CISMHE

UPDATED
FINAL REPORT
MAY, 2013

ENVIRONMENTAL IMPACT ASSESSMENT OF JELAM TAMAK H.E. PROJECT, UTTARAKHAND

Prepared for :
THDC India Limited

CENTRE FOR INTER-DISCIPLINARY STUDIES OF
MOUNTAIN & HILL ENVIRONMENT
UNIVERSITY OF DELHI, DELHI

PREFACE

Jelam Tamak H.E. Project proposed by THDC Ltd. is located on the Dhauliganga river in Joshimath sub-division of Chamoli district, Uttarakhand. The project is run-of-the-river scheme, envisages a 28 m high barrage, a reservoir with an surface area of nearly 38 ha and 4.4 km long head race tunnel. The installed capacity of the project is 108 MW. Total land required for the various project components is 96.27 ha. The project would affect 4 revenue villages by acquiring their private naap land, van panchayat land and grazing land.

EIA report has been prepared in two volumes, the first volume essentially covers project description, baseline data on land, water, biological, air and social environments and assessment of the impacts. The second volume deals with all mitigation measures and covers various Environmental Management Plans, viz. Catchment Area Treatment plan, Biodiversity Management plan, Resettlement & Rehabilitation plan, Rehabilitation Muck Dumping Area, etc. All the mitigation measures to be undertaken by the project developers have been dealt with in detail along with cost estimates for each plan. All the chapters prepared for EIA and EMP reports have been prepared by CISMHE through primary and secondary sources except Environmental Flow Assessment study.

December, 2012 **Principal Investigator**

CISMHE

CENTRE FOR INTERDISCIPLINARY STUDIES
OF MOUNTAIN & HILL ENVIRONMENT
UNIVERSITY OF DELHI

UNDERTAKING

This is to certify that the EIA/EMP report of Jelam Tamak H.E. Project is based on the original work carried out by Centre for Interdisciplinary Studies of Mountain & Hill Environment (CISMHE), University of Delhi. We also certify that the work has not formed the part of other EIA report and/or has not been copied from other published or unpublished reports. The information taken from the secondary source is well referred to in the report.

Principal Investigator

3rd Floor, Academic Research Centre, Patel Marg, University of Delhi, Delhi -110007. INDIA
Phone : 27666341 • Ph. & Fax : 27666163
E-mail : info@cismhe.org • Wedsite : www.cismhe.org

NABET

National Accreditation Board
for Education and Training

NABET/ EIA/ 02/ 12/52
The Director
Centre for Interdisciplinary Studies of Mountain & Hill Environment
3rd Floor, ARC Building, University of Delhi,
Patel Marg, Delhi - 110007
(Kind Attention: **Prof Maharaj Krishan Pandit**)

February 27, 2012

Dear Sir,

QCI – NABET Scheme for Accreditation of EIA Consultant Organization

This is with reference to your application for QCI – NABET Accreditation as EIA Consultant Organization.

We are pleased to inform you that based on Document & Office Assessments, the Accreditation Committee has recommended conditional accreditation of Centre **for Interdisciplinary Studies of Mountain & Hill Environment** as per the scope given in **Annexure I (A & B)**. Also find attached herewith the following:

a. Detailed terms & conditions of accreditation **(Annexure II)**.
b. Results of various aspects of assessment of your organization **(Annexure III)**.
c. The format which is to be followed for mentioning the names of the experts involved in the EIA reports prepared by you **(Annexure IV)**.

Please confirm the correctness of spellings of the names of the experts mentioned in Annexure I B. Please check the QCI website for the Minutes of the Accreditation Committee Meeting held on February 07, 2012 for observations related to your application for compliance. You are also advised to visit QCI website to check clarifications on the Scheme issued from time to time for necessary actions at your end.

The accreditation of your organization will be for a period of three years starting January 10, 2012. The annual renewal of the accreditation will be confirmed after surveillance assessment every year. Surveillance assessments will be conducted to ensure compliance with NABET Scheme including the details mentioned in your Quality Manual and the terms & conditions mentioned in Annexure II.

May we request you for an early payment of the annual fees and your confirmation of acceptance of the terms and conditions attached. This will enable us to issue you the requisite accreditation certificate.

We thank you for your esteemed support in making this scheme successful and for your participation in this national cause.

Thanks and best regards,

Yours sincerely,

(Vipin Sahni)
Director

Annexure I-A

Name of the Consultant: **Centre for Interdisciplinary Studies of Mountain & Hill Environment**

3rd Floor, ARC Building, University of Delhi,
Patel Marg, Delhi - 110007

Sectors Approved – 01 Nos.

Sl. No.	**Sector No.**	**Name of Sector**	**Category A/B**
1	3	River Valley, Hydel, Drainage and Irrigation projects	A

Total = 01 Sector*

Sectors allocated to individual EIA Coordinators are mentioned in Annexure I-B

(Vipin Sahni)
Director

TEAM COMPOSITION AND EXPERTISE

S.No.	Name of Expertise	Field	Areas Approved By NABET
1.	Professor M.K. Pandit	Ecology & Biodiversity (Flora and Impact Assessment)	Coordinator
2.	Dr. J.P. Bhatt	Ecology & Biodiversity (Fauna, Impact Assessment) Water Pollution & Aquatic Ecology	Coordinator EB & WP
3.	Dr. D.C. Nautiyal	Ecology & Biodiversity (Flora)	EB
4.	Dr. Sanjay Pattanayak	Geology	
5.	Dr. Vikrant Jain	Geology & Hydrology & Ground Water	Geology, HG
6.	Dr. Dorje Dawa	Land Use/ Land Cover, Hydrology & Ground Water Risk Hazardous Management	LU & ISW
7.	Mr. R. Mehta	GIS-Remote Sensing (Land Use/ Land Cover)	LU
8.	Mr. Basudev Singh Bisht	Socio-Economic	SE
9.	Ms Sudha Tiwari	Laboratory work & Aquatic Ecology	EB
10.	Mr. Aniket	Laboratory work	EB

* All analysis work associated with CISMHE laboratory under the University of Delhi.

TOR Compliance

A. **BASELINE DATA**	**EIA Report**
1.0. Geological, geophysical and Geo-hydrological Aspects	
1.1. Geography and physiography of the project area.	Page: 3-1 to 3-9
1.2. Regional geology and structure of the catchment	Page: 5-1 to 5-7
1.3. Snow-fed and rain-fed catchment to be demarcated. Rainfall-runoff data to be assess.	Fig. 7.1, Fig. 7.4
1.4. Seismicity, tectonics and history of past earthquakes in the area.	Page: 5-16 to 5-22
1.5. Critical review of the geological features around the project area.	page : 5-8 to 5-14
1.6. Impact of the project on geological environment	Page: 5-21 to 5-22; 15-11
1.7. Hydrology of the basin	Page: 4-2 to 4-3; 3-2 to 3-4
Hydro-meteorology, drainage systems	
Catastrophic events like cloud bursts & flash floods, if any would be documented.	Page: 4-9 to 4-25
Sedimentation rate to be estimated.	Page: 4-8
Water availability for the project and the aquatic fauna. To record the inflows/outflows, historical flows, seepage at/from the upstream projects/ diversion structures of the Dhauliganga river. Measurements of flow from the tributaries in the study stretch and other surface water channels joining Dhauliganga in the study stretch.	Page: 4-4 to 4-8
The flow measurements shall be planned and executed in such a way that average, maximum, mean maximum, mean minimum and absolute lean flows will be modeled or measured.	Page: 4-4 to 4-8
Lean season release of water for downstream will be specified. The study of comprehensive downstream impact shall also include area upto 10 km downstream of the confluence of TRC with river and shall address overall ecological impact.	Page: 14-1 to 14-8
Downstream hazards (available data on floods, including design and maximum probable floods)	Page: 1-4 to 1-8
1.8 **Study of Design Earthquake Parameters**: To identify the current and potential landslide prone areas in and around the Jelam-Tamak HEP, assess the possible induced landslide risks; and design/plan for protection and management measures for preventing landslide, earthquake and erosion.	Page: 5-8 to 5-16
2.0 Biological Resources	
2.1. **Flora of the Project's Influence Area**: Survey the flora, major habitats and sub-habitats, biodiversity indices, species abundance, density, composition, growth rate and phenology.	Page: 8-1 to 8-6; 8-17 to 8-26
Prepare succinct documentation on the flora, fauna and biodiversity resources of the Dhauliganga basin and project influence area.	Page: 8-1 to 8-40; 9-1 to 9-14
Predominant flora, introduced exotic flora and the resultant impact.	Page: 8-1 to 8-40;
Forest and forest types: Total forest cover, type of forests, change in forest cover and threats and degradation of forests.	Page: 8-1 to 8-4
Vegetation profile, number of species in the project area, etc.	Page: 8-4 to 8-6; 8-6 to 8-13
Community Structure through Vegetation mapping	Page: 8-16 to 8-29
Species Diversity Index (Shanon-Weaver Index) of the biodiversity in the project area.	Page: 8-29

Importance Value Index (IVI) of the predominate species in the project area.	Page: 8-20 to 8-28
Documentation of economically important plants, medicinal as well as timber, fuel wood etc.	Page: 8-41 to 8-43
Microflora of Dhauliganga basin.	Page: 8-30 to 8-32
Endemic, endangered and threatened species and their geographical distribution.	Page: 8-39 to 8-40
Impact of impoundment and construction activities on the vegetation.	Page: 15-4
Location of any Biosphere Reserve, National park or sanctuary in the vicinity of the project, if any.	Page: 10-1 to 10-9
2.2. Fauna of the Project's Influence Area: Survey the fauna (consisting of invertebrates, amphibians, avifauna or birds, and mammals); establish biodiversity indices, such as species abundance, density, composition, structure and growth rate.	
Inventorisation of terrestrial wildlife (consisting of invertebrates, amphibians, reptiles, birds and mammals).	Page: 9-1 to 9-14
Present status of wildlife.	Page:9-8 to 9-9
Zoogeographic distribution/ affinities.	Page: 9-1; 9-2 to 9-9
Endemic, threatened and endangered species including their habitat and associations.	Page:9-8 to 9-9
Small vertebrate or invertebrate communities.	Page: 11-10
2.3. Impact on animal distribution, migration routes (if any), habitat fragmentation and destruction due to dam building activity.	Page: 15-4
2.4. Avifauna	
Status	Page: 9-5 to 9-8
Resident/Migratory/Passage migrants	Page: 9-5 to 9-8
Impact of project on threatened /endangered taxa, if any.	Page: 15-5 to 15-6
2.5. Aquatic Ecology	
Collect and examined the water samples from different sampling stations in all three season (pre monsoon, monsoon and post monsoon). Additional water quality samples will be collected from source of drinking water and each of the channel carrying sewage into the river.	Page: 11-1 to 11-24
To study the relevant literatures for existence of other rare, endangered, endemic or threatened aquatic fauna like macro-invertebrates, zooplankton, benthos etc.	Page: 11-1 to 11-24
Conservation status	Page 11-23 to page 11-24
Fish and Fisheries (verified the fish population and fish diversity by the consultation with fishery expert, local fishermen, fish sellers or fish consumers in the stretch of Dhauliganga river) impacts of managed flow scenario on the migratory and resident fish population	Page: 11-22 to 11-24
Fish migrations (particularly for anadromous fish, if any), fish passing hazards	Page: 11-22 to 11-24
Breeding grounds (identify all spawning and rearing habitats in Dhauliganga and its tributaries)	Page: 11-22 to 11-24

Impact of dam building on fish migration and habitat degradation. The study would cover project influence area of 10 km around the project. For assessment related to the managed river flow issues, the sub-study would primarily concentrate on the river stretch between proposed intake structure and the tailrace outlet.	Page: 15-10
Pollution load in Dhauliganga river, the volume and quality of sewage (treated or otherwise) entering in the study stretch during the project's life.	Page: 15-5 to 15-6
2.6. Conservation areas and status of threatened /endangered taxa	
Biotic pressures	
Management plan for conservation areas and threatened /endangered taxa.	Page: 11-1 to 11-8 of EMP
2.7. Impacts of managed flow on the quality of water, shoreline vegetation, aquatic ecology, induced erosion, sedimentation, flushing and pollution load etc.	Page: 14-1 to 14-8
3.0. Remote Sensing & GIS Studies	
False colour composite map of the project area.	Fig. 7.1
Delineation of critically degraded area in the directly draining catchment on the basis of Silt Yield Index as per the methodology of AISLUS.	Fig. 8.6 of EMP
Land use and Land cover mapping.	Figs. 7.4; 7.5; 7.6
Drainage pattern/map.	Fig. 3.1; Fig. 3.2
Soil map.	Fig. 6.1; Fig. 6.2
Geo-physical features, slope and relief maps.	Fig. 3.5; Fig. 3.6; Fig. 3.8; Fig. 3.9
4.0. Socio-economic Aspects	
4.1. Use of water: To identify all direct and indirect use of water (drinking, washing/bathing, agricultural and other purposes) in the study stretch-though consultation with local communities, officials of the Government Departments.	Page: 11-10; Table 11.5
4.2. Information on water borne disease through community consultation and sample household level survey	Page: 15-7
4.3. Land details (agricultural, van panchayat or forest land required for the project)	Page: 13-5; 13-9
4.4. Demographic profile	Page: 13-3 to 13-4; 13-7 to 13-9
4.5. Ethnographic profile	Page: 13-2 to 13-3
4.6. Economic Structure	Page: 13-6; 13-11 to 13-12
4.7. Development profile	Page: 13-4; 13-6
4.8. Agriculture practices	Page: 13-6; 13-11
4.9. Cultural and aesthetic sites	Page: 13-1 to13-2
4.10. Infrastructure facilities: education, health, hygiene, communication, network, etc.	Page: 13-3 to 13-12

4.11. Impact on socio-cultural and ethnographic aspects due to dam building.	Page: 15-7
4.12. Community use of the natural flora and fauna	Page: 8-37 to 8-39
Report would include list of all the project Affected Families with their names, education, land holdings, other properties, occupation.	Page: 13-14 to 13-16
5.0. Downstream impact on water, land and human environment due to drying up of river in the stretch between dam site and power house site.	Page: 15-3; 15-11
6.0. Collection of data pertaining to water (Physico-chemical and biological parameters), air and noise environment and likely impacts during construction and post construction period.	Page: 11-1 to 11-6; 12-2 to 12-6
7.0. Positive as well as negative impacts likely to be accrued due to the project are to be listed.	Table 15.1
8.0. Air and Noise Environment	
8.1 Baseline information on ambient air quality in the project area covering aspects like SPM, RSPM, Sox, Nox.	Page: 12-2 to 12-6
8.2. Noise environment.	Page: 12-5 to 12-6
8.3. Use of TBM need to be explored. For conventional controlled blasting the charge density, amount of delay and schematic plan etc. need to be provided.	Page: 17-1 to 17-11 in EMP
8.4. Traffic density in the project area.	Page: 12-2
9.0. Construction methodology and schedule	Page: 17-1 to 17-11 in EMP
B. IMPACT PREDICTION	
Impact prediction is a way of mapping the environmental consequences of the significant aspects of the project and its alternatives. Environmental impact can never be predicated with absolute certainty and this is all the more reason to consider all possible factors and take all possible precautions for reducing the degree of uncertainty.	
The following impact of the project should be assessed:	
1.0. Air	
1.1. Change in ambient levels and ground level concentrations due to total emissions from point, line and area sources	Page: 15-6 to 15-7
1.2. Effects on soils, materials, vegetation and human health.	Page: 15-2; 15-3
If DG sets are to be used for construction power, then the impact of emissions on the vegetation and air environment.	Page: 15-6 to 15-7
2.0. Noise	
2.1. Changes in ambient levels due to noise generated from equipment and movement of vehicles	Page: 12-2
2.2. Effect on fauna and human health	Page: 15-7
3.0. Water	

3.1. Changes in quality	1Page: 15-5 to 15-6
3.2. Sedimentation of reservoir	Page 15-3
3.3. Impact on fish fauna, their population and migratory behaviour, spawning and breeding biology	Page: 15-6; 15-10
3.4. Loss of riparian vegetation	Page: 15-10
3.5. Impact of sewage disposal	Page: 15-5 to 15-6
4.0. Land	
4.1. Changes in land use and drainage pattern	Page: 15-3 and 15-9
4.2. Changes in land quality including effects of waste disposal	Page: 15-4 to 15-5
4.3. Riverbank and their stability	Page: 15-12
4.4. Land slide and flood scenario	Page 15-3
5.0. Biological	
5.1. Deforestation and shrinkage of animal habitat	Page: 15-9
5.2 Impact on fauna and flora (including aquatic species if any) due to decreased flow of water	Page: 15-4 to 15-5
5.3. Impact on rare and endangered species, endemic species, and migratory path/ route of animals, if any.	Page: 15-4 to 15-5
5.4. Impact of edge degradation and fragmentation on the natural habitats (protected or otherwise) in the vicinity of the project.	Page: 15-4
5.5. Impact on breeding and nesting grounds	Page: 15-5
5.6. Impact of impoundment and construction activities on the vegetation.	Page: 15-4 to 15-5
5.7 Indicate the nature, magnitude and extent of any direct, indirect or cumulative impacts on the terrestrial flora and fauna of the Biosphere Reserve/ other protected areas.	Page: 14-13 to 15-18
6.0. Socio-Economic	
6.1 Impact on the local community including demographic changes (including food, medicinal plants, agricultural pesticides etc.)	Page: 15-3 and 15-10
6.2 Impact on cultural properties like archaeological, paleontological, historical, religious, pilgrim properties and sacred groves.	Page: 15-7 to 15-8
6.3. Impact on economic status	Page: 15-8
6.4. Impact on human health, hygiene and communicable disease risks due to the construction and operation of the project	Page: 15-7
6.5 Impact of the immigrant labour and project personal on the local environment and on the host population, including health risks such as HIV/AIDS.	Page: 15-7
6.6. Impact of increased traffic	Page: 15-6
C. ENVIRONMENT MANAGEMENT PLAN	

On the basis of predicted environment impacts, Environment Management plans will be formulated with precise action plans incorporating year-wise physical and financial targets. The EMP shall include the following Action Plans:	**EMP Report**
1. **Catchment Area Treatment Plan**	
Delineation of micro-watersheds in the river catchment and mapping of critically degraded areas requiring various biological and engineering treatment measures. Identification of areas for treatment based upon Remote Sensing & GIS methodology and Silt Yield Index (SYI) method of AISLUS coupled with ground survey. The prioritization of watershed for treatment based upon SYI. Spatial information in each micro watershed should be earmarked on maps in the scale of 1:50,000. The CAT plan would be prepared with year-wise Physical and Financial details.	Page: 8-1 to 8-25; Figs. 8.1 to 8.8
2. **Creation of Green Belt Plan around the Periphery of the Reservoir**.	Page: 9-1 to 9-9
3. **Biodiversity Conservation and Management Plan** for conservation and preservation of endemic, rare and endangered species of flora and fauna (in consultation with the State Wildlife Department). The applicable policy and legal provisions related to protection and conservation of flora, fauna and biodiversity in India and in Uttarakhand.	Page: 11-1 to 11-8
4. **Reservoir fisheries development** for conservation/ management of fishes.	Page: 12-1 to 12-4
5. **Resettlement & Rehabilitation (R&R) Plan** along with social/ community development plan. R&R plan would be framed in consultation with the Project Affected Persons (PAPs), Project authorities and the State Government.	Page: 13-1 to 13-27
6. **Muck Disposal Plan** (Suitable sites for dumping of excavated materials would be identified in consultation with the State Pollution Control Board and Forest Department).	Page: 2-1 to 2-7; Figs. 2.1 to 2.4
7. Restoration and Landscaping of Working Areas: reclamation of borrow pits (quarry sites) and construction areas.	Page: 6-1 to 6-7
8. **Public Health Delivery System** establish the sewage treatment facility in the project area and minimize the spreading of water born disease in the area.	Page: 5-1 to 5-5
9. **Energy Conservation Measures**	Page: 4-1 to 4-4
10. **Solid Waste Management Plan** for domestic waste from colonies and labour camps etc.	Page: 3-1 to 3-6
11. **Water and Air Quality & Noise Environment Management** during construction and post-construction periods.	Page: 7-1 to 7-4
12. Environmental Monitoring Programme (with Physical & Financial details covering all the aspects from EMP).	Page: 15-1 to 15-8
13. **A summary of cost estimate for all the plans**	
Cost for implementing all the Environmental Management Plans including the cost for implementing Environmental Monitoring Programme.	Page: 19-1
ADDITIONAL TOR, MARCH 2007	
Three seasons (pre-monsoon, monsoon and post monsoon) data for environment baseline parameter to be provided.	Page: 2-2 of EIA

Snow-fed and rain-fed catchment to be demarcated. Rainfall-runoff data to be given	Fig. 7.1,Fig. 7.4of EIA
Sedimentation rate to be estimated.	Page: 4-8 of EIA
Lean season downstream release of water to be specified. The study of comprehensive downstream Impact shall also include area up to 10 kms downstream of the confluence of TRC with river and shall address overall ecological impact.	Page: 14-1 to 14-8;
Use of TBM need to be explored for conventional controlled blasting the charge density, amount of delay and schematic plan etc need to be provided.	Page: 17-1 to17-11 of EMP
List of microflora (Cryptogram) to be provided.	Page 8-32 to 8-32 of EIA
False colour composite map to be provided.	Fig. 7.1 of EIA
The proposed TOR does not specify any action vis-à-vis the Project area being highly sensitive to earthquake and landslide. A study of site specific earthquake design parameters is necessary for these Projects. The water availability of the Project in the PFR is based on regional model and does not take into account snowfed and rainfed catchment. Moreover no rainfall-run off data was used	Annexure-V in the supplementary information regarding site specific seismic design parameters having been finalised by IIT, Roorkee and approved by an CSDP, CWC. The site specific hydrology is based on DPR and given in Chapter 4 of EIA report.
ADDITIONAL TOR, MARCH 2011	
Revised form-I to be submitted along with revised land requirement.	Submitted
Riparian flow to be 20% of average discharge of 04 leanest month, higher during other season and 30% of the 90% dependable flow in the 10 daily periods during monsoon.	Reconsiderd
Table consisting of 10 daily discharge rainfall values for the entire year should be given. Actual rain fall data may be provided.	Secondary data is not available.
A distance of at least 1 km free river reach between the TWL discharge point of the U/S project to be maintained with normal uninterrupted river flow.	Page: 1-15 to 1-16 of EIA
The lateral distance of the base of the muck retaining structures to be at least 30 m away from the river bed at HFL with proper approach road.	Page: 2-1 to 2-7; of EMP Figs. 2.1 to 2.4 of EMP
GLOF Studies to be conducted.	Page: 4-9 to 4-25 of EIA
Study on impact on aquatic ecology due to higher submergence may be carried out.	Page: 15-3 to 15-4 of EIA
Possibility of introducing fish into the riverine stretch/ reservoir area shall be explored. Accordingly , a fish ladder may be provided.	Page: 12-1 to 12-4 of EMP
A chapter providing detailed schemes for improving the health, education and livelihood of the local people should be provided.	Page: 5-1 to 5-5; 13-8 to 13-22 of EMP
Drinking water may be provided.	Page: 13-26 of EMP

Pre work Videography of springs and overland structures along the HRT route shall me carried out and documented and any damage due to project activity and the affected people shall be compensated.	Page: 16-1 to 16-3 of EMP
REVISED ADDITIONAL TOR, APRIL 2012	
The minimum continuous release from the barrage as environmental flow during lean season will be 2.97 cumec. During other seasons the release has to be higher and during monsoon season, it will be 5 cumec. However, a site specific study should be conducted for environmental flow and whichever is higher shall be adopted Diurnal variation should be kept the minimum in releasing water from the dam.	Page: 14-1 to 14-8 of EIA

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CHAPTER 12 AIR ENVIRONMENT

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Chapter 1

INTRODUCTION & PROJECT DESCRIPTION

1

INTRODUCTION & PROJECT DESCRIPTION

1.1 GENERAL

The proposed Jelam Tamak H.E. Project is located on Dhauliganga river in Joshimath sub-division of Chamoli district in Uttarakhand. Dhauliganga is a largest head water tributary of Alakananda, originates from Kamet glacier. Kamet glacier lying above 6060 m is the source of this river. In the downstream, Dhauliganga river flows towards southwest and receives water from Geldhong (Gal) glacier on its right bank. In the downstream it maintains its southwestward course till it reaches Khal Kurans. In this stretch it receives sufficient water from a right bank tributary near Shepak Kharak. At Gamsali, Amrit Ganga flowing Deoban glacier drains into the Dhauliganga river on its right bank. At Kuikuti the river receives water from Girthi ganga on its left bank. Dhauliganga confluences with Alaknanda river at Vishnuprayag on left bank (altitude 1440 m).

Proposed barrage is located between 30^0 37' 35.4"N latitude and 79^o49'39.5"E longitude while power house is located between 30º 36' 45" N latitude and 79º 47' 15" E longitude (**Fig. 1.1**). The nearest rail head of the project site is Rishikesh (about 300 km away) and the nearest Airport is at Dehradun. The project site is approachable from Rishikesh by National Highway-58 up to Joshimath (about 257 km) and by Joshimath-Niti passes Border Road (57 km).

1.2 PROJECT RATIONALE

1.2.1 Hydropower Potential in India

As per the Central Electricity Authority of India 2009, total hydro-power potential in India is nearly 14,8701 MW of which the capacity of 37,328.4 MW (25.10%) is commissioned, the capacity under development is 13824 MW (9.29%) and the capacity yet to be developed is 97548.6 MW (65.6%). India is currently facing an energy deficit. According to estimates by the Central Electricity Authority, the demand for peaking power in the Northern Region alone is projected to rise from 35,145 MW during 2007-2008 to 48137 MW in 2011-12. To meet the all India peak demand and energy requirement at the end of 12th Plan, a capacity addition of more than 1,00,000 MW has been assessed during 12th Plan (2012-2017), which includes 30,000 MW of hydro power.

1.2.2 Necessity of Hydropower Development in Uttarakhand

Uttarakhand and northern region is facing a power deficit of 2.8% and 9.1%, respectively. With the limited non renewable source of energy it is realized to increase the share of hydro-electric energy from 25% to 40% as compared with thermal energy. Since Uttarakhand has huge water resources so that it can play an important role in contributing the hydro-power energy in power sector. There is an urgent need to develop its 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.

1.2.3 Hydro Power Potential in Uttarakhand

The hydro power potential of the State is assessed by the CEA on 31 January 2009. Total identified capacity is 18,175 MW, in which developed capacity is 3056.1 MW (16.81%), capacity under development is 1850 MW (10.18%) and capacity yet to be developed is 13269 MW (73.01%). The details of major hydro power projects commissioned in the State of Uttarakhand are listed in Table 1.1.

Table 1.1 Major hydro power projects commissioned and under construction in Uttarakhand

S. No.	Project	Capacity (MW)
1.	Maneri Bhali Stage II	340
2.	Lakhawar Vyasi Stage-I	300
3.	Lakhawar Vyasi Stage-II	120
4.	Alaknanda H.E. project	300
5.	Rishiganga I H.E. project	70
6.	Rishiganga II H.E. project	35
7.	Lata Tapovan H.E. project	171
8.	Singoli Bhatwari H.E. project,	99
9.	Srinagar H.E.Project	330
10.	Vishnuprayg Scheme	400
11.	Tehri Dam & Hydropower Project- Stage-I	1,000
12.	Tehri Dam & Hydropower Project -Stage-II (PSP)	1,000

13.	Koteshwar Dam & Hydropower Project	400
14.	Dhauliganga H.E. Project, Stage -I	280
15.	Kotli Bahel H.E. project 1A	850
	Total	**5,774**

Source: PFR of respective project

1.2.4 Power Potential in Alaknanda Basin

The Alaknanda basin has a vast potential for water resources development, substantial of which is yet to be harnessed. Accordingly, a number of hydro-power schemes have been envisaged on river Alaknanda and its tributaries, many of which are in different stages of construction/ investigations. The list of major projects in Alaknanda basin is given in Table 1.2.

Table 1.2 Major Hydro Schemes under construction or proposed in Alaknanda basin

S.No.	Name of Scheme	River	Capacity (MW)
1	Alaknanda H.E. project	Alaknanda	240
2	Jelam Tamak	Dhauliganga	128
3	Malari Jelam	Dhauliganga	55
4	Rishi Ganga-I	Rishiganga	70
5	Rishi Ganga-II	Rishiganga	35
6	Tamak Lata H.E. project	Dhauliganag	280
7	Lata Tapovan H.E. Project	Dhauliganga-Alaknanda	310
8	Tapovan Vishnugad H.E. Project	Dhauliganga – Alaknanda	520
8	Vishnugad Pipalkoti H.E.project	Alaknada	444
9	Gohana Tal	Birahiganga	60
10	Devarsi Dam	Pinder	300
11	Rambara H.E. project	Mandakini	-
12	Phata Byung H.E. project	Mandakini	-
13	Singoli Bhatwari H.E. project	Mandakini	99
14	Srinagar project	Alaknanda	330

Sou*rce*: PFR of respective projects

1.3 JELAM TAMAK H.E. PROJECT: PROJECT DESCRIPTION

Jelem Tamak H.E. Project is proposed to tap hydropower potential of Dhauliganga between Jelam and Tamak villages (**Fig. 1.2a,b**). The water of Dhauliganga river is proposed to be diverted by a water conductor system located on its right bank for power generation. Three units each of 36 MW (108 MW) located in underground powerhouse on the right bank of Dhauliganga have been proposed based on the feasibility study. Project involves a 28 m high and 83 m long barrage at altitude 2623.50 m, a horse shoe concrete lined head race tunnel of 4.402 km length, an underground power house and 308 m long trail race tunnel. The scheme envisages the utilization of design discharge of 57.58 m^3/sec and the drop of about 207.54 m for power generation. The annual energy generation in a 90% dependable year is 505.12 GWh. Detailed salient features of Jelam Tamak H.E. Project are given in Table 1.3.

Table 1.3 Salient features of the proposed project Jelam Tamak

1. Project Location	
State	Uttarakhand
District	Chamoli
River	Dhauliganga
Diversion Site	Near Jelam Village
2. Hydrology	
Catchment area	1666 km^2
Area under snow	879.00 km^2
Rain fed area	787.00 km^2
Elevation of Snow Line	4900 m a.s.l.
Standard Project Flood	1906 m^3/s
3. Reservoir	
Full Reservoir Level (F.R.L.)	2648.5 m
Minimum Draw-down Level (M.D.D.L.)	2638.8 m
Length of Reservoir at FRL	3.3 km
Area of Reservoir at FRL	37.92 Ha
Gross storage	5.50 million m^3
Live storage	3.218 million m^3
4. Barrage	
Coordinates	Lat. 30º 37’ 35.4” N; Long. 79 º 49’ 39.5” E

River Bed Level	EL 2623.50 m
Barrage Top Level; Barrage Height	EL 2651.50 m; 28m
No. & Size (W x H) of bays	5 barrage bays and 1 under-sluice bay, 8.0 m x 6.0 m each
Sill Level – Barrage bays	EL 2624.50 m
Sill level – Under-sluice bay	EL 2623.50 m
5. **Radial Gates and Stoplogs**	
Gate Type	Radial
No & size (W x H)	6 Nos., 8.0 m x 6.0 m
Hoist Type	Twin Hydraulic Cylinders
Stoplogs Type (common for barrage & under sluice gates	Vertical Lift Slide type
No & size	1 Set, 8.0 m x 8.30 m
Hoist Type	Gantry Crane using a lifting beam
6. **Intake**	
Configuration	Twin intake on right bank, each feeding a desanding chamber
Invert level	EL 2630.40 m
Crest level (top of skimmer wall)	El 2632.30 m
Gates	One service and one bulkhead gate in each intake
Size (W x H)	3.8m x 3.8m, for both gates
Hoist Type	Electrically operated rope drum hoist
7. **Trash racks**	
Type and Number	Fabricated steel panels; 8 Nos.
Size of opening (W x H)	3.0 m x 6.8 m
Size of trash rack panels (W x H)	3.0 m x 1.828 m
Sill level	2632.30 m
Inclination of trash rack	10º (with vertical)
8. **Intake Ducts**	
Nos.	2
Size of each duct (W x H)	3.8 m x 3.8 m, rectangular

	Length of each duct	24.9 m
9.	**Feeder Tunnels**	
	Nos.	2
	Size of each tunnel	3.8 m, D-shape
	Length	146.0 m & 125.0 m
10.	**De-sanding Chambers**	
	No. & Size (L x W x H)	2 Nos., 200.0 m x 12.0 m x 13.6 m
	Size of particles to be removed	>0.2 mm
	Discharge for each chamber	38 m^3/s
	Flushing discharge for each chambers	5.80 m^3/s
11.	**Headrace Tunnel**	
	Design Discharge	57.58 m^3/s
	Finished Size and shape	5.2 m; Horseshoe
	Length	4404.58 m
	Thickness of lining	300 mm
12.	**Surge Shaft**	
	Type	Restricted-orifice; Underground
	Diameter – Shaft/Orifice	12.0 m/2.3m
	HRT invert at surge shaft	2603.80 m
	Surge shaft bottom (Top of orifice slab)	2611.0 m
	Surge Shaft Top	2671.0 m
	Total Height	60.0 m
	Upsurge/Down surge levels	2668.4 m / 2614 m
13.	**Pressure Shaft**	
	Configuration	One no. main pressure shaft with trifurcation at machine centerline level
	Grade of Steel	ASTM A537, Class II
	Main Pressure Shaft – Length Diameter	245.1 m 4.0 m
	Intermediate Branch – Length Diameter	11.0 m 3.25 m
	Unit Penstocks – Lengths Diameter	41 m, 28.30 m and 33.0 m 2.3 m

14.	**Penstock Valve**	
	Number and Type	One no.; Lattice type Butterfly Valve
	Elevation of Valve Centre Line	2605.80 m
	Diameter	4.00 m
15.	**Powerhouse Complex**	
	Installed Capacity	108 MW (3x36MW)
	Location	Underground, about 1 km upstream of Tamak village
	Coordinates	Lat: 30º 36’ 45” N; Long: 79 º 47’ 15” E
	Powerhouse Cavern (L x W x H)	101m x 19.5m x 39.7m
	Transformer Hall Cavern (L x W x H)	79 m x 13.5m x 22m
	Collection Gallery – Length; Width Invert/Crown El.	58.45 m; 12 m 2422.0 m / 2444.50 m
16.	**Main Inlet Valve**	
	Type	Spherical
	Number and Diameter	3 Nos.; 1.65m
	Elevation of Valve Centre Line	2420.50 m
17.	**Turbine**	
	Number and Turbine Type	3 Nos.; Vertical Axis Francis
	Turbine Centre Line El.	2420.50 m
	Rated Discharge per Unit	19.19 m^3/s
	Turbine Speed	428.57 rpm
	Rated net head	207.54 m
	Maximum tail water level	2432.77 m (HFL)
	Minimum tail water level	2426.57 m
	Normal Tail Water level	2427.73 m
18.	**Generator**	
	Number and Type	3 Nos.; Suspended Type
	Generator Output and Voltage	40.00 MVA; 11 kV ± 10%
	Generator Frequency	50 ± 5% Hz
	Power factor	0.9

19. EOT Cranes	
P.H. crane: Nos. and capacity	1 No.- 100 T / 20 T / 10T
GIS crane: Nos. and capacity	1 No. – 10 T
Penstock valve crane: Nos. and capacity	1 No. – 60 T / 16 T
20. Tailrace Tunnel	
Length	308.0 m
Size (W x H)	7m X 9m
Tailrace Outlet Gate - Type Size (W x H) Hoist	Vertical lift fixed wheel type 7m X 6m Rope Drum
Outfall weir sill elevation	2426.8 m
21. Switchyard	
Type and Location	Surface; On the right bank of the river, in front of construction adit portal
Area (L x W)	85.0 m x 30.0 m
22. Estimated Cost(In Rs)	
Civil works	696.87 Cr
E & M works	177.94 Cr
Total basic cost	874.81 Cr
Interest during construction & Financing Charges	243.31 Cr
Total (Generation works) excluding Transmission	1290.25 Cr
Cost per MW installed	11.95 Cr
Construction Period	52 months, excluding 6 months for pre-construction activities
23. Power Benefits	
90% dependable energy	505.12 MU
50% dependable energy	519.13 MU

24. Financial Aspects	
1st year tariff	Rs. 6.05
Levellised Tariff (with 12% free power to the State)	Rs. 5.22

1.4 PROJECT BACKGROUND

Jelam Tamak H.E. Project was identified during Government of India's 50,000 MW hydro-power initiative. The developmental processes of the project are described below:

- November 2005 – Implementation agreement signed with Govt. of Uttarakhand.
- December 2005 - MoEF accorded site clearance (Stage I) for survey & investigation works & preparation of PFR.
- June 2006 – Ministry of Power accorded approval for expenditure for Stage-I survey & investigation works.
- March 2007 - MoFE accorded environmental clearance for pre-construction activities and approved TOR/scoping for preparation of EIA report (EIA notification, September 2006) for installed capacity of 60 mw.
- January 2008 – Feasibility Report submitted to CEA for approval.
- April 2008 – Commercial viability accorded by CEA for an installed capacity of 126mw.
- June 2009 – Ministry of Power accorded investment approval for Stage II activities.
- July 2009 – Three season EIA studies taken up.
- December 2010 – DPR (128 MW) prepared and submitted to CEA for TEC.
- As per DPR the installed capacity of the project is 128 MW due to revised & approved hydrology by CWC.
- February 2011- Draft EIA report completed for public hearing.
- February 2011- THDC requested MoEF for capacity revision from 60 MW to 128 MW.
- March 2011 - THDC's proposal for capacity revision from 60 MW to 128 MW considered by EAC in its 47th and 48th meeting. MoEF conveyed approval of capacity revision from 60 MW to 128 MW with 12 nos. additional TORs. Out of 12 TORs THDC requested to review 02 TORs

e.g. minimum environmental flow during monsoon season and 01 km free flow between the u/s and d/s projects.

- December 2011/ April 2012 - EAC (MoEF) in 54th / 57th meeting considered the proposal of THDC of shifting the TRT outlet to 200m upstream, the best possible shift, due to the adverse geology of the area, slide prone zone and the strategic defence road to the Indo-China border. Also a distance of 1 km free riverine stretch between TWL of Malari-Jelam and FRL of Jelam-Tamak HEP and 2.5 km between TWL of Tamak-Lata and FRL of Lata-Tapovan HEP shall be maintained as per stipulation of the MOEF.
- July 2012 – MOEF approved final TORs with the above riverine stretches between the upstream and downstream projects and environmental flow of 2.97 cumecs during lean season and 5 cumecs during monsoon season. Due to new conditions, the Jelam Tamak H.E. Project envisages an installed capacity of 108 MW.
- August 2012 – CEA approved the revised capacity of 108 MW of DPR regarding power potential studies.
- September 2012 – Public Hearing conducted successfully at project site by SPCB, Dehradun.
- September 2012 – High Level Committee (HLC) of GoUK approved the land case for diversion of forest land of 88.29 ha and its submission to MOEF, New Delhi.
- November 2012 – THDC submitted the land case for stage-I forest clearance.

1.5 REQUIREMENT OF LAND FOR THE PROJECT

LAND REQUIREMENT

Total requirement for the land for various activities is 96.27 ha. Of 96.27 land, Forest land accounts for 88.29 ha and Naap land is 7.98 ha. The land belongs to Jelam, Tamak and Jumma villages. Van Panchayat land to be acquired is 9.8 ha and belongs to Dronagiri village. The maximum land of 38.33 ha including river bed area is required for reservoir (Table 1.4).

Table 1.4 Break up of the land required for various project components of Jelam Tamak H.E. Project

Components	Forest Land (ha)	RF land (ha)	Van Panch. Land (ha)	Naap Land (ha)	Total (ha)
Reservoir area up to EL. 2650.00	29.29		9	0.04	38.33

Balance land for barrage	2.2		0.8	-	3
Land required above intake, desanders, HRT part etc,	2.92			-	2.92
Owners 'colony	4.83			-	4.83
Rock Quarry	0.31			-	0.31
RBM	4.76	5.02			9.78
Disposal area at barrage site	7.22				7.22
Disposal area near HRT	0.85				0.85
Disposal area near Jumma		1.17		0.34	1.51
Disposal area near Power house				0.36	0.36
Roads	9.38	0.82		-	10.2
Central workshop, fuel pump, auto repair shop	1.44			-	1.44
Area above power house complex & balance HRT		4.76		-	4.76
Explosive magazine area	0.03			-	0.03
Plant, store, etc. in barrage area	0.81			-	0.81
Plants, weir house, penstock, fabrication yard, etc in powerhouse area		1.27			1.27
Aggregate processing plant, stockpile area & river bed material.	1.41			-	1.41
Contractor's colony near Jumma nallah				7.24	7.24
	65.45	13.04	9.8	7.98	96.27

1.6 ALTERNATIVE LAYOUTS

Initially, the layout proposed for the Jelam Tamak Hydroelectric Project during the envisaged construction of diversion barrage/weir across the Dhauliganga River near the village Jelam (30°37'00"N : 79°50'00"E; SOI toposheet No. 53 N/4), a water conductor system comprising 6.2 km long HRT aligned on the right bank of Dhauliganga, a 9.0 m diameter and 120 m high open to sky surge shaft, 3.5 m diameter & 330 m long pressure shafts and powerhouse with installed capacity of 128 MW located on right bank of Dhauliganga near Tamak village (30°36'00"N : 79°47'00"E; SOI toposheet No. 53 N/4). During feasibility stage, another alternative with water conductor system and powerhouse located on the left bank of the river Dhauliganga was also studied. As per this alternative, the diversion barrage is located near Jelam as in case of Alternative-1. The design discharge was proposed to be conveyed to the powerhouse site through a 7.36 km long headrace tunnel located on the left bank of Dhauliganga. It is observed that the HRT alignment crosses a deep nala that joins the main river from left flank. It was apprehended that the proposed HRT could daylight in this nala. Since this nala carries large amount of avalanche debris, it was difficult to cross the nala on the surface. Crossing this nala in the subsurface would have involved shifting the HRT further towards hill side resulting in increase in its length and also that of intermediate adit proposed for HRT. Since the existing road in the area is located on the right bank of the river, the location of components of the project on left bank would have required development of additional accesses to different appurtenants. In addition to above, no suitable site for locating switch yard/ pothead yard site could be identified on the left bank of the river in the area proposed for the powerhouse. Keeping constraints discussed above in view, the left bank alternative was not favoured and therefore it was decided not to pursue it further and right bank alternative was finally adopted for further studies.

1.6.1 Alternative Diversion Sites

The site selected for diversion structure on the river Dhauliganga during the pre-feasibility stage is located slightly upstream of Jelam village. The proposed diversion barrage/weir is located in the area exposing gneisses of Badrinath Formation. The gneisses are migmatitic, banded and have intercalation of quartzite, schists. The foliation strikes in general in NW-SE direction with moderate to steep dips towards NE. Local variation in dips is observed as a result of warping and/or folding. However, during Feasibility stage four alternative sites, namely B1, B2, B3 and B4 were studied (**Fig. 1.3**). Of these the alternative site B1 is in the vicinity of that identified during pre-feasibility stage and other three downstream of it. The proposed alternative diversion site B1 was located across the river Dhauliganga about 300m upstream of Jelam village. The river at this site flows through a moderately wide valley with steep abutments that expose gneisses belonging to Badrinath Formation of central Crystalline Group.

The river bed is covered by fluvial deposits comprising medium grained sand with boulders, cobbles and pebbles. It is observed that proportion of sand in these deposits is high as compared to clasts. The bedrock comprising granite gneiss is exposed on the abutments right from riverbed level. The bedrock exposed on the abutments is foliated and traversed by two sets of joints in addition to those parallel to foliation. The foliation strikes in general in NW-SE direction and dips towards NE by 30° – 65°. Since the bedrock is exposed extensively on both the abutments, the intake can be located on the right bank in bedrock. The subsurface explorations carried out at the site in the riverbed indicated that the depth to bedrock varies from 39 to 81m. Therefore the site is suitable to construct a diversion barrage founded on permeable foundation. The alternative site B2 proposed during feasibility stage studies is located about 200m downstream of the alternative site B1. The river at this alternative site flows through a moderately wide valley with steep abutment slopes. The riverbed is covered by medium to fine grained sand with boulders, cobbles and pebbles of gneiss and quartzite. It is observed that proportion of fines in the riverbed deposits is high as compared to coarser fraction. Both the abutments at the site are steep and rise to about 100m above riverbed.

The bedrock comprising granitic gneiss is exposed on the left abutment right from riverbed level whereas the right abutment is covered by slope wash and fluvio-glacial deposit which appear to be quite thick. It was also observed that a nala debouches into the river from right bank just near the proposed barrage axis at this site. This nala is reported to bring large amount of debris during high flows. Keeping this and the fact that existence of thick overburden on the right abutment would necessitate huge excavation and slope stabilization efforts to locate power intake structure, this alternative site was not preferred for locating the diversion structure. Keeping in view constraints mentioned above and gentle gradient of the river bed, and problem of crossing Dronagiri Gad in case of left bank alternative, another site B3 for locating the diversion structure was identified. This proposed alternative site is located about 100m downstream of confluence of Dronagiri, a left bank tributary of Dhauliganga and about 2.8 km downstream of Alternative site B1. The river at this site flows through a narrow valley with both the abutments covered by overburden which appears to be quite thick. The appraisal of the site indicated that lot of excavation is required at this site to accommodate the diversion structure and power intake since both the abutments is covered by thick overburden. It was also observed that Dronagiri brings lot of silt and avalanche debris that may reduce the live storage capacity of the pondage and endanger the safety of diversion structure. It was not found suitable site for locating the head works and hence not pursued further. Another alternative site, B4 located about 150m upstream of confluence of Dronagiri Gad with Dhauliganga was identified and about 2.0 km downstream of alternative site B1. The river at this site flows through a moderately wide valley with steep abutments. Bedrock comprising granite gneiss belonging to Badrinath Formation is exposed on both abutments at riverbed level. Since the riverbed at this site is adequately wide, the diversion structure in the form of a barrage on a permeable foundation can be located here without any problem. Since bedrock is extensively exposed at this site on right abutment right from riverbed level, the power intake can be located in bedrock. Another advantage of this site is that the length of HRT in case of this alternative will be about 4.5 km as compared to that at alternative site B1. However, the topographic surveys carried out at feasibility stage indicated a level drop of 32m between alternatives B1 and B4 that could result loss of 15% of energy. Considering the reduction in generation due to loss of 32m head, the site B1 was preferred during feasibility stage. The appraisal of the site indicated that bedrock could be located deep in the riverbed as it is located upstream of a blockade site. It is suitable for a barrage founded on permeable foundation. During DPR stage study, subsequent to feasibility stage (FR) both the alternative sites considered in FR were examined carefully and two alternative axes namely Alternative-1 and Alternative-2 were selected for further detail study. Alternative-1 axis was envisaged about 50m downstream of B1 axis and Alternative-2 was proposed at about 510m upstream of B4 axis. During DPR stage resurvey of the project area indicated that the drop in the elevation of the river bed between Alternative-1 near B1 site and Alternative-2 near B4 site is restricted to about 6m that could be easily compensated by raising the height of the diversion structure. It was also observed that in addition to reduction in length of HRT by about 1.5km, wide river valley in the reach between two alternative sites could be utilized to store more quantity of water. Since the FRL of the reservoir could be maintained at same elevation as that in case of Alternative B1, the same energy generation as at B1 could be maintained. Keeping the above in view, it was decided to adopt the alternative site B4 for further studies. However, in view of presence of overburden on the left abutment along the barrage axis, same was optimized by shifting it towards upstream by 510m where bedrock is exposed on both abutments right from riverbed level. The finally adopted barrage axis (Alternative-2, Dronagiri axis) along with other alternatives is shown in **Figure1.3**.

1.6.2 Alternative Powerhouse Sites

During feasibility stage two alternative sites for locating powerhouse were identified. In one proposal the powerhouse is located underground in the hill on the right bank of Dhauliganga just upstream of Tamak village. The other site proposed for surface powerhouse is located on a flat terrace on the right bank of Dhauliganga just upstream of confluence of Wauti Gadhera with Dhauliganga. The site identified for surface powerhouse was explored through one drill hole (DH-01) during feasibility stage, drilled towards hill side end of the terrace. The drill hole indicated the presence of bedrock at 9m depth. However, the space available on the terrace was not considered sufficient for locating both powerhouse and switch yard on the surface and therefore locating the powerhouse in the underground was preferred at that stage. The area around the proposed alternative sites exposes quartzite with thin alternations of schist and gneiss belonging to Pandukeshwar Formation of Central Crystalline Group. The bedrock is foliated with foliation striking in N40°W – S40°E and dipping by 40° towards E. The bedrock, in addition to foliation, is traversed by two prominent sets of joints. The rocks appear to be competent to host the powerhouse cavern. Keeping this in view, the feasibility studies of both the sites were continued during DPR stage.

1.6.3 Selection of Layout

Keeping in view the merits and demerits of different alternative layouts and sites identified for different appurtenant structures during feasibility stage studies, it was decided to pursue the following two alternatives layouts:

Alternative-1: It envisages construction of a diversion barrage across the river Dhauliganga about 50m downstream of alternative site B-1 near the village Jelam, a 5.2m diameter and about 6.2 km long Headrace Tunnel aligned on the right bank of Dhauliganga and a 128 MW installed capacity powerhouse on the same bank of the river near the village Tamak. It was decided to pursue the further studies for both surface and underground alternatives and select the better one.

Alternative-2: It envisages construction of a diversion barrage across the river Dhauliganga at the alternative site B-4 identified during feasibility stage studies. The axis of diversion structure includes a barrage founded on permeable foundation with axis located about 650m upstream of the confluence of Dronagiri Nala, a 5.2m diameter and about 4.428 km long HRT on the right bank of the river and a 128 MW installed capacity powerhouse on the same bank of the river. It was decided to pursue the further studies for both surface and underground powerhouse alternatives and select the better one.

Alternative – 2a (Final Scheme): The final layout of the Jelam Tamak H.E. Project after incorporating the TORs stipulated by MoEF is given in **Fig. 1.2 (a,b)**.

1.7 CASCADE DEVELOPMENT

Jelam Tamak H.E. Project (JT HEP) is a run-of-the- river scheme being developed by THDC, India Ltd as per the implementation agreement signed with Government of Uttarakhand. On the upstream of this project is Malari Jelam H.E. Project (MJ HEP) which is also a run-of-the-river scheme being developed by THDC India Ltd. On the downstream is Tamak Lata H.E Project, (TL HEP) which is being developed by Uttarakhand Jal Vidyut Nigam Ltd (UJVNL Ltd) (**Fig.1.4**).

The DPR of JT HEP has been completed and submitted to CEA, New Delhi for TEC. The DPR of MJ HEP is under advanced stage of preparation and shall be submitted to CEA shortly. As part of the free flow requirement of the MoEF, THDC shall maintain distance between the TRT outlet of MJ HEP and reservoir tail level of JT HEP, both projects being developed by THDC, though all the site investigations have been completed for MJ HEP, which would require revision but considering the fact that the DPR has not been so far submitted with CEA. As regards the downstream project of TL HEP, UJVNL has not so far submitted the DPR to CEA and the free flow condition shall be required to be fulfilled by them as per the MoEF, which to stipulate as under

> *"A distance of 1 km free riverine stretch between TWL of Malari Jelam and FRL of Jelam Tamak HEP , 200 m between TWL of Jelam Tamak and FRL of Tamak Lata HEP and 2.5 km between TWL of Tamak Lata and FRL of Lata Tapovan HEP shall be maintained."*

1.8 POLICY, LEGAL & ADMINISTRATIVE FRAMEWORK

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

1.8.1 Constitutional Provision

1.8.1.1 *In relation to water resources*

- As per Constitution of India water is primarily a State subject and the role of Government of India comes in only in the case of interstate river waters.
- States are free to enact "water" laws and frame policies in accordance with this provision.
- Regulation and development of inter-state rivers and river valleys is under the control of the Union.
- Indian Parliament may, by law (1) provide for the adjudication on any dispute or complaint with respect to the, distribution or control of the waters of, or in, any inter-state river or river valley" and (2) "that neither the Supreme Court nor any other court shall exercise jurisdiction I respect of any such dispute or complaint" as referred to in (1).

1.8.1.2 *In related to environment*

The first constitutional provisions related to environment were made in the Forty-Second Amendment to the Indian Constitution. This amendment was passed in response to India being party to Stockholm Declaration adopted by the International Conference on Human Environment in 1972. The Forty-Second Amendment introduced Article 48-A into the Directive Principles of State Policy in Chapter IV of the constitution. The article declared the State's responsibility to protect and improve the environment and safeguard the forests and wildlife of the country. Another provision, included in Article 51-A (g), stipulated the duty of every citizen to "protect and improve the natural environment including forests, lakes, rivers and wildlife and to have compassion for living creatures". These amendments imposed an obligation on the Government and the courts to protect the environment for the people and the nation.

1.8.2 Policy Framework

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

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

i.) National Forest Policy (NFP), 1988
ii.) National Water Policy (NWP), 2002
iii.) National Rehabilitation and Resettlement Policy (NRRP), 2007
iv.) Environment (Protection) Act, 1986

1.8.3 Legal Framework

The legal environmental framework stems from the national commitment to a clean environment, mandated in the Constitution in Articles 48 A and 51 A(g) and strengthened by judicial interpretation of Article 21. It is recognized that maintaining a healthy environment is not the state's responsibility alone, but also that of every citizen. The Ministry of Environment & Forests (MoEF) is the nodal regulatory agency of the Central Government for planning, promotion, co-ordination and overseeing the formulation and implementation of environmental and forest policy, legislations and programmes. Regulatory functions like grant of Environment Clearance (EC), Forest Clearance (FC) are part of the mandate of this agency.

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

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

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

1.8.4 Administrative Framework

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

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

1.9 PURPOSE AND SCOPE OF EIA STUDY

It is necessary to know about the possible impacts of any developmental activity, project, plan, policy or programme on the environment. The objective of Environmental Impact Assessment (EIA) is to ensure that development is sustained with minimal environmental degradation. The 108 MW Jelam Tamak Hydroelectric Project falls under the Category-A of the Schedule requiring prior environmental clearance (EC) as per EIA Notification, 2006. To meet the statutory requirement of EC by the Ministry of Environment and Forests (MoEF), Government of India, the present study of Environmental Impact Assessment (EIA) has been carried out for the proposed project. THDC has retained Centre for Studies on Mountain and Hill Environment (CISMHE), University of Delhi, as environmental consultant, to undertake the EIA study and to prepare EIA report for the said project. In doing so, the EIA is expected to serve one or more of the purposes, viz., (i) decision making during project development, (ii) choosing among various project design alternatives and (iii) integrating environmental cost into the project cost.

The scope of EIA study has been determined through scoping, the second stage of EC process. Hence, the scope of the present study is listed in the Terms of Reference (TOR) accorded by the MoEF during scoping and pre-construction clearance for the said project in March 2007 and subsequently amended especially for environmental flow and free riverine stretch by MoEF letters in May 2011 and July 2012. The baseline data for the prediction of impacts and Environmental Management Plan for Jelam Tamak H.E. Project are collected for the catchment area, influence zone

(10 km) radius of the project's components and project activities area (direct impacted areas). The baseline data of catchment area is supplemented basically from secondary sources and also emphasis has been given to free draining catchment as Malari Jelam is located in upstream of the proposed Jelam Tamak H.E. Project. The baseline data for influence zone is furnished by secondary as well as primary sources while direct impact zone has been surveyed to collect the primary data.

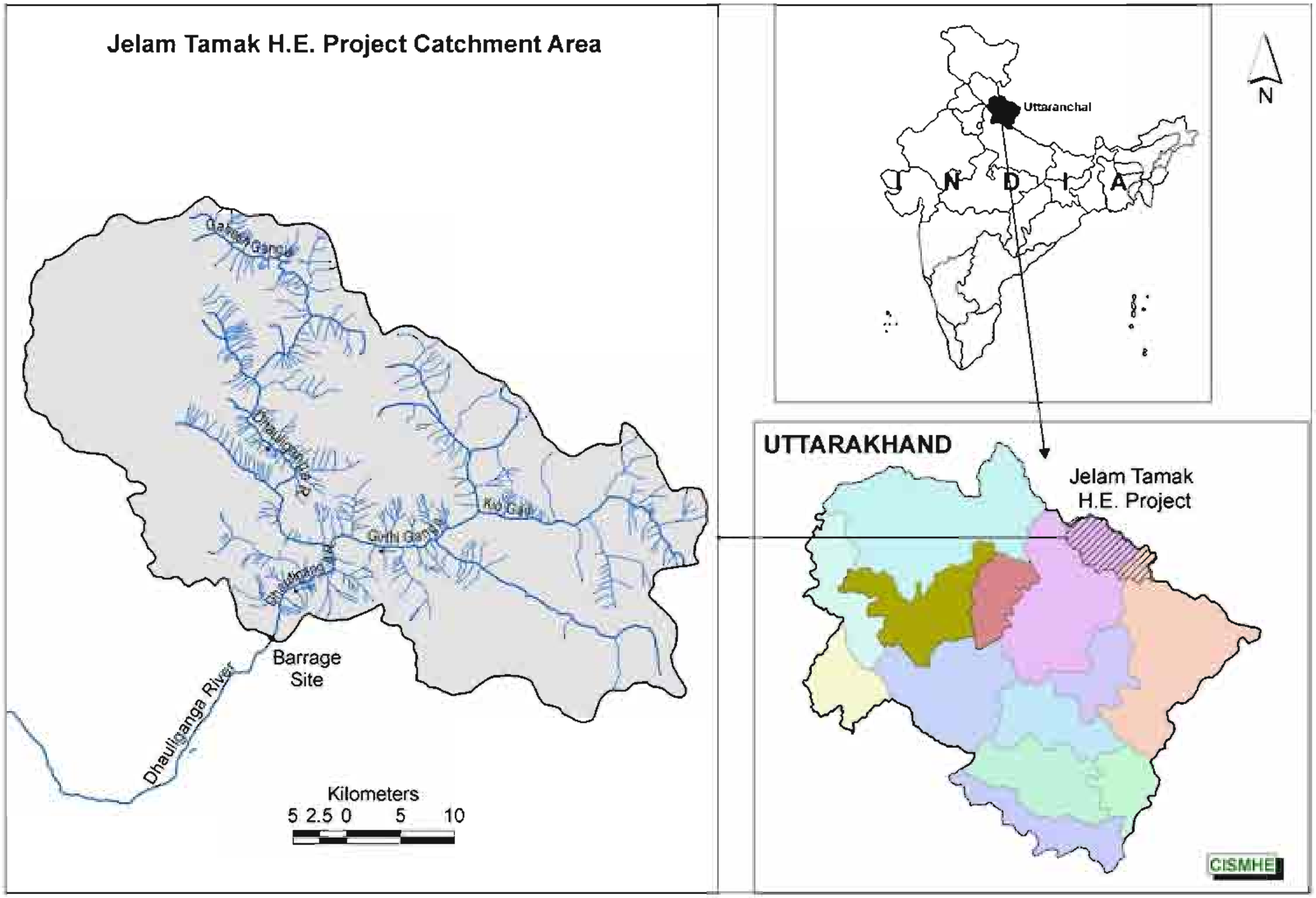
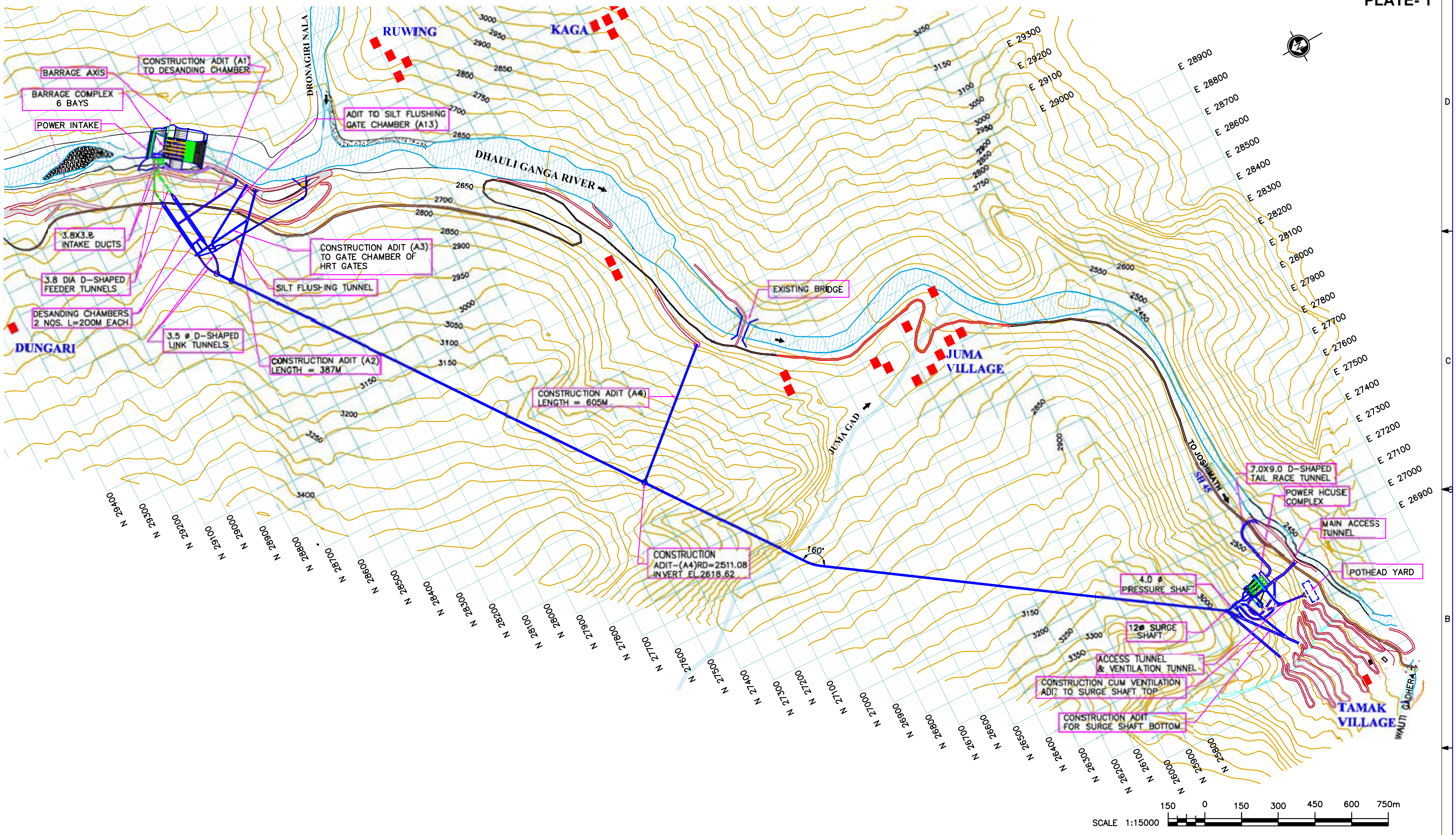


Fig. 1.1 Location map of Jelam Tamak H.E. Project

PLATE- 1



SNC•LAVALIN
Engineering India

Client: THDC INDIA LIMITED

Project:
JELAM TAMAK
HYDROELECTRIC PROJECT
Uttarakhand, India.

Title:

GENERAL LAYOUT PLAN

Format A3 (mm)

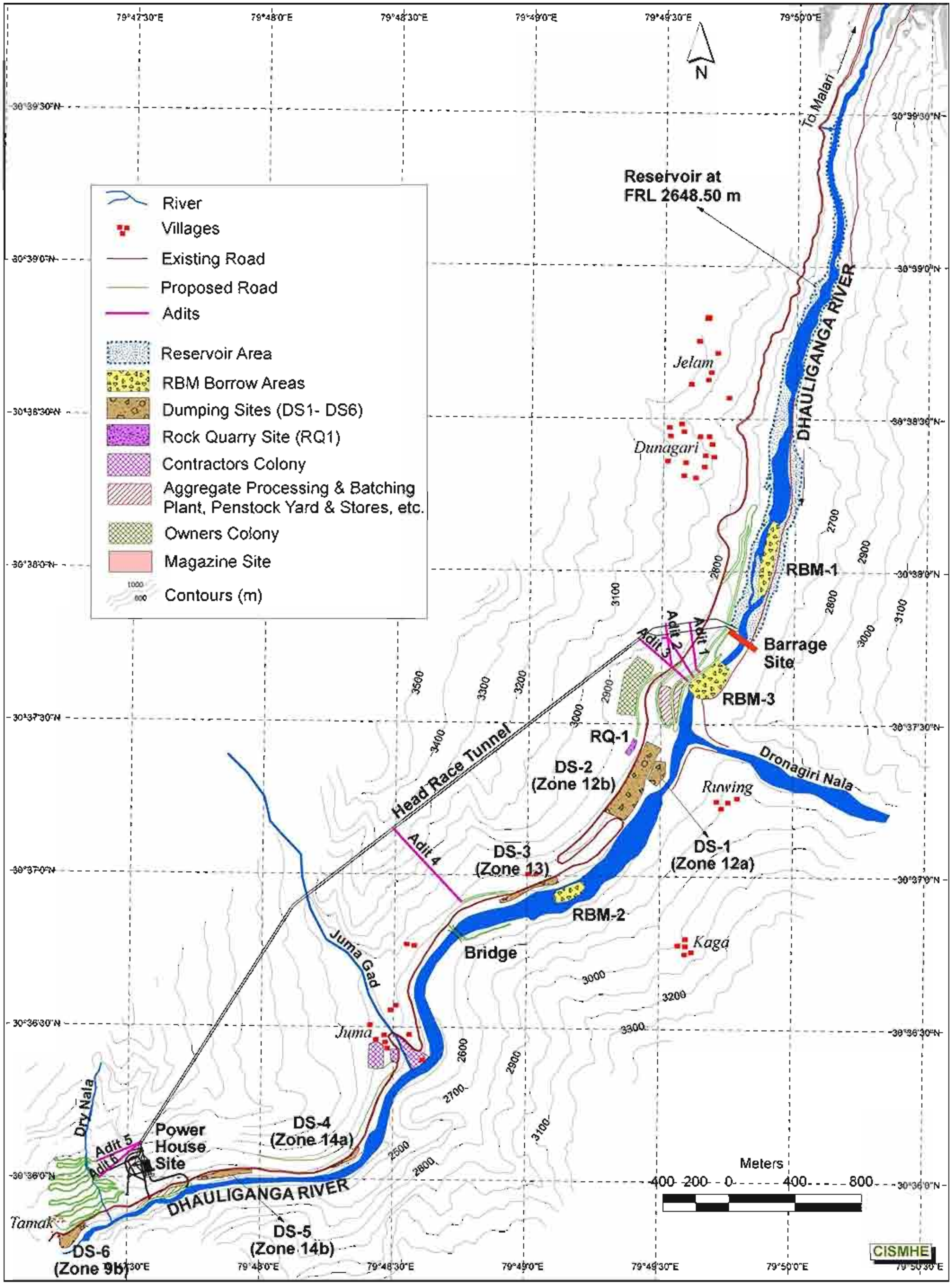


Fig.1.2b Layout map showing associated activities of the Jelam Tamak H.E. Project

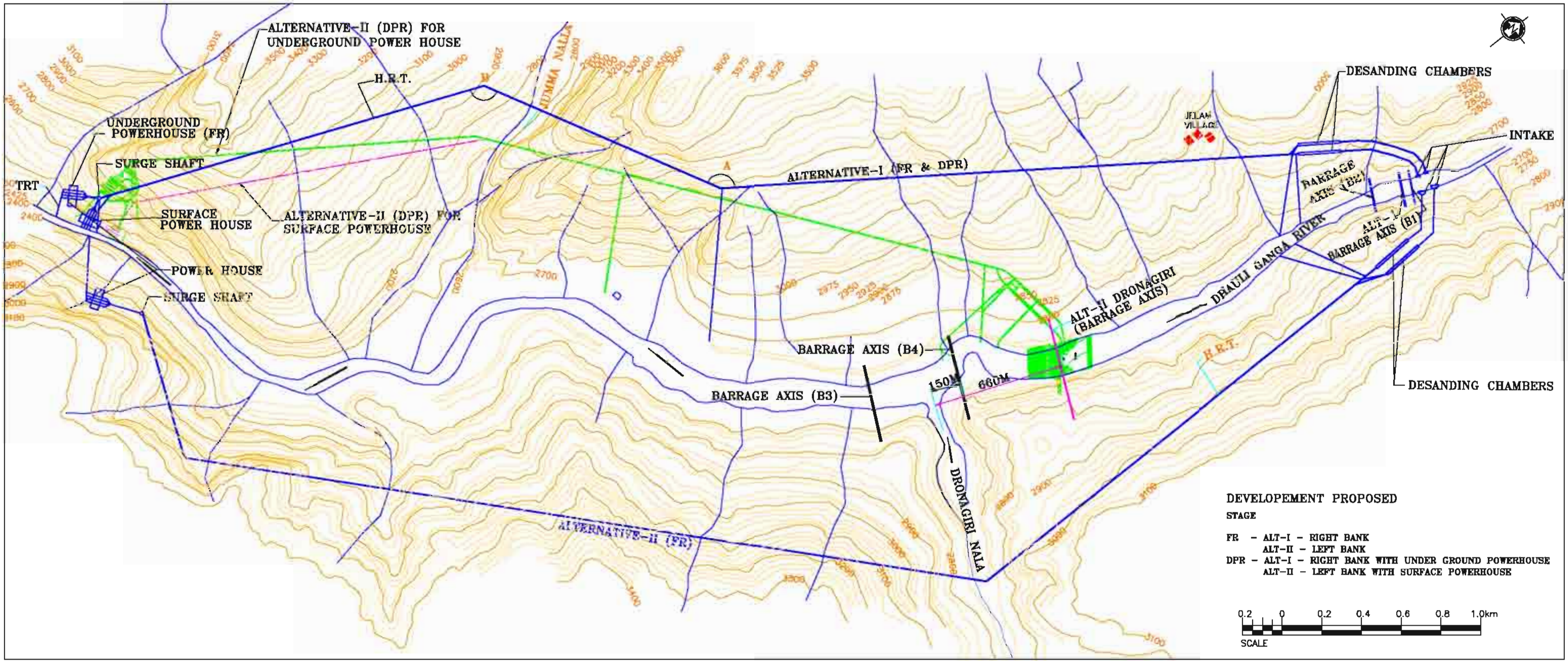


Fig.1.3 Map showing alternative sites for Jelam Tamak H.E. Project

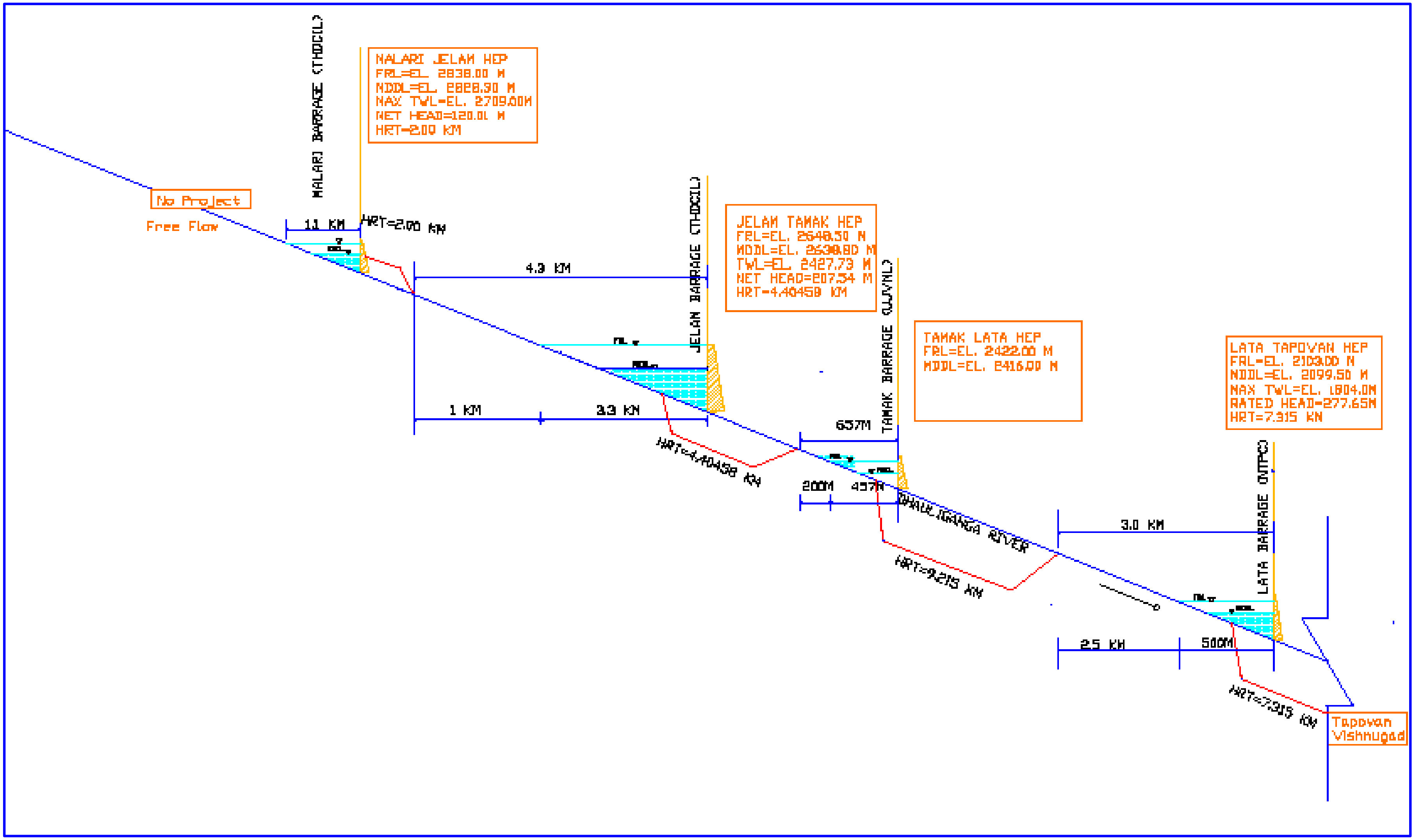


Fig.1.4 Cascade diagram of various projects on Dhauliganga river

Chapter 2

METHODOLOGY

2

METHODOLOGY

In the present standard methods, earlier developed at the Centre and published elsewhere, were followed for Environmental Impact Assessment of Jelam Tamak H.E. project (CISMHE, 1993, 1998, 2000, 2002, 2005, 2008; Clark, et al., 1981, Sassaman, 1981; Lohani and Halim, 1987, Biswas & Geping, 1987). Studies on water resource development projects by various authors were particularly consulted in the present study as well (Bisset, 1987; Dee, *et al*., 1973; Duke, *et al*., 1979 and lEUP, 1979). A brief account of the methodologies and matrices followed in the present study of Jelam Tamak H.E. Project is given below under different headings. All the methods were structured for the identification, collection and organization of environmental impact data. The information thus, gathered has been analysed and presented in the form of a number of visual formats for easy interpretation and decision-making.

2.1 STUDY AREA

The proposed Jelam Tamak H.E. Project is located in Joshimath sub division of Chamoli district in Uttrakhand. The proposed barrage site is located between 30^0 37’ 35.4”N Latitude and 79^o 49’39.5”E Longitude. The study area was bifurcated into areas of direct and indirect impacts. The area of indirect impacts includes the catchment area of proposed Jelam Tamak H.E. Project which comprises nearly of 1666 sq km. The indirect impacts on the various aspects included in EIA were also assessed in the 10 km radius of the proposed project (influence zone). The areas of direct impacts constituted the area of major activities like barrage site, submergence area and other proposed activity sites. The various aspects depending on the magnitude of impacts were studies in the areas of direct impacts.

2.2 SURVEYS

Primary surveys were conducted in different seasons of the year to collect data on geology, flora, fauna, forest types and ecological parameters including soil and water (**Fig. 2.1a,b**). During these surveys data and information were collected on geophysical and biological attributes of the catchment area in brief, influence area (10 km radius) and project areas in details. In addition, detailed surveys and studies were also conducted for understanding aquatic ecology and fish life, if any of Dhauliganga river and tributaries. Primary surveys in the entire catchment area were also conducted for the purpose of ground truthing and augmenting the remotely sensed data. For this purpose various attributes such as land features, rivers, forests and vegetation types were recorded on the ground in the catchment area. A detailed schedule of the survey and samplings is given below.

S.N.	Duration of Survey	Parameters studied
1	November, 2008	Water, Fauna, flora, Geology, Soil, Fish, Air
2	March, 2009	Water, Fauna, Flora, Fish, Ground truthing Air environment
4	August, 2009	Water, Fisheries, Fauna, Ground truthing, Catchment area Surveys
5	September, 2012	Ecological sampling

The detailed methodologies of various parameters are described in the following paragraphs.

2.3 PHYSIOGRAPHY

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

2.4 LAND USE AND LAND COVER

Land use and land cover mapping was carried out by standard methods of analysis of remotely sensed data followed by ground truthing, ground control point data collection and interpretation of satellite data. We sourced raw satellite data from National Remote Sensing Agency (NRSA), Hyderabad and Earth Science Data Interface (ESDI) at Global Land Cover Facility maintained by Department of Geography, University of Maryland, NASA and Institute for Advanced Computer Studies at Maryland, USA. Digital image processing of the satellite data and the analysis of interpreted maps were carried out using ERDAS Imagine 9.2 and ArcGIS 9.1 for GIS analysis.

2.4.1 Database

Digital data on CDROMs of IRS P6 from NRSA and data from LANDSAT-7 ETM+ was used for the present studies and the project area was extracted from the full scenes. The details of the satellite data used in this study are as follows:

Satellite	Sensor	Path/Row	Date	Data type & Bands
IRS P6	LISS-IV	99/50	23-11-2007	Digital (1,2,3,4)
LANDSAT 7	ETM+	145/39	16-11-2005	Digital (1,2,3,4,5,7)

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

2.4.2 Base Map Preparation

The base map of the study area was prepared using topographic sheets of the Survey of India of the entire catchment, using various permanent features like roads, rivers or any other land based features. These features were transferred to the base map. Since the area has high drainage density, we only transferred and considered the main streams for the purpose. This was followed by the preliminary interpretation of satellite data and a preliminary interpretation key was prepared. The preliminary interpreted maps thus prepared were taken to field for ground checking.

2.4.3 Ground Truth Collection

A reconnaissance survey was carried out in the Dhauliganga catchment during different seasons in 2008 and 2009. These surveys were undertaken basically to understand the terrain and vegetation and the vegetation associations of the study area. During this visit the preliminary interpreted data was checked and necessary corrections made. The ground truth data checks were completed in as many as 3 such visits to different parts of the river catchment. The physiographic features on satellite data appearing in different tones and textures were used to correlate image elements and ground features for accurate identification. Subsequently, field visits were undertaken in three seasons for water, air and soil sampling and other parameters. These field surveys were also utilized to further collect the necessary ground truth throughout the study area. The interpretation key was finalized and the satellite images were interpreted as per the objectives of the project and all the thematic details were transferred to base map on 1:50,000 scale. The preparation of final maps was followed by final ground checks, which form the most essential part of the mapping. The final interpreted maps were taken to field and refined after the ground checks.

2.4.4 Classification Scheme

The classification scheme adopted for the preparation of land use/ land cover maps and related thematic maps was done on 1:50,000 scale for preparing the environmental management plan, action plan for watershed management and the catchment area treatment plan. Different forest classes were identified and the degraded areas and scrubs were delineated for the purpose of preparation of erosion maps. The high altitude grasslands/ alpine pastures and agricultural areas were also identified and delineated. The non-forest land cover in the form of rocky land, moraines, glaciers, lakes, etc. was also demarcated for the calculation and classification of erosion intensity.

2.5 SOIL

The soils of the catchment area, influence zone (10 km radius) and project sites (proposed barrage site to power house site) are described in this section. The soils are classified by using the standard method of NBSS (1998).

In order to analyses the physical, chemical and biological characteristics of soils the soil samples were retrieved from the catchment area (S1), proposed barrage site (S2) and proposed power house site (S3) for three seasons (**Fig. 2.1a**). The samples were taken from different locations and the replicates were grouped into 3 sites. An average value was calculated for each parameter at each site. Samples were collected with the help of auger. Soils were removed from upper temporary layer (generally, 5 cm or more according to the soil profile) with the help of digger; samples were retrieved form 10- 25 cm in depth and about 10x10 sq cm in width. The physical properties included moisture content, water holding capacity, bulk density and pore size measurement (soil texture). Soil moisture was calculated by evaporating moisture from pre-weighed soil, at 105 ^{o}C for 24 hours in an oven and reweighed the soil. Standard methods for soil analysis were followed as given in Jackson (1958) for bulk density, soil texture and water holding capacity. The soil was divided into 6 textural classes by using sieves of different mesh sizes viz. >2000 µm for gravel, pebbles, cobbles and boulders, 500 – 2000 µm for very coarse and coarse sand, 200 – 500 µm for medium fine sand, 50-200 µm for very fine sand and 20 – 50 µm for coarse and medium silt and > 20 µm for fine silt and clay.

Chemical characteristics of soil were determined by measuring the pH, conductivity, chloride, phosphate, nitrate and organic matter. Soil pH and conductivity were measured by the instruments pHScan and TDScan 3 (Oakton, Eutech Instruments), respectively. Phosphate and nitrate were determined by the ion specific meter (Hanna Instruments). Chloride estimation was done by colorimetric analysis given by Adoni (1985) while organic matter was calculated by Walkley's method (Walkley, 1947).

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

2.6 FOREST TYPES AND FLORISTICS

i) *Study area*

The proposed Jelam Tamak H.E. Project is located in Joshimath sub-division of Chamoli district in Uttrakhand. For description of vegetation, the study area was bifurcated into areas of direct and indirect activities. Catchment area and influence area (10 km radius) include area of indirect activities, while barrage site, submergence site and other project activity sites constituted the area of major activities. The proposed barrage site is located between 30^o 37' 35.4''N latitude and 79^o 49' 39.5''E longitude.

For details on forest types and forest cover in the catchment area, primary surveys were carried out in the catchment area supplemented with the working plans and records of Joshimath Forest sub-division. The forests present in the Jelam Tamak and adjoining areas have been grouped into different forest types following the classification of Champion & Seth (1968), Negi (1989, 1996), Chowdhery (1996) and Muddgal & Hajra (1999).

Influence area (i.e. 10 km radius from power house site, barrage site and HRT), extensive surveys were carried out along the altitudinal gradient (1800 - 3000 m). The important sites for the primary surveys were (**Fig. 2.1b**):

i) Area between Surai Thota and Jumma
ii) Area beyond Jumma upto Dunagiri
iii) Area between Juma and Jelam
iv) Area above Kosha village up to Malari

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

ii) *Samplings*

The detailed account of ecological study and plant communities has been described based on the primary surveys in the project area. Sampling was undertaken following the Nested quadrat sampling method. During our surveys in 2008, 2009 and 2012, six sites viz., power house site, barrage site, submergence site, upstream site, downstream of barrage site, and downstream of powerhouse site were selected for vegetation structure study on the basis of the presence of forest patches in the area. Along each site, ten quadrats of 10m x 10 m size were laid for tree layer. The size and number of quadrats needed were determined using the species area curve (Misra, 1968). Within each 10m x 10 m quadrat, a ten nested sub-quadrat of 5 x 5m were established for analyzing saplings and shrubs. The herbs were analysed by placing ten quadrats of 1 m x 1 m size randomly on each site. Circumference at breast height (cbh at 1.37 m from the ground) of all trees with > 31.5 cm was recorded individually per species. Based on the quadrat data, frequency, density and cover (basal area) of each species were calculated. The tree basal area was also determined as an index of dominance as:

Basal area = p r^2

Or C=2 p r

Where C= Circumference at breast height

r = Radius

Tree basal area was used to determine the relative dominance of species while cover were used for herbs. The importance value index (IVI) for each species was computed by summing relative frequency, relative density and relative dominance of the individuals (Philips, 1959).

The diversity index for all the layers at each site was computed by using Shanon-Wiener information index (Shanon Wiener, 1963) as :

$$H = -S (ni/n) x LN (ni/n)$$

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

2.7 FAUNA

In order to collect the information on the fauna (mammals, birds, herpetofauna, butterflies) in the catchment area, influence zone (10 km radius) and project areas of Jelam Tamak H.E Project primary as well secondary sources were utilized. Secondary information was gathered with the following methods.

i. The Forest Working Plans of the Forest Divisions falling in the project area were referred to for secondary information on the wildlife of the catchment area.
ii. Interviews of local villagers for the presence and relative abundance of various animal species within each locality.
iii. Data collection on habitat condition, animal presence by direct sighting and indirect evidences.
iv. Direct sighting and indirect evidences such as calls, signs, tracks and pallets of mammals were recorded along the survey routes taking aid from Prater (1980).
v. A detailed survey of birds was carried out in the project sites and catchment area using the literatures of Ali & Ripley (1983) and Grewal et al. (2002). The criteria of IUCN (2012), Wildlife Protection Act (1970) and Zoological Survey of India (1994) were followed to describe the conservation status of the species.

The primary surveys were carried out for three seasons. A detailed survey was carried out for the mammals, birds, reptiles and butterflies. We selected various sites which would likely to be disturbed by the various activities of the project. General surveys were adopted following the following tracts (**Fig. 2.1b**):

i) River Dhauliganga to Malari village (F1)
ii) Uphill of malaria village (F2)
iii) Kaga Dunagiri tract (F3)
iv) Barrage site to power house site (F4)
v) Suraithoda area (F5)

In addition to general survey, sampling at various locations were carried out for birds and butterflies for two seasons only. The surveys were carried out from 6:00 to 10:00 for birds and 11:00 to 15:00 for butterflies. We used point count method to determine the abundance and species richness of birds species (Rose et.al. 2006). All species were identified in a point, measured as 25 m radius from a fixed point for duration of 20 min. The species flew over the canopy and unidentified species were not included in the analyses. For a habitat we laid down 4 – 5 points randomly, spaced with about 100 m. We avoided roads and footpaths for the sampling in close and open canopy areas.

We followed transect count method of Pollard and Yates (1993) and Rose et al. (2006) to determine butterfly richness and abundance. We laid down a transect of 100 m. It was divided into imaginary boxes, 5 m to either side and above; traversed at a uniform pace of 15 min. All unidentified species were not included in the analyses. Sampling of birds and butterfly with the help of point and transact methods were carried out at following sites:

i) Malari village
ii) Dunagiri
iii) Project sites (barrage and Power house sites)
iv) Surai Thoda area

2.8 AQUATIC ECOLOGY & WATER QUALITY

The water sampling was conducted at different locations in the 30 km river stretch of Dhauliganga river. The replicate samples from different locations were grouped into 5 sampling sites namely W_1, W_2, W_3, W_4 and W_5 and a tributary Jelam nala (Jn) (**Fig.2.1a**). An average value for each parameter was calculated to describe the water quality. Sampling site W_1 involved river stretch around the proposed barrage site, W_2 site covered the river continuum near proposed powerhouse site and site W_3 included downstream stretch near Suraithoda. The samples were also retrieved from upstream (W_4) and downstream (W_5) of Dhauliganga – Alaknanda confluence. In addition, small tributaries of Dhauliganga river like Jelam nala was sampled in different seasons to know their impacts on the main stream.

The sampling was carried out for three seasons (Post-monsoon, pre-monsoon and monsoon,). A total of 15 physical and chemical parameters and 5 biological parameters were studied to assess the river water quality. Discharge of the river water was measured calculating the average depth of river (d), width of river (w) and average current velocity of the river water (v) (d x w x v); it was confirmed with the discharge data provided by the DPR of Jelam Tamak H.E. project. The water current velocity at all sites was measured with the help of float method. A 20 m stretch of the river was measured and marked at both ends. A float was thrown at upper end and the time taken by the float to travel the marked distance, was recorded by a stop watch. The water temperature was recorded with the help of graduated mercury thermometer. Care was taken in measuring the temperature as it was recorded from surface, column and near the bottom of the river. An average value of these readings was computed. The pH was recorded with the help of pHScan (Eutech) and pH meter (EI – 132 E) in the field. For the turbidity of water, samples were collected in sampling bottles from different sites in the field and brought to the laboratory for analysis. The turbidity was recorded with the help of Nephelometer or turbido meter (EI – 331 E). The total dissolved solids were measured with the help of TDScan 1 (Eutech) at each site. Similarly conductivity was recorded with the help of TDScan 3 (Eutech) at the site. Dissolved oxygen was measured by using digital DO meters (Eutech ECDO 602K). Total alkalinity, alkalinity as carbonates and bicarbonates, total hardness, Ca and Mg contents, chloride and heavy metals were measured by performing standard methods for testing water and waste water described by APHA (2005) and Adoni (1985). Nitrate ($NO_3 – N$) and phosphate ($PO_4 – P$) were measured using HAANA instruments (HI 93728 and HI 93713, respectively).

Biological characteristics that we assayed involved the status of total coliforms, zooplankton, suspended algae, phytobenthos and macro-invertebrates. A presumptive test (presence/absence test) was performed for the estimation of total coliforms. The method described by Central Pollution Control Board (CPCB), New Delhi was adopted for this purpose. For the quantification of zooplankton and suspended algae 50 liters of water for each community was filtered at each site by using plankton net made up of fine silk cloth (mesh size 25 µm). The study was repeated three times at each site and the samples were pooled. The filtrate collected for suspended algae was preserved in the Lugol's solution while unpreserved samples of zooplankton were brought to the laboratory. Epilithic phytobenthos were obtained by scrapping the surface of rocks and boulders (4x4 cm^2) with the help of a hard brush. Three replicates, obtained from each site were pooled and preserved in Lugol's solution for further analyses. Before going further for other analysis of the suspended algae and benthic samples the density was estimated by using drop count method. The suspended algae and phytobenthos were identified with the help of Sarod and Kamat (1984), Hustedt and Jensen (1985) and Edmondson (1959). The zooplankton was identified by using literatures of Edmondson (1959) and Battish (1992).

The macro-invertebrates were obtained with the help of a square foot Surber's sampler or a square foot quadrat. The substrate, mainly stones were disturbed and immediately transferred to a bucket underwater and later rinsed thoroughly to dislodge all the attached macro-invertebrates. The organisms trapped in the Surber's sampler were also transferred to the bucket. The material was sieved through 100µm sieve. Samples were collected in three replicates and pooled for further analysis. The samples were preserved in 3% formalin or 70% ethyl alcohol. The organisms obtained were then counted after identifying them up to family level by the procedure described by Pennak (1953) and Edmondson (1959). Biological monitoring working Party score (BMWP, 1978) and Average Score Per Taxon (ASPT) (Armitage, et al., 1983) were used to assess the water quality.

2.9 AIR QUALITY

The level of suspended particulate matter (SPM), respirable suspended particulate matter (RSPM), non-respirable suspended particulate matter (NRSPM), NO_2 and SO_2 were recorded in the ambient air by running respirable dust sampler (Envirotech APM 460 BL) with gaseous sampling attachment (Envirotech APM 411 TE). The sampler was run in nearby areas like Malari village and Joshimath during August and in March month at Joshimath.

Noise levels measured in the area at various sites. It was measured at the proposed barrage site (N1), proposed power house (N2), downstream of power house (N3), upstream and downstream of Vishnuprayag (N4) and Jelam Nala (N5) (**Fig.2.1a**). The noise level was recorded with the help of noise recorder D2023 (cygnet type 2 as per IS 9779, 1981) at the project area, in the villages, and inside the forest.

Traffic density was recorded on the Joshimath to Malari state highways at various sites in different seasons. Per hour traffic density was recorded at morning, noon and evening of the day.

2.10 SOCIO-ECONOMIC ASPECTS

Socio-economic profile includes brief description of Uttarakhand, district Chamoli and sub-division Joshimath, where the proposed project lies, history and ethnography of the area. A detailed account on the demography, education, occupation, land use/land cover and other amenities of the villages located in 10 km radius and project affected villages is discussed in EIA report. In order to collect the baseline data for preparation of R & R plan a door to door survey for project affected families was carried out for the proposed project. A detailed questionnaire was prepared for this purpose and the same is placed at Annexures I - III. The surveys and preparation of the plan included the following procedure:

- The land for the acquisition was identified by the project authority with revenue department
- Door to door socio-economic survey of the project-affected families/owner of Jumma, Jelam and Longshekhadi villages was conducted to collect the base line data. Data was collected on various parameters e.g. Demography, Occupation, Education, Quality of life, Income patterns, Land holdings, Amount of land loss due to this project, etc. This detailed information has been used in preparation of the R&R plan.
- Discussion was held with all project affected families/persons, who have expressed their willingness to accept the project. Project authorities had meetings with project affected families in different villages (Annexure IV)

2.11 ASSESSMENT OF IMPACTS

Impact prediction and assessment are the most important of parts of the EIA study. After collection of baseline data, it is important to identify the impacts of developmental activities on the environment. The impacts were identified and predicted using the model outlined in Eriction (1994). The model includes i), direct impacts, ii) indirect impacts, iii) cumulative impacts. iv) positive impacts, v) negative impacts, vi) reversible impacts, vii) irreversible impacts. The outputs and inputs related to evaluation of impacts are given in **Figure 2.2**.

There are various methods of impact evaluation ranging from simple checklist, matrices to complex computerized model and network. The present impacts were quantified with the help of Modified Leopold matrix. It is comprised of rows and column, corresponding to project action and environmental variables, respectively. The each cell of the matrix was assigned with a score ranging from 1-5. The positive and negative impacts were symbolized by (+) and (-). The score was weighted by the nature, magnitude, significance and longevity of the impacts.

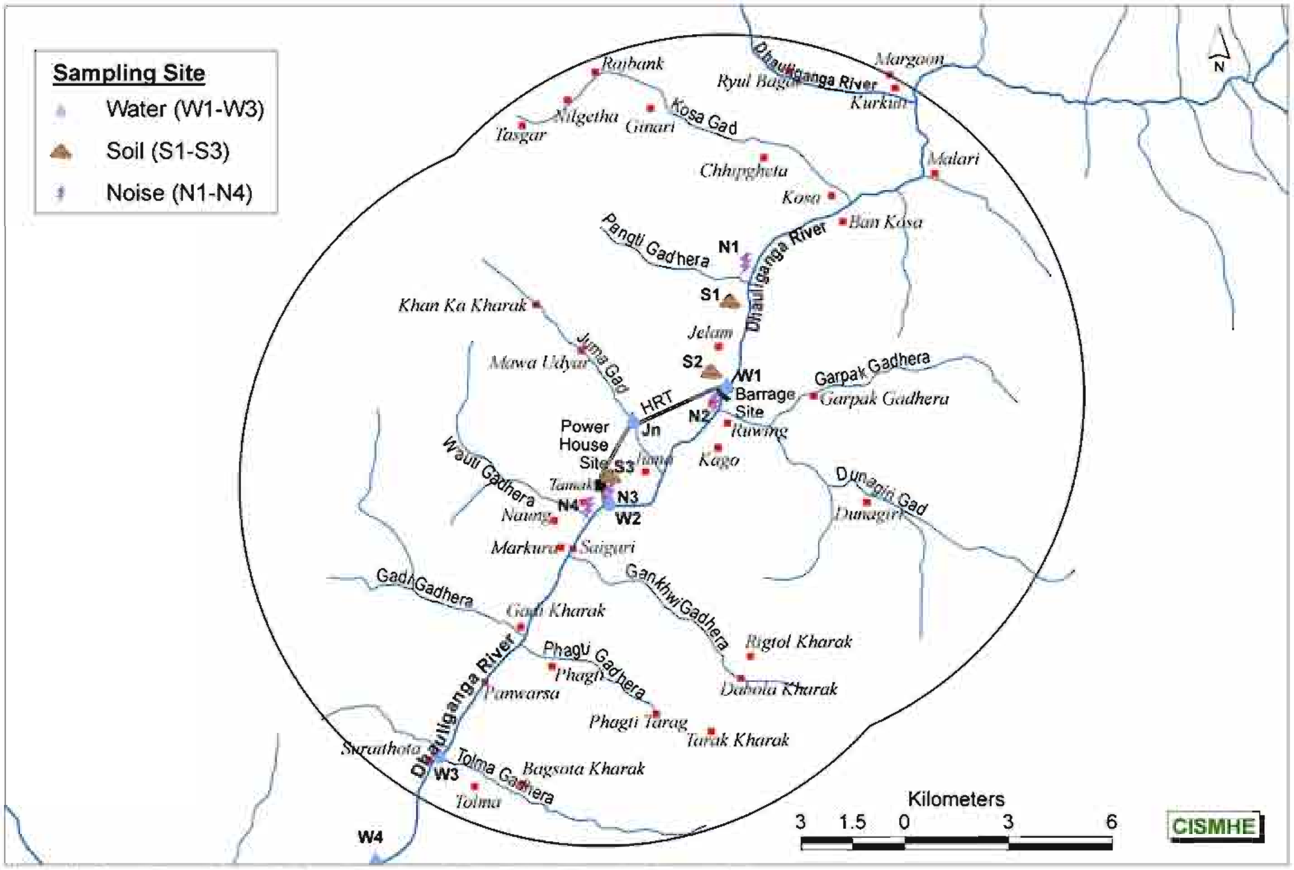


Fig. 2.1a Sampling sites at different location of the Jelam Tamak H.E. project area

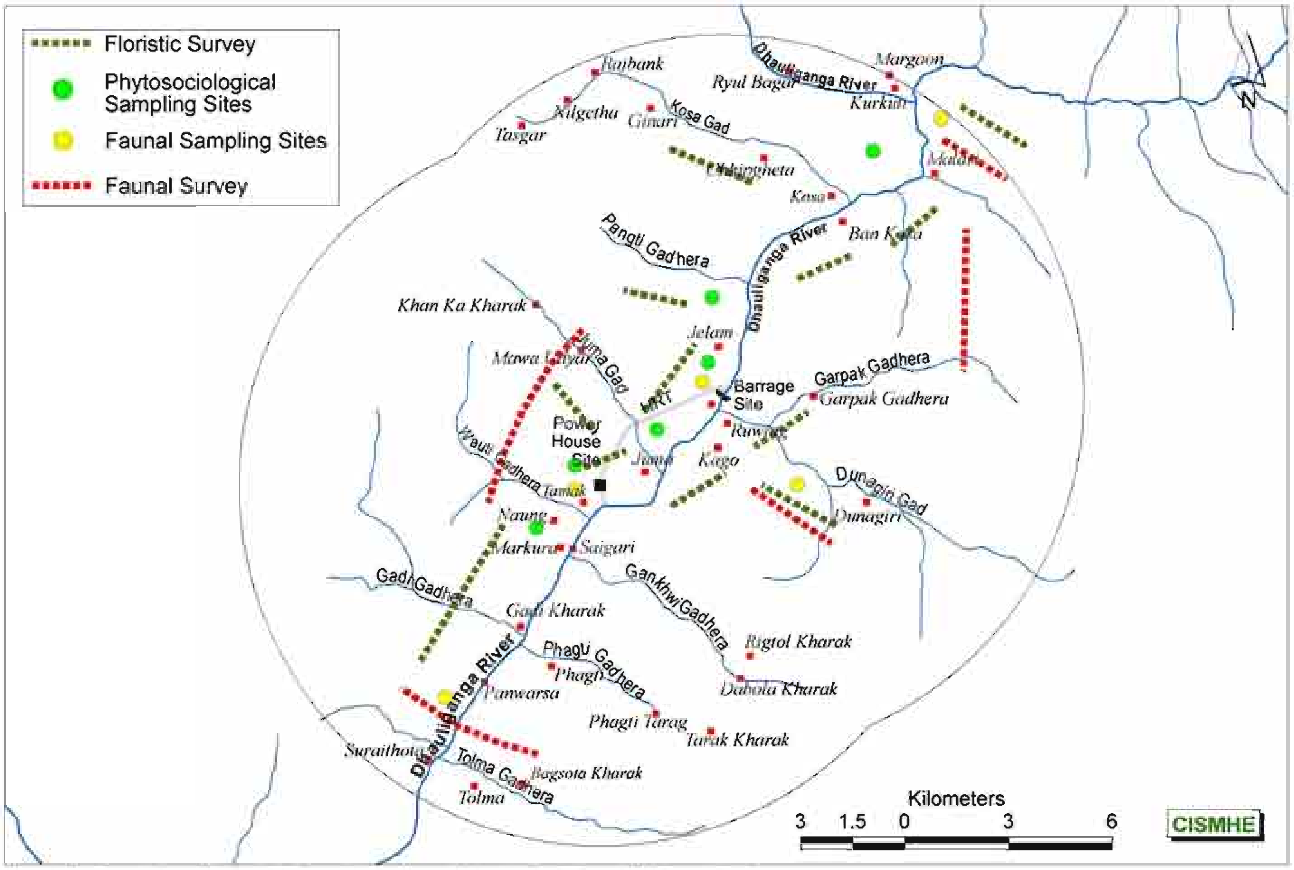


Fig. 2.1b Sampling sites at different location of the Jelam Tamak H.E. project area

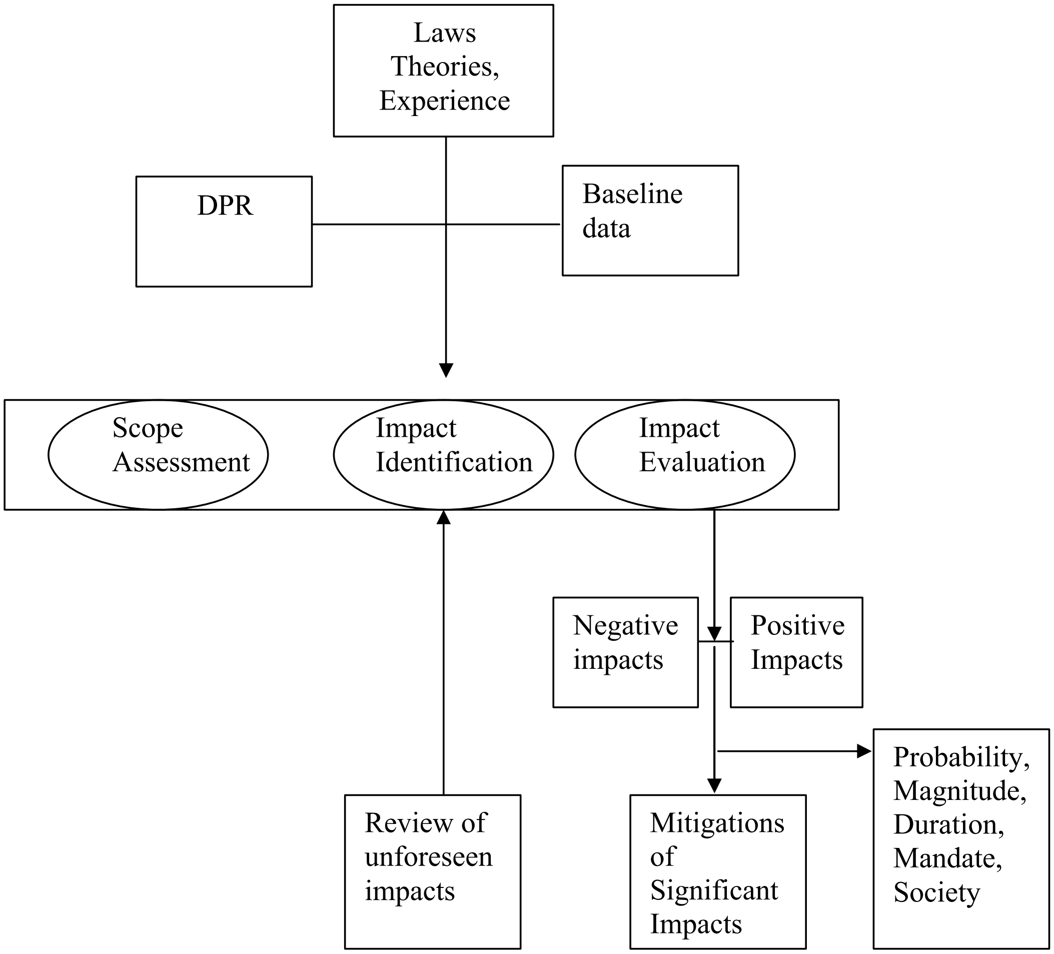


Fig. 2.2 Inputs and outputs related to evaluation of impacts

Chapter 3
PHYSIOGRAPHY

3
PHYSIOGRAPHY

3.1 INTRODUCTION

The physiographic condition of a region refers to the sculptures on the natural landscape and ongoing changes by several geomorphic agents like water, glacier, wind etc. These agents are controlled by the prevalent climatic conditions of the region and the internal dynamism of the earth. For a hydroelectric project, the study of physiographic condition of the river catchment is very crucial as it has a strong control on water availability and sediment load supplied to the river. The present chapter deals with physiography of the Jelam Tamak catchment area in the upstream of the proposed Jelam Tamak H.E. barrage site.

The catchment area of the proposed schemes spreads in the range of 30^0 33’ 22” N to 31^0 00’ N latitudes and 79^0 34’ 52” E to $80^0$15’ 08” E longitudes. In the present study, various physiographic parameters were analyzed through remote sensing and GIS techniques. A comprehensive database of different physiographic aspects was formulated for all catchment. Secondary sources like Survey of India (SOI) toposheets and satellite data were utilized in preparation of different thematic maps. Analysis and interpretation of this spatial database were achieved by using GIS techniques. The results were confirmed after ground truthing at specific locations. The outcome of this study is discussed in the following sections.

Eventually, influence study area for each of the physiography parameters were calculated. Influence zone area was necessary because MoEF (Ministry of Environment and Forest) has been following a general practice of baseline data to be collected in a 10 km radius of a project while conducting EIA studies. A base map was developed to demarcate the influence zone of the Jelam Tamak H.E. Project, it covers an area of 43235.25 ha. This base map was prepared using the distance calculation in GIS (Geographical information system). Points map of barrage site and power house site were used in calculating the 10 km radius of influence area. Therefore, all the physiographic spatial maps will be further examined within the 10 km radius of power house and barrage site. It is called as the study area (Influence zone and the submergence area).

3.2 DRAINAGE NETWORK

There are large numbers of small and large tributaries in the Jelam Tamak catchment (**Fig. 3.1**). The head water of the main river channel Dhauliganga originates from the glacier clad and snow capped peak of Ganesh Parvat, which is elevated at a height of 6531 m. Initially the river is called as Ganesh Ganga when it originates from Ganesh Parvat from Greater Himalayan range in the northern part of the catchment. It is called as Dhauliganga river after Shepak Kharak. The Dhauliganga river in the catchment area has a length of 60 km up to the barrage site from the head water region. It is largely fed by tributaries on the left bank, however, glaciers and snow capped mountains are widely spread on the right bank but there are few rivers originating from the right bank. Some of the prominent rivers in the catchment area are Amrit Ganga, Girthi Ganga, Jainti Gad, Chuba Gad, Kosa Gad, and Siraunch Ghar. In the following section the right bank and left bank rivers will described with their head water regions (see Table 3.1).

3.2.1 Left Bank Rivers

In the initial course Dhauliganga is called as Ganesh Ganga and it flows for 18 km towards South-East where it is joined by glacier fed river from the North-east of the catchment (see **Fig.3.1**). The aspects of the head water region of these small tributaries are mostly north facing and therefore slopes are covered with glaciers. To the south-west it is joined by several small seasonal and perennial streams. It flow further for 8.6 km and joined by another glacier fed river system. This tributary originates from northern part of Dhamion glaciers and flows for 8.6 km westward, later it is joined by several tributaries along the left bank. After which the river flows for another 4.1 km towards south and it is joined by small rivulets and streams. Most of these rivulets are seasonal. Before Niti village there are two rivers flowing westwards, both the streams have their head water region in the western facing Dhamian Glaciers. Some of the prominent river system along the left banks are Jainti gad and Girthi Ganga rivers.

Jainti Gad

This river has its head water region in the Dhamian glaciers. It originates from west facing glaciers and further fed by small streams and rivulets before it drains into Dhauliganga. The stream has a length of 6.3 km and the slopes along the lower altitude are largely covered with scarce vegetation.

Girthi Ganga

It is the largest tributary along the left bank. The river flows for almost 40 km. It flows North-westwards from the Girthi Glaciers in the southern part of the catchment. Besides, the head water region of the Girthi Ganga is also spread in the Bhilmagroar Glacier. It drains large tributary of Kio gad, Chubak Gad and Siraunch Ghar. Kio Gad and Siraunch Gad are the largest tributary systems. These three tributary systems will be discussed in the following paragraphs. On the Left bank of Girthi Ganga, Chubak Gad and Kio Gad are the largest river systems (see **Fig.3.1**).

Right bank tributary of Girthi Ganga

The sub-tributaries of Kio Gad are widely spread in the Dhamian Glaciers in the northern part of the catchment and Bancha Dhura Peak in the eastern part of the catchment which lies in the Tibet region. The main channel of Kio Gad originates from the snow capped peak of Bancha Dhurha elevated at a height of 5715 m a.s.l. The Kio Gad exhibits a dendrite pattern. It flows approximately for a length of 24 km in Tibet and enters India, and flow further 5 km before it drains into the Girthi Ganga draining several glacial streams from both the banks. At the point of origination the stream is called as Jhangu Gad. It flows towards south-west and later it is joined by glacial stream from the left bank which flows north-westward from the head water region. Another glacial stream joins from left bank (Chibarrgeu Gad) which flows for 9 km towards north from the head water region (see **Fig.3.1**).

On the right bank of Girthi Ganga, Chubang Gad originates from Dhamian Glaciers and it flows for 19 km southwards. It is a large tributary system and characterized with dendrite drainage pattern. While it originates from the head water region it is called as Rimkhim Gad, initially the stream flows east and then south for approximately 7 km where it is joined by small glacial stream from the north. After the confluence it is called as Yong gad flowing further for 4 km south and it is joined by Shalshal gad from the left bank. Yong gad flows further for 5 km and it is joined to seasonal streams on both adjacent banks and thereafter it transforms into Chubag Gad. It traverses for 4 km before it joins into Kio gad (see **Fig.3.1**).

After Kio Gad there are several small seasonal streams making their way into Girthi Ganga. Another prominent stream along the right bank of the Girthi Ganga is Chubak Gad which flows from north to south from the stretch of Dhamian Glacier. From the head water region to the point of confluence it flows for 7.7 km draining few seasonal streams. Thereafter, Girthi Ganga flows further 2 km and drains into Dhauliganga river (see **Fig.3.1**).

Left Bank tributary of Girthi Ganga

The only prominent Left bank tributary of Girthi Ganga is Siruanch Ghar with its head water region in the extreme south of the catchment. The head water region is spread in the Siruanch glacier draining several glacial streams. The stream flows for 7.7 km to south and joins Girthi Ganga. Thereafter, Girthi Ganga flows for another 4 km to west and falls into Dhauliganga near Kurkuti village.

3.2.2 Right bank tributaries

Amrit Ganga

The only prominent tributary that flow on the right bank of Dhauliganga is Amrit Ganga. It flows from the snow capped glaciers in the north draining large number of glacial streams on either bank. It flows for 11.8 km south and drains into Dhauliganga near Gamsali village.

Kosa Gad

After the confluence of Amrit Ganga and Dhauliganga it flows further 13 km towards south, in this course it is joined by several seasonal and perennial rivers. Afterwards it is met by Kosa Gad on right bank which originates from Hathi Parbat glacier elevated in the range of 5600-5900 m asl. It flows for 11.7 km before it drains into Dhauliganga river.

Pangti Gadhera

After the confluence of Kosa Gad and Dhauliganga river it flows further 2 km towards south, thereafter it is joined by another small tributary of Pangti Gadhera. The river has a length of 4.9 Km from the head water region to the point of confluence (Table 3.1 and see **Fig.3.1**).

Drainage area in the influence area is illustrated in the map given in **Figure 3.2**. The influence area from the barrage site and power house is extended up to 43235.25 ha. The two major tributaries that flow into the Dhauliganga river up to the barrage site are Kosa Gad and Pangti Gadhera. From the downstream of the barrage site up to power site there are large numbers of tributaries joining the main river channel of Dhauliganga. Along the left bank Dunagiri Gad is one of the largest tributary system that drains into the main river channel. Dunagiri Gad is fed by several small tributaries and one of the prominent tributary of 1st stream order is Garpak Gadhera. The Dunagiri Gad Joins with main river channel near the Ruwing. Along the right bank Juma gad flows towards SE and drains into the main river channel near the Juma village.

Downstream of the power house is featured with more tributaries. Streams along the left bank are Phagati gadhera, Gankwi Gadhera and Tolma Gadhera. The head water region of Gankwhi Gadhera is characterized with permanent glaciers. Along the right bank Wauti Gadhera,Gadi Gadhera are the main tributary systems that joins the river channel.

3.3 DIGITAL ELEVATION MODEL

Topographical data and its aspects are the main input in much of environmental models. Most of the environmental models such as the soil erosion susceptibility model, geomorphologic and land cover mappings rely on topographical data as one of the major input (Zomer and Ives, 2002). Topography in GIS is usually termed as Digital elevation model (DEM). DEM as the term indicates a digital description of the terrain relief. A DEM can be stored in different forms: contours lines, TIN (triangulated interface network), raster based array of cells. DEM stores the surface height by means of array of elements which are called as pixels. Generally DEM (**Fig.3.3**) formed the basis for generation of elevation-relief, slope and aspect maps, which are shown in **Figure 3.5**, **Figure 3.7** and **Figure 3.8**, respectively.

Raster based DEM was prepared from the toposheet of Survey of India. The toposheet was scanned and digitized in GIS platform. Similarly, thematic maps for elevation-relief and aspect were also generated using the base map of the DEM. The mountain ranges in the NW, with a height up to 7425 m a.s.l (**Fig.3.3**). The low lying valley from Kio Gad confluence with Girthi Ganga and Amrit Ganga confluence to the barrage site is elevated at a gradient height of (~2000 m asl).

The influence zone of 10 km radius area is spread over an area of 43235.25 ha of land. (see **Fig. 3.4**). The highest elevation range are spread along the higher ridges and extends up to 6031 m a.s.l where as lower elevated area along the valley near the barrage site and power house site the elevation is 2124 m.

Table 3.1 Drainage network, major tributaries and catchment characteristics of Dhauliganga

Main Tributary	Right Bank/Left Bank	Place of confluences with the Dhauliganga river	Major streams joining the tributary	Catchment Characteristics
Jainti Gad	Left	Jainti		The catchment is elongated in nature. The higher ridges are elevated within a range of 4200-5400 m asl. Upper part of the catchment is largely covered with snow and glaciers. However terrace agriculture is being practiced in the lower elevation zone near the confluence with Dhauliganga. Lower elevation zones are partly covered with scarce grassland on the steep slopes on the either bank of the river. The catchment area is largely covered with barren land.
Girthi Ganga	Left	Kurkuti	Kio Gad (Chubag Gad, Chibarrgeu Gad) Siruanch Ghar and Chubak Gad	Girthi ganga is the largest tributary as well as the largest basin the Dhauliganga catchment area. The catchment is covered with three glaciers of Siruanch, Bhilmagroar glacier in the Tibet and Girthi Glacier. The head water region of the catchment i.e., eastern part of the basin is largely spread with Snow capped mountains and Glaciers and moraines. Lower part of the catchment i.e., western part of the catchment is characterized with scarce vegetation and grassland.
Amrit Ganga	Right	Gamsali		Amrit ganga catchment is very narrow. And the head water resource is covered with large glaciers. The catchment is covered with sparse vegetation and grassland. The catchment is spread on a elevation range of 3000 meters to 6000 m asl. Agriculture is devoid in the upper and middle part of the catchment. However, a small part of the area near Gamsali village terrace cultivation is practiced.
Kosa Gad	Right	Malari		Kosa basin is situated adjacent to the Amrit ganga. The catchment is spread in an elevation zone of 2275 m to 6200 m asl. The River has two head water source and therefore it is charactized with two bifurcated valleys; one towards the Hathi Parbat and second towards the Kaag Bushandi. The lower part of the valley has extremely steep slopes with mixed coniferous forest.
Pangti Gadhera	Right	Jelam (before Barrage site)		The basin of Pangti Gadhera is the smallest. The head water region is sourced only few kilometers from the point of confluence. The slopes are steep with open and mix coniferous forests.

3.4 SLOPE

There are seven slope classes classified in the catchment area. The most predominant slope class in the Jelam Tamak project area is Steep and very steep. These two classes are spread on an area of 21.02% and 20.71% of the total catchment area. Therefore much of the area is covered with extreme slope classes where loose soils and barren lands are highly susceptible to soil erosion. Steep and very steep slope classes are widely spread across both the banks of Dhauliganga river. Moderately sloping is spread on an area of 17.7% of the total catchment area. This slope class is very common along the lower lying valley. Other slope classes are given in Table 3.2 and **Figure 3.5**.

Table 3.2 Slope range and corresponding area of Jelam Tamak catchment

Slope	Area	Percent
Flat	6068.629	3.56
Gently Sloping	6835.731	4.01
Moderately Sloping	13688.51	8.03
Strongly Sloping	22177.77	13.01
Moderately steep	30206.77	17.72
Steep	35832.18	21.02
Very steep	35406.02	20.77
Escarpments	20251.49	11.88

As shown in the **Figure 3.6** of the influence area, the very steep slope class is widely spread in the demarcated area of power house and barrage site. The very steep slope class amounts to 36.09% of the total influence area of 43235.25 ha. This slope class is susceptible to soil erosion and moreover it is spread near the barrage site. Beside slope class escarpment is also widely spread with area coverage of 13984.37 ha. Other slope classes and their area coverage are given in the **Figure 3.6**.

3.5 ASPECT

As given in the illustrated in map **(Fig.3.7)** all the facet of the aspect are uniformly spread in the catchment area. Moreover flat is predominantly covered in the catchment area with >40,000 ha of land. Three facets NW-N-NE, NE-E-SE and SE-S-SW are uniformly spread in the catchment, all these three classes accounts (~34000-36000 ha) of land under the corresponding aspect classes (see Table 3.3).

Table 3.3 Aspect classes and corresponding area of Jelam Tamak catchment

Aspect	Area	Percent
Flat	40145	23.55
NW-N-NE	34809.4	20.42
NE-E-SE	36769.8	21.57
SE-S-SW	34468.4	20.22
SW-W-NW	24274.5	14.24
Total	**170467**	

3.6 RELIEF

As shown in the **Figure 3.8** relief thematic layer is classified into 17 bands with 300 meter band width. Band width 4800-5100 m is predominantly spread in an area of 32627.40 ha which accounts to 19.14% of the total catchment area. In addition the elevation band classes 4200-4500 m, 4500-4800 m, 5100-5400 m and 5400-5700 m are also predominantly spread in the catchment area. All these classes together account ~60% of the total catchment area. Moreover these bands are head water region for many tributaries of Yong Gad, Amrit Ganga and seasonal tributaries. Higher band widths (> 5700m) and lower band width (< 4200 m) are less frequent in the catchment area. In Table 3.4 details of the band width classes with area and percent is given. The 3-dimensional (3-D) perspective view of the Dhauliganga river catchment up to the proposed barrage site is shown in **Figure 3.8a**.

As shown in **Figure 3.9** within the influence zone, maximum area coverage falls in the band width of 3900-4200 m and 4200-4500 m with area coverage of 13.8% and 13.9% respectively. The former band width forms the head water region of several tributaries downstream of the powerhouse where as the latter band width forms water region of several tributaries upstream of the barrage site. Higher band width of 4500-4800 m has area coverage of 11.25% of total influence area. The lower band width of 3300-3600 m and 3600-3900 m covers 10.92% and 12.69% respectively. All these five band classes' accounts for 62% of the total area coverage of influence zone.

Table 3.4 Relief band width classes and corresponding area of Jelam Tamak catchment

Relief	Area	Per cent
Up to 2700	34.09342	0.02
2700-3000	1227.363	0.72
3000-3300	2897.941	1.70
3300-3600	5250.387	3.08
3600-3900	7824.44	4.59
3900-4200	11438.34	6.71
4200-4500	20882.22	12.25
4500-4800	29473.76	17.29
4800-5100	32627.4	19.14
5100-5400	28655.52	16.81
5400-5700	17933.14	10.52
5700-6000	6443.656	3.78
6000-6300	3528.669	2.07
6300-6600	1346.69	0.79
6600-6900	579.5881	0.34
6900-7200	238.6539	0.14
>7200	68.18684	0.04
Total	**170450.1**	

3.7 ENVIRONMENTAL IMPLICATION

The stretch up to barrage site requires special attention for the purpose of catchment area treatment in case of soil erosion and high siltation during the monsoon period. There are vast area of land which are highly susceptible to soil erosion. Very steep accounts 20.7% of the total catchment area, however in the influence zone the area it is spread in area more than 36% of the total influence area. Therefore an appropriate management plan is necessary for the purpose to mitigate and reduce soil erosion in the free draining area.

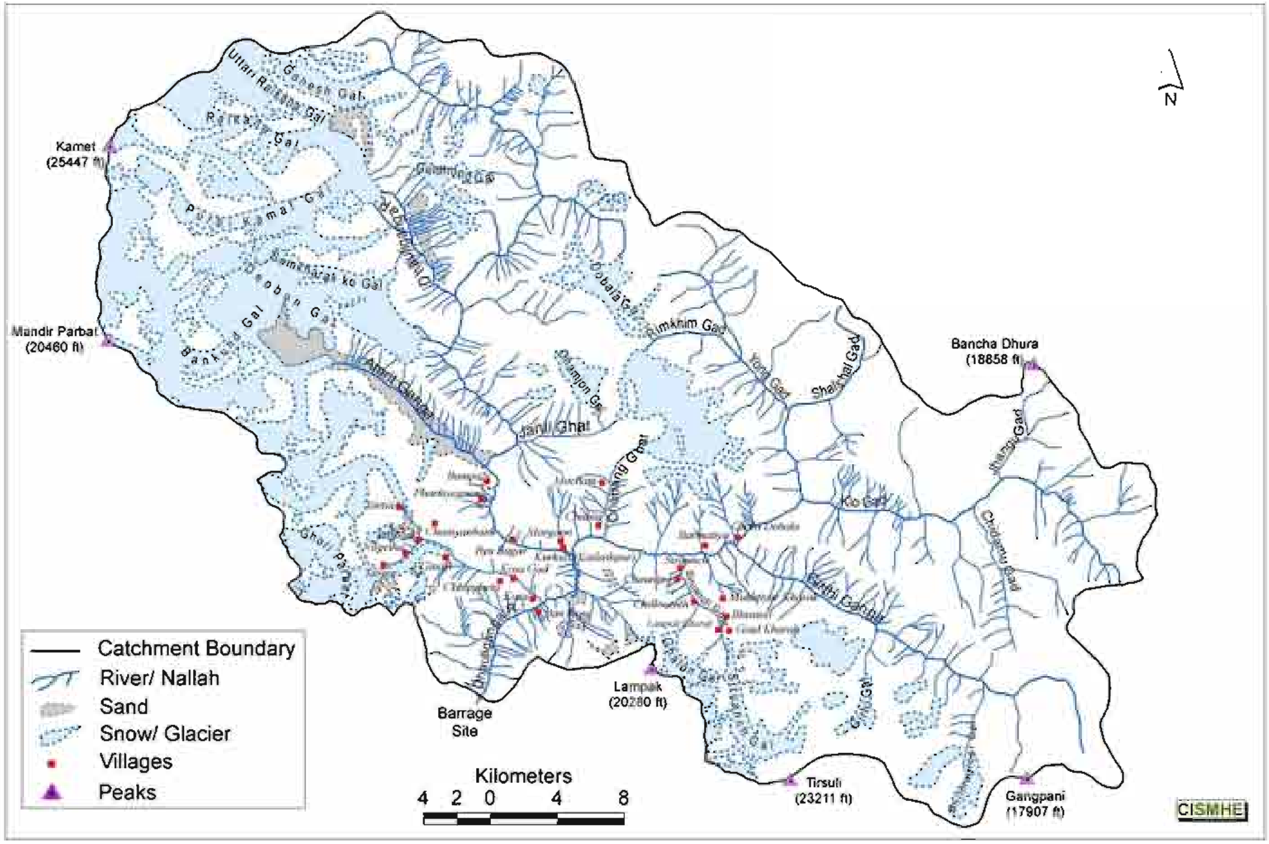


Fig.3.1 Drainage map of Dhauliganga river up to the proposed barrage site of Jelam-Tamak H.E. Project

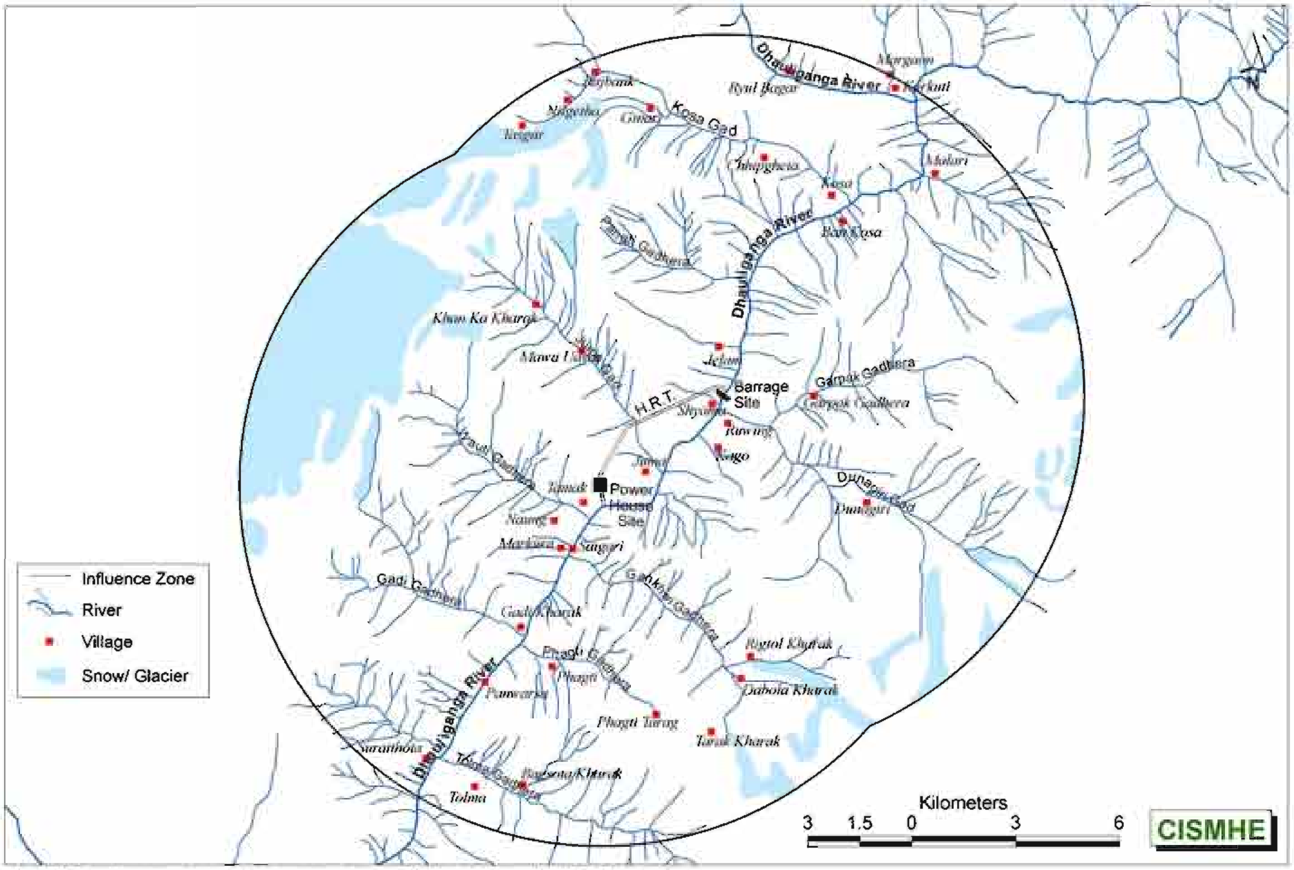


Fig.3.2 Drainage map of influence zone of Jelam-Tamak H.E. Project

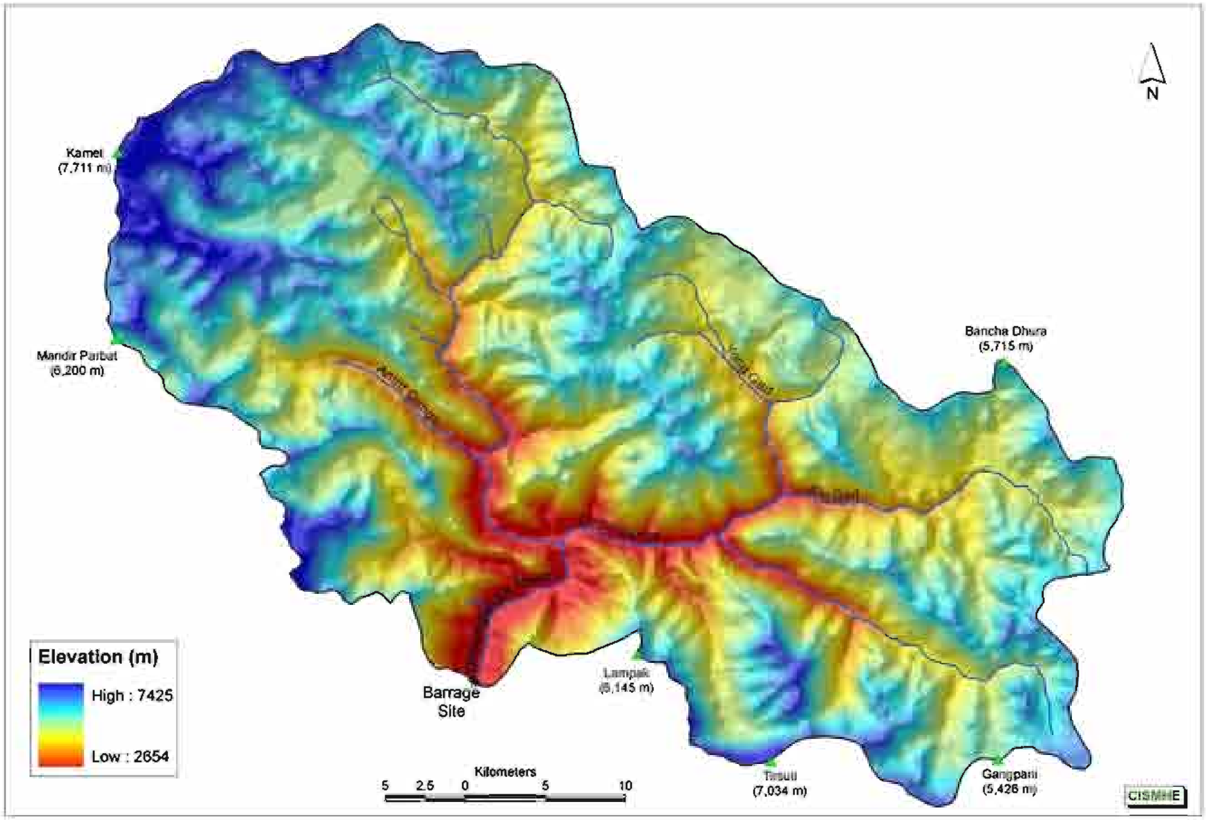


Fig.3.3 Digital Elevation Model (DEM) up to the proposed barrage site of Jelam Tamak H.E. Project

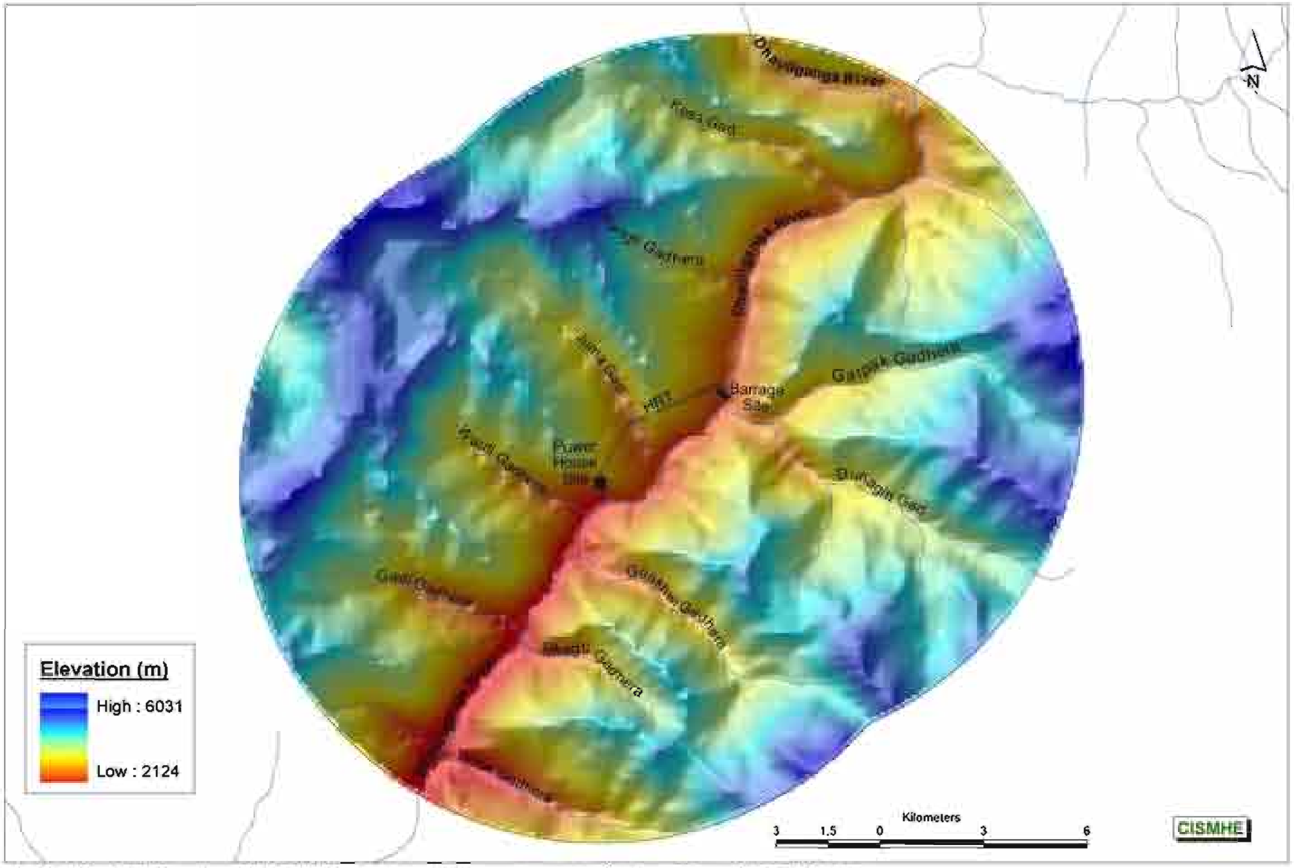


Fig.3.4 Digital Elevation Model (DEM) map of influence zone of Jelam-Tamak H.E. Project

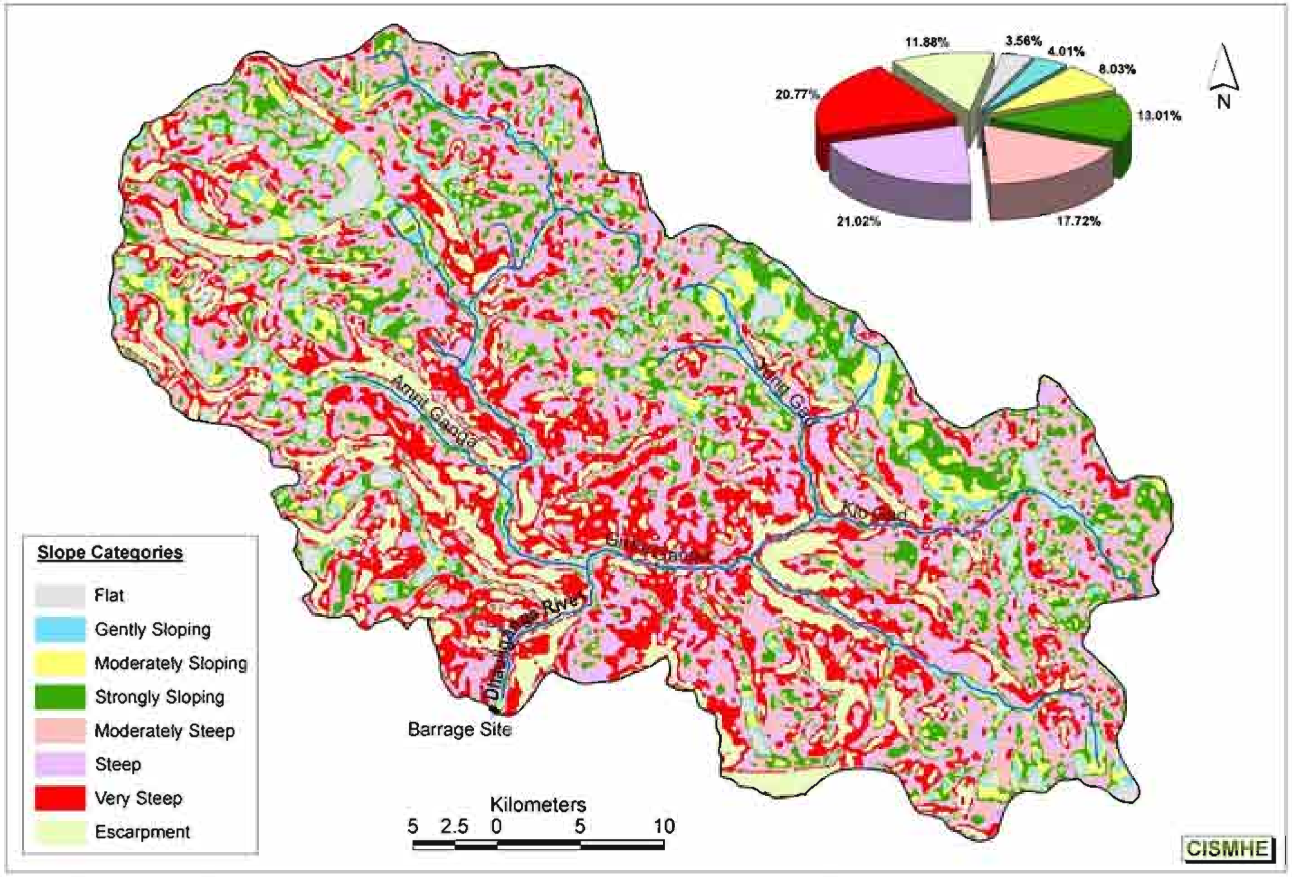


Fig.3.5 Slope map of Dhauliganga river catchment up to the proposed barrage site of Jelam Tamak H.E. Project

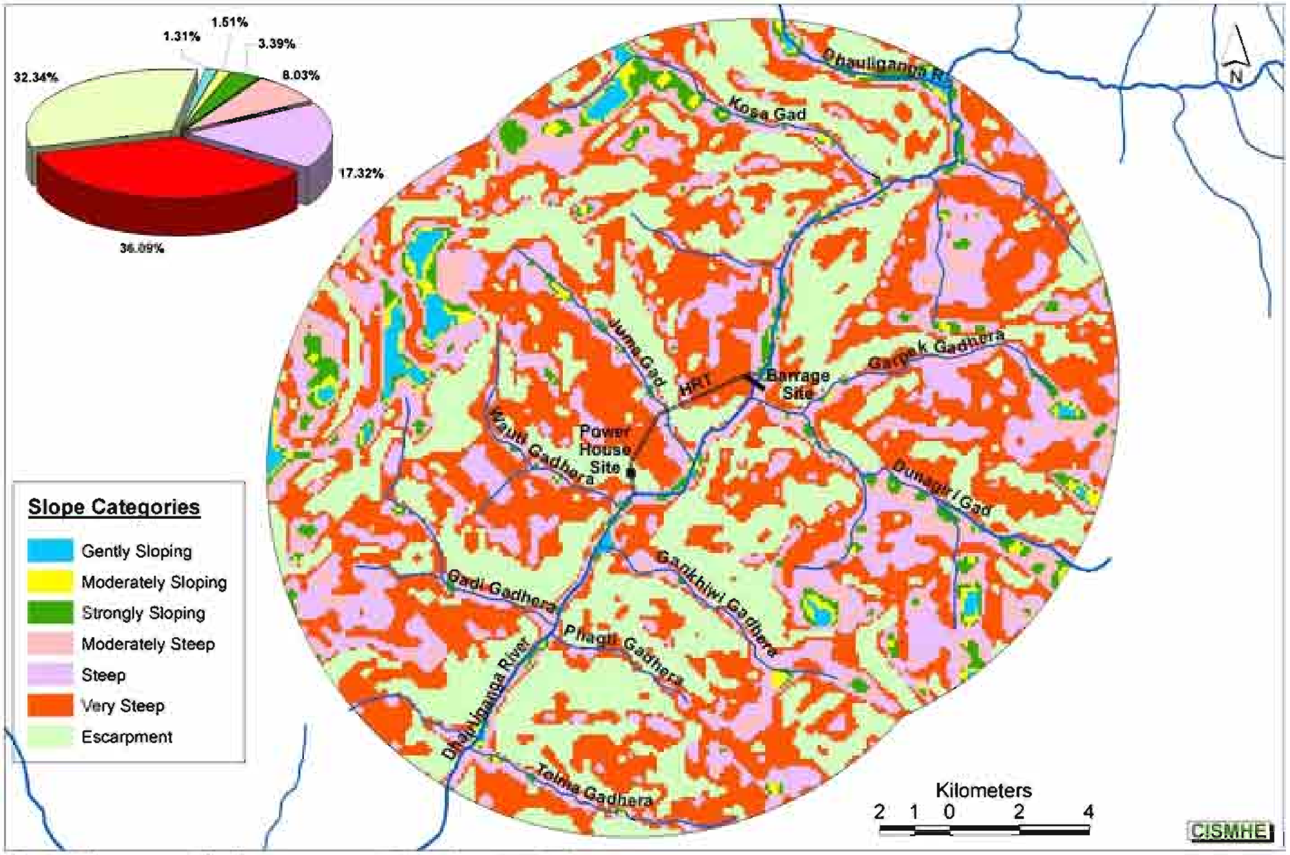


Fig.3.6 Slope map of influence zone of Jelam Tamak H.E. Project

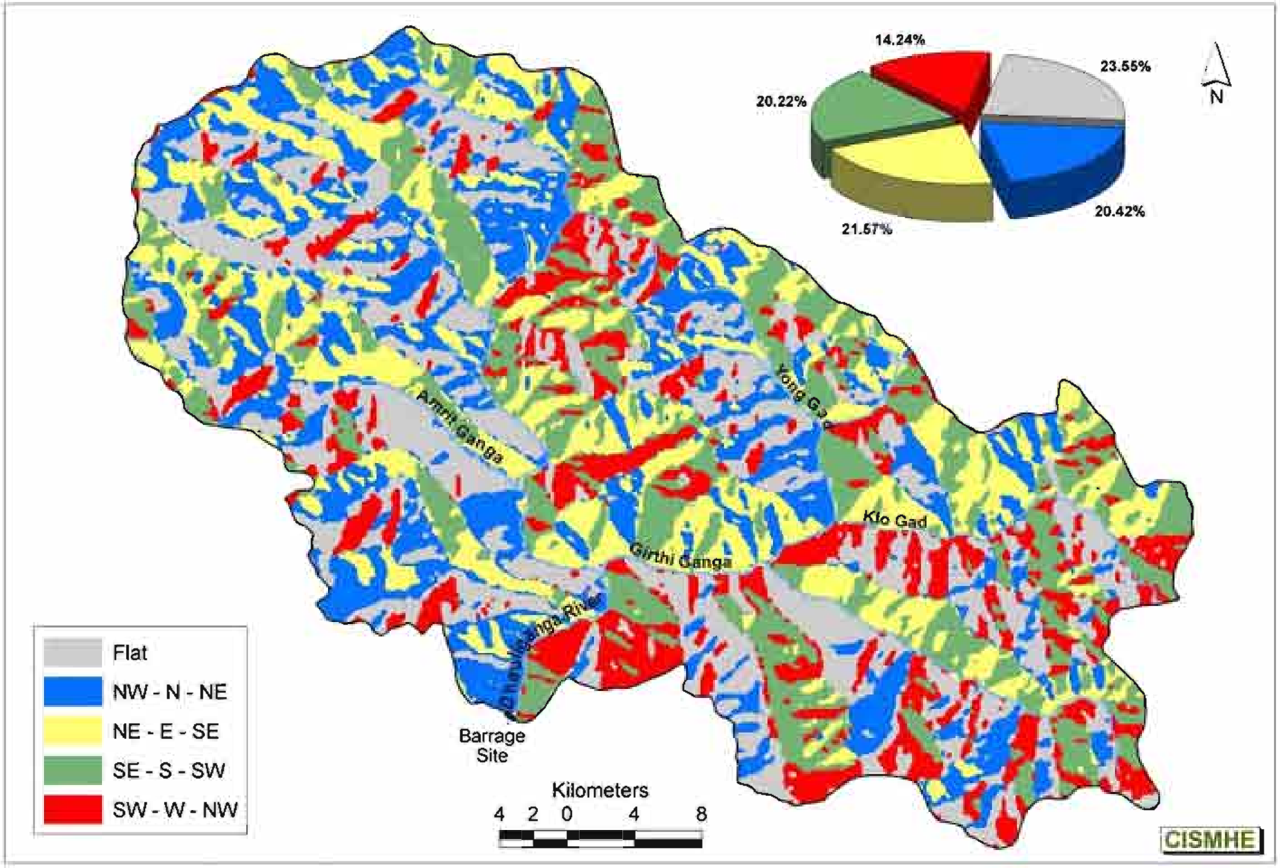


Fig.3.7 Aspect map of Jelam Tamak H.E. Project up to the proposed barrage site

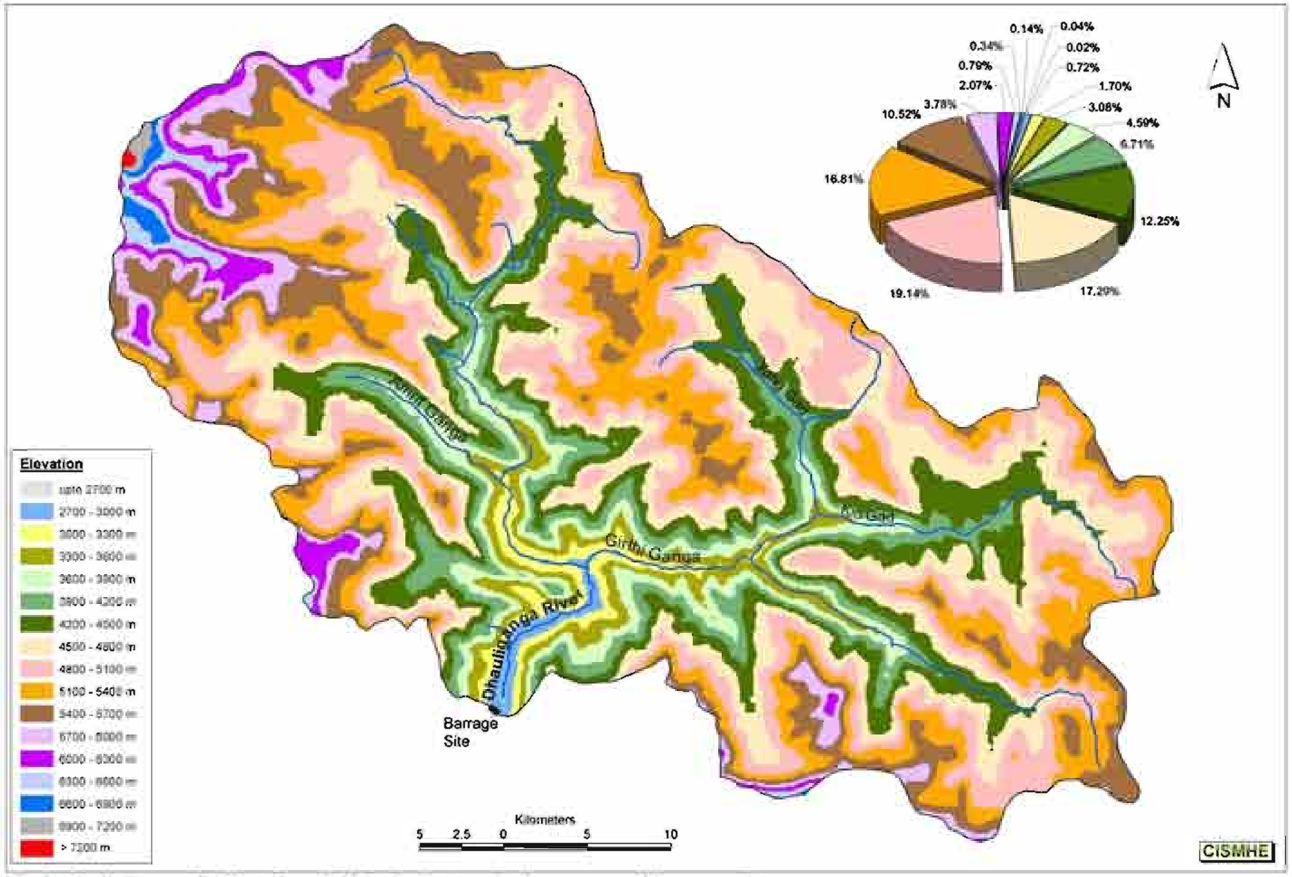


Fig.3.8 Relief map of Jelam Tamak H.E. Project up to the proposed barrage site

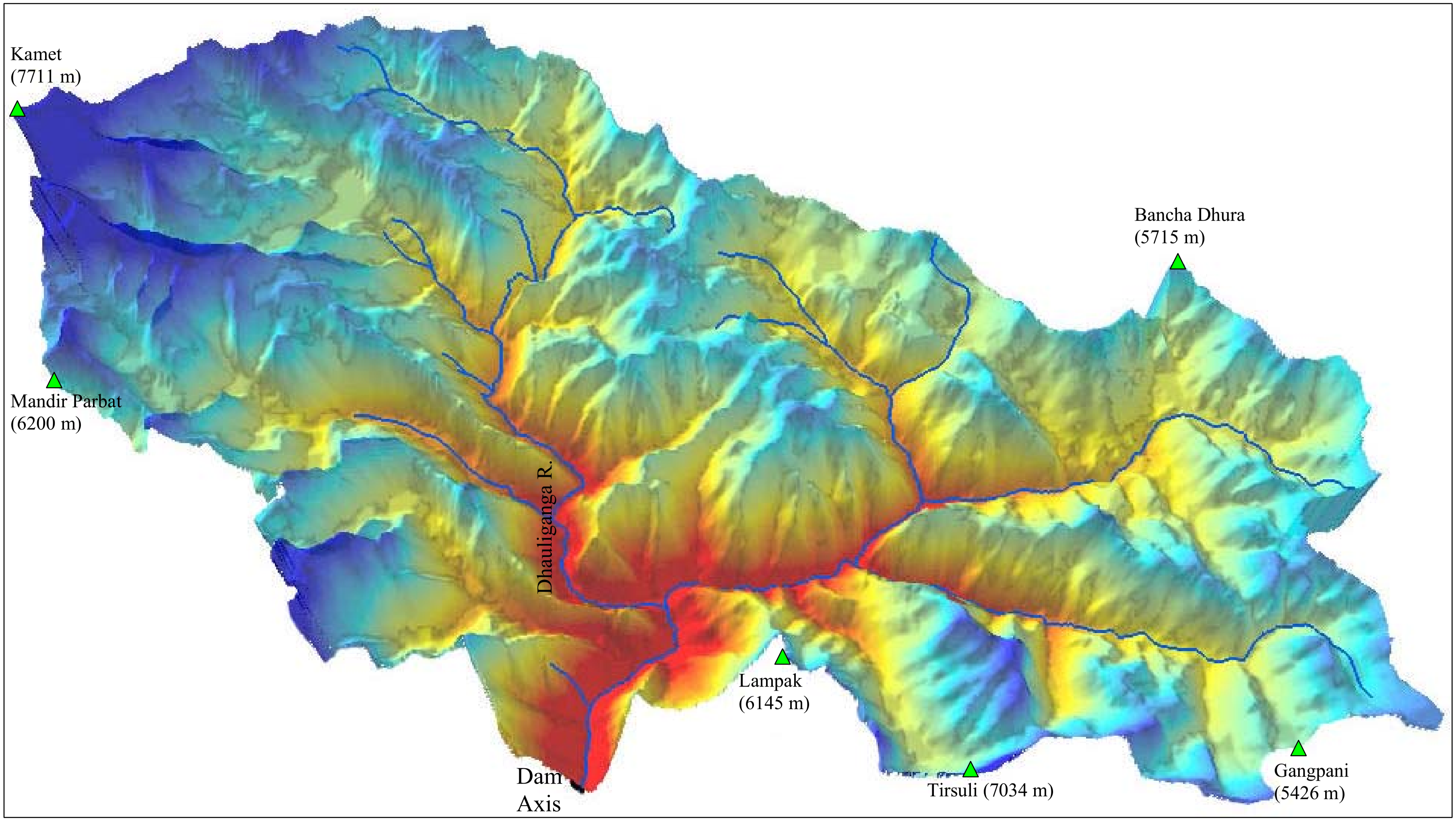


Fig.3.8a 3-D perspective view of Dhauliganga river up to the proposed dam axis of the Jelam Tamak H.E. Project

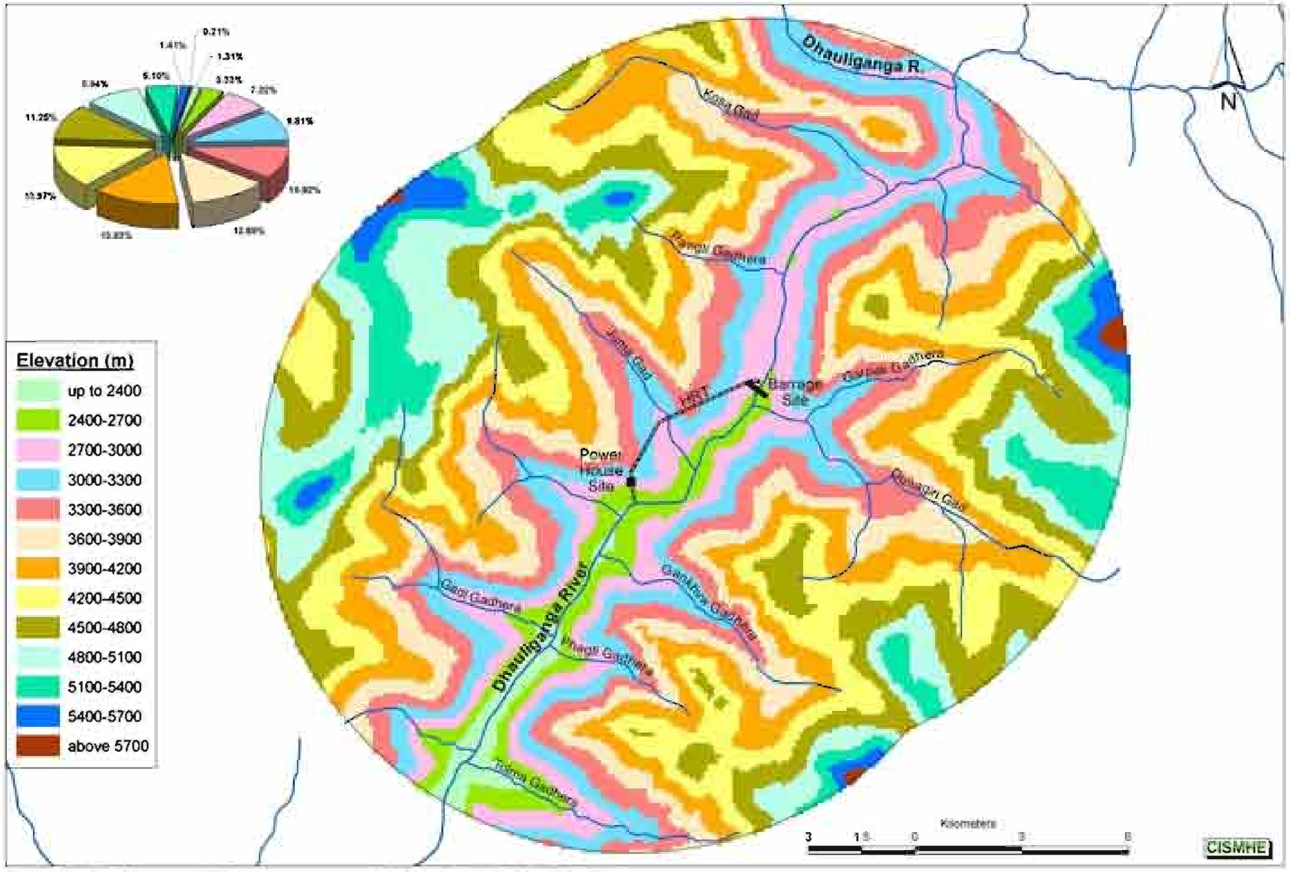


Fig.3.9 Relief map of influence zone of Jelam Tamak H.E. Project

Chapter 4

HYDROMETEOROLOGY

4

HYDROMETEOROLOGY

4.1 INTRODUCTION

Hydrometeorology of a river basin is controlled by rainfall, temperature, direction of wind, evapo-transpiration, drainage network etc. These meteorological, physical and environmental factors are guided by geographical position and topography of the basin, which in turn controls the vegetation, rock and soil covers. These hydro-meteorological parameters not only manifest the prevalent environment of a river basin, but also determines the setting up and viability of any development project and its management in it. Therefore availability of water and hydro-meteorological conditions in a basin is the key to the development of any hydroelectric project. Consequently the hydro-meteorological parameters are needed to be studied in detail in the context of hydropower development. All the hydro meteorological parameters varies over the year and this changing pattern is intricately associated with the ecology and impetus the ecological functionalities of the region. Therefore, this chapter discusses some aspects of hydro-meteorological system in the Jelam Tamak basin with reference to the development of proposed Jelam Tamak H.E. Project.

4.2 CATCHMENT CHARACTERISTICS

The Jelam Tamak H.E. Project is located on Dhauliganga river, a tributary of Alaknanda joining from the north at Joshimath. Dhauliganga is majorly a glacier fed river and it originates from the Kamat Glaciers which flows south to north-westwards before it joins Alaknanda. The catchment area of the proposed schemes spreads between 30^0 33’ 22” N to 31^0 00’ N latitudes and 79^0 34’ 52” E to 80^0 15’ 08” E longitudes. The terrain has highly undulating peaks with complex mountain topography. The rivers and streams along the higher reach flows through the steep valleys and steep gradients. The catchment consideration forms the inner parts of the lesser Himalayas and outer part of the Greater Himalayas. It presents extremely rugged topography with very high altitude mountain systems. The high altitudes are snow covered, whereas medium altitudes are largely covered with pine trees. The high ridges, which separate different river systems trend in NW-SE to WNW-ESE direction. The northern slopes in the catchment are gentler as compared to southern slopes due to influence in dip slope. The valleys are V-shaped, steep and narrow gorges. The river Alaknanda flowing south westerly is the principal draining agency in the Northern part of the area. The tributaries of Alaknanda include Dhauli Ganga, Birchi Ganga and Mandakini (modify after land use has to be done and Drainage).

4.3 CLIMATIC CONDITIONS OF THE UTTARAKHAND STATE

The catchment area of Jelam Tamak H.E Project lies in the northern part of the Uttarakhand. Therefore the area is characterized with cold weather. The State also experience the Monsoonal rhythm like other states and the year may accordingly divided into the following four main seasons according to seasonal distribution of temperature and rainfall and other broad climatic conditions prevailing over the region. It will be discussed in the following section of Precipitation and Rainfall. The state receives heavy rain almost throughout the year and practically without any dry months. In general, the major parts of the state is characterized with Alpine climate with cold winter and warm summer, whereas a small part of the state i.e., lowland area of Dehradun and Rishikesh is apparently warm during the summer with an average temperature of 33°C. Monthly temperature greatly varies according to the specific location and their local conditions. Temperatures are low for nine months in most part of the state and moreover the northern part of the state has low average temperature of 7°C during December and January where as southern part i.e., the lowland area is rather slightly warmer with an average temperature of 14°C. The average annual precipitation in the southern parts at Nainital, Dehradun and Roorkie are 2680 mm, 2180 mm and 1080 m respectively (Joshi, 2004). However in the northern part of *Lesser Himalaya* and the *Great Himalaya* the precipitation is comparatively lower than the southern part. In Chamoli district the average annual rainfall is of 980 mm (Joshi, 2004).

4.4 RAINFALL

The rainfall of the project area is controlled by two geoclimatic factors viz. its location in high altitude and seasons of the Himalayan belt. There are four seasons over a year viz. i) The cold weather season (Mid-December- Mid-March) ii) The summer of pre-monsoon (Mid-march-Mid June). iii) SW (South west) Monsoon or the season of general rains between (Mid-June-Mid-September). iv) Retreating Monsoon or the Post Monsoon (Mid-September-Mid December). Precipitation data was available at barrage site. Maximum rainfall was received during the month of August and September with a precipitation of 187 mm and 170 mm respectively. Winter months are characterized with lower precipitation with maximum of 54.8 mm in January. With the onset of March the rainfall decreases and it increases by the onset of monsoon.

4.5 WIND SPEED AND WIND DIRECTION

Wind speed and wind direction were directly assessed by CISMHE during our field visits in 2008-2009. These parameters were recorded for four sites (d/s of barrage Site, Power house Site, Jelam Nala and d/s of power House site) for the two seasons. Wind data for the pre-monsoon was acquired during March-2009 and for the post-Monsoon season was acquired during November-2008. The maximum wind speed of 16.3 Km/hr during the pre-monsoon was recorded at downstream of the barrage site and the lowest of 1.5 Km/r was recorded at d/s of the power house site. During the post-monsoon season, maximum of 12.7 Km/hr and minimum of 2.5 km/hr of wind speed were recorded at d/s of barrage site and power house site respectively (see Table 4.1). Followed by wind direction was recorded for pre-monsoon and post-monsoon seasons. During the pre-monsoon and post monsoon the wind direction at d/s of barrage site was S-N. The wind direction at the d/s of the power house site for pre-monsoon season was NE-WS direction and during the post-monsoon season was N-W direction respectively (see Table 4.1).

Table 4.1 Wind speed and Wind direction in the vicinity of project area.

Pre-Monsoon (May, 2009)		
Location	**Wind direction**	**Wind(Km/h)**
d/s Barrage Site	S to N	16.3
Power house Site	N to S	3.6
Jelam Nala	W to E	6.7
d/s Power House site	NE to WS	1.5
Post- Monsoon (November, 2008)		
Location	**Wind direction**	**Wind(Km/h)**
d/s Barrage Site	S-N	12.7
Power House Site	N-W	2.5
Jelam nala	W-N	13.4
d/s Power House site	N-W	11.5

4.6 WATER DISCHARGE AND WATER AVAILABILITY

4.6.1 Water Discharge Pattern

The water discharge for the Jelam Tamak basin was unavailable. Therefore d/s water discharge data was used and it was extrapolated. Later the water flow pattern for 35 years in the Jelam Tamak catchment was developed (**Fig. 4.1**). As the figure illustrates, the maximum and minimum 10-daily discharge was recorded in the middle of July and end of February, respectively. The average water discharge varies from 12.01 cumec in February to 111.19 cumec in July. There is a major increase in the water discharge in the month of May and slows down in the middle of September. With the onset of monsoon, the maximum discharge in the river was more than 149.40 cumec and reaches the peak in the month of July. The other peak discharges in the river are observed in middle of August (181.90 cumec) and beginning of July (174.60 cumec). From end of the September onwards, the water discharge in the river gradually decreases. However, heavy rainfall in the higher reaches during September may increase the water discharge in the river. During the monsoon period, average 10-daily discharge varies from 164.80 cumec in the month of August to 115.23 cumec in the month of June. In lean season, mean 10-daily discharge varies from 3.1 cumec in the month of January to 50.10 cumec in the month of December. Water discharge data was recorded at Tamak near power house site for the year 2007-2008. The discharge varies from 6.2 cumec in November to 180.2 cumec in August (**Fig. 4.2**).

4.6.2 Water availability and Optimization study

The total annual inflow rate in the Jelam Tamak H.E. Project site during 1972-73 to 2007-2008 water years is presented in **Figure 4.3**. As earlier stated that discharge data was extrapolated using data sources from d/s discharge data. In most of the years, the annual inflow shows above 1000 Mcum. The maximum inflow of 2,659.59 Mcum was recorded in the year 1998-1999, while the minimum of 819.9965 Mcum was recorded in the year 1982-1983. Further if the total energy generation in the years for which hydrological data is available (35 years) is arranged in descending order, the (35+1)*0.9th year would represent the 90 per cent dependable year (1991-1992). The 90 per cent dependable year is a year in which the annual energy generation has the probability of being equal to or in excess of 90 per cent of the expected period of operation of the scheme. The average 10-daily water discharge in Dhauliganga river at the barrage site for 90% dependable year (1971-1972) and 50% dependable year (1996-1997) is shown in Table 4.2. In the 50% dependable year water discharge ranges from 6.5 to 135.8 cumecs with minimum in the month of March and maximum in the month of June. In the 90% dependable year water discharge ranges from 12.9 to 64.7 cumecs with minimum in the months of February and March and maximum in the month of June (Table 4.2).

Table 4.2 Water availability and optimization for 90% dependable and 50% dependable years

Month	**10 Daily**	**1971-72 (90% dependable year)**	**1996-97 (50% dependable year)**
Jun	I	64.7	86.6
	II	62.8	113.3
	III	61	135.8
Jul	I	60.3	102.0
	II	51.5	126.9
	III	63.4	130.9
Aug	I	63.6	132.7
	II	61.6	134.6
	III	57.4	104.2
Sep	I	52	101.4
	II	45.7	84.3
	III	43.4	70.0
Oct	I	42.1	51.0
	II	40.7	38.2
	III	32.3	28.1
Nov	I	32.6	22.2
	II	22.6	17.0
	III	18.6	14.2
Dec	I	16.8	12.9
	II	17.2	11.4
	III	15.3	9.8

Jan	I	15.9	8.9
	II	16.4	8.1
	III	14.3	7.7
Feb	I	13.4	7.1
	II	13.9	6.8
	III	12.9	6.5
Mar	I	12.9	6.7
	II	13.2	6.7
	III	15.7	6.8
Apr	I	16.8	8
	II	22.7	9.7
	III	23.6	18.8
May	I	27.8	23.4
	II	48.4	17.8
	III	60.5	38.6

4.6.3 Water Discharge Pattern in Downstream Tributaries

In the downstream of proposed barrage 4 tributaries, namely Dunagiri Gad (left bank), Jumma Gad (right bank), unnamed Gad (left bank) and Bhosing Gad (left bank) contribute to discharge of Dhaulingang river. Dunagiri is largest tributary, joins the river Dhauliganga at 0.52 km downstream of proposed barrage. Water discharge in Dunagiri Gad varies from 1.17 to 10.67 cumec with minimum in February and maximum in July. Bhosing Gad is last tributary in between barrage and TRT, joins Dhauliganga 4.04 km downstream of Barrage. The annual water discharge in Bhosing Gad varies from 0.04 to 0.38 cumec (Table 4.3; **Fig. 4.4**)

Table 4.3 10 daily water discharge pattern of downstream tributaries of Dhauliganga river

Months		Dunagiri Gad	Unnamed gad	Jumma Gad	Bhosing Gad
Jun	I	7.34	0.23	1.34	0.26
	II	8.01	0.26	1.46	0.29
	III	9.16	0.29	1.67	0.33
Jul	I	9.72	0.31	1.77	0.35
	II	10.32	0.33	1.88	0.37
	III	10.67	0.34	1.94	0.38
Aug	I	10.18	0.33	1.86	0.36
	II	9.65	0.31	1.76	0.34
	III	8.82	0.28	1.61	0.31
Sep	I	8.04	0.26	1.47	0.29
	II	6.92	0.22	1.26	0.25
	III	5.80	0.19	1.06	0.21
Oct	I	4.90	0.16	0.89	0.17
	II	4.28	0.14	0.78	0.15
	III	3.36	0.11	0.61	0.12
Nov	I	2.81	0.09	0.51	0.10
	II	2.39	0.08	0.44	0.09
	III	2.07	0.07	0.38	0.07
Dec	I	1.83	0.06	0.33	0.07
	II	1.67	0.05	0.30	0.06
	III	1.51	0.05	0.28	0.05
Jan	I	1.34	0.04	0.24	0.05
	II	1.27	0.04	0.23	0.05
	III	1.22	0.04	0.22	0.04
Feb	I	1.17	0.04	0.21	0.04
	II	1.17	0.04	0.21	0.04
	III	1.18	0.04	0.22	0.04
Mar	I	1.24	0.04	0.23	0.04
	II	1.31	0.04	0.24	0.05
	III	1.48	0.05	0.27	0.05
Apr	I	1.73	0.06	0.32	0.06
	II	2.16	0.07	0.39	0.08
	III	3.06	0.10	0.56	0.11
May	I	4.25	0.14	0.77	0.15
	II	5.79	0.18	1.05	0.21
	III	7.31	0.23	1.33	0.26

4.7 FLOOD PEAK

The variation pattern of flood peaks shows that the peaks attain high level every 8 to 10 years for Tamak dam axis site. To assess the flood peaks at the dam axis we considered the above discharge data from 1972-1973 to 2007-2008 years provided by THDC-DPR, 2010. High flood peaks were observed in 1998-1999, 2003-2004, 1978-1979 and 1988-1989. In 1998-1999 the observed peak was 2659.59 Mcum and in 2003-2004 the observed peak was 1884.35 Mcum.

4.8 SEDIMENTATION IN THE RESERVOIR

The slopes on both the banks of the reservoir are very steep. To assess the sedimentation, the data for Tamak dam site was calculated from DPR (2010). Of the total silt load the proportion of coarse silt is high in all the months and that of the fine silt is lowest. The fine silt fraction has concentration similar to that of medium silt during monsoon and pre-monsoon. The average (average of averages) of suspended sediment load at Tamak site has been worked out on the basis of observed sediment data at Tamak (THDC, 2010). Based on this data, the average suspended load of 14 months at Tamak works out to be 0.433 g/l of which coarse, medium and fine constitute 0.338 g/l, 0.038 g/l and 0.055 g/l, respectively (see Table 4.4). The highest sediment load was observed in the months of June and July.

Table 4.4 Sediment load at barrage site in g/l for coarse, Medium and Fine

Month	Coarse (g)	Medium (g)	Fine (g)	Total Sediment (g)
April, 2007	0.038	0.046	0.044	0.145
May, 2007	0.250	0.114	0.198	0.562
June, 2007	3.576	0.159	0.366	4.102
July, 2007	0.864	0.111	0.173	1.148
August, 2007	0.069	0.017	0.007	0.093
September	0.116	0.070	0.028	0.214
October, 2007	0.044	0.034	0.010	0.090
November, 2007	0.012	0.003	0.001	0.017
December, 2007	0.007	0.003	0.000	0.008
January, 2008	0.015	0.003	0.001	0.019
February, 2008	0.008	0.001	0.000	0.009

March, 2008	0.031	0.001	0.000	0.033
April, 2008	0.015	0.003	0.001	0.020
May, 2008	0.015	0.003	0.001	0.020
June, 2008	0.016	0.003	0.001	0.020
Average	0.338	0.038	0.055	0.433

4.9 ENVIRONMENTAL IMPLICATIONS

The stretch up to barrage site requires special attention for the purpose of catchment area treatment in case of soil erosion and high siltation during the Monsoon period. In addition the instantaneous flood peaks attained in 1998-1999 (2659.59 Mcum) and in 2003-2004 (1884.35 Mcum) considered. Therefore an appropriate disaster management plan is necessary for the purpose of catastrophic events like dam break failure. Continual release of certain cumec into the downstream stretch will help to maintain and sustain the ecological functions in this region.

4.10 GLACIAL LAKE OUTBURST FLOODS

Detailed studies on the glacial lake outburst floods (GLOF) have been provided by project developers. The studies were carried out by Jain et al (2012). In order to include the report in the chapter of Hydrometeorology, it has been formatted accordingly, however, original contents was not changed. All references cited from this contribution have been included in Bibliography section of the EIA report.

The Himalayan region has permanent snow fields and in winter most of the high-altitude regions experience snowfