro-thermal species.

Unless the desired flow is maintained downstream of the barrage, aquatic ecology in general and fisheries in particular would be affected.

Impacts on migratory fish species

The obstruction created by the dam would hinder the migration of certain migratory species especially *Schizothorax* (from upper reaches to the lower reaches) and Mahaseer (from lower reaches to the upper reaches). This species undertakes annual migration for feeding and breeding. Finding their migratory path obstructed due to the dam, they are expected to congregate below the dam wall and will be indiscriminately caught by the poachers. This can lead to adverse impact on the migratory fish species. Adequate measures for their sustenance have been recommended as a part of Environmental Management Plan, outlined in Chapter-6 of this Report.

CHAPTER-5

DEMOGRAPHIC AND SOCIO-ECONOMIC ASPECTS

5.1 INTRODUCTION

The proposed Rupsiabagar Khasiabara hydroelectric Project lies in tehsil Munsiyari of district Pithoragarh. As part of EIA study, a detailed assessment of socio-economic parameters has been undertaken. The objective of this study was to ascertain the overall socio-economic conditions prevailing in the vicinity of the study area and also the population that is likely to be affected due to land acquisition for the project. Further, the study also assessed the impacts that are likely to be accrued as a result of the construction and operation of the proposed project. The norms for formulation of Rehabilitation and Resettlement (R&R) plan for the Project Affected Families (PAFs) have also been outlined in this chapter.

5.2 DEMOGRAPHIC & SOCIO-ECONOMIC PROFILE OF THE STUDY AREA

The demographic and socio-economic profile description is based on the census data (Primary Census Abstract) of year 2001 of tehsil Musyari and district Pithoragarh. The study area comprises of 42 villages, which would be hereafter referred to as the Study Area Villages (SAVs). All the SAVs lie in the Tehsil Munsyari, district Pithoragarh.

5.2.1 Demography

The total population residing in the study area is about 10595 in 2372 households. The male and female population within the SAVs account for about 48.84% and 51.15% percentage of total SAVs population. The number of females per 1000 males and family size in the SAVs are 1047 and 4.5, respectively. The village-wise demographic details in the SAVs are shown in Table 5.1.

TABLE-5.1

Demographic profile of the study area villages

Study Area Villages	No. of Households	Population			Sex ratio	Family size
		Total	Males	Females		
Basantkot	41	220	105	115	1095	5.37
Bhaiskhal	66	300	135	165	1222	4.55
Bunie	56	279	151	128	848	4.98
Chauna	75	324	139	185	1331	4.32
Chulkot	52	246	120	126	1050	4.73
Darati	64	265	128	137	1070	4.14
Darkot	87	340	155	185	1194	3.91
Dhapa	86	376	181	195	1077	4.37
Dheelam	30	164	84	80	952	5.47
Dhuratoli	43	233	119	114	958	5.42
Dolma	19	87	39	48	1231	4.58
Dumar Malla	41	160	74	86	1162	3.90
Dumar Talla	62	265	120	145	1208	4.27
Gaila Malla	20	105	53	52	981	5.25
Gaila Tala	21	107	53	54	1019	5.10

Study Area Villages	No. of Households	Population			Sex ratio	Family size
		Total	Males	Females		
Ghor Patta Talla	62	227	103	124	1204	3.66
Ghorpatta Malla	268	1155	686	469	684	4.31
Harkot	58	276	121	155	1281	4.76
Jalath	68	251	127	124	976	3.69
Josha	181	880	431	449	1042	4.86
Khata	3	12	8	4	500	4.00
Kotal Gaon	52	236	107	129	1206	4.54
Kultham	34	160	82	78	951	4.71
Leelum	16	45	25	20	800	2.81
Malupati	27	124	60	64	1067	4.59
Matena	26	131	56	75	1339	5.04
Papri	99	446	218	228	1046	4.51
Pato	61	245	117	128	1094	4.02
Pattharkot	18	110	59	51	864	6.11
Phalyati	24	123	67	56	836	5.13
Phapha	65	259	130	129	992	3.98
Pyangti	8	39	16	23	1438	4.88
Quiri	36	154	68	86	1265	4.28
Rapti	43	213	97	116	1196	4.95
Ropar	13	67	29	38	1310	5.15
Sain Polu	77	366	182	184	1011	4.75
Sainar	22	101	43	58	1349	4.59
Suring	79	339	150	189	1260	4.29
Uchhaiti	35	149	79	70	886	4.26
Ugarali	3	12	7	5	714	4.00
Walthi	197	855	385	470	1221	4.34
Zimiya	34	149	66	83	1258	4.38
SAV Total	**2372**	**10595**	**5175**	**5420**	**1047**	**4.47**

Source: ***Primary Census Abstract, 2001***

5.2.2 Caste profile in the SAVs

The indigenous population is a considerable group in terms of numbers within the study area. The Scheduled Tribe (ST) population constitutes about 28.3% of the total

population of the SAVs. The Scheduled Caste (SC) population also amounts for about 23.9% of the total population of SAVs. However, population belonging to other castes is observed in sizable numbers, accounting for about 47.8% of the total population in the SAVs. The village-wise distribution of total population, SC and ST population in the SAVs are depicted in Table 5.2.

TABLE-5.2

Caste profile in the study area

Study Area Villages	Total Population	SC Population		ST Population	
		Nos.	%age	Nos.	%age
Pato	245	46	*18.8*	144	*58.8*
Bunie	279	57	*20.4*	138	*49.5*
Leelum	45	0	*0.0*	21	*46.7*
Sain Polu	366	235	*64.2*	73	*19.9*
Jyu Zimiya	149	0	*0.0*	146	*98.0*
Quiri	154	0	*0.0*	154	*100.0*
Uchhaiti	149	0	*0.0*	0	*0.0*
Dhuratoli	233	0	*0.0*	0	*0.0*
Phapha	259	5	*1.9*	4	*1.5*
Basantkot	220	4	*1.8*	0	*0.0*
Chulkot	246	116	*47.2*	130	*52.8*
Khata	12	0	*0.0*	0	*0.0*
Gaila Malla	105	0	*0.0*	0	*0.0*
Gaila Tala	107	0	*0.0*	0	*0.0*
Pattharkot	110	9	*8.2*	0	*0.0*
Rapti	213	75	*35.2*	0	*0.0*
Ropar	67	0	*0.0*	0	*0.0*
Walthi	855	168	*19.6*	20	*2.3*
Dolma	87	15	*17.2*	0	*0.0*
Pyangti	39	0	*0.0*	0	*0.0*
Dhapa	376	27	*7.2*	247	*65.7*
Kultham	160	0	*0.0*	24	*15.0*
Dheelam	164	2	*1.2*	7	*4.3*
Ugarali	12	0	*0.0*	0	*0.0*
Dumar Talla	265	135	*50.9*	106	*40.0*

Study Area Villages	Total Population	SC Population		ST Population	
		Nos.	%age	Nos.	%age
Sainar	101	25	*24.8*	34	*33.7*
Jalath	251	104	*41.4*	111	*44.2*
Dumar Malla	160	32	*20.0*	59	*36.9*
Darkot	340	96	*28.2*	197	*57.9*
Phalyati	123	0	*0.0*	0	*0.0*
Suring	339	19	*5.6*	248	*73.2*
Darati	265	131	*49.4*	88	*33.2*
Ghorpatta Malla	1155	334	*28.9*	407	*35.2*
Ghor Patta Talla	227	61	*26.9*	109	*48.0*
Papri	446	73	*16.4*	149	*33.4*
Matena	131	58	*44.3*	14	*10.7*
Harkot	276	118	*42.8*	111	*40.2*
Malupati	124	0	*0.0*	20	*16.1*
Chauna	324	8	*2.5*	22	*6.8*
Kotal Gaon	236	78	*33.1*	53	*22.5*
Josha	880	423	*48.1*	137	*15.6*
Bhaiskhal	300	81	*27.0*	25	*8.3*
SAV Total	**10595**	**2535**	***23.9***	**2998**	***28.3***

Source: ***Primary Census Abstract, 2001***

5.2.3 Literacy Levels in the SAVs

The literacy rate in the SAVs is 59.3%. The male and female literacy rate is 72.1% and 47% respectively. The village-wise details of literacy in the SAVs are given in Table 5.3.

TABLE-5.3

Literacy profile in the study area

Study Area Villages	Total Population	Literate Population					
		Total (Nos.)	Total Literacy Rate (%)	Males (Nos.)	Male Literacy Rate (%)	Females (Nos.)	Female Literacy Rate (%)
Pato	245	101	*41.2*	63	*60.00*	38	*33.04*
Bunie	279	158	*56.6*	104	*77.04*	54	*32.73*
Leelum	45	25	*55.6*	19	*12.58*	6	*4.69*
Sain Polu	366	187	*51.1*	126	*90.65*	61	*32.97*
Zimiya	149	91	*61.1*	51	*42.50*	40	*31.75*

Study Area Villages	Total Population	Literate Population					
		Total (Nos.)	Total Literacy Rate (%)	Males (Nos.)	Male Literacy Rate (%)	Females (Nos.)	Female Literacy Rate (%)
Quiri	154	94	*61*	49	*38.28*	45	*32.85*
Uchhaiti	149	86	*57.7*	58	*37.42*	28	*15.14*
Dhuratoli	233	148	*63.5*	87	*48.07*	61	*31.28*
Phapha	259	139	*53.7*	92	*109.52*	47	*58.75*
Basantkot	220	118	*53.6*	74	*62.18*	44	*38.60*
Chulkot	246	138	*56.1*	85	*217.95*	53	*110.42*
Khata	12	8	*66.7*	7	*9.46*	1	*1.16*
Gaila Malla	105	56	*53.3*	31	*25.83*	25	*17.24*
Gaila Tala	107	47	*43.9*	29	*54.72*	18	*34.62*
Pattharkot	110	47	*42.7*	32	*60.38*	15	*27.78*
Rapti	213	119	*55.9*	71	*68.93*	48	*38.71*
Ropar	67	31	*46.3*	19	*2.77*	12	*2.56*
Walthi	855	539	*63*	291	*240.50*	248	*160.00*
Dolma	87	42	*48.3*	20	*15.75*	22	*17.74*
Pyangti	39	21	*53.8*	13	*3.02*	8	*1.78*
Dhapa	376	241	*64.1*	134	*1675.00*	107	*2675.00*
Kultham	160	71	*44.4*	48	*44.86*	23	*17.83*
Dheelam	164	75	*45.7*	55	*67.07*	20	*25.64*
Ugarali	12	8	*66.7*	6	*24.00*	2	*10.00*
Dumar Talla	265	185	*69.8*	95	*158.33*	90	*140.63*
Sainar	101	47	*46.5*	22	*39.29*	25	*33.33*
Jalath	251	168	*66.9*	99	*45.41*	69	*30.26*
Dumar Malla	160	108	*67.5*	62	*52.99*	46	*35.94*
Darkot	340	233	*68.5*	119	*201.69*	114	*223.53*
Phalyati	123	69	*56.1*	47	*70.15*	22	*39.29*
Suring	339	239	*70.5*	121	*93.08*	118	*91.47*
Darati	265	174	*65.7*	101	*631.25*	73	*317.39*
Ghorpatta Malla	1155	859	*74.4*	575	*845.59*	284	*330.23*
Ghor Patta Talla	227	153	*67.4*	82	*84.54*	71	*61.21*
Papri	446	261	*58.5*	149	*513.79*	112	*294.74*
Matena	131	63	*48.1*	32	*17.58*	31	*16.85*
Harkot	276	144	*52.2*	84	*195.35*	60	*103.45*
Malupati	124	50	*40.3*	30	*20.00*	20	*10.58*
Chauna	324	183	*56.5*	101	*127.85*	82	*117.14*
Kotal Gaon	236	116	*49.2*	65	*928.57*	51	*1020.00*
Josha	880	434	*49.3*	279	*72.47*	155	*32.98*
Bhaiskhal	300	202	*67.3*	106	*160.61*	96	*115.66*

Study Area Villages	Total Population	Literate Population					
		Total (Nos.)	Total Literacy Rate (%)	Males (Nos.)	Male Literacy Rate (%)	Females (Nos.)	Female Literacy Rate (%)
SUV Total	**10595**	**6278**	***59.3***	**3733**	***72.14***	**2545**	***46.96***

Source: ***Primary Census Abstract, 2001***

5.2.4 Occupational Profile in the SAVs

The village-wise details of occupational profile within the SAVs are outlined in Table 5.4. As per this table, about 46.9% of the total population in the SAVs is engaged in various economically productive activities, and have been designated as "Total Workers" by the Census. On the other hand, the remaining 53.1% are Non-workers or dependent population. Amongst the working population, about 62.4% constitute the Main workers, while the Marginal workers comprise about 37.6% of the total working population. The major occupation in the study area is agriculture.

TABLE-5.4
Occupational profile in the study area

Study Area Villages	Total Population	Total Workers		Main Workers		Marginal Workers		Non Workers	
		Nos.	%age *	Nos.	%age **	Nos.	%age **	Nos.	%age *
Pato	245	131	*53.5*	44	*33.6*	87	*66.4*	114	*46.5*
Bunie	279	133	*47.7*	88	*66.2*	45	*33.8*	146	*52.3*
Leelum	45	25	*55.6*	22	*88.0*	3	*12.0*	20	*44.4*
Sain Polu	366	165	*45.1*	63	*38.2*	102	*61.8*	201	*54.9*
Zimiya	149	102	*68.5*	63	*61.8*	39	*38.2*	47	*31.5*
Quiri	154	96	*62.3*	66	*68.8*	30	*31.3*	58	*37.7*
Uchhaiti	149	77	*51.7*	25	*32.5*	52	*67.5*	72	*48.3*
Dhuratoli	233	23	*9.9*	22	*95.7*	1	*4.3*	210	*90.1*
Phapha	259	128	*49.4*	72	*56.3*	56	*43.8*	131	*50.6*
Basantkot	220	47	*21.4*	20	*42.6*	27	*57.4*	173	*78.6*
Chulkot	246	108	*43.9*	27	*25.0*	81	*75.0*	138	*56.1*
Khata	12	6	*50.0*	3	*50.0*	3	*50.0*	6	*50.0*
Gaila Malla	105	47	*44.8*	25	*53.2*	22	*46.8*	58	*55.2*
Gaila Tala	107	50	*46.7*	36	*72.0*	14	*28.0*	57	*53.3*
Pattharkot	110	57	*51.8*	57	*100.0*	0	*0.0*	53	*48.2*
Rapti	213	68	*31.9*	59	*86.8*	9	*13.2*	145	*68.1*

Study Area Villages	Total Population	Total Workers		Main Workers		Marginal Workers		Non Workers	
		Nos.	%age *	Nos.	%age **	Nos.	%age **	Nos.	%age *
Ropar	67	34	*50.7*	12	*35.3*	22	*64.7*	33	*49.3*
Walthi	855	416	*48.7*	103	*24.8*	313	*75.2*	439	*51.3*
Dolma	87	30	*34.5*	28	*93.3*	2	*6.7*	57	*65.5*
Pyangti	39	22	*56.4*	15	*68.2*	7	*31.8*	17	*43.6*
Dhapa	376	185	*49.2*	145	*78.4*	40	*21.6*	191	*50.8*
Kultham	160	85	*53.1*	32	*37.6*	53	*62.4*	75	*46.9*
Dheelam	164	80	*48.8*	35	*43.8*	45	*56.3*	84	*51.2*
Ugarali	12	7	*58.3*	7	*100.0*	0	*0.0*	5	*41.7*
Dumar Talla	265	131	*49.4*	126	*96.2*	5	*3.8*	134	*50.6*
Sainar	101	41	*40.6*	28	*68.3*	13	*31.7*	60	*59.4*
Jalath	251	132	*52.6*	80	*60.6*	52	*39.4*	119	*47.4*
Dumar Malla	160	75	*46.9*	62	*82.7*	13	*17.3*	85	*53.1*
Darkot	340	153	*45.0*	126	*82.4*	27	*17.6*	187	*55.0*
Phalyati	123	61	*49.6*	60	*98.4*	1	*1.6*	62	*50.4*
Suring	339	145	*42.8*	132	*91.0*	13	*9.0*	194	*57.2*
Darati	265	128	*48.3*	71	*55.5*	57	*44.5*	137	*51.7*
Ghorpatta Malla	1155	362	*31.3*	297	*82.0*	65	*18.0*	793	*68.7*
Ghor Patta Talla	227	57	*25.1*	45	*78.9*	12	*21.1*	170	*74.9*
Papri	446	194	*43.5*	122	*62.9*	72	*37.1*	252	*56.5*
Matena	131	81	*61.8*	53	*65.4*	28	*34.6*	50	*38.2*
Harkot	276	155	*56.2*	121	*78.1*	34	*21.9*	121	*43.8*
Malupati	124	74	*59.7*	56	*75.7*	18	*24.3*	50	*40.3*
Chauna	324	188	*58.0*	123	*65.4*	65	*34.6*	136	*42.0*
Kotal Gaon	236	161	*68.2*	52	*32.3*	109	*67.7*	75	*31.8*
Josha	880	552	*62.7*	443	*80.3*	109	*19.7*	328	*37.3*
Bhaiskhal	300	160	*53.3*	39	*24.4*	121	*75.6*	140	*46.7*
SUV Total	**10595**	**4972**	*46.9*	**3105**	*62.4*	**1867**	*37.6*	**5623**	*53.1*

Source: ***Primary Census Abstract, 2001***
Note: **** = In proportion to Total population ** = In proportion to Total workers***

5.3 SOCIO-ECONOMIC IMPACTS

5.3.1 Immigration of labour population

The construction phase of any project is rather an unsettled stage characterized by uncertainties and often

disorders. The basic problem relates to management of large population which migrates to the construction area in search of jobs. Those who would migrate to this area are likely to come 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 which would not have been possible otherwise. Due to longer residence of this population in one place, a new culture, having a distinct socio-economic similarity would develop which will have its own entity.

The benefits however, are always not a certainty and depend on several factors. Often, they are directly related to the way construction phase is handled by the project authorities and their sensitivity to various socio-economic problems that could develop during this phase.

Job opportunities will improve significantly in the project area and its surrounding. 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. The project will open a large number of jobs to the local population during both project construction and operation phases.

The total population in the study area at present is of the order of 10,595. The total population migrating into the project area as skilled, semi-skilled and un-skilled labour force is of the order of about 8200. Thus, the population in the area would increase by about 77% during project construction phase. The availability of infrastructure could be a constraint during the initial construction phase. Certain facilities like health, education, etc could be subsidized for the construction workers. The facilities of desired quality are often not made available in the initial stages. The adequacy of water supply, sewage treatment, housing, etc. should therefore, be ensured before and adequate measures should be taken at the very start of the project.

5.3.2 Increased incidence of water-related diseases

The vectors of various diseases breed in shallow areas not very far from the margins of the water spread area. The magnitude of breeding sites for mosquitoes and other vectors in the impounded water is in direct proportion to the length of the shoreline. Since, the increase in water spread area is marginal and restricted

within the gorge, the increase in breeding sites for various disease vectors is expected to be only negligible. Thus, incidence of malaria would be negligible as a result of the construction and operation of the proposed project. Other factors like aggregation of labour, clearance of vegetation and excavation may also lead to a marginal increase in some incidence of malaria in and around the project area.

Normally, mosquitoes, which are the vectors for transmission of malaria are observed upto an elevation upto 2000 m above sea level. The proposed project is located at an elevation of below 2000 m above mean sea level. Thus, if adequate control measures are not undertaken, there could be marginal increase in the incidence of malaria, especially during construction phase. Further, the labour camps could be vulnerable to increased incidence of water-borne diseases, if adequate measures are not undertaken.

5.3.3 Impacts on cultural/religious/historical monuments

As per our assessment, no monuments of cultural/religious/historical importance are reported in the project as well as study area villages. Thus, no impact on such structures is envisaged.

5.3.4 Impacts due to acquisition of private lands

The total land required for the project is 264 ha, of which 158.4 ha is government land and the balance is government land. A socio-economic survey of the project affected families has been undertaken as a part of the EIA study to ascertain their socio-economic status. Based on the findings of the survey Resettlement & Rehabilitation Plan shall be will be formulated.

5.4 RESETTLEMENT AND REHABILITATION (R&R) ASPECT

5.4.1 Need for R&R Plan

R&R plan is essential because of the following:

- Though the land is acquired for national interest, the acquisition is most often involuntary. The affected persons could face involuntary eviction and may have no choice but to accept the consequences. The affected person, therefore, needs to regain his previous levels of standard of living.
- Improper resettlement and rehabilitation is the root cause of discontentment and alienation among Project Affected Persons (PAPs). No project can be successfully implemented without the cooperation of the local population.

5.4.2 Basic issues involved in framing R&R plan

Acquisition of land induces a large scale change in land use patterns and can destroy the economic base. The R&R Plan is to be formulated so that after a reasonable transition period, the displaced persons improve, or at least regain their previous standard of living, earning capacity and production levels. The transition gap is to be reduced to a minimum.

5.4.3 Category of PAPs and RAP entitlements

The categories of PAPs and their entitlements as per the NTPC, Resettlement and Rehabilitation Policy (June 2005) are listed in Table-5.5.

TABLE-5.5

Category PAPs and RAP entitlements as per R&R policy of NTPC

Category	Description	No. of PAPS
A	PAPs owning agricultural land in the acquired area since last three years before the Section 4 notification and whose entire land has been acquired. The list shall be prepared based on the revenue records as on the date of Section 4 notification under LA Act.	233
B	PAPs owning agricultural land in the acquired area since last three years before the Section 4 notification and losing partial land and becoming marginal farmer (left with un-irrigated land holding upto one ha or irrigated holding upto half ha). The list shall be prepared based on the revenue records as n the date of Section 4 notification under LA Act.	458
C	PAPs owning agricultural land in the acquired area since last three years before the Section 4 notification and losing partial land and becoming small farmer (left with unirrigated land holding upto two ha or irrigated holding upto one Ha). The list shall be prepared based on the revenue records as on the date of Section 4 notification under LA Act.	16
D	PAPs owning agricultural land in the acquired area since last three years before the Sec 4 notification and losing partial land but not covered in either Cat B or C. The list shall be prepared based on the revenue records as on the date of Section 4 notification under LA Act.	2
E	Agricultural labourer PAP including squatters and encroachers who normally is a resident of the affected area for a period not less than three years immediately before Section 4 notification, who does not own land in	35

Category	Description	No. of PAPS
	the acquired area but who earns his/her livelihood principally by manual labour on agricultural land therein immediately before such notification and who has been deprived of his/her livelihood. The list shall be prepared based on the socio-economic survey, verification by the Gram Panchayat and duly certified by Collector or his/her authorized representative.	
F	Non agricultural labourer PAP including squatters and encroachers who is not an agricultural labourer PAP, but is normally residing in the affected zone for a period of not less than three years immediately before the Section 4 notification and who does not own any land but who earns his livelihood principally by manual labour or as a rural artisan or having any client relationship with PAP community, immediately before acquisition and has been deprived of his/her such livelihood due to acquisition. The list shall be prepared based on the socio-economic survey, verification by the Gram Panchayat and duly certified by Collector or his/her authorized representative.	633
G	PAPs losing partial lands in case of projects/schemes related to railway lines e.g. in MGR transportation for fuel, connecting roads outside the project and its associated area, laying pipelines for fuel and ash transportation etc. wherein only a narrow stretch of land extending several kilometers is being acquired. The list shall be prepared based on the revenue records as on the date of Section 4 notification under LA Act. (In case of acquisition of homesteads in such a case shall fall in Category I). However, three years residence is required for belonging to this category also. In case of acquisition of major portion of their land holding (say 75% of land or more, however, in such a case shall fall in Category A to D, subject to a minimum acquisition of one acre.	-
H	Occupiers i.e. PAPs of STs in possession of forest land since 25th Oct. 1980. The list shall be prepared based on the socio-economic survey, verification by the Gram Panchayat, State/Central Forest Department and duly certified by Collector or his/her authorized representative.	-
I	PAPs who are Homestead Oustees (HSO), residing in the area and owning house since last three years before the Section 4 notification under LA Act and whose house has been acquired by the process of law.	

Source: R&R Policy, NTPC (June 2005)
Note: PAP numbers in categories A, B, C, D are assessed from the Revenue records and field studies. While PAP numbers in Category E and F have been assessed from the Census Data

5.4.4 COMPENSATION FOR ACQUIRED PROPERTIES

The project affected families losing land and/or homesteads plots will be compensated by the project authority in line and within the provisions of the Land Acquisition Act, 1984. In addition, they will also receive compensation of homesteads being acquired, based on assessment and evaluation carried-out by the project authority. Further other properties, such as fruit bearing and timber trees will be assessed and compensation amount will be due to the respective PAFs. Compensation will also be paid to the various public utility buildings, structures, spaces, etc, which will be given to the concerned departments/ agencies.

5.4.5 PLAN FOR RESETTLEMENT

Self-resettlement

PAPs of Category – I and willing to resettle on their own or shift to some alternate location will be encouraged for self resettlement. Financial assistance for self-resettlement shall be provided generally at the rate of 5 (five) times of the basic compensation payable for the house, excluding solatium and interest, under land Acquisition Act subject to a minimum of Rs. 50,000/- and a maximum of Rs. 100,000/- in each case (Based on CPI index as on 1.6.04 subject to upward revision). No other benefit like allotment of plot in RC, infrastructure at place of resettlement etc shall be extended in case of individual self- resettlement.

However, if a group of 25-30 PAPs resettle at one place, basic infrastructure facilities could be considered as detailed below.

En-masse resettlement (Resettlement Colony)

The resettlement colony shall be considered where the PAPs are those HSOs who have not opted for self-resettlement and are 100 (hundred) or more. If the number of such HSOs is less than 100, they shall have to opt for self-resettlement. The land for RC will be made available by the State Government free of cost and free of any

encumbrances preferably at one place at the time of inception of the project. In case the Government has to acquire private land for the purpose of resettlement, it should be ensured that such acquisition of land should not lead to another list of PAPs. The Government may also purchase land through consent award and may enter into agreement for this purpose. The cost of this land should not however, exceed than that of the land being acquired for the project. The cost in that case will also be borne by NTPC. However, in case the cost of land is higher than the rates payable for the acquired land, the NTPC liability will be to the extent of

maximum rate paid for the acquired land. Difference, if any will have to be borne by the State Government.

Title of the land in RC: The land title for the plot allotted shall be transferred in the joint name of allottee and his/her spouse on free hold basis. In case of no spouse the land title will be allotted in his/her name. The registration charges, if any, will be paid by NTPC as per actuals. The remaining common land in RC will be treated as revenue/Gram Sabha land and entry in the revenue record will be made accordingly. This will be implemented in consultation with State Government.

In case of resettlement of more than 25-30 PAPs of category H in an area or a village, NTPC may consider provision of basic infrastructure depending upon the need and requirement and consultation with the stakeholders. The details of the provisions adopted for resettlement plan is depicted in Table 5.6.

TABLE 5.6

Resettlement provisions

Provision as per NTPC Policy	***Disbursement***
Allotment of homestead land: The HSOs, who have not opted for self-resettlement, shall be settled in Resettlement Colony developed by NTPC. **Each family losing homestead will be provided a plot of 200 sq.mt. in the Resettlement Colony free of cost**.	As per our assessment, there are about 15 families who are likely to lose their homestead as a result of land acquisition. About 3000 m^2 (0.3 ha) of land would be required for providing houses. This land would be provided to the HSOs free of cost. The land for resettlement purpose would be identified by the District Administration. In addition provision of about 50% of this land would also have to be made to provide Civic Amenities and Infrastructure Facilities. Thus the total land required for resettlement purposes works-out to(1.5 x 0.3) **0.45 ha.**
House building assistance @ Rs. 150,000 per PAFs losing homestead.	A provision of **Rs. 2.25 million** (15 HSOs x Rs. 150,000) may be earmarked for providing house building assistance.
Additional resettlement benefits	
Shifting Grant: NTPC shall bear the actual cost of transportation of the building materials and other moveable properties including self, family members, cattle etc belonging to the PAPs from the place of displacement to resettlement colony or the place of resettlement generally within 25 Kms of accessible roads in any transport arranged by NTPC. Alternatively, **a lump-sum grant of Rs. 20,000/-** (Based on CPI index as on 1.6.04 subject to upward revision) will be paid to each HSO for self transportation/shifting. This is inclusive of transportation of man, material, reusable goods, wood, cattle etc, if any.	NTPC shall bear the actual cost of transportation of the building materials and other moveable properties including self, family members, cattle etc belonging to the PAPs from the place of displacement to resettlement colony or the place of resettlement generally within 25 Kms of accessible roads in any transport arranged by NTPC. A provision of **Rs. 0.30 million** (Rs. 20000 x 15 HSOs) for this purpose.
Resettlement Grant: A fixed resettlement grant of Rs 30,000/- (Based on CPI index as on 1.6.04	A provision of **Rs. 0.45 million** (Rs. 30000 x 15 HSOs) as a fixed resettlement grant @ Rs 30,000/- (Based

subject to upward revision) will also be provided to each HSO. This is inclusive of Rs 5000/- towards assistance for construction of cattle-shed, if any.	on CPI index as on 1.6.04 subject to upward revision) has been made for the HSO. This cost is inclusive of Rs 5000/- towards assistance for construction of cattle-shed, if any.
Assistance for transit accommodation in case of emergency acquisition: In the case of acquisition of land in emergent situation such as Section 17 of the land Acquisition Act 1894 or similar provision of other Act in force, each PAP shall be provided with transit accommodation or suitable monetary assistance for the same, pending resettlement and rehabilitation scheme.	***Will be complied as per Policy provision***

Infrastructure Facilities

The infrastructure facilities and basic minimum amenities shall be augmented to ensure that the displaced population (HSOs) in the resettled colony or the village may secure for themselves a reasonable standard of community life to minimize the problems associated with fresh settlement in new localities. The facilities/ amenities shall be considered in the resettlement colonies or the villages where more than 25-30 HSOs have self resettled.

In addition community development works will also be undertaken in the project affected villages where PAPs continue to reside even after acquisition. These facilities will also be available to the host population and the neighbouring community and facilitate socio economic development of the area.

The land, if required, shall be made available by the State Government. The location for these facilities shall be decided in consultation with the State Government and/or Panchayat.

The facilities/ amenities will vary depending upon local requirements and may include the following:

- A secondary school is suggested based on a sizeable resettlement colony and host population. The Secondary School will be constructed with drinking water facility in each school. The total cost of construction of a Secondary school with drinking water well would be = **Rs. 0.60 million** (@ Rs. 600000 per school + drinking water well). One well with trough is provided for 50 families or less, as per norm.
- A community centre is suggested in the resettlement area. This facility could be used by the host population and the nearby villagers as well. The total cost for construction of Community Center will be = **Rs. 0.40 million**
- One dispensary is proposed to be provided in the resettlement area or being located in a big sized resettlement, village/colony. The total cost envisaged for construction of Dispensary will be **= Rs, 0.10 million**
- Attempt has been taken to locate the resettlement villages near to the existing roads. However, approach road to colony will be provided apart from a network of 4m wide internal roads inside the colony. A lump-sum cost of about Rs. 0.1 million per km is being kept for this purpose. A total provision of **Rs. 4.5 million** has been earmarked.
- Provision to provide electricity to each resettlement village will be undertaken as far as practicable.
- Space for Panchayat Ghar, Veterinary dispensary, fair price shops, etc., has been identified for big sized villages (50 - 100 families or more). The project authority will move the line departments to make it functional.
- The following infrastructure facilities have been proposed for each colony.

Space allocated is 20% of the homestead plots area.

- Open space for weekly market
- Open space for plantation wherever possible
- Colony plantation is proposed around the boundary
- Space for worship, religious mela wherever possible
- Thus, a provision of **Rs.13.5 million** needs to be earmarked for providing infrastructure facilities at the resettlement colonies.

Efforts will be made to involve the PAPs in the creation of infrastructure facilities by giving contracts to their 'cooperative societies or otherwise for construction works to the extent possible. This will also help in developing a sense of ownership among the PAPs and also help to involve the PAPs in a fruitful manner. A provision of Rs. Million would be required to be earmarked for resettlement purposes for the displaced families, the details of which are depicted in Table 5.7.

TABLE 5.7

Provision for implementation of Resettlement Plan

S. No.	Resettlement provisions	Cost (Rs. million)
1.	Requirement of Land for homesteads 0.45 ha	
2.	House building assistance	2.25
3.	Shifting grant	0.30
4.	Resettlement grant	0.45
5.	Secondary school	0.60
6.	Community Centre	0.40
7.	Dispensary	0.10

8.	Access roads	4.50
9.	Other infrastructure facilities	13.50
Total		**22.10**

5.4.6 REHABILITATION PLAN

Land For Land (LFL)

The "land for land" option will be applicable to Category A, B, C & D PAPs only. Quantum of land for rehabilitation will be as per the actual land acquired, subject to the ceiling of maximum of one hectare of irrigated land or two hectare of un-irrigated/ cultivable wasteland subject to availability of Government land in the districts. Land availability for allotment for this purpose will be explored with the State Government. If Government land is not available, PAPs will be facilitated for purchase of land on a "willing buyer-willing seller" basis. The limit of purchase of land in this case will be two hectare. For this purpose the following process will be adopted.

Land price for the purpose of purchase of land will be fixed after consultation with the State Government and the VDAC on the basis of market price of the good agriculture land in the vicinity generally within 25 km radius but normally not exceeding the 1.3 times of the rate paid for the acquisition of good agriculture land as per LA Act. The basic land compensation amount paid (i.e. excluding solatium and interest) will be adjusted against this amount.

In addition, land development amount @ Rs. 10,000/- (Rs. ten thousand) per acre as per entitlement (Based on Prices CPI as on 1.6.04 and subject to revision from time to time)and actual land registration and stamp duty charges as per entitlement will also

be paid as per entitlement to those, who actually purchase the land and submit the required papers. The PAPs who though, losing less than one acre of land, purchase land upto one acre out of the grants and compensation money they would be reimbursed the actual stamp duty and registration charges of upto one acre.

About 81.734 ha of land would be required for LFL. The identification of alternative land for LFL and the cost of that land would be decided by the District Administration. "Land Development cost" for this 81.734 ha would be **Rs. 0.82 million**.

In situation, where the LFL option is not feasible because of scarcity of land in the particular area, this option shall not be applicable to Category A, B, C & D PAPs and they will be eligible for Rehabilitation Grant.

In case of Category E & Category F PAPs who are landless but are dependant only on the acquired land for livelihood, also buy land through the grants provided to them, NTPC will consider incentivising their purchase by reimbursing actual stamp duty and registration charges upto one acre of purchase of land.

Rehabilitation Grant (RG)

One time RG will be paid to eligible categories. If a category-A PAP does not wish to go for LFL option, he/she will also be paid one time RG. The RG will be generally 1000 days Minimum Agricultural Wage (MAW) in the concerned State/ UT at the time of Section 4 notification under LA Act. For the categories B to F, the RG will be generally 750 days MAW. For the category G a one time RG of 500 MAW normally will be payable with no other additional rehabilitation benefit. For the Category H the RG will vary depending upon the type of PAP as per Category A to G. The implementation

process has been delineated in para 3.4.4. An illustrative amount on an assumption of MAW @ Rs 70/- per day will be as detailed in Table 5.8.

TABLE 5.8

Details of Rehabilitation grant

S. No.	Category	Rehabilitation Grant Unit rate (Rs)	Disbursement
1.	A	LFL or Rs 70,000/-	There are 233 PAP under this category. Thus a provision of **Rs. 16.31 million** (233 PAPs x Rs. 70000) is being kept for this purpose.
2.	B to F	52500/-	458 PAPs in Cagetory "B" 16 PAPs in Category "C" 2 PAPs in Category "D" 35 PAPs in Category "E" 633 PAPs in Category "F" Thus, a provision of **Rs. 59.535 million** as rehabilitation grant is being kept for this category.
3.	G	35000/-	-

In case of rehabilitation of any rural artisan/small trader and a self employed person falling in Category F who was having a shop in the affected area, a one time financial assistance of Rs 15,000/ (Based on CPI index as on 1.6.04 subject to upward revision) will also be provided in addition to RG for construction of working shed/shop, in case he continues with his earlier vocation. About 2 PAP who own shop near the powerhouse site, which is likely to be acquired. A one time financial assistance @ Rs. 15,000/- be given to these PAPs. Thus, provision of **Rs. 0.03 million** is being kept for this purpose.

Subsistence Grant

Keeping in view the time required for stabilizing the resettlement process, each PAP shall normally get a monthly subsistence allowance equivalent to 20 days of Minimum Agricultural Wages per month for a period of one year upto 250 days of MAW, starting from the date of relocation/displacement and physically handing over of the acquired land.

About 15 PAFs who are likely to lose their homestead. Thus, subsistence grant is proposed to be given to these 15 PAFs. A provision of **Rs. 0.263 million** is being kept for providing subsistence grant to the 15 PAFs.

Additional benefits to ST PAPs

- Each tribal PAP shall get additional financial assistance equivalent to 500 days MAW for loss of customary rights/usage of forest produce in case the acquisition has affected their such rights.
- Efforts will be made to resettle such PAPs close to their natural habitat in a compact block to the extent possible so that they can retain their ethnic, linguistic and cultural identity.
- If an resettlement colony is built for these PAPs, a provision for their community and religious gathering will be also ensured.
- Tribal PAPs resettled out of the district/ taluk will get 25% higher R&R benefits in monetary terms.
- If any reservoir is constructed and owned by NTPC as a result of its construction of any hydro electric project, the tribal PAPs of the affected area having fishing rights in the river/pond/dam will be given the fishing rights in the reservoir area.
- In case during acquisition of any land for NTPC project, it is found out by the State Government that tribal land has been alienated in violation of the laws

and regulations in force on the subject, it would be treated as null and void and R&R benefits would be available only to the original tribal land owner.

The details of provision required for implementing the rehabilitation plan is depicted in Table 5.9.

TABLE-5.9

Provision required for implementing Rehabilitation plan

S. No.	Resettlement provisions	Cost (Rs. Million)
1.	Requirement of Land for "land for land" = 81.75 ha	
2.	Land development cost	0.82
3.	Rehabilitation Grant (for Category – A)	16.31
4.	Rehabilitation Grant (for Category – B – F)	59.535
5.	Financial assistance for construction of shops	0.03
6.	Subsistence grant	0.263
Total		**76.958**

Loss of Common Property Resources

During the construction of any project specially in the case of hydro projects, should any common property resources like grazing lands, cremation grounds, religious structures/places etc or any existing facilities such as irrigation, water supply, road, electricity, communication system, path etc be adversely affected due to execution of the project, remedial measures will be taken and incorporated in the project specific

5.5 INSTITUTIONAL SET UP

(A) Consultation and Participation

The consultation with PAPs and NGOs are vital for assessing their requirement of

R&R. This will be done in NTPC in a participative manner through following formal mechanisms.

- ***Public Information Centre (PIC)***

  To maintain transparency and keep PAPs informed, NTPC will establish PICs at projects where relevant documents would be kept for reference for the period of formulation and implementation of RAP. PAPs will also be encouraged to register their queries/grievances at PIC. R&R staff will be available at PICs for interacting with PAPs. The PIC shall function till completion and closure of RAP.

- ***Village Development Advisory Committee (VDAC)***

  For institutionalizing the public consultation for preparation and implementation of rehabilitation schemes/ RAPs, in a participative manner, NTPC shall establish VDACs for the period of formulation and implementation of RAP. The members of VDAC may include representatives of PAPs, Gram Panchayats, Block Development Officer, other representatives of State Government and NGOs etc.

  Regular meetings shall be held, the records maintained and shared. The VDAC will be established immediately after initiating notifications under section 4 of LA Act and establishment of project R&R Cell and shall continue till the completion and closure of RAP.

- ***Sociologist***

  R&R requires complex mix of skills to address the need of understanding social, cultural and traditional aspects of the people affected due to setting up of the project as also for better communication with PAPs and other stakeholders. To fulfill these objectives, sociologists with requisite qualification will be deployed immediately on establishment of Project R&R Group till completion and closure of RAP.

- ***NGOs***

  NGOs are identified as important stakeholders and will be involved in consultation process as well as during the implementation of various activities of RAP. This will, however, depend on specific requirements and need felt by the project.

(B) Implementation Monitoring and Evaluation

The R&R scheme will be monitored and evaluated periodically during the implementation of R&R plan by RHO and Corporate R&R Group. The external agency may be considered, if felt necessary.

The R&R activities are the responsibility of the R&R Group. A dedicated R&R group shall be constituted at the project, regional headquarter (RHO) and Corporate Centre.

- ***Project R&R Group***

  The R&R group at site will be in close interaction with the State Authorities during the preparation and implementation of the Plan. Although NTPC will develop the plots and infrastructure facilities in the resettlement colony and

actively implement the R&R Plan, assistance of the State Authority will be taken for administrative services like allotment of plots etc. Constant dialogue and regular meetings with the concerned State authorities will be maintained. Implementation will be planned, monitored and corrective measures, if required, will be incorporated in the Plan. Apart from the State Govt., the PAPs, the village leader including the Pradhans will also be consulted and associated during the implementation of the plan. Involvement of R&R group at site will continue till completion of implementation of RAP, preparation and submission of ICR and evaluation of the completed RAP.

- ***Regional R&R Group***

  The R&R group at the RHO will have the responsibility for monitoring and evaluation of the implementation of RAP with respect to the time and cost frame and for any other assistance as may be required by the project during the implementation.

- ***Corporate R&R Group***

  The R&R Group at the CC will be primarily responsible for policy matters, providing guidance to RHO and projects on R&R matters, assist in approval of Rehabilitation Action Plan (RAP) of the project and coordination with external agencies. After approval of the RAP, the same will be handed over to Corporate Monitoring Group (CMG) for regular monitoring through Project Review Team (PRT) meetings etc.

- ***Social Impact Evaluation (SIE)***

An audit of the RAP plan shall be conducted by the Project/Regional Headquarter (RHO) in the form of a Social Impact Evaluation (SIE) study/survey on completion of the plan in consultation with Corporate R&R Cell. Evaluation could be done through the development of a Standard of Living Index (SOLI) and the same will be evaluated pre and post acquisition of affected versus unaffected villages. The external agency may be considered, if felt necessary. Audit will also evaluate whether all activities identified in the RAP have been completed satisfactorily and will give recommendation for necessary modification/corrective measure, if any, for the future projects. Individual PAP-wise data will also be compiled for comparison of his pre and post acquisition status and restoration of livelihood

(C) Grievance Redressal System

In every project, a Village Development Advisory Committee (VDAC) comprising of representatives of PAPs, State Government & NTPC shall be formed. Any PAP, if aggrieved for not being offered the admissible benefit as provided for under this Policy, may first move, by petition for redressal of its grievance to the VDAC. In case the aggrieved PAP is not satisfied by the action taken by the VDAC he may prefer an appeal to the Head of the Project. In case the aggrieved PAP is still not satisfied by the action taken by the Head of the Project, he/ she may appeal to the Executive Director of the region, whose decision, however, will be final and binding.

(D) Time schedule for RAP

- **Formulation of RAP**

The RAP will be formulated after the finalization and certification of the list of PAPs by the District Administration.

- **Duration of RAP**

  The implementation of RAP will start after the signing of agreement with the individual PAP. The duration of RAP will vary between projects to project but normally will not exceed the scheduled date of commissioning of the project.

- **Completion and Closure of R&R activities**

  On completion of audit the R&R activities would be deemed as completed and the R&R group at the project would be closed and all data pertaining to R&R shall be handed over to project HR department. On closure of R&R group, community development requirements, if any, would be the responsibility of project CSR Group. An implementation completion report (ICR) will also be made and shared with the stakeholders.

5.6 POST-PROJECT MONITORING

Status of availability of alternative homestead for project affected persons, development of infrastructural facilities such as schools, sewer networks, roads, etc. are some of the aspects which could be considered for monitoring and modifications may be suggested if required. It needs to be appreciated that R&R issues are politically sensitive issues and often need timely attention. For such reasons, it is suggested that the monitoring be conducted by an independent agency not connected with the project. Therefore, an independent Consultant having experience in monitoring R&R studies in similar settings. The Consultant will review the rehabilitation

and resettlement program after 2nd, 4th and 6th year from the completion of the R&R activity. It is suggested that a sample survey of the PAFs could be undertaken by the Monitoring agency, to appraise the situation of the PAFs post R&R activities. An amount of Rs. 180,000 is being kept for the first phase of monitoring. Thereafter, for the second phase of monitoring Rs. 200,000 (after adding 10% escalation) and finally Rs. 220,000 for the third phase of monitoring (after adding 10% escalation) is being kept. Thus, a total provision of **Rs.0.6 million** can be earmarked for this purpose.

5.7 BUDGET FOR R&R

A total provision of Rs. Million would be required to implement the R&R plan for the PAFs of Rupsiya Bagar – Khasiyabara H. E. Project. The details of the budget are highlighted in Table 5.10

TABLE 5.10

Budget for R&R

S. No.	Resettlement provisions	Cost (Rs. million)
1.	Resettlement plan	22.10
2.	Rehabilitation plan	76.958
3.	Post project monitoring	0.60
Total		**99.658**

CHAPTER-6

ENVIRONMENTAL MANAGEMENT PLAN

6.1 GENERAL

Based on the environmental baseline conditions, planned project activities and impacts assessed earlier, this Chapter outlines the Environmental Management Plan (EMP) enumerating set of measures to be adopted to minimize the adverse impacts. The most reliable way to ensure the implementation of EMP is to integrate the

management measures in the overall project planning, designing, construction and operation phases. This will ensure that there are adequate funds/resources for supervision and implementation of the management plans. For every issue discussed in the following sections, costs for implementation of the management measures have also been estimated.

6.2 CONTROL OF POLLUTION FROM LABOUR CAMPS DURING CONSTRUCTION PHASE

The aggregation of large labour population and technical staff during construction phase is likely to put significant stress on various facets of environment. The increase in total population during construction phase is expected to increase by 8,200. This is almost 77% of the existing population of the study area which comprises of 42 villages. As a result, existing infrastructure facilities would come under severe stress as a result of immigration of labour population.

The various issues covered in environmental management during construction phase are:

- Facilities in labour camps
- Sanitation & sewage treatment facilities
- Solid waste management

6.2.1 Facilities in labour camps

Normally, it has been observed in construction phase of many projects that labour camps are not well planned and are generally haphazard in their layouts, without adequate facilities. The spatial distribution of concentration of construction activities ensures that labour population is likely to be concentrated at two or three major construction sites, i.e. dam, power house and adit sites. It is recommended that project proponents can compulsorily ask the contractor to make semi-permanent structures for their workers. These structures could be tin sheds. These sheds can have internal compartments allotted to each worker family. The labour camp site shall have electricity and ventilation, water supply and community latrines.

6.2.2 Provision of water supply

The water for meeting domestic requirements may be collected from the rivers or streams flowing upstream of the labour camps. The water can then be transferred to the labour camps, stored in tanks and utilized. The water quality in general is good and can be used after chlorination. In addition, water can be fluoridized before use, so that ill-effects on health due to consumption of water with low fluorine can be avoided.

Efforts should also be made so that water sources and sewage disposal sites are placed far from each other. The settlements of the population likely to migrate in the area to provide various allied activities shall also be placed at a distance from the drinking water sources.

6.2.3 Sanitation facilities

One community latrine can be provided per 20 persons. The sewage from the community latrines can be treated in a sewage treatment plant (STP) comprising of aerated lagoon and secondary settling tank. For each labour camp, a sewage treatment plant can be commissioned. The effluent from the STP can be disposed in natural water body. The drinking water facilities and waste disposal sites will be located away from each other.

The total construction time for the project is about 6 years. At peak construction phase, there will be an increase in population by 8,200. To ensure that the sewage from the labour camps do not pollute the river water, it has been estimated that about 410 community latrines and 2 STPs (comprising of Aerated lagoon and secondary settling tank) are proposed to be commissioned. The total cost required will be Rs 10.2 million (Refer Table-6.1).

TABLE- 6.1

Cost Estimate for sanitary facilities for labour camps

S. No.	Unit	Rate (Rs./unit)	*Number*	1.1.1.2 Total cost (Rs. million)
1.	Community latrines	20,000	410	8.20
2.	Sewage treatment plants along with sewerage system			2.00

	upto disposal site	
	Total	**10.20**

In addition to above, O&M cost @ Rs 0.306 million/year will also be required. The O&M cost has to be borne for the entire construction phase of the project, i.e. 64 months. Considering an annual increase of 10% per annum, the total expenditure on O&M shall be of the order of Rs.2.04 million.

6.2.4 Solid waste management from labour camps

During construction phase, labour population is likely to concentrated mainly at two sites. The increase in population is expected to be of the order of 8,200. The average per capita solid waste generated is of the order of 210 gm/day/person. The solid waste likely to be generated from labour camps shall be of the order of 1.7 tonne/day. Adequate facilities for collection, conveyance and disposal of solid waste shall be developed.

For solid waste collection, number of masonry storage vats should be constructed at appropriate locations in various labour camps. These vats should be emptied at regular intervals and the collected waste can then be transported to landfill site.Two covered trucks to collect the solid waste from common collection point and transfer it to the disposal site should be put to service. A suitable landfill site should be identified and designed to contain municipal waste from various project township, labour colonies, etc. A total provision of Rs.6.13 million needs to be earmarked for this purpose. The details are given in Table-6.2.

TABLE-6.2

Details of expenditure required for solid waste management

Item	Cost (Rs. million)
Preparation of land fill site	0.20
Two covered trucks for conveyance of solid waste	3.00

to landfill site @ Rs.1.5 million/truck.	
Manpower cost for 8 persons @ Rs.5000/month for 6 years including 10% escalation/year	3.70
Total	**6.90**

An O&M cost of Rs 0.207 million/year will be required. The same is required for the entire construction phase (64 months). Considering an annual increase of 10% per year, the total expenditure on O&M shall be Rs 1.37 million.

The silt generated from various project activities shall be used as a covering material at muck disposal sites or areas to be brought under green belt development.

Generally, from sanitary landfill sites, there is little risk from methane generated due to the decay of vegetable matters, as it slowly diffuses at low concentration through the covering material.

Paper and other material also flies off the landfill area due to wind action. This often creates a nuisance in the immediate vicinity of the landfill site. The landfill site, therefore, needs to be skirted with wire fence of about 3 m high wire fence with paper catchers to avoid fly of papers.

6.3 ENVIRONMENTAL MANAGEMENT IN ROAD CONSTRUCTION

The approach roads will have to be constructed as a part of the access to the construction site. In a hilly environment, construction of roads sometime disturbs the scenic beauty of the area. In addition, landslides are often triggered due to road construction because of the loosening of rocks by water trickling from various streams. Steeply sloping banks are liable to landslides, which can largely be controlled by provision of suitable drainage. The basic principle is to intercept and divert as much water as possible, before it arrives at a point, where it becomes a problem. The other erosion hazard is that of surface erosion of the bank, which is best controlled by vegetation. However, in a steeply sloping terrain, difficulty lies in growing vegetation on steeply sloping banks. Engineering solutions such as surface drainage, sub-

surface drainage, toe protection and rock bolting can be used. Landslides can be stabilized by several methods-engineering or bio-engineering measures alone or a combination of these. The cost required for implementation of various measures has already been incorporated in the overall budget earmarked for construction of roads.

In hilly terrain, road construction often generates significant quantity of wastes (muck) due to the stripping of the rocks to make way for the roads. The stripped muck is generally cleared by dumping the material along the slopes. These dumped material if not properly utilized finally flows down to the valleys and ultimately finds its way to the river. However, it is recommended to adopt a more systematic approach. The stripped material should be collected and used for construction of retaining walls, breast walls, drainage and topping the road for gaining uniform gradient. Surplus muck, if any, be dumped in the designated muck disposal area which will have check dams to prevent the muck to flow down into the river. After disposal operation is complete at the dump site, the dump yard should be contoured and vegetated.

The details of proposed roads and bridges in the project area are mentioned below

The various aspects to be considered while making the project roads are briefly described in the following paragraphs.

Construction

- Area for clearing and grubbing shall be kept minimum subject to the technical requirements of the road. The clearing area should be properly demarcated to save desirable trees and shrubs and to keep tree cutting to the minimum.

- Where erosion is likely to be a problem, clearing and grubbing operations shall be so scheduled and performed that grading operations and permanent erosion control of features can follow immediately thereafter, if the project conditions permit; otherwise temporary erosion control measures should be provided between successive construction stages. Under no circumstances, however, should very large surface area of erodible earth material be exposed at any one time by clearing and grubbing.
- The method of balanced cut and fill formation should be adopted to avoid large difference in cut and fill quantities.
- The cut slopes should be suitably protected by breast walls, provision of flat stable slopes, construction of catch water and intercepting drains, treatment of slopes and unstable areas above and underneath the road, etc.
- Where rock blasting is involved, controlled blasting techniques should be adopted to avoid over-shattering of hill faces.
- Excavated material should not be thrown haphazardly but dumped duly dressed up in a suitable form at appropriate places where it cannot get easily washed away by rain, and such spoil deposits may be duly turfed or provided with some vegetative cover.

Drainage

- All artificial drains should be linked with the existing natural drainage system.

- Surface drains should have gentle slopes. Where falls in levels are to be negotiated, check dams with silting basins should be constructed and that soil is not eroded and carried away by high velocity flows.
- Location and alignment of culverts should also be so chosen as to avoid severe erosion at outlets and siltation at inlets.

Grassing and Planting

- Tree felling for road construction/works should be bare minimum and strict control must be exercised in consultation with the Forest Department.
- Depending on the availability of land and other resources, afforestation of roadside land should be carried out to a sufficient distance on either side of the road.

An amount of Rs. 7.25 million has been earmarked for environmental management during road construction. The details are given in Table-6.3.

TABLE-6.3
Details of expenditure for implementation of measures for management of impacts during road construction

S. No.	Item	Cost (Rs. million)
1.	Clearing and grubbing @ Rs.0.1 million/km	2.50
2.	Provision of breast walls, construction of catch water and interceptor drains @ Rs.0.5 million/km	1.25
3.	Provision of drainage system along roads @ Rs.0.1 million/km	2.5
4.	Roadside plantation, etc. @ Rs.0.04 million/km	1.0
	Total	**7.25**

An O&M cost of Rs. 0.218 million/year will be required. The same is required for the entire construction phase (64 months). Considering an annual increase of 10% per year, the total expenditure on O&M shall be Rs 1.45 million.

6.4 RESTORATION PLAN FOR QUARRY SITES

During construction of a hydropower project large quantities of construction materials are required. The quarries need to be properly stabilized after excavation of construction material is completed. The recommended stabilization measures are described in the following paragraphs.

The top soil is proposed to be removed before the start of quarrying. The removed top soil will be kept separate and stock piled so that it could be reused subsequently for the rehabilitation of quarry sites after the completion of quarrying activity.

The extraction of construction material from quarries results in formation of depressions, which are proposed to be filled up by the dumping waste material generated during quarrying. The dumped material shall act as ecological pioneers and would initiate the process of succession and colonization. Boulders of moderate sizes would be used to line the boundary of the path.

The top soil removed before the start of the project activity would be used for covering the filled up depressions/craters at the quarry sites. Fungal spores naturally present in the top soil would aid the plant growth and natural plant succession.

Subsequently, Vesicular-arbuscular mycorrhizal (VAM) fungi method shall be used for soil reclamation. For the reclamation of the top soil, microflora isolated from rhizophenic soil and root surroundings (nearby areas), VAM fungi isolated from the roots of the plant species growing in these areas and organic manure would be used either individually or in different combinations.

Top soil obtained from the project sites, before the start of the quarrying activity, would be reclaimed by using VAM fungi. Seedlings will then be transferred to the enriched top soil for the colonization of their roots with VAM fungi. The procedure will be standardized for each of the plant species to achieve optimal colonization of roots by VAM fungi as climate, soil and vegetation types of the areas to be treated would determine the success of VAM fungi in the reclamation of the degraded areas.

In addition to the use of VAM fungi for the enrichment of the top soil, revegetation of the quarry sites is recommended through fast growing grasses. The grasses spread by creeping rootstocks or rhizomes and will also help in binding the soil at these sites. This would initiate the process of colonization of the degraded areas by plant species. This can be followed by growing perennial grass species. It is also proposed to plant nitrogen-fixing herbaceous legumes (*Trifolium repens* and *Lespedeza juncea*) and non-leguminous shrub (*Elaeagnus parvifolia*) will be planted at these sites to increase the nitrogen levels of the soil. The entire process will lead to help in the stabilization of the quarry sites,in a time period of about 5 years.

Gabions and retaining walls will be erected at the filled up depressions of quarry sites to provide necessary support particularly at the quarry sites, where there are moderately steep slopes.

TABLE 6.4

Cost estimates for stabilization of quarries

Component	Cost (Rs. million)
Pre-construction Measures Removal of top soil, transportation & stock piling	0.30
Restoration Measures i) Diversion channels	0.30 0.50

ii) Retaining walls iii) Filling of the craters iv) Preparation of mounds	0.30 0.20
Reclamation and Phytoremediation **1.1.1.1.17.1.1 i) Field works:** - Collection of microflora from the field - Nursery development - Plantation and maintenance of successfully colonized seedings	3.0
ii) Laboratory Works: - **Selection, culturing and maintenance of strains** - Preparation of mother cultures - Confirmation of successful colonization	2.0
iii) Manpower components - 6 years for laboratory to land transfer and - 5 years for monitoring and maintenance	1.54
Total	**10.88**

An O&M cost of Rs.0.33 million/year will be required. The same is required for the entire construction phase (64 months). Considering an annual increase of 10% per year, the total expenditure on O&M shall be Rs 2.19 million.

6.5 MANAGEMENT OF MUCK DISPOSAL

Muck generated from excavation of any project component is required to be disposed in a planned manner so that it takes a least possible space and is not hazardous to the environment. In the hilly area, dumping is done after creating terraces thus usable terraces are developed. The overall idea is to enhance/maintain aesthetic view in the surrounding area of the project in post-construction period and avoid contamination of any land or water resource due to muck disposal.

Suitable retaining walls shall be constructed to develop terraces so as to support the muck on vertical slope and for optimum space utilization. Loose muck would be

compacted layer wise. The muck disposal area will be developed in a series of terraces of boulder crate wall and masonry wall to protect the area/muck from flood water during monsoons. In-between the terraces, catch water drain will be provided.

The terraces of the muck disposal area will be ultimately covered with fertile soil and suitable plants will be planted adopting suitable bio-technological measures.

The basic aim and objectives of the muck management plan are to:

- protect these areas from soil erosion
- develop these areas by afforestation
- develop them into parks, gardens etc.
- utilize the maximum quantity of muck for development of infrastructure of the project
- develop these areas in harmony with the landscape of the project area.

The proposed project would generate about 1.65 Mm^3 is likely to be generated. A part of the muck would be used in construction of the various civil structures for the project and the balance shall be disposed at designated sites of for which adequate area shall be earmarked.
An amount of Rs. 15 million can be earmarked for this purpose. An O&M cost of Rs. 0.45 million shall be required. Considering an escalation @ 10% every year, an amount of Rs. 2.75 million can be earmarked for this purpose.
Various activities proposed as a part of the management plan are given as below:

- Land acquisition for muck dumping sites
- Civil works (construction of retaining walls, boulder crate walls etc.)
- Dumping of muck
- Levelling of the area, terracing and implementation of various engineering control measures e.g., boulder, crate wall, masonry wall, catchwater drain.
- Spreading of soil
- Application of fertilizers to facilitate vegetation growth over disposal sites.

For stabilization of muck dumping areas following measures of engineering and biological measures have been proposed

Engineering Measures

- Wire crate wall
- ii) Boulder crate wall

- iii) R.C.C
- iv) Catch water Drain

Biological Measures

- Plantation of suitable tree species and soil binding species
- Plantation of ornamental plants
- Barbed wire fencing

6.6 RESTORATION AND LANDSCAPING OF PROJECT SITES

The construction of the proposed project, including its various appurtenances e.g. dam, power house, approach roads, labour camps, project colony, etc. would disturb the existing topography and physiography. Although, no major alteration of the area is expected as the layout has been so conceived that no major impacts on this account are anticipated. It is proposed to landscape the area, so that it integrates with the natural surroundings and the beauty of the area is restored. Accordingly, it is proposed to develop small gardens at 2 locations and few viewpoints along the periphery of the submergence area and power house site.

The landscaping plan is detailed as below:

- Garden complex
- View points
- Landscaping.

The above referred measures are described briefly in the following paragraphs:

Garden Complex: A garden with local ornamentation plants/orchids and trees should be created at two locations, i.e. one each near the dam and project colony sites. All plants will be properly labelled with scientific and/or common names.

Creation of viewpoints: Two viewpoints will be created one near the powerhouse and other at suitable place along the periphery of the submergence area. These view points will be slab type extension above the ground, which will be properly reinforced

and fenced to avoid any undesirable incidence. It will be given a shed and plantation of ornamental plants will be done near it.

Landscaping: Various sites in the area will be stabilized by constructing a series of benches. The walls that will be constructed for containing the slope will be embedded with local stone to integrate with the aesthetics of the area.

A total provision of Rs. 2.0 million can be earmarked for restoration and landscaping of project sites.

6.7 GREENBELT DEVELOPMENT

The forest loss due to various project appurtenances has been compensated as a part of compensatory afforestation. However in addition to these, it is proposed to develop greenbelt around the perimeter of various project appurtenances.

The general consideration involved while developing the greenbelt are:

- Local/nature trees growing upto 10 m or above in height with perennial foliage should be planted around various appurtenances of the proposed project.
- Planting of trees should be undertaken in appropriate encircling rows around the project site.
- Generally fast growing trees should be planted
- Since, the tree trunk area is normally devoid of foliage upto a height of 3 m, it may be useful to have shrubbery in front of the trees so as to give coverage to this portion.

For reservoir periphery, following measures are recommended :

A green belt around the reservoir will be created which will not only improve the aesthetics and vegetal cover, but would also present land slides along the reservoir periphery. The creation of green belt on either side of the reservoir will ensure protection of the reservoir area from any minor slips due to fluctuation in the water level. The slopes on both the banks will be planted with suitable tree species for creation of a green belt around the reservoir rim. In areas with moderately steep slopes indigenous, economically important, soil binding tree species will be planted,

which are able to thrive well under high humidity and flood conditions. The following measures are recommended:

(i) The green belt will start from the immediate vicinity of the reservoir rim on both the banks, up to the tail of the reservoir wherever moderately steep slopes are available for plantation.

(ii) The average width of the green belt will vary with the topography. A minimum of 2 layers of plantation will be developed.

(iii) Water loving species, preferably *Salix alba*, *S. acmophylla, Populus alba* and *P. ciliata* will be planted in the row nearest to the reservoir rim. The soil present at this level and the air moisture are favourable for the survival and growth of these species.

(iv) Species like *Aesculus indica*, *Grevellia robusta*, etc. will occupy the middle portions of the green belt.

v) The outermost layer of the green belt will be composed of hardy tree species and shrubby mix to withstand any external influences/ pressures of grazing, browsing by cattle and sheep, etc. In this layer the species *Grevellia robusta*, *Ficus* spp., and *Quercus* sp. will be planted in the inner as well as outer rows.

The plantation and maintenance of the plantation area should also be done by the project proponents in association with the state government. A total area of about 30 ha including area around reservoir periphery is proposed to be developed under greenbelt development. A provision of Rs. 1.2 million @ Rs. 40,000/ha can be earmarked for this purpose. The species to be planted under greenbelt development programme shall be finalized in consultation with the Forest Department.

6.8 COMPENSATORY AFFORESTATION

The loss of vegetal cover can be compensated by compensatory afforestation. The Indian Forest Conservation Act (1980) stipulates:

- if non-forest land is not available, compensatory forest plantations are to be established on degraded forest lands, which must be twice the forest area affected or lost, and
- if non-forest land is available, compensatory forest are to be raised over an area equivalent to the forest area affected or lost.

The total land involved in the project is about 264 ha including private land. In Uttarakhand, the entire land is considered as forest land. Accordingly a compensatory afforestation scheme is on double of degraded forest land on 528 ha has been formulated to compensate the loss of forest. The total cost of afforestation works out to Rs. 21.12 million. @ Rs. 40,000/ha.

Compensatory afforestation will be through state forest department as per the stipulations of forest clearance. Sufficient provisions shall also be earmarked for:

- NPV towards forest land diversion
- Cost of trees in forest area to be diverted.

6.9 PROVISION OF FREE FUEL

It is recommended that, during the construction phase of hydroelectric projects, the project authorities have to make proper/ adequate arrangements for meeting the demand of fuel supply to the labourers/ workmen engaged through the contractors so that illegal felling of tress does not take place in the near by forest area situated around the project as these projects are normally located in the far-flung remote areas to the forests. The basic aim and objectives behind this direction by the Ministry are to:

- control the illegal felling of trees
- make a sound and eco-friendly project by providing proper fuel arrangements to the labourers/ workmen
- make the project responsible for catering to the demand of fuel for labourers / workmen
- maintain the forest cover and environment of the region, where project is being located.

As a part of EMP, it is recommended to:

- make a clause mandatory in the contract of every contractor involved in project construction to provide supply of fuel to their labourers, so that trees are not cut for meeting their fuel demands.
- establish LPG godown within the project area for providing LPG cylinder to run community

kitchens.

- establish kerosene oil depot near project area with the help of state government to ensure proper supply of kerosene oil.

NTPC in association with the state government should make necessary arrangements for distribution of kerosene oil and LPG. These fuels would be supplied at subsidized rates to the local/contract laborers for which provision should be kept in the cost estimate. The total cost required for provisions of fuel works out to Rs. 36.68 million. The details are given in Tables 6.5 to 6.7.

TABLE-6.5

Cost estimate for LPG distribution

Year	No. of Employees	Annual requirement @1cylinder per family per month (No. of cylinders)	Total Cost @Rs. 400/cylinder (Rs. million) * including 10% escalation per year	Subsidy to be borne by NTPC @ 50% (Rs. million) * including 10% escalation per year
I	400	4800	1.92	0.96
II	500	6000	2.64	1.32
III	600	7200	3.48	1.74
IV	600	7200	3.84	1.92
V	600	7200	4.22	2.11
VI	600	7200	4.64	2.32
	Total		**20.74**	**10.37**

TABLE-6.6

Cost estimate for Kerosene distribution

Year	No. of labours	Quantity @10 litre per labour per month (litre/yr)	Total Cost @ Rs. 20/litre (Rs. million) * including 10% escalation per year	Subsidy to be borne by @ 50% (Rs. million) * including 10% escalation per year
I	1000	180,000	3.60	1.80

Year	No. of labours	Quantity @10 litre per labour per month (litre/yr)	Total Cost @ Rs. 20/litre (Rs. million) * including 10% escalation per year	Subsidy to be borne by @ 50% (Rs. million) * including 10% escalation per year
II	1500	270,000	6.53	3.27
III	2000	300,000	8.72	4.36
IV	2000	300,000	9.60	4.80
V	2000	300,000	10.56	5.28
VI	2000	300,000	11.61	5.81
	Total		**50.62**	**25.31**

TABLE-6.7

Cost estimate for provision of fuel

S.No.	Fuel	Cost (Rs. million)
1.	**LPG for Technical staff**	**10.37**
2.	**Kerosene for labour population**	**25.31**
	Total	36.68

6.10 WILDLIFE CONSERVATION PLAN

As per the available data the project and its surrounding areas do not have much of wildlife. Around the main construction areas i.e. the dam site, power house site, etc. where construction workers congregate, some disturbance in the wildlife population may occur. However, in view of the low wildlife concentration in the area, the impacts due to various construction activities could be marginal. Further the labourers may also involve in collection of firewood, small timber and fodder from the nearby forest areas. Some of them may involve in illicit felling and trading of timber and other forest products.

To minimize indirect impacts due to congregation of labour population, it is recommended to develop appropriate surveillance measures. It is recommended that check posts be installed near major construction sites and labour camps. It is recommended to develop 2 check posts, which should be operational during construction phase. Each check post should have guards. A range officer should supervise the guards of various check posts. It is also recommended that the staff manning these check posts have adequate communication equipment and other facilities. It is proposed that 2 jeeps and wireless sets at each check post has been suggested. Apart from inter-linking of check posts, the communication wireless link needs to be extended to Divisional Forest Office and the local police station also. he cost involved on this account will be of the order of Rs 5.85 million.

The details are given as below:

• 8 guards @ Rs.4000 per month	Rs. 384,000
• One range officer @ Rs.9, 000 per month	Rs. 108,000
• Total cost for one year	Rs. 492,000
• Cost for 6 years (Assuming 10% increase per year)	Rs. 3.79 million
• Cost of construction of check posts (Rs. 500,000 X 2) and provision of arm & Ammunition, communication system, etc.	Rs. 1.0 million
• Communication cost	Rs.0.06 million
• Purchase of 2 Jeeps @ Rs.0.5 million/jeep	Rs.1.00 million
Total	**Rs. 5.85 million**

6.11 PUBLIC HEALTH DELIVERY SYSTEM

The increase in water fringe area provides suitable habitats for the growth of vectors of various diseases and they are likely to increase the incidence of water-related

diseases. The suggested measures to minimize the incidence of vector-borne diseases are given in following paragraphs:

- Site selected for labour camps should not be in the path of natural drainage.
- Adequate drainage system to dispose storm water drainage from the labour colonies should be provided.
- Adequate vaccination and immunization facilities should be provided for workers at the construction site.
- The labour camps and resettlement sites should be sufficiently away from a main water body or quarry areas.

1.1.1.1.17.1.2

1.1.1.1.17.1.3 Development of medical facilities

A population of about 8,200 is likely to congregate during the construction phase. The labour population will be concentrated at two to three sites. It is recommended that necessary and adequate medical facilities be developed at the project site. It is recommended that the dispensary should be developed during project construction phase itself, so that it can serve the labour population migrating in the area as well as the local population.

Proposed Health Facilities at Construction sites and labour camp

It is possible that during the construction work, technical staff operating different equipment are not only exposed to the physical strain of work but also to the physical effects of the environment in which they are working. The workers and other technical staff may come up with common manifestations such as insect bites, fever, diarrhoea, work exhaustion and other diseases. In addition they may invariably come up with injuries caused by accidents at work site. Under all circumstances, workers need immediate medical care.

A first-aid post is to be provided at each of the major construction sites, so that

workers are immediately attended to in case of an injury or accident.

This first-aid post will have at least the following facilities :

- First aid box with essential medicines including ORS packets
- First aid appliances-splints and dressing materials
- Stretcher, wheel chair, ambulance etc.

Health Extension Activities

The health extension activities will have to be carried out in the villages situated in the nearby areas. It is important to inculcate hygienic habits of environmental sanitation specially with respect to water pollution by domestic wastes. There would be possibility of the transmission of communicable diseases due to migration of labour population from other areas at the construction site.

The doctors from the dispensary should make regular visits to these villages and organize health promotional activities with the active participation of the local village Panchayat, NGOs and available local health functionaries. The health functionaries would undertake the following tasks as a part of health promotional activities:

- Collect water samples to ascertain the potability of water from different sources so as to monitor regular disinfection of drinking water sources.
- Maintain close surveillance on incidence of communicable diseases in these villages.
- Maintain close liaison with the community leaders and health functionaries of different departments, so that they can be mobilized in case of an emergency.

The Total cost required for implementation of Public Health Delivery System is Rs. 37.57 million including Health check up for the labourers. The details are given in the following paragraphs.

A. Expenditure on salaries

Dispensary

		Number	Monthly Emoluments (Rs.)	Annual expenditure (Rs.)
	Doctors	4	20,000	960,000
	Nurse	8	8,000	768,000
1.1.1.4	**Male Multi-purpose**	**4**	**6,000**	**288,000**
1.1.1.5	**Health Workers**			
	Attendants	4	4,000	192,000
	Drivers	4	3,000	144,000
	Total			23,52,000

First Aid Posts

	Health Assistants	*2*	*5,000*	*120,000*
1.1.1.6	**Dressers**	**2**	**3,000**	**72,000**
	Total			192,000

Total Expenditure (A) = Rs.2,544,000

B. Expenditure on Material and Supplies

Dispensary

Non-recurring

i)	4 Vehicles (Closed Jeep) and	Rs. 20,00,000
ii)	Furniture, etc.	Rs. 1,00,000
	Total	Rs. 21,00,000

Recurring

i)	Drugs and Medicine,	Rs. 300,000/yr
ii)	Contingencies	Rs. 100,000/yr
iii)	2 First-Aid Posts at construction sites	Rs. 60,000/yr
	Total	Rs. 460,000/yr

C. Infrastructure

Dispensary: Considering the number of rooms, staff quarters and open space etc., it is estimated that 10,000 sq.feet of plot will be required for dispensary, out of which about 8000 sq.feet will be the built-up land which includes staff quarters, etc. The construction cost for RCC structure will be Rs.500/sq.feet excluding land cost. The cost of construction of Dispensary will be Rs.4.0 million. The land can be purchased by the project proponents from the State Government. An amount of Rs.0.4 million can be earmarked for purchase of land.

2 First Aid Posts: These shall be of temporary nature and will be constructed with asbestos sheets, bamboo, etc. It will cost @ Rs.100,000/First Aid Post. The total cost for constructing two First Aid Posts will be of the order of Rs.0.2 million.

The total cost for developing the infrastructure will be (Rs.4.0 + Rs.0.4 + Rs.0.2 million) Rs.4.6 million.

D. Recurring Expenditure

*	Expenditure on salaries	:	Rs. 2,544,000/yr
*	Expenditure on materials & supplies	:	Rs. 460,000/yr
	Sub-Total (D)		Rs. 3,004,000/yr
Total expenditure for 6 years (A) (considering 10% escalation per year period)		:	Rs. 23.16 million

E. Non-Recurring Expenditure

*	Infrastructure (Construction of Dispensary & 2 First aid posts)	:	Rs. 4.60 million
*	Expenditure on materials & supplies	:	Rs. 2.10 million
	Total (E)		Rs. 6.70 million

Total (D + E) **Rs. 29.86 million**

Health checkup

Full health screening of labourers a provision of Rs. 1 million/year can be earmarked.

The same is required for the entire construction phase (64 months). Considering an annual increase of 10% per year, the total expenditure on be Rs 7.71 million.

The total cost on public health delivery system shall be (29.86 + 7.71) Rs. 37.57 million.

6.12 CONTROL OF AIR POLLUTION

The air pollution is basically generated due to primary crushing and fugitive dust from the heap of crushed material. The various crushers need to be provided with cyclones to control the dust generated while primary crushing the stone aggregates. It should be mandatory for the contractor involved in crushing activities to install cyclone in the crusher. Hence, the cost for this aspect has not been included in the cost for implementing EMP.

The fine aggregates stacked after crushing needs to be stacked till the time it is consumed. It is suggested that these stacks should be regularly sprayed with water to prevent the entrainment of fugitive emissions.

In addition, fugitive emissions are also likely to be entrained as a result of movement of earth movers, vehicular traffic on unpaved roads, etc. It is recommended to regularly spray water over such areas to prevent entrainment of fugitive emissions.

6.13 CONTROL OF WATER POLLUTION

Construction Phase

During project construction phase, sufficient measures need to be implemented to ameliorate the problem of water pollution from various sources. The sewage generated from various labour camps shall be treated in Sewage treatment plants and disposed by discharging into river Goriganga.

The construction activities would require crushers to crush large lumps of rocks to the requisite size for producing coarse as well as fine aggregates. The effluent generated from these crushers will have high suspended solids. The effluents shall be treated. In Settling tanks of appropriate size before disposal

During tunneling work the ground water flows into the tunnel along with construction water which is used for various works like drilling, shortcreting, etc. The effluent thus generated in the tunnel contains high suspended solids. Normally, water is collected in the side drains and drained off into the nearest water body without treatment. It is recommended to construct a settling tank of adequate size to settle the suspended impurities. It is expected that about 2 to 3 adits shall be required for the tunneling work. Thus, effluents are expected to be generated from 2 to 3 locations.

The sludge from the various settling tanks can be collected once in 15 days and disposed at the site designed for disposal of municipal solid wastes from the labour camps. The sludge after drying could also be used as cover material for landfill disposal site. An amount of Rs. 1.0 million shall be earmarked for construction of various settling tanks.

An amount of Rs. 0.03 million/year can be earmarked for O&M. The total cost required for O&M during construction phase of 64 months considering 10% escalation shall be Rs. 0.20 million.

Operation phase

In the project operation phase, a plant colony with 300 quarters is likely to be set up. It is recommended to provide a suitable Sewage Treatment Plant (STP) to treat the sewage generated form the colony. The cost required for construction of sewage treatment plant (STP) in the project colony has already been covered in the budget

earmarked for construction of the project colony. Hence, the cost for the same has not been included in the cost for implementing EMP.

6.14 FISH MANAGEMENT

a) Release of minimum flow

The construction of the proposed project will lead to reduction in flow, especially during lean season months, in the intervening stretch between the dam site and the tail race outfall point. Such a situation will adversely affect the benthic communities and fish. Snow trout and Mahaseer species are likely to be affected as a result of obstruction in their migration created by the proposed dam.

The river stretch between dam site and tail race disposal at certain places may retain some water in shallow pools subjecting the fish to prey by birds and other animals. Such a condition will also enable the locals to catch fish indiscriminately. It is therefore, very essential for the project authorities to maintain the minimum flow for the survival and propagation of invertebrates and fish. In order to avoid the possible loss of aquatic life, a minimum flow of 2.5 cumecs shall always be released from the dam.

b) Sustenance of Endemic Fisheries

Commercial fishing is not in vogue in the project area. Snow trout (*Schizothorax richardsonii*) is the endemic species. The dam on river Goriganga to be developed as a part of the project will act as a barrier to the free movement of fish species. Since, *Snow trout* is categorised as vulnerable species amongst the threatened fishes of India, scientific management of the existing stock needs be adopted. It is proposed to implement supplementary stocking programmes for the project area. In addition to reservoir area, it is proposed to stock river Goriganga for a length of 10 km each on the upstream and the downstream side of the dam site. The rate of stocking is proposed as 100 fingerlings of about 30 mm size per km. For reservoir area, the rate of stocking could be 200 fingerlings of about 30 mm size per ha. The stocking can be done annually by the Fisheries Department, State Government of Uttarakhand. To achieve this objective, facilities to produce seed of trout need to be developed at suitable sites. The cost required for developing of hatcheries shall be Rs. 2.52 million. The dimension of the hatching nurseries and rearing unit and their approximate cost is given in Table-6.8. The recurring expenditure for hatchery will be 1.755 million/year.

The total recurring expenditure for 5 year including 10% escalation will be Rs. 10.71 million. The detail of recurring expenditure are given in Table-6.9.

TABLE-6.8

Cost required for development of hatcheries

Farm Component	Area (m)	Number	Rate of flow (lpm)	Cost (Rs. million)
Hatchery building	15x 6 x 5	1	-	0.30
Hatching trough each with 4 trays each	2.0x0.5x 0.4	20	3.0-5.0	0.20
Nursery ponds (Cement lined)	3.0 x 0.75 x 0.5	9	25-50	0.27
Rearing tanks (cement lined)	10.0x 1.5 x 1.0	9	75-100	0.45
Stock raceways (cement lined)	30.0 x 6.0x 1.5	2	150-200	0.30
Storage – cum – Silting tank	4.0 x 4.0	1	-	0.10
Office store & laboratory room	8.0 x 6.0	3	-	0.6
Watchmen hut	4. 4.0	1	-	0.2
Other items like Dragnet, wide mouth earthen pots miniature happa bucket bamboo patches etc.	Lumpsum			0.1
Total				**2.52**

TABLE-6.9
Recurring expenditure for hatchery

S.No.	Particular	Number	Rate	Amount (Rs. million
1.	Salaries			
i)	Farm Manager	1	25000/month	0.30
ii)	Farm Assistants	1	15000/ month	0.18
iii)	Farm Attendants	1	10000/ month	0.12
iv)	Chowkidars	1	10000/ month	0.12
2.	Fish food	Lumpsum		0.10
3.	Brooders	200 kg	150	0.30
4.	Ponds manuring			
i)	Cow dung	20 tons	200/tons	0.004
ii)	Urea	100 kg	10/kg	0.001
iii)	Potash, phosphate	100 kg	100/kg	0.10
5.	Lime	300 kg	10/kg	0.03
6.	Training and Research	Lumpsum		0.10
7.	Chemical	Lumpsum		0.10

8.	Maintenance	Lumpsum		0.10
9.	Travel	Lumpsum		0.10
10	Miscellaneous	Lumpsum		0.10
	Sub-total for one year **Total recurring expenditure for six years including 10% escalation (B)**			1.755 **13.53**

Thus total cost for fish seed farm will be Rs. **16.05 million** (Rs. 2.52 + 13.53 million).

The above facility can be developed and implemented by Fisheries Department, State Government of Uttarakhand at an appropriate site. Seeds can be transported from this hatchery. The supply of seeds can also be augmented by collecting them from natural sources. Production, transportation and stocking of fish material is a highly technical subject for which project proponent may not have the required expertise. Thus, implementation of this proposal may be done by the Fisheries Department. The funding can be done by Project Proponents.

6.15 NOISE CONTROL MEASURES

Noise pollution can be mitigated at the source itself. As discussed in Chapter-4, the ambient noise levels would have marginal increase up to about 1 km from the major construction sites. The increased level of noise will, however, not have any significant adverse impact. The effect of high noise levels on the construction labour is to be considered. It is known that continuous exposure to high noise levels above 90 dB(A) affects the hearing ability of the workers/operators and hence has to be avoided.

Other physiological and psychological effects have also been reported in literature, but the effect on hearing ability has been specially stressed. To prevent these effects, it has been recommended by international specialist organisations that the exposure period of affected persons be limited as specified in Table-4. .

Alternatively, they should be provided with effective personal protective measures such as ear muffs or ear plugs to be worn during periods of exposure.

The other measures to control noise could be as follows:

- Equipment and machineries should be maintained regularly to keep the noise generation at the design level;
- Silencers and mufflers of the individual machineries to be regularly checked.

6.16 ROADSIDE PLANTATION

In this project, major components like Dam, power intake and surge shaft as well as adits are near to existing roads. However, a project of this magnitude would require construction of sufficient length of roads to facilitate construction activities. In the proposed project, new roads have to be constructed. It is proposed to develop 3 rows of trees at 5 m interval along both sides of the road. The cost of plantation per hectare is estimated at Rs.40,000. A provision of Rs.0.80 million has already been earmarked for various works including roadside plantation in Section-6.3 (refer Table-6.3) of this Report. Hence, no separate provision for roadside plantation needs to be earmarked.

6.17 LANDSLIDES

The proposed project area is located in a landslide prone area for which adequate management measures need to be incorporated. Unscientific landuse pattern is the major cause for the present deteriorating situation for which appropriate land use regulation measures need to be implemented. Social and economic upliftment, generating new local resource based small eco-friendly practices on steeper slopes, etc. can be other measures which can be implemented to control landslide hazards. Various measures

recommended for control of landslides are given in the following paragraphs.

Discouraging new developments in hazardous areas by:

- Disclosing the hazard prone areas to land developers
- Adopting utility and public facility service area policies.
- Informing and educating the public
- Manning a record of hazard.

Removing or converting existing development through:

- Acquiring or exchanging hazardous properties
- Discontinuing non-conforming uses
- Reconstructing damaged areas after landslides
- Removing unsafe structures
- Clearing and redeveloping blighted areas before landslides.

Regulating new development in hazardous areas by:

- Enacting grading ordinances
- Adopting hill side development regulations
- Amending landuse zoning and regulations creating hazard reduction zones and regulations
- Enacting subdivision ordinances.

Protecting existing development by:

- Controlling landslides and slumps
- Controlling mudflows and debris flows
- Controlling rock falls
- Operating monitoring, warning and equation system.

In addition to above appropriate landslide control measures including various biological and engineering measures shall be implemented. These are listed as below:

Biological Treatment measures

- Pasture Development
- Compensatory Afforestation
- Agro-forestry
- Contour farming

Engineering Treatment measures

- Wire Crate walls
- Gabion structures
- Check dams
- Contour and Graded Trenching
- Step Drains
- Stone Masonry.

6.18 ESTABLISHMENT OF ENVIRONMEMNTAL LABORATORY

An independent laboratory with facilities for chemical analysis should be set up in due course. A separate air conditioned dust-proof room will have to be provided for installing analytical instruments. An amount of Rs. 2.00 million shall be earmarked for this purpose.

6.19 ESTABLISHMENT OF AN ENVIRONMENTAL MANAGEMENT CELL

It is recommended that project proponents establish an Environmental Management Cell at the project site with requisite manpower. The task of the Cell will be to coordinate various environmental activities, to carry out environmental monitoring and to evaluate implementation of environmental mitigatory measures. The Environmental Management Cell will report to the appropriate authority having adequate powers for effective implementation of the Environmental Management Plan.

6.20 SUMMARY OF IMPACTS AND EMP

A summary of impacts and proposed measures along with the implementing agencies is given in Table-6.10.

TABLE-6.10

Summary of Impacts, suggested management measures and implementing agency

S.No	Parameters	Impact	Management Measures	Implementing Agency
1.	**LAND ENVIRONMENT**			
	Construction phase	• Increase in turbidity in the river downstream of dam and power house sites	• Proper collection and disposal of construction spoils.	• NTPC
		• Increased incidence of water related diseases and other health problems	• Development of PHC's, first aid centre, anti-mosquito spray	• NTPC & District Public Health Department
		• Generation of	• Disposal at	• NTPC

S.No	Parameters	Impact	Management Measures	Implementing Agency
		solid wastes from labour camps/colonies.	designated landfill sites.	
2.	**WATER RESOURCES**			
	Operation phase	• River stretch from dam site to tailrace outfall will have reduced flow during lean season.	• Minimum flow will be released to maintain the riverine ecology and dilution of domestic effluent.	• NTPC
		• Negligible siltation and sedimentation problems	• No impact, still treatment is proposed to be done in directly draining catchment	• Forest Department/ NTPC
3.	**WATER QUALITY**			
	Construction phase	• Water pollution due to disposal of sewage from labour colonies.	• Provision of community toilets, and sewage treatment plant	• NTPC
		• Disposal of effluents with high turbidity from crushers commissioned at various sites and effluents from adits at tunnel.	• Provision of settling tanks.	• Project Contractor
	Operation phase	• Deterioration of water quality in the dry stretch of river due to	• Minimum flow will be released	• NTPC

S.No	Parameters	Impact	Management Measures	Implementing Agency
		reduced flow during the lean season. • Disposal of sewage from project colony.	• Commissioning of Sewage Treatment Plant (STP)	• NTPC
4.	**TERRESTRIAL FLORA**			
	Construction phase	• Cutting of trees for meeting fuel wood requirements by labour. • Acquisition of forest land.	• Provision of subsidized kerosene and LPG to construction labour and technical staff. • Compensatory afforestation.	• Project Contractor/ NTPC • Forest & Revenue Department/ NTPC
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.	• No major wildlife is found, hence impact is not expected to be significant. However, wild life conservation/surveillance plan has been recommended • Surveillance through check posts is recommended	• Forest Department • Forest Department
6.	**AQUATIC ECOLOGY**			
	Construction phase	• Marginal decrease in aquatic productivity due to increased	• Treatment through settling tanks	• Project Contractor

S.No	Parameters	Impact	Management Measures	Implementing Agency
	Operation phase	turbidity and lesser light penetration. • Impacts on migration of snow trout. • Drying of river stretch downstream of dam site up to tail race outfall	• Stocking of river Goriganga upstream and downstream of dam site. • Release of minimum flow	• Fisheries Department. • NTPC
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 to labourers	• Project contractor
8.	**AIR ENVIRONMENT**			
	Construction phase	• Emissions due to crusher operation at various sites	• Commissioning of cyclone in each crusher.	• Project contractor
9.	**SOCIO-ECONOMIC ENVIRONMENT**			
	Construction phase	• Acquisition of land and other properties.	• Compensation as per R&R package.	• NTPC
10.	**INCREASED INCIDENCE OF WATER-RELATED DISEASES**			
	Construction phase Operation phase	• Increased water-borne diseases • Increase in water-related	• Provision of community toilets and STP. • Medical check-up of labour and	• Project contractor/ NTPC • NTPC & Public Health

S.No	Parameters	Impact	Management Measures	Implementing Agency
		diseases due to creation of suitable habitats for growth of vectors.	development of medical facilities. • Spray of chemicals to avoid growth of vectors	Department

CHAPTER-7

CATCHMENT AREA TREATMENT PLAN

7.1 NEED FOR CATCHMENT AREA TREATMENT

It is a well-established fact that reservoirs formed by dams on rivers are subjected to sedimentation. The process of sedimentation embodies the sequential processes of erosion, entrainment, transportation, deposition and compaction of sediment. The study of erosion and sediment yield from catchments is of utmost importance as the deposition of sediment in reservoir reduces its capacity, and thus affecting the water availability for the designated use. The eroded sediment from catchment when deposited on streambeds and banks causes braiding of river reach. The removal of top fertile soil from catchment adversely affects the agricultural production. Thus, a well-designed Catchment Area Treatment (CAT) Plan is essential to ameliorate the above-mentioned adverse process of soil erosion.

Soil erosion may be defined as the detachment and transportation of soil. Water is the major agent responsible for this erosion. In many locations, winds, glaciers, etc. also cause soil erosion. In a hilly catchment area as in the present case erosion due to water is a common phenomenon and the same has been studied as a part of the Catchment Area Treatment (CAT) Plan.

The Catchment Area Treatment (CAT) plan highlights the management techniques to control erosion in the catchment area. Life span of a reservoir in case of a seasonal storage dams is greatly reduced due to erosion in the catchment area. The catchment area considered for treatment is about 46321 ha. The sub-watershed in the catchment area considered for the present study is given in Figure-7.1.

The catchment area treatment involves

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

In the present study `**Silt Yield Index' (SYI)**, method has been used. In this method, the terrain is subdivided into various watersheds and the erodibility is determined on relative basis. SYI provides a comparative erodibility criteria of catchment (low, moderate, high, etc.) and do not provide the absolute silt yield. SYI method is widely used mainly because of the fact that it is easy to use and has lesser data requirement. Moreover, it can be applied to larger areas like sub-watersheds, etc.

7.2 APPROACH FOR THE STUDY

A detailed database on natural resources, terrain conditions, soil type of the catchment area, socio-economic status, etc. is a pre-requisite to prepare treatment plan keeping in view the concept of sustainable development. Various thematic maps have been used in preparation of the CAT plan. Due to the spatial variability of site parameters such as soils, topography, land use and rainfall, not all areas contribute equally to the erosion problem. Several techniques like manual overlay of spatially index-mapped data have been used to estimate soil erosion in complex landscapes.

Geographic Information System (GIS) is a computerized resource data base system, which is referenced to some geographic coordinate system. In the present study, real coordinate system has been used. The GIS is a tool to store, analyze and display various spatial data. In addition, GIS because of its special hardware and software characteristics, has a capacity to perform numerous functions and operations on the various spatial data layers residing in the database. GIS provides the capability to analyze large amounts of data in relation to a set of established criteria.

In order to ensure that latest and accurate data is used for the analysis, satellite data has been used for deriving land use data and ground truth studies too have been conducted.

The various steps covered in the study are as follows:

- Data acquisition
- Data preparation
- Output presentation

The above mentioned steps are briefly described in the following paragraphs.

7.2.1 Data Acquisition

The requirement of the study was first defined and the outputs expected were noted. The various data layers of the catchment area used for the study are as follows:

- Slope Map
- Soil Map
- Land use Classification Map
- Current Management Practices
- Catchment Area Map.

7.2.2 Data Preparation

The data available from various sources was collected. The ground maps, contour information, etc. were scanned, digitized and registered as per the requirement. Data was prepared depending on the level of accuracy required and any corrections required were made. All the layers were geo-referenced and brought to a common scale (real coordinates), so that overlay could be performed. A computer programme was used to estimate the soil loss. The formats of outputs from each layer were firmed up to match the formats of inputs in the program. The grid size to be used was also decided to match the level of accuracy required, the data availability and the software and time limitations. The format of output was finalized. Ground truthing and data collection was also included in the procedure.

For the present study IRS 1C-LISS III digital satellite data was used for interpretation & classification. The classified land use map of the catchment area considered for the study is shown as Figure-7.2. The land use pattern of the catchment is summarized in Table-7.2.

TABLE-7.2
Landuse pattern of the catchment area

Category	Area (ha)	Percentage
Dense Vegetation	7000	15.11
Open Vegetation	14453	31.20
Barren Rocky Outcrops	12260	26.47
Open scrub	1890	4.08
Snow cover	10481	22.03
Water	196	0.42
Settlement	41	0.09
Total	**46321**	**100.00**

Digitized contours from toposheets were used for preparation of Digital Elevation Model (DEM) of the catchment area and to prepare a slope map. The first step in generation of slope map is to create surface using the elevation values stored in the form of contours or points. After marking the catchment area, all the contours on the toposheet were digitized (100 m interval). The output of the digitization procedure was the contours as well as points contours in form of x, y & z points. (x, y location and their elevation). All this information was in real world coordinates (latitude, longitude and height in meters above sea level).

A Digital Terrain Model (DTM) of the area was then prepared, which was used to derive a slope map. The slope was divided in classes of slope percentages. The slope map is enclosed as Figure-7.3.

Various layers thus prepared were used for Modeling. Software was prepared to calculate the soil loss using input from all the layers.

7.2.3 Output Presentation

The result of the modeling was interpreted in pictorial form to identify the areas with high soil erosion rates. The primary and secondary data collected as a part of the field studies were used as an input for the model.

7.3 ESTIMATION OF SOIL LOSS USING SILT YIELD INDEX (SYI) METHOD

The Silt Yield Index Model (SYI), considering sedimentation as product of erosivity, erodibility and arial extent was conceptualized in the All India Soil and Land Use Survey (AISLUS) as early as 1969 and has been in operational use since then to meet the requirements of prioritization of smaller hydrologic units.

The erosivity determinants are the climatic factors and soil and land attributes that have direct or reciprocal bearing on the unit of the detached soil material. The relationship can be expressed as:

Soil erosivity = f (Climate, physiography, slope, soil parameters, land use/land cover, soil management)

Silt Yield Index

The Silt Yield Index (SYI) is defined as the Yield per unit area and SYI value for hydrologic unit is obtained by taking the weighted arithmetic mean over the entire area of the hydrologic unit by using suitable empirical equation.

Prioritization of Watersheds/Subwatersheds:

The prioritization of smaller hydrologic units within the vast catchments are based on the Silt Yield Indices (SYI) of the smaller units. The boundary values or range of SYI values for different priority categories are arrived at by studying the frequency distribution of SYI values and locating the suitable breaking points. The watersheds/ sub-watersheds are subsequently rated into various categories corresponding to their respective SYI values.

The application of SYI model for prioritization of sub watersheds in the catchment areas involves the evaluation of:

a) Climatic factors comprising total precipitation, its frequency and intensity,
b) Geomorphic factors comprising land forms, physiography, slope and drainage characteristics,
c) Surface cover factors governing the flow hydraulics and
d) Management factors.

The data on climatic factors can be obtained for different locations in the catchment area from the meteorological stations whereas the field investigations are required for estimating the other attributes.

The various steps involved in the application of model are:

- Preparation of a framework of sub-watersheds through systematic delineation
- Rapid reconnaissance surveys on 1:50,000 scale leading to the generation of a map indicating erosion-intensity mapping units.
- Assignment of weightage values to various mapping units based on relative silt-yield potential.
- Computing Silt Yield Index for individual watersheds/sub watersheds.
- Grading of watersheds/sub watersheds into very high, high medium, low and very low priority categories.

The area of each of the mapping units is computed and silt yield indices of individual sub watersheds are calculated using the following equations:

a. Silt Yield Index

$$SYI = \frac{\Sigma (Ai \times Wi) \times 100}{Aw}; \quad \text{where } i = 1 \text{ to } n$$

1.1.1.7 Aw

1.1.1.8 Where

Ai = Area of ith unit (EIMU)
Wi = Weightage value of ith mapping unit
n = No. of mapping units
Aw = Total area of sub-watershed.

The SYI values for classification of various categories of erosion intensity rates are given in Table-7.3.

1.1.1.1.17.1.4 TABLE-7.3

Criteria for erosion intensity rate

Priority categories	SYI Values
Very high	> 1300
High	1200-1299
Medium	1100-1199
Low	1000-1099
Very Low	<1000

7.4 WATERSHED MANAGEMENT – AVAILABLE TECHNIQUES

Watershed management is the optimal use of soil and water resources within a given geographical area so as to enable sustainable production. It implies changes in land use, vegetative cover, and other structural and non-structural action that are taken in a watershed to achieve specific watershed management objectives. The overall objectives of watershed management programme are to:

- increase infiltration into soil;
- control excessive runoff;
- Manage & utilize runoff for useful purpose.

Following Engineering and Biological measures have been suggested for the catchment area treatment.

1. Engineering measures

- Step drain
- Angle iron barbed wire fencing
- Stone masonry
- Check dams

2. Biological measures

- Development of nurseries
- Plantation/afforestation
- Pasture development
- Social forestry

The basis of site selection for different biological and engineering treatment measures under CAT are given in Table-7.4.

1.1.1.1.17.1.5

1.1.1.1.17.1.6

1.1.1.1.17.1.7

1.1.1.1.17.1.8

1.1.1.1.17.1.9 TABLE-7.4

Basis for selection of catchment area treatment measures

Treatment measure	Basis for selection
Social forestry, fuel wood and fodder grass development	Near settlements to control tree felling
Contour Bunding	Control of soil erosion from agricultural fields.
Pasture Development	Open canopy, barren land, degraded surface
Afforestation	Open canopy, degraded surface, high soil erosion, gentle to moderate slope
Barbed wire fencing	In the vicinity of afforestation work to protect it from grazing etc.

Treatment measure	Basis for selection
Step drain	To check soil erosion in small streams, steps with concrete base are prepared in sloppy area where silt erosion in the stream and bank erosion is high due to turbidity of current.
1:4:8 Stone masonry	Steep slopes, sliding surfaces, less vegetative cover and where silt erosion is high
Nursery	Centrally located points for better supervision of proposed afforestation, minimize cost of transportation of seedling and ensure better survival.

7.5 CATCHMENT AREA TREATMENT MEASURES

The total catchment area is 15043.96 ha. The erosion category of various watersheds in the catchment area as per a SYI index is given in Table-7.5. The details are shown in Figure-7.4. The area under different erosion categories is given in Table-7.6.

TABLE-7.5

Erosion intensity categorization as per SYI classification

Watershed number	Area	SYI values	Category
W1	2000	1146	Medium
W2	2760	1207	High
W3	1118	1216	High
W4	2233	1105	Medium
W5	1167	975	Very low
W6	1890	1160	Medium
W7	2582	1081	Low
W8	2274	1036	Low
W9	1565	1013	Low
W10	1586	950	Very Low
W11	1604	1001	Low
W12	1506	1232	High
W13	1683	1118	Medium
W14	1124	1021	Low
W15	657	1243	High
W16	823	1052	Low
W17	481	1050	Low
W18	1024	1147	Medium
W19	863	1229	High
W20	803	1013	Low
W21	1466	1050	Low

Watershed number	Area	SYI values	Category
W22	258	1250	High
W23	2243	1145	Medium
W24	839	1258	High
W25	1673	1219	High
W26	865	1215	High
W27	857	1078	Low
W28	799	1155	Medium
W29	921	1098	Low
W30	1250	1148	Medium
W31	910	1218	High
W32	1619	1063	Low
W33	1207	1110	Medium
W34	1688	1148	Medium

TABLE-7.6

Area under different erosion categories

Category	Area (ha)	Percentage
Very low	2753	5.9
Low	16119	34.8
Medium	16037	34.6
High	11455	24.7
Very High	-	-
Total	**46364**	**100.00**

The objective of the SYI method is to prioritize sub-watershed in a catchment area for treatment. The total area under high erosion category is 11457 ha. The various measures suggested for catchment area treatment are mentioned in Figure 7.5, expenses of which have to be borne by the project proponents.

7.6 COST ESTIMATE

The cost required for Catchment Area Treatment is Rs. 89.0 million. The details are given in Tables -7.7 and 7.8. the year wise expenditure is given in Table-7.9

TABLE-7.7

Cost estimate for Catchment Area Treatment - Biological Measures

S.No.	Item	Rate/unit (Rs.) (including maintenance cost)	Target	
			Physical	Financial (Rs. million)
1.	Gap Plantation	31,200/ha	1123	35.04
2.	Pasture Development	15,000/ha	401 ha	6.02
3.	Afforestation	40,000/ha	587	23.48
4.	Fuel wood and fodder plantation	40,000/ha	60	2.40
5.	Nursery development	3,00,000/no.	2 no	0.60
6.	Maintenance of nursery	2,70,000/no	2 no.	0.54
7.	Barbed wire fencing	100,000/km	3 km	0.30
8.	Watch and ward for 3 years for 10 persons	5000/ man-month	360 man months	1.80
	Total (A)			**70.18**

TABLE-7.8
Cost estimate for Catchment Area Treatment - Engineering Measures

S.No.	Item	Rate (Rs.)	Unit	Target	
				Physical	Financial (Rs. million)
1.	Step drain	5000	RMT	700 RMT	3.50
2.	Check dam	150,000	No.	19 No.	2.85
	Total (B)				**6.35**

Total cost for Biological and Engineering measures = Rs. 76.53 million (A)
Administrative expenditure

- Government Expenditure 3% of A (including O&M) Rs. 2.30 million
- Establishment cost 8% of A Rs. 6.12 million
- Contingency 5% of A Rs. 3.82 million

Total Rs.88.17 million

Say Rs. 89 million

1.1.1.1.17.1.10 TABLE-7.9

Yearwise target (physical and financial) for Catchment Area Treatment Plan

Measures	Year I		Year II		Year III		To
	Physical	Financial (Rs. million)	Physical	Financial (Rs. million)	Physical	Financial (Rs. million)	Physical
Biological measures							
Gap Plantation (800 trees/ha)	400 ha	12.48	400 ha	12.48	323 ha	10.08	1123 ha
Afforestation	200 ha	8.0	200 ha	8.0	187 ha	7.48	587
Fuelwood and Fodder plantation	30 ha	1.20	30 ha	1.20	-	-	60 ha
Pasture Development	201 ha	3.02	200 ha	3.0	-	-	401 ha
Nursery development	2 No.	0.60	-	-	-	-	2 No.
Maintenance of Nursery	-	-	-	0.27	-	0.27	
Barbed wire fencing	2 km	0.20	1 km	0.10	-	-	3 km
Watch and ward	-	0.60	-	0.60	-	0.60	-
Sub-Total (A)		**26.10**		**25.65**		**18.43**	
Engineering measures							
Step Drain	400 m^3	2.00	300 m^3	1.50	-	-	700 m^3
Check Dam	10 nos.	1.50	9 No.	1.35	-	-	19 no.
Sub-Total (B)		**3.50**		**2.85**		**-**	
Total (A+B)		**29.60**		**28.50**		**18.43**	

CHAPTER – 8

ENVIRONMENTAL MONITORING PROGRAMME

8.1 THE NEED

Environmental monitoring is an essential component for sustainability of any water resources project. It is an integral part of any environmental assessment process. Any water resources development project introduces complex inter-relationships in the project area between people, various natural resources, biota and the many developing forces. Thus, a new environment is created. It is very difficult to predict with complete certainity the exact post-project environmental scenario. Hence, monitoring of critical parameters is essential in the project operation phase. An Environmental Monitoring Programme has been designed with the following objectives:

- Assess the changes in environmental conditions, if any, during construction and operation of the project.
- Monitor the effective implementation of mitigatory measures.
- Warning of any significant deterioration in environmental quality so that additional mitigatory measures may be planned in advance.

8.2 AREAS OF CONCERN

From the monitoring point of view, the important parameters are water quality, landuse, ecology, etc. An attempt is made to establish early warning of indicators of stress on the environment. Suggested monitoring details are outlined in the following sections.

8.3 WATER QUALITY

Construction Phase

It is proposed to monitor the effluent before and after treatment from Oxidation ditch. The frequency of monitoring could be once per month. Since, 2 to 3 oxidation ditches are proposed at various labour camps, a total of (3 oxidation ditch * 12 months* 2 samples, i.e. before and after treatment) 72 samples/year need to be analysed. The parameters to be monitored include pH, Bio-chemical Oxygen Demand, Total Suspended Solids and Total Dissolved Solids. The

cost of treatment of one sample is expected to be Rs.1,500. Thus, total cost for analysis of 72 samples is expected to be Rs. 0.11 million/year. The analysis work can be done by a laboratory recognized by the State Pollution Control Board. The construction phase is likely to last for six years. Considering escalation @10% per year, the cost required for monitoring during construction phase shall be Rs. 0.85 million.

Operation phase

The surface water quality of the impounded water and river Goriganga needs to be monitored thrice a year. The proposed parameters to be monitored are as follows:

pH, temperature, electrical conductivity, turbidity, total dissolved solids, calcium, magnesium, total hardness, chlorides, sulphates, nitrates, DO, COD, BOD, Iron, Zinc and Manganese. The sampling sites shall be:

- 1 km upstream of the dam site.
- Reservoir water.
- 1 and 3 km downstream of the confluence of the tail race discharge.

The total cost of analysis will be Rs.0.04 million per year. This analysis shall be done throughout the entire life of the project. The analysis work can be conducted by a reputed external agency recognized by State Pollution Control Board or the same can be done inhouse by NTPC.
During project operation phase, a Sewage Treatment Plant (STP) is proposed to be set up to treat the effluent from the project colony. Once every week, it is envisaged to analyse a sample each before and after treatment from the STP. The parameters to be analysed include pH, Biochemical Oxygen Demand, Chemical Oxygen Demand, Total Suspended Solids and Total Dissolved Solids. The cost of analysis of 104 samples @Rs.1500 per sample works out to Rs.0.16 million/year. Thus, total cost for analysis in project operation works out to Rs.0.20 million/year.
The analysis work can be conducted by a reputed external agency recognized by State Pollution Control Board or the same can be done inhouse by NTPC

8.4 AIR QUALITY AND METEOROLOGY

Construction Phase

The ambient air quality monitoring during construction phase can be carried out by an external agency, approved by State Pollution Control Board at four stations namely Dam site, Patom, Bhikarpani and Power House Site. Every year monitoring is to be done for the following three seasons:

- Winter
- Summer
- Post-monsoon

The frequency of monitoring could be twice a week for four consecutive weeks at each station for each season. The parameters to be monitored are Respirable

Particulate Matter (RPM) and Suspended Particulate Matter (SPM), Sulphur dioxide (SO_2) and Nitrogen Oxides (NOx).

Every year, ambient air quality is to be monitored for (4 stations * 2 days/week * 4 weeks x 3 seasons) 96 days. A total cost of Rs. 0.29 million @ Rs. 3000/day can be earmarked for this purpose. Considering escalation 10% every year, cost required for ambient air quality monitoring during construction phase shall be Rs. 2.24 million.

A meteorological laboratory can be set up at one of the ambient air quality monitoring stations. Automatic recorders for temperature, humidity, wind speed & direction, rainfall needs to be commissioned at the site. An amount of Rs.0.4 million can be earmarked for this purpose.

8.5 NOISE

Construction Phase

Noise emissions from vehicular movement, operation of various construction equipment may be monitored during construction phase at major construction sites. The frequency of monitoring could be once every three months. For monitoring of noise generators an Integrating Sound Level Meter will be required, for which a provision of Rs. 0.05 million can be earmarked.

8.6 SOIL EROSION AND SILTATION

Project Operation Phase

Soil erosion rates, slope stability of embankments of barrage, efficacy of soil

conservation measures, need to be closely monitored twice a year. The study can be done by the staff of the proposed Environmental Management Cell. The study should be undertaken throughout the life of the project so as to design the soil erosion prevention measures and also for the rehabilitation/decommissioning of the project.

Following parameters like soil erosion rates, stability of bank embankment would be measured. In addition to above, soil quality at various locations in the catchment area needs to be monitored once every year. The parameters to be monitored are pH, organic matter and texture. A provision of Rs.0.2 million per year has been made for this purpose.

8.7 ECOLOGY

Project Construction Phase

A detailed ecological survey covering forestry, fisheries, wildlife is recommended during entire construction phase. The survey can be conducted once every year for the entire construction period. The various aspects to be covered include:

- Qualitative & Quantitative assessment of flora and fauna.
- Monitoring of restoration of muck disposal area.

A provision of Rs.0.5 million/year can be earmarked for this purpose. Considering 10% escalation per year, cost required during construction phase of 6 years shall be Rs. 3.86 million.

Project Operation Phase

Monitoring of aquatic ecology will be essential to achieve sustainable yield of fish. Some of the parameters to be monitored are phytoplanktons, zooplanktons, benthic life and fish composition, etc.

The parameters can be monitored twice every year at the water sampling sites given in Section-8.3 of this Chapter. The monitoring can be conducted by a reputed external agency for which an amount of Rs.0.30 million per year can be earmarked.

Status of afforestation programmes, greenbelt development, changes in migration patterns of the aquatic and terrestrial fauna species should be studied. The staff at the proposed unit of the Environmental Management Cell can undertake the work. A provision of Rs.0.2 million per year can be kept for this purpose.

8.8 INCIDENCE OF WATER-RELATED DISEASES

Project Construction Phase

Identification of water-related diseases, adequacy of local vector control and curative measures, status of public health are some of the parameters which should be

closely monitored three times a year with the help of data maintained in the government dispensaries/hospitals.

Implementation : Public Health Department,
& Dispensary constructed as a part of project
Cost per annum : Rs.0.1 million

Considering 10% escalation every year, cost required during construction phase of 6 years shall be Rs. 0.77 million.

Project Operation Phase

Increased prevalence of various vector borne diseases and adequacy of local vector control and curative measures need to be monitored. The monitoring can be done three times in a year.

Implementation : Dispensary at the project site

Cost per annum : Rs.0.10 million

8.9 Landuse Pattern

Project Operation Phase

During project operation phase, it is proposed to monitor land use pattern once every year. An amount of Rs.0.3 million per year can be earmarked for this purpose.

8.10 SUMMARY OF ENVIRONMENTAL MONITORING PROGRAMME

The details of environmental monitoring programme are given in Tables 8.1 and 8.2 respectively.

1.1.1.9 TABLE-8.1
Summary of Environmental Monitoring Programme during Project Construction Phase

S. No.	Item	Parameters	Frequency	Location
1.	Effluent from Oxidation ditches	pH, BOD, COD, TSS, TDS	Once every month	Before and after treatment from Oxidation ditch
2.	Water-related diseases	Identification of water related diseases, adequacy of local vector control and curative measure, etc.	Three times a year	Labour camps and colonies
3.	Noise	Equivalent noise level	Once in	At major

S. No.	Item	Parameters	Frequency	Location
		(L_{eq})	three months	construction sites.
4.	Ambient Air quality	SPM, RPM, SO_2 and NOx	Three times a year	At major construction sites

TABLE-8.2

Summary of Environmental Monitoring Programme during

1.1.1.1.17.1.10.1 Project Operation Phase

S. No.	Items	Parameters	Frequency	Location
1.	1.1.1.1.17.1.11 ater	pH, Temperature, EC, Turbidity, Total Dissolved Solids, Calcium, Magnesium, Total Hardness, Chlorides, Sulphates, Nitrates, DO. COD, BOD, Iron, Zinc, Manganese	Three times a year	• 1 km upstream of barrage site • Water spread area • 1 and 3 km downstream of Tail Race discharge
2.	Effluent from Sewage Treatment Plant (STP)	pH, BOD, COD, TSS, TDS	Once every week	• Before and after treatment from Sewage Treatment Plant (STP)
3.	Soil	pH, EC, texture, organic matter	Once in a year	Catchment area
4.	Erosion & Siltation	Soil erosion rates, stability of bank embankment, etc.	Twice a year	-
5.	Ecology	Status of afforestation programmess of green belt development, aquatic ecology	Twice a year	-
6.	Water-related diseases	Identification of water-related diseases, sites, adequacy of	Three times a year	• Villages adjacent to project sites

S. No.	Items	Parameters	Frequency	Location
		local vector control measures, etc.		
7.	Aquatic ecology	Phytoplanktons, zooplanktons, benthic life, fish composition	Once a year	• 1 km upstream of barrage site • Water spread area • 1 and 3 km downstream of Tail Race discharge
8.	Landuse	Landuse pattern using satellite data	Once in a year	Catchment area
9.	Meteorological aspects	Wind direction & velocity temperature humidity, rain	Three times a year	Project site

CHAPTER-9

DISASTER MANAGEMENT PLAN

9. 1 DISASTER MANAGEMENT PLAN

Preventive actions and emergency preparedness plans recommended as a part of the Disaster Management plan (DMP) are given in the following paragraphs.

Surveillance

It is suggested to establish an effective dam safety surveillance and monitoring programme including rapid analysis and interpretation of instrumentation and observation data alongwith periodic inspection and safety reviews and evaluation. Such programmes will have to be implemented during the following five critical phases in the life cycle of a dam:

1. Design and Investigation Phase
2. Construction Phase
3. First Reservoir Filling
4. Early Operation Period

5. Operation and Maintenance Phase

Emergency Action Plan

An emergency is defined as a condition of serious nature which develops unexpectedly and endangers downstream property and human life and requires immediate attention. Emergency Action Plan should include all potential indicators of likely failure of the dam, since the primary concern is for timely and reliable identification and evaluation of existing or potential emergency.

Preventive Action

Engineers responsible for preventive action should identify sources of equipment needed for repair, materials, labour and expertise for use during an emergency. The amount and type of material required for emergency repairs should be determined for each dam, depending upon its characteristics, design, and construction history and past behaviour.

It is desirable to stockpile suitable construction materials at the dam site. The anticipated need of equipment should be evaluated and if these are not available at the dam site, the exact location and availability of these equipment should be determined and specified. The sources/agencies must have necessary instructions for assistance during emergency.

Communication System

An efficient communication system and a downstream warning system is absolutely essential for the success of an emergency preparedness plan. The difference

between a high flood and a dam-break situation must be made clear to the downstream population.

Evacuation Plans

Emergency Action Plan includes evacuation plans and procedures for implementation based on local needs. These could be:

- Demarcation/prioritization of areas to be evacuated.
- Notification procedures and evacuation instructions.
- Safe routes, transport and traffic control.
- Safe areas/shelters.
- Functions and responsibilities of members of evacuation team.

Notifications

Notifications would include communications of either an alert situation or an alert situation followed by a warning situation. An alert situation would indicate that although failure or flooding is not imminent, a more serious situation could occur unless conditions improve. A warning situation would indicate that flooding is imminent as a result of an impending failure of the dam. It would normally include an order for evacuation of delineated inundation areas.

Cost estimate for providing wireless/VSAT equipments, warning sirens, two manpower and awareness programmes need to be organized for villages falling within the areas those are likely to be inundated in even of a hypothetical dambreak:

1.	Provision of wireless/V-SAT in villages	Rs. 3.0 million
2.	Warning signals/Sirens	Rs. 0.25 million
3.	Awareness programmes	Rs. 1.00 million
	Total	**Rs. 4.25 million**

Manpower is proposed to be arranged by the district authorities with their remuneration to be borne by the project authorities.

CHAPTER-10

COST ESTIMATES

10.1 COST FOR IMPLEMENTING ENVIRONMENTAL MANAGEMENT PLAN

The total amount to be spent for implementation of Environmental Management Plan (EMP) is Rs. 385.08 million. The details are given in Table-10.1. The cost is excluding of the following costs:

- **NPV towards forest land diversion**
- **Cost of trees in forest area to be diverted**
- **Excluding compensation for cost of private land to be acquired**

TABLE-10.1

Cost for implementing Environmental Management Plan

S. No.	Item	Cost (Rs. million)
1.	**Sanitary facilities in Labour camps**	**10.20**
2.	**Solid waste collection and Disposal system**	**6.90**
3.	**Management of Impacts due to construction of roads**	**7.25**
4.	**Restoration of Quarry sites**	**10.88**
5.	**Muck Management Plan**	**15.00**
6.	**Restoration and Landscaping of Construction sites**	**2.00**
7.	**Greenbelt Development**	**1.20**
8.	**Compensatory Afforestation**	**21.12**
9.	**Fuelwood distribution**	**36.68**
10.	**Wildlife Conservation**	**5.85**
11.	**Public Health Delivery System**	**37.57**
12.	**Construction of settling tanks at construction sites**	**1.00**
13.	**Sustenance of riverine fisheries**	**16.05**
14.	**Catchment Area Treatment (CAT) Plan**	**89.00**
15.	**Resettlement and Rehabilitation Plan**	**99.66**
16.	**Disaster Management Plan (DMP)**	**4.25**
17.	**Establishment of an Environmental Laboratory**	**2.00**
18.	**Purchase of instruments (Refer Table-10.2)**	**0.75**
19.	**O&M cost (Refer Table-10.3)**	**10.00**
20.	**Environmental Monitoring during construction phase (Refer Table 10.4)**	**7.72**
	Total	385.08

TABLE-10.2

Cost for purchasing instruments for meteorological, discharge and noise monitoring

S. No.	Item	Cost (Rs. million)
1.	**Meteorological instruments**	**0.50**
2.	**Flow monitoring equipment**	**0.20**
3.	**Noise meter**	**0.05**
	Total	0.75

TABLE-10.3

O&M cost for implementing Environmental Management Plan

S. No.	Item	Cost (Rs. million/yr)	No. of months	Total cost (Rs. million) including escalation
1.	**Sanitary facilities in labour camps**	**0.306**	**64**	**2.04**
2.	**Solid waste collection and disposal system**	**0.184**	**64**	**1.37**
3.	**Management of impacts due to construction of roads**	**0.218**	**64**	**1.45**
4.	**Quarry stabilization**	**0.139**	**64**	**2.19**
5.	**Muck Disposal**	**0.450**	**48**	**2.75**
6.	**Settling tank**	**0.030**	**64**	**0.20**
	Total			10.00

10.2 COST FOR IMPLEMENTING ENVIRONMENTAL MONITORING PROGRAMME

The cost required for implementation of the Environmental Monitoring Programme during project construction phase shall be Rs. 6.10 million/year. The details are given in Table 10.4.

TABLE-10.4

Cost for implementing Environmental Monitoring Programme during project construction phase

S. No.	Item	Cost (Rs. million/year)
1.	**Effluent quality**	**0.85**
2.	**Ambient air quality**	**2.24**
3.	**Ecology**	**3.86**
4.	**Public Health**	**0.77**
	Total	7.72

The cost required for implementation of the Environmental Monitoring Programme during project operation phase is of the order of Rs.1.3 million/year. A 10% annual price increase may be considered for every year. The details are given in Table-10.5.

TABLE-10.5

Cost for implementing Environmental Monitoring Programme during project operation phase

S. No.	Item	Cost (Rs. million/year)
1.	**Water quality**	**0.2**
2.	**Soil erosion**	**0.2**
3.	**Aquatic Ecology**	**0.3**
4.	**Afforestation works**	**0.2**
5.	**Public health**	**0.1**
6.	**Landuse pattern**	**0.3**
	Total	1.3

EXECUTIVE SUMMARY

1. INTRODUCTION

1. 1 GENERAL

Power development is one of the key infrastructural elements for the economic growth of the country. NTPC Ltd. was set up in November, 1975 with the objective of planning, promoting and organizing integrated development of thermal power in the country. Since, then, NTPC has been a key player in the power sector of the country and has emerged as a major power company of international standard and repute. Considering the track record of the company, Government of India, subsequently allowed NTPC to venture into hydropower development and other non-conventional energy sources. The major hydro projects under construction are Kol dam (800 MW) in Himachal Pradesh, Loharinag Pala (600 MW) and Tapovan Vishnugad (520 MW) in Uttarakhand.

1. 2 PROJECT BACKGROUND

NTPC Ltd. is planning to set up Rupsiabagar Khasiyabara Hydro-electric Power Project (3x87 MW) in Pithoragarh district of Uttarakhand State. The Memorandum of Understanding (MOU) has been signed in this regard between NTPC and the State Government of Uttarakhand. As per this MOU, NTPC shall carry out detailed investigations and prepare DPR for obtaining clearances from statutory authorities.

The approval of draft Terms of Reference for EIA study, which is also site clearance for the project was accorded by Ministry of Environment and Forests (MOEF) vide their letter dated 23/03/07.

1.3 LOCATION AND DESCRIPTION OF SITE

The Rupsiabagar Khasiyabara hydroelectric project envisages construction of a concrete gravity dam over river Goriganga for hydropower generation. The dam site is located near village Paton, district Pithoragarh, Uttarakhand. The nearest town from the project site is Munsiyari. The project location map is shown in Figure1.

The study area (Refer Figure-2) can be divided into three parts:

- Submergence area
- Area within 10 km of periphery of water spread area and other appurtenances of the project.
- Catchment area

2. PROJECT DETAILS

The project envisages to harness hydropower potential of river Goriganga, by constructing a 62 m high dam with a submergence area of about 4.50 ha. The project comprises of dam, desilting chamber, water conveyance system, Surge shaft, power house and tailrace channel. The installed capacity of the project will be 261 MW. The design discharge is 69.13 cumec. The project site is located near Paton village of Munsiyari Tehsil in district Pithoragarh, Uttarakhand. The project comprises of the following main components:

- River diversion works
- Dam and Appurtenant works
- Power intakes
- Underground desilting chambers
- Headrace Tunnel
- Surge shaft
- Pressure Shaft and pen stock
- Surface Power house and Switchyard
- Tail Race Channel
- Approach roads

The project layout map is enclosed as Figure-3. The total land required for the project is 264 ha. The details are given in Table-1.

TABLE-1
Land requirement for Rupsiabagar Khasiyabara hydroelectric project
(Unit : ha)

Project Appurtenance	Govt. Land	Private Land	Total
Project area including reservoir	19.2	12.8	32.0
Infrastructure/township colony	109.2	72.8	182.0
Quarry and muck disposal	30.0	20.0	50.0
Total	**158.4**	**105.6**	**264.0**

3. ENVIRONMENTAL BASELINE STATUS

As a part of the EIA study, detailed data collection including field studies and secondary data on various aspects were conducted to ascertain the baseline environmental status. Following sections describe the baseline status of the environment.

3.1 WATER ENVIRONMENT

3.1.1 Water resources

The 1-day probable maximum precipitation (PMP) value of Goriganga sub-basin is adopted as 33.41 cm. A Probable Maximum Flood (PMF) value of 4312.70 cumec has been adopted for proposed project. Using the Dicken's formula the 10,000 year flood value for Pancheswar is 15041.36 cumecs. Using this relation, the 10000 year flood at Rupsiabagar Khasiyabara project site has been estimated as 3685.15 cumec.

3.1.2 Water Quality

Apart from domestic sources, there are no other sources of pollution observed in the project area. As a part of the field studies, water samples from river Goriganga and other tributaries from various locations were collected. The water quality has been monitored for three seasons. The concentration of TDS level ranged from 42 to 51 mg/l, which is much lower than the permissible limit of 500 mg/l specified for domestic use. The EC level as observed in various seasons 53 to 78 μs/cm. The concentration

of various cations and anions, e.g. calcium, magnesium, chlorides, nitrates are also well below the permissible specified for meeting drinking water requirements.

The total hardness in various water samples ranged from 38-48 mg/l. The low calcium and magnesium levels are responsible for soft nature of water. The BOD values are well within the permissible limits, which indicate the absence of organic pollution loading. This is mainly due to the low population density and absence of industries in the area. The low COD values also indicates the absence of chemical pollution loading in the area. The marginal quantity of pollution load which enters river Goriganga, gets diluted.

The concentration of various toxic compounds e.g., cyanides and phenolic compounds were observed to be well within the permissible limits. Likewise, concentration of heavy metals too was observed to be well below the permissible limits. This indicates the absence of pollution sources. The Total Coliform is higher than permissible limits. However, in past, no major water-borne epidemic has been reported in the area.

3.2 METEOROLOGY AND AIR ENVIRONMENT

3.2.1 Meteorology

The climate is hot and moist (tropical) in the sub-mountain zone and in the river valley below 600 m in elevation. At higher elevations, the climate becomes sub-tropical upto altitudes 1,200 m, co-temperate upto 1,800 m and cold temperate between 1,800 and 2,400 m. At still higher altitudes, the climate is almost polar. The annual average precipitation over the basin is 778.3 mm. The rainfall occurs throughout the year. The rainfall is received in two spells, i.e. under the influence of south-west monsoons in the months from July to September and the winter rainfall in the months of January and February. January is the coolest month with average monthly average temperature of the order of 8.3^{o}C. Generally, August is the hottest month of the year with mean monthly maximum temperature of about around 25.3 ^{o}C. Humidity is higher in monsoon month (84 to 90%). In other months of the year it is comparatively low. Winter months have the lowest humidity.

3.2.2 Ambient air quality

Ambient air quality in the project area and its surroundings was assessed in winter, summer and post-monsoon seasons. The parameters studied were Respirable Particulate Matter (RPM), Suspended Particulate Matter (SPM), SO_2 and NOx. The frequency of monitoring was twice a week for four consecutive weeks at four stations.

Based on the findings of the ambient air quality survey, conducted for three seasons, it can be concluded that the ambient air quality is quite good in the area. Values of various parameters, e.g. SPM, RPM, SO_2 and NOx were well within the permissible limits specified for residential, rural and other areas. The absence of pollution sources and low population density in the area are the attributable factors for excellent quality of ambient air in the area.

3.3 Noise Environment

Baseline noise data has been measured using A-weighted sound pressure level meter. Sound Pressure Level (SPL) measurement in the outside environment was made using sound pressure level meter. The monitoring was conducted in winter, summer and post-monsoon seasons. The monitoring was carried out in day time. The day time equivalent noise level at various sampling stations ranged from 34.5 to 37.9 dB(A) in summer season. In post-monsoon season, day time equivalent noise level ranged from 36.0 to 37.8 dB(A) at various sations. Similarly in winter season, day time equivalent noise level at various stations ranged from 35.0 to 37.2 dB(A). The noise levels were observed to be well within permissible limits specified for residential area.

3.4 LAND ENVIRONMENT

3.4.1 Landuse pattern

The land use pattern of the study area has been studied through digital satellite imagery data. Digital IRC-1C/1D and Panchromatic remote sensing satellite data was procured from National Remote Sensing Agency (NRSA), Hyderabad. The land use pattern of the study area is outlined in Table-2.

TABLE-2

Land use pattern of the study area

Land use/cover	Area in ha (% of Study Area)
Open vegetation	5681 (13.13)
Medium Vegetation	19629 (45.35)
Scrubs	768 (1.77)
Barren rocky outcrop	14112 (32.61)
Snow cover	2891 (5.52)
Water Bodies	689 (1.59)
Settlements	10 (0.02)
Total	**48280 (100)**

The major land use category in the study area is Medium vegetation and barren land and which account for 45.35% and 32.61% of the study area respectively. The other dominant landuse categories are open vegetation (13.13%). The area under snow cover and scrubs is 5.52% and 1.77% of the study area respectively.

3.4.2 Geology

The rocks of the lesser Himalayas group mostly consisting of quartzites with phyllites and basic rocks are exposed in the river section and power house slopes of the project area. These rocks types form prominent hill slope on either side of the river and well exposed in the river section and a tributary stream. The proposed head race tunnel alignment passes through a rough and rugged terrain. The river section close to the power house site is occupied by fluvio-glacial deposits comprising boulders of gneisses, quartzite, schist and phyllites of varied types with sand in between.

3.4.3 Seismology

Earthquake activity in Uttarakhand has been prolific in the last two hundred years. The state comes under Seismic Zones IV and V of Seismic Zoning Map of India, which correspond to Zone Factors of 0.36 and 0.24 (effective peak ground acceleration in terms of ‘g’) (IS 1893 part 2002).

3.4.4 Soils

As a part of the field studies, soil samples were collected from various locations in

the catchment area. The soils are in neutral range. The EC levels are low. The EC levels indicate that the salt content in the soils is low. The level of various nutrients and organic matter indicates low to moderate soil productivity.

3.6 BIOLOGICAL ENVIRONMENT

3.6.1 Vegetation

The altitude in the study area ranges from 1200 m to 4000 m. Forests or vegetation in an area varies with altitude and topography. The major forest type observed in the study area including the project area is dense mixed Banj (Oak) forest. At higher elevations within the study area, scrubs are observed. The following forest categories are observed in the study area:

- Oak forests
- Deodar forests
- Himalayan pastures

Ecological Survey

The terrestrial ecological survey has been conducted for three seasons. The survey for summer, monsoon and winter seasons were conducted in the months of April 2006,July 2006 and December 2006 respectively. A total number of 73, 71 and 66 plant species were recorded during floristic survey in the various sampling locations in summer, monsoon and winter season, respectively. The number of plant species belonging to different groups is summarised in Table-3. No rare and endangered species was reported from the project area and its surroundings. The list of various floral species observed in the study area is given in Table-4.

TABLE-3
Summary table of plants belonging to different groups listed during the vegetation survey

Plant Group	No. of species		
	Summer	Monsoon	Winter
Tree	26	26	26
Shrub	20	15	18
Herb	27	30	22

Total	**73**	**71**	**66**

TABLE - 4
List of floral species observed in the study area

Botanical Name	**Local Name**
TREES	
Aesandra butyracea **Roxb**.	Chiura
Aesculus indica **Colebr.**	Pangar
Alnus nepalensis **D. Don**	Utees
Betula alnoides **Buch-Ham**	Saur Bhojapatra
Betula utilis **D. Don**	Bhojpatra
Carpinus viminea **Lindley**	Putli
Cedrella toona **Hiern**	Tun
Celtis australis **Hook.**	Kharik
Dalbergia sissoo **Roxb.**	Sisham
Dandroclamus strictus **Nees**	Bans
Ficus glomerata **Roxb.**	Gular
Ficus hispida **L.**	Totmila
Ficus palmate **Forsk**	Bedu / Anjir
Ilex excelsa **Hook.**	Gauloo
Juglans regia **L.**	Akhrot
Litsea glutinosa **Robinson**	Singrau/Maida lakri
Myrica esculenta **Buch-Ham**	Kaphal
Pinus wallichiana **AB Jeckson**	Kail
Pterocarpus marsupium **Roxb**.	Bija Sal
Quercus leucotrichophora **Camus**	Banj
Rhamnus persica **Boissier**	Chirla
Rhododendron arboreum **Smith**	Burans
Rhus japonica **L.**	Beshmeel
Salix acutifolia **Hook.**	Bhains
Trewia nudiflora **L**.	Gutel
SHRUBS	
Ageratum conizoides **L**.	Gundrya
Artemisia vulgaris **Clarke**	Kunja
Artemisia nilagirica **Clarke**	Kunja
Berberis aristata **DC**	Kingor
Berberis lycium **Royle**	Kingor
Bistorta amplexicaulis **D. Don**	Kutrya
Boehmeria platzphylla **D. Don**.	Khagsa
Cannabis sativa **L.**	Bhang
Cissus rependa **Vahl**	Pani-bel

Botanical Name	Local Name
Colebrookia oppositifolia **Smith**	Binda
Cotoneaster microphyllus **Wall**	Bugarchilla
Callicarp arboria **Roxb**.	Kumahr
Duchesnea indica **Andrews**	Bhiun-Kaphal
Girardinia diversifolia **Link**	Bhainsya Kandali,
Indigofera heterantha **Wall**	Sakina
Indigofera pulchella **Roxbr.**	Saknya
Salix elogans **Wall**	Bhotiana
Smilax aspera **L.**	Kukurdara
Spermadictyon sauveolens **Roxb.**	Padera
Urtica dioica **L.**	Kandali
Zenthoxylum armetus **DC**	Timroo
HERBS	
Acorus calamus **L.**	Bauj, Bach
Agrostis nervosa **Nees**	
Anaphalis adnata **Wall**	Bugla
Anemone vitifolia **Buch-Ham**	Mudeela
Artemisia japonica **Thunb.**	Patee, Pamsi
Bergenia ciliata **Haworth**	Silpara,
Bistorta amplexicaulis **D. Don**	Kutrya
Centella asiatica **L.**	Brahmibuti
Curcuma aromatica **Salisbury**	Ban Haldi
Cymbopogon msrtinii **Watson**	Priya-ghas
Cynodon dactylon **L.**	Dubla,
Echinops cornigerus **DC.**	Kantela
Eulaliopsis bineta **Hubbard**	Babula
Iris kumaonensis **D. Don**	Phyaktuli
Reinwardtia indica **Dumortier**	Phiunli
Rumes nepalensis **Sprengel**	Khatura
Solanum nigrum **L.**	Makoi
Stephania glabra **Roxb.**	Gindadu
Themeda anathera **Hackel**	Golda

The tree density observed at various sampling stations is given in Table-5.

TABLE-5

Tree density at various sampling sites

Sampling Station	Tree density (No./ha)
Submergence area	652
Village Lilam	548
Power house site	528

The major land acquisition is envisaged at dam site, power house area where tree density ranges from 528 to 652 trees/ha. This indicates medium density of tree cover in the area.

3.5.2 Fauna

The major part of the catchment area lies in the central Himalayas which has a relatively less rainfall as compared to that of eastern part of the Himalayas and the climate is temperate to sub-temperate with fairly heavy snowfall above 2500 meters. It has restricted the wildlife habitat significantly.

The important faunal species reported in the project area and its surroundings are documented in Table-6.

TABLE-6

Major faunal species reported in the project area and its surroundings

S. No.	Zoological Name	English Name	Local Name	Schedule as per wild life protection Act
MAMMALS				
11.	*Felis bengalensis*	Leopard cat	Ban Biralu	I
12.	*Felis chaus*	Jungle cat	Ban Biralu	II
13.	*Hystrix indica*	Indian Porcupine	Solu	IV
14.	*Lepus nigricollis*	Indian hare	Khargosh	IV
15.	*Macaca mulatto*	Rhesus Monkey	Banar	II
16.	*Muntiacus muntjak*	Barking deer	Kakar	III
17.	*Nemarhaedus ghural*	Goral	Gural	III
18.	*Panthera pardus*	Leopard	Bagh	I
19.	*Selenarctos thibetanus*	Himalayan Black Bear	Rikh	II

S. No.	Zoological Name	English Name	Local Name	Schedule as per wild life protection Act
20.	*Sus scrofacristatus*	Wild Boar	Jungli suwar	III
BIRDS				
9.	*Acridotheres tristis*	Indian Myana	Myana	IV
10.	*Alectoris Chukar*	Chukor Patridge	Chakor	
11.	*Aquila crysaetos*	Himalayan Golden Eagle	Garud	
12.	*Arborophila torqueola*	Hill Patridge	Titar	IV
13.	*Bubo bubo bengalensis*	Eagle Owl	Ghughu	IV
14.	*Corvus macrorhynchos*	Jungle Crow	Kawwa	V
15.	*Corvus splendens*	House crow	Kawwa	V
16.	*Dendrocopos himalayensis*	Himalayan Woodpecker	Kathphorwa	IV
REPTILES				
4.	*Agama tuberculata*	Common lizard	Chhipkali	
5.	*Argyrogena ventromaculatus*	Gray's rat snake	Saanp	IV
6.	*Varanus bengalensis*	Indian monitor lizard	Goh	I
4.	*Xenochrophis piscator*	Checkered keel-back	Saanp	II
5.	*Ptyas mucosus*	Rat snake	Saanp	II

3.5.3 Aquatic Ecology

The aquatic ecological survey has been conducted for three seasons. The survey for summer, post-monsoon and winter seasons were conducted in the months of April 2006,July 2006 and December 2006 respectively. The river Goriganga is a high altitude tributary of the river Sarda. Periphyton and phytoplankton were represented by 16 genera of the families of Bacillariophyceae (12), Chlorophyceae(2), and Myxophyceae(1). However, maximum 15 genera of periphyton were represented by the families of Bacillariophyceae, Cholorophyceae and Myxophyceae in winter season.

The total species of Zooplanktons were observed during summer, monsoon

and winter season represented by the taxa of cladocerans (01) and rotifers (03). Density of zooplankton ranged from 19.2-58.8 individual/l^{-1}. The diversity indices (Shannon-Weiner) of zooplankton ranged from 1.126 to 1.824 at all the sites.

3.5.4 Fisheries

The list of major species observed during survey are given in Table-7.

TABLE-7

Inventory of fish dwelling in Goriganga in the Rukpsiyabagar-Kharsiabara HEP area, Uttarakhand

Name of the Fish	Local Name
Family Cyprinidae	
Schizothorax richardsonii	Asala
Schizothorax sinuatus	Asala
Schizothorax kumaonensis	Asala
Tor tor	Dansulu
Tor putitora	Dansula
Garra lamta	Gondal
Garra gotyla gotyla	Gondal
Crossocheilus latius	Sunhera
Barilius bendelisis	Fulra
Barilius barna	Fulra
Barilius vagra	Fulra
Labeo dyocheilus	Kharont
Family Cobitidae	
Noemacheilus montanus	Gadiyal
Noemacheilus botia	Gadiyal
Noemacheilus rupicola	Gadiyal
Family Sisoridae	
Glyptothorax pectinopterus	Nau

Name of the Fish	Local Name
Pseudoecheneis sulcatus	Mungria Nau

4. PREDICTION OF IMPACTS

4.3 WATER ENVIRONMENT

4.3.1 Water Resources

The river stretch downstream of the dam site up to the confluence point of tail race discharge will have reduced flow due to diversion of water for hydro-power generation for a distance of about 9.4 km. There are significant number of streams out-falling in the river stretch between the dam and the tailrace discharge outfall site.

The reduction in flow is expected upto a distance of 3.5 km downstream of dam site, where River Kwirigad outfalls into river Goriganga on the left bank. Similarly perennial streams confluence into river Goriganga about 3.9 km and 6.2kmdownstreamofdamsite. The reduction in flow or drying of the river in the intervening stretch is not likely to have any adverse impact on the downstream users. This is mainly because of the fact that settlements/villages within this stretch are not dependent on the water of river Goriganga.

4.3.2 Water quality

c) Construction phase

Effluent from labour colony

The peak migrant population is likely to be of the order of 2,600. The quantum of sewage generated due to this population is expected to be of the order of 0.15 mld. The sewage from construction colonies shall be treated in oxidation ditch before disposal.

Effluent from crushers

The effluent from the crushers would contain high suspended solids. It is proposed to treat the effluents from crushers in settling tanks.

d) Operation phase

Effluent from project colony

During operation phase, only a small number of O&M staff will reside in the colony. The sewage generated would be provided biological treatment before discharge.

4.3.3 Sediments

The proposed project is envisaged as a runoff the river scheme with a barrage/dam. At regular

intervals, the gates of the barrage shall be opened to flush the sediments. Thus, in the proposed project, sedimentation problems are not anticipated.

4.4 CLIMATE AND AIR ENVIRONMENT

Ambient Air Quality

In a water resources project, air pollution occurs mainly during project construction phase. The major source of air pollution during construction phase are:

- Pollution due to fuel combustion in various construction equipment
- Fugitive emission from crusher
- Impact due to vehicular movement.

Pollution due to fuel combustion

The major construction equipment would be operated through electricity. Therefore, fossil fuel combustion would be minimal. Diesel would be used only in contingency. Thus, no significant impact on ambient air quality is expected as a result of operation of various construction equipment.

Emissions from various crushers

During crushing operations, there would be emissions of dust particles. These emissions would be controlled through cyclone. Further, the labour camps would be located on the leeward side at appropriate location.

Impact due to vehicular Movement

The vehicular movement is likely to lead to entrainment of dust. However such ground level emissions do not travel for long distances. Thus, no major adverse impacts are anticipated on this account.

4.2.1 Impact on noise environment

The operation of construction equipment is likely to have insignificant impact on the ambient noise level.

4.3 IMPACTS ON LAND ENVIRONMENT

4.3.1 Quarrying operations

The project would require about 1.3 lakh m^3 of coarse aggregate, 0.5 lakh m^3 of fine aggregate and 115,000 m^3 of sand. A part of the excavated material generated during tunneling operations will be utilized as construction material. Two quarries are proposed to be used for the project. About 80% of the requirement are proposed to be met from Bhadeli

quarry and the balance requirement is proposed to be met from Jimmyghat quarry. Sand is proposed to be acquired from river Goriganga close to power house site. It is proposed to stabilize the quarry sites once the extraction of construction material is over.

4.4 IMPACTS ON ECOLOGY

4.4.1 Terrestrial Ecology

Increased human interferences

A large population (2,600) is likely to congregate in the area during the project construction phase. This population residing in the area may use fuel wood (if no alternate fuel is provided). Therefore, alternate fuel should be provided to such population. Further, community kitchens should be provided using LPG or diesel as fuel.

Acquisition of forest land

The total land requirement for the project is 264 ha. In Uttarakhand, the entire land is considered to be government land under the ownership of Forest Department. As a part of the EIA study, detailed Ecological survey has been conducted for three seasons. Based on the findings of the survey, it can be concluded that the tree density in the project area to be acquired shows that the area has medium density forest. Though the project area is located in an ecologically sensitive area, the forest in and around the project area are quite degraded. No rare or endangered species are observed. The density of trees in the submergence area is about 652/ha. Likewise at the power house site, the tree density is 528/ha. Normally in a good forest, the tree density is of the order of 1000-1200 per ha. The diversity too is high in such forests. In the proposed project area, 12-15 tree species only were observed at various sampling sites. No rare and endangered floral species are observed. Thus, forests in the project area can be categorized as having medium density, hence, no major adverse impacts due to various activities during project construction and operation phases are envisaged.

Disturbance to wildlife

The operation of various construction equipment, and blasting is likely to generate noise. These activities can lead to some disturbance to wildlife population. From the available data, the project area does not have significant wildlife population. Likewise, area does not fall in the migratory routes of animals.

Impacts due to increased accessibility

During the project operation phase, the accessibility to the area will improve due to construction of roads, which in turn may increase human interferences leading to marginal adverse impacts on the terrestrial ecosystem. At present, major wildlife population is not observed or reported from the project area and its surroundings. Thus, no impact is expected on these sites.

4.4.2 Aquatic Ecology

c) Construction phase

Due to construction of the proposed hydroelectric project, huge quantity of debris is expected to be generated at various construction sites. The debris, if a separate area for dumping of the material is not marked, invariably would flow down the river during heavy precipitation, which would adversely affect the aquatic life. Therefore, a well defined muck disposal plan has been formulated to minimize impacts on this account.

Operation phase

The completion of Rupsiabagar –Khasiyabara Hydroelectric Project would bring about significant changes in the riverine ecology, as the river transforms from a fast-flowing water system to a quiescent lacustrine environment.

Amongst the aquatic animals, it is the fish life which would be most affected. The migratory fish species, e.g. snow trout is likely to be adversely affected due to obstruction created by the proposed dam. With the completion of dam, flow in the downstream stretch of the river would be reduced considerably more so during the lean period. Appropriate management measures have been recommended as a part of Environmental Management Plan.

5. SOCIO-ECONOMIC ASPECTS

5.1 STUDY AREA DETAILS

The study area comprises of 42 villages, which would be hereafter referred to as the Study Area Villages (SAVs). All the SAVs lie in the Tehsil Munsyari, district Pithoragarh. The total population residing in the study area is about 10595 in 2372 households. The male and female population within the SAVs account for about 48.84% and 51.15% percentage of total SAVs population. The number of females

per 1000 males and family size in the SAVs are 1047 and 4.5 respectively. The Scheduled Tribe (ST) population constitutes about 28.3% of the total population of the SAVs. The Scheduled Caste (SC) population also amounts for about 23.9% of the total population of SAVs. The literacy rate in the SAVs is 59.3%. The male and female literacy rate is 72.1% and 47% respectively.

5.2 SOCIO-ECONOMIC ASPECTS OF PAFS

The total land to be acquired is 264 ha of which 105.6 ha is the private land. About 1377 families are likely to be affected as a result of acquisition of land for various project appurtenances.

The details are given as below:

- No. of families losing only land 1362
- No. of families losing both homestead and land 15

Total 1377

As a part of the Comprehensive EIA study, a socio-economic survey covering about 211 families was conducted. The filled-in survey schedules were scrutinized for internal discrepancies both in the field as well as in Delhi. Thereafter the schedules were coded and fed into computer for analysis. Based on the results and opinions of the affected population (as captured through the schedules), the socio-economic profile of the PAFs has been reported and the Resettlement and Rehabilitation Plan has been prepared in line with the NTPC R&R Policy.

5.3 IMPACTS ON SOCIO-ECONOMIC ENVIRONMENT

5.3.1 Immigration of labour population

The peak labour force and technical staff required is estimated at about 2,600. Job opportunities will improve in this area. At present most of the population sustains by agriculture and allied activities. The project will open a large number of jobs to the local

population both during project construction and operation phases.

5.3.2 Increased incidence of water-related diseases

The construction of barrage may convert the riverine ecosystem into a lacustrine ecosystem. The vectors of various diseases breed in shallow areas not very far from the margin of the water spread area. The project would increase the shoreline as compared to the pre-project shoreline of river Goriganga. Thus, there would be increase in the potential breeding sites for various disease vectors.

Normally, mosquitoes, which are the vectors for transmission of malaria are observed upto an elevation of 2000 m above sea level. The proposed project is located at an elevation of below 2000 m. Thus, measures need to be undertaken at these sites to prevent proliferation of mosquitoes. The flight of mosquito is generally limited upto 1 to 2 km from the breeding sites. Thus, it is recommended that borrow area are located at least 2 km from major habitations or labour camps/colonies.

5.4 REHABILITATION AND RESETTLEMENT PLAN

5.4.1 Rehabilitation Plan

THE COST REQUIRED FOR IMPLEMENTATION OF REHABILITATION PLAN SHALL BE RS. 136.91 MILLION. THE DETAILS ARE GIVEN IN TABLE-8.

TABLE-8

Details of Rehabilitation grant

S. No.	Category	Rehabilitation Grant Unit rate (Rs)	Disbursement
1.	A	LFL or Rs 70,000/-	There are 233 PAP under this category. Thus a provision of **Rs. 16.31 million** (233 PAPs x Rs. 70000) is being kept for this purpose.
2.	B to F	52500/-	458 PAPs in Cagetory “B” 16 PAPs in Category “C” 2 PAPs in Category “D” 35 PAPs in Category “E”

			633 PAPs in Category "F" Thus, a provision of **Rs. 59.535 million** as rehabilitation grant is being kept for this category.
3.	G	35000/-	-

5.4.2 Resettlement Plan

Compensation for houses

About 15 families will be losing houses. As per the norms being used in the resettlement, a plot of 200 sq.m. has to be provided to each of the displaced family. The total land requirement will be 0.3 ha. About 50% of the land in addition to the land required for construction of houses is to be acquired to provide for the infrastructure facilities. Thus, total land requirement for construction of houses shall be 0.45 ha.

Construction of houses

For construction of house, each family losing house is entitled for an assistance of Rs. 150,000 which amounts to a total of Rs. 2.25 million.

Shifting Grant

Each family will get Rs. 20,000 for shifting of building material, belongings, cattle, etc. from the affected zone to the resettlement zone. The total expenditure amounts to Rs. 0.3 million.

Resettlement Grant

Each family would be given Rs. 30,000 as Rehabilitation grant. The total expenditure on this account works out to Rs. 0.45 million.

Infrastructure development

It is proposed to resettle the oustees at 1 new resettlement site.

The total expenditure on implementation of resettlement plan shall be Rs. 22.10 million (Refer Table-9).

TABLE 9

Provision for implementation of Resettlement Plan

S. No.	Resettlement provisions	Cost (Rs. million)
1.	Requirement of Land for homesteads 0.45 ha	
2.	House building assistance	2.25
3.	Shifting grant	0.30
4.	Resettlement grant	0.45
5.	Secondary school	0.60
6.	Community Centre	0.40
7.	Dispensary	0.10
8.	Access roads	4.50
9.	Other infrastructure facilities	13.50
Total		**22.10**

5.4.3 Budget

A total provision of Rs. 99.658 million would be required to implement the R&R plan for the PAPs of Rupsiya Bagar – Khasiyabara H. E. Project. The details of the budget are highlighted in Table 10.

TABLE -10

Budget for R&R

S. No.	Resettlement provisions	Cost (Rs. million)
1.	Resettlement plan	22.10
2.	Rehabilitation plan	76.958
3.	Post project monitoring	0.60
Total		**99.658**

6. ENVIRONMENTAL MANAGEMENT PLAN

6.1 Control of pollution from labour camps during construction phase

The aggregation of large labour population and technical staff during construction phase is likely to put significant stress on various facets of environment. The various issues covered in environmental management during construction phases are described in this section.

6.1.1 Facilities in labour camps

It is recommended that project authorities can compulsorily ask the contractor to make

semi-permanent structures for their workers. These structures could be tin sheds. These sheds can have internal compartments allotted to each worker family. The sheds will have electricity and ventilation system, water supply and community latrines. The water for meeting domestic requirements may be collected from the rivers or streams flowing upstream of the labour camps. The water quality in general is good and can be used after chlorination.

6.1.2 Sanitation facilities

One community latrine can be provided per 20 persons. The sewage from the community latrines can be treated in oxidation ditch before disposal.

6.1.3 Solid waste management from labour camps

For solid waste collection, suitable number of masonry storage vats, each of 2 m^3 capacity should be constructed at appropriate locations in various labour camps. These vats should be emptied at regular intervals and should be disposed at identified landfill sites. Suitable solid waste collection and disposal arrangement shall be provided. A suitable landfill site should be identified and designed to contain municipal waste from various project township, labour colonies, etc.

6.1.4 Provision of free fuel

NTPC shall make necessary arrangements with their contractors to provide fuel to labour population migrating in the area. Appropriate fuel depot should be established in consultation with State Government.

6.2 ENVIRONMENTAL MANAGEMENT IN ROAD CONSTRUCTION

The approach roads will have to be constructed as a part of the proposed project. Steeply sloping banks are liable to landslides, which can largely be controlled by provision of suitable drainage. Landslides is proposed to be stabilized by several methods i.e. engineering or bio-engineering measures alone or a combination of these. Engineering solutions such as surface drainage, sub-surface drainage, toe protection and rock bolting can be used.

6.3 MANAGEMENT OF MUCK DISPOSAL SITES

In the hilly area, dumping is done after creating terraces; thus usable terraces are developed. The overall idea is to enhance/maintain aesthetic view in the surrounding area of the project in post construction period & avoid contamination of any land or water resource due to muck disposal. Suitable retaining walls shall be constructed to develop terraces so as to support the muck on vertical slope and for optimum space utilization. The muck disposal sites should be reclaimed with vegetation.

6.4 RESTORATION AND LANDSCAPING OF PROJECT SITES

It is proposed to develop small gardens at two locations. Similarly, two viewpoints are also proposed to be constructed.

6.5 GREENBELT DEVELOPMENT

It is proposed to develop greenbelt around the perimeter of various project appurtenances, selected stretches along reservoir periphery, etc. This will be carried out in consultation with the State Forest Department.

6.6 PUBLIC HEALTH DELIVERY SYSTEM

A population of about 2,600 is likely to congregate during the construction phase. The labour population will be concentrated at two or three sites. There is no medical facility in the immediate vicinity of the project area. It is proposed to develop a dispensary as a part of the proposed Rupsiabagar-Khasiyabara hydroelectric project.

Two first-aid posts are proposed to be provided, so that workers are immediately attended to in case of an injury or accident.

This first-aid post will have at least the following facilities :

- First aid box with essential medicines including ORS packets
- First aid appliances-splints and dressing materials
- Stretcher, wheel chair, etc.

The other recommended measures are listed as below:

- The site selected for habitation of workers should not be in the path of natural drainage.
- Adequate drainage system to dispose storm water drainage from the labour colonies should be provided.
- Adequate vaccination and immunization facilities should be provided for workers at various construction sites.
- The labour camps and resettlement sites should be at least 2 to 3 km

away from quarry areas.

6.7 COMPENSATORY AFFORESTATION

The total land involved in the project is about 264 ha including private land. In Uttarakhand, the entire land is considered as forest land. Accordingly a compensatory afforestation scheme is on double of degraded forest land on 528 ha needs to be done. Compensatory afforestation will be done by State Forest Department as per the stipulations outlined as a part of forest clearance.

6.8 CONTROL OF AIR POLLUTION

The air pollution is basically generated due to primary crushing and fugitive dust from the heap of crushed material. The various crushers need to be provided with cyclones to control the dust generated while primary crushing the stone aggregates. It should be mandatory for the contractor involved in crushing activities to install cyclone in the crusher.

6.9 CONTROL OF WATER POLLUTION

CONSTRUCTION PHASE

The construction activities would require crushers to crush large lumps of rocks to the requisite size for producing coarse as well as fine aggregates. The effluent generated from these crushers will have high suspended solids. The effluents shall be treated. In settling tanks of appropriate size before disposal

Operation phase

In the project operation phase, about 50 persons are likely to be involved for which a project colony is proposed to be commissioned. The colony will have suitable Sewage Treatment Plant (STP) to treat the sewage generated from the colony

6.10 FISH MANAGEMENT

a) Release of minimum flow

The dry segment of river between barrage/dam site and tail race at certain places may have shallow water subjecting the fish to prey by birds and other animals. Such a condition will also enable the poachers to catch fish indiscriminately. It is therefore, very essential for the project authorities to maintain the minimum flow of 2.5 cumec for the

survival and propagation of invertebrates and fish. In order to avoid the possible loss of aquatic life, at least minimum flow of water should always be released from the dam.

b) Sustenance of Endemic Fisheries

Snow trout (*Schizothorax richardsonii*) is the endemic species. The dam on river Goriganga to be developed as a part of the project will act as a barrier to the free movement of fish species. It is proposed to implement supplementary stocking programmes for the project area. In addition to reservoir area, it is proposed to stock river Goriganga for a length of 10 km each on the upstream and the downstream side of the dam site. The rate of stocking is proposed as 100 fingerlings of about 30 mm size per km. For reservoir area, the rate of stocking could be 200 fingerlings of about 30 mm size per ha. The stocking can be done annually by the Fisheries Department, State Government of Uttarakhand.

6.11 WILDLIFE CONSERVATION

To minimize indirect impacts due to congregation of labour population, it is recommended to develop appropriate surveillance measures. It is recommended that check posts be installed near major construction sites and labour camps. It is recommended to develop 2 check posts, which should be operational during construction phase. Each check post should have guards. A range officer should supervise the guards of various check posts. It is also recommended that the staff manning these check posts have adequate communication equipment and other facilities. It is proposed that 2 jeeps and wireless sets should be provided at each check post. Apart from inter-linking of check posts, the communication wireless link needs to be extended to Divisional Forest Office and the local police station also.

6.12 NOISE CONTROL MEASURES

Workers operating in high noise should be provided with effective personal protective measures such as ear muffs or ear plugs to be worn during periods of exposure. The other measures to control noise could be as follows:

- Equipment and machineries should be maintained regularly to keep the noise generation at the design level;
- Silencers and mufflers of the individual machineries to be regularly checked;
- Exposure of workers to high noise areas, should be limited as per maximum exposure periods specified by OSHA.

6.13 ESTABLISHMENT OF ENVIRONMEMNTAL LABORATORY

An independent laboratory with facilities for chemical analysis should be set up at the project site. A separate air conditioned dust-proof room will have to be provided for installing analytical instruments.

6.14 ESTABLISHMENT OF AN ENVIRONMENTAL MANAGEMENT CELL

It is recommended that the project proponent should establish an Environmental Management Cell at the project site with requisite manpower. The task of the Cell will be to coordinate with regulatory agencies, to carry out environmental monitoring and to evaluate implementation of environmental mitigatory measures. The Environmental Cell will report to the appropriate authority having adequate powers to implement the required measures.

7. CATCHMENT AREA TREATEMNT (CAT) PLAN

Silt Yield Index (SYI) method has been used to prioritize sub-watershed in a catchment area for treatment. The area under very high and high erosion categories is to be treated at the project proponent cost. In the catchment area of the proposed project, there is no area under very high erosion category. Hence, CAT plan has been suggested for high erosion category, as a part of the present EIA study, the expenses of which have to be borne by project proponents. The total area under high erosion category is 11457 ha. The cost required for Catchment Area Treatment is Rs. 89.0 million.

8. SUMMARY OF ENVIRONMENTAL MONITORING PROGRAMME

An Environmental Monitoring Programme should be undertaken during construction and operation phase of the project. The details of environmental monitoring programme are given in Tables - 11 and 12 respectively.

TABLE-11

Summary of Environmental Monitoring Programme during Project Construction Phase

S. No.	Item	Parameters	Frequency	Location
1.	Effluent from Oxidation ditches	pH, BOD, COD, TSS, TDS	Once every month	Before and after treatment from Oxidation ditch
2.	Water-related diseases	Identification of water related diseases, adequacy of local vector control and curative measure, etc.	Three times a year	Labour camps and colonies
3.	Noise	Equivalent noise level (L_{eq})	Once in three months	At major construction sites.
4.	Ambient Air quality	SPM, RPM, SO_2 and NOx	Three times a year	At major construction sites

TABLE-12

Summary of Environmental Monitoring Programme during Project Operation Phase

S. No.	Items	Parameters	Frequency	Location
1.	Water	pH, Temperature, EC, Turbidity, Total Dissolved Solids, Calcium, Magnesium, Total Hardness, Chlorides, Sulphates, Nitrates, DO. COD, BOD, Iron, Zinc, Manganese	Three times a year	• 1 km upstream of barrage site • Water spread area • 1 and 3 km downstream of Tail Race discharge
2.	Effluent from Sewage Treatment Plant (STP)	pH, BOD, COD, TSS, TDS	Once every week	• Before and after treatment from Sewage Treatment Plant (STP)
3.	Soil	pH, EC, texture, organic matter	Once in a year	Catchment area
4.	Erosion & Siltation	Soil erosion rates, stability of bank embankment, etc.	Twice a year	-

S. No.	Items	Parameters	Frequency	Location
5.	Ecology	Status of afforestation programmess of green belt development	Twice a year	-
6.	Water-related diseases	Identification of water-related diseases, sites, adequacy of local vector control measures, etc.	Three times a year	• Villages adjacent to project sites
7.	Aquatic ecology	Phytoplanktons, zooplanktons, benthic life, fish composition	Once a year	• 1 km upstream of barrage site • Water spread area • 1 and 3 km downstream of Tail Race discharge
8.	Landuse	Landuse pattern using satellite data	Once in a year	Catchment area
9.	Meteorological aspects	Wind direction & velocity temperature humidity, rain	Three times a year	Project site

9. DISASTER MANAGEMENT PLAN

Emergency actions and Preventive action Plans calculated as a part of the Disaster Management Plan (DMP).

Emergency action plan includes all potential indicators of likely failure of the dam because it is the primary concern for timely and reliable identification and evaluation of existing or potential emergency.

Preventive action includes equipments needed for repair, materials, labour and expertise for use during emergency

Such plans will be implemented during the following five critical phases in the life cycle of a dam:

- Design and Investigation Phase
- Construction Phase
- First Reservoir Filling

- Early Operation Period
- Operation and Maintenance Phase

10. COST ESTIMATES

10.1 COST FOR IMPLEMENTING ENVIRONMENTAL MANAGEMENT PLAN

The total amount to be spent for implementation of Environmental Management Plan (EMP) is Rs. 385.08 million. The details are given in Table-13. The cost is excluding of the following costs:

- NPV towards forest land diversion
- Cost of trees in forest area to be diverted
- Excluding compensation for cost of private land to be acquired

TABLE-13

Cost for implementing Environmental Management Plan

S. No.	Item	Cost (Rs. million)
1.	Sanitary facilities in Labour camps	10.20
2.	Solid waste collection and Disposal system	6.90
3.	Management of Impacts due to construction of roads	7.25
4.	Restoration of Quarry sites	10.88
5.	Muck Management Plan	15.00
6.	Restoration and Landscaping of Construction sites	2.00
7.	Greenbelt Development	1.20
8.	Compensatory Afforestation	21.12
9.	Fuelwood distribution	36.68
10.	Wildlife Conservation	5.85
11.	Public Health Delivery System	37.57
12.	Construction of settling tanks at construction sites	1.00
13.	Sustenance of riverine fisheries	16.05
14.	Catchment Area Treatment (CAT) Plan	89.00
15.	Resettlement and Rehabilitation Plan	99.66
16.	Disaster Management Plan (DMP)	4.25
17.	Establishment of an Environmental Laboratory	2.00
18.	Purchase of instruments (Refer Table-14)	0.75

S. No.	Item	Cost (Rs. million)
19.	O&M cost (Refer Table-15)	10.00
20.	Environmental Monitoring during construction phase (Refer Table 16)	7.72
	Total	**385.08**

TABLE-14

Cost for purchasing instruments for meteorological, discharge and noise monitoring

S. No.	Item	Cost (Rs. million)
1.	Meteorological instruments	0.50
2.	Flow monitoring equipment	0.20
3.	Noise meter	0.05
	Total	**0.75**

TABLE-15

O&M cost for implementing Environmental Management Plan

S. No.	Item	Cost (Rs. million/yr)	No. of months	Total cost (Rs. million) including escalation
1.	Sanitary facilities in labour camps	0.306	64	2.04
2.	Solid waste collection and disposal system	0.184	64	1.37
3.	Management of impacts due to construction of roads	0.218	64	1.45
4.	Quarry stabilization	0.139	64	2.19
5.	Muck Disposal	0.450	48	2.75
6.	Settling tank	0.030	64	0.20
	Total			**10.00**

10.2 COST FOR IMPLEMENTING ENVIRONMENTAL MONITORING PROGRAMME

The cost required for implementation of the Environmental Monitoring Programme during project construction phase shall be Rs. 7.72 million/year. The details are given in Table 16.

TABLE-16

Cost for implementing Environmental Monitoring Programme during project construction phase

S. No.	Item	Cost (Rs. million/year)
1.	Effluent quality	0.85
2.	Ambient air quality	2.24
3.	Ecology	3.86
4.	Public Health	0.77
	Total	**7.72**

The cost required for implementation of the Environmental Monitoring Programme during project operation phase is of the order of Rs.1.3 million/year. A 10% annual price increase may be considered for every year. The details are given in Table-17.

TABLE-17

Cost for implementing Environmental Monitoring Programme during project operation phase

S. No.	Item	Cost (Rs. million/year)
1.	Water quality	0.2
2.	Soil erosion	0.2
3.	Aquatic Ecology	0.3
4.	Afforestation works	0.2
5.	Public health	0.1
6.	Landuse pattern	0.3
	Total	**1.3**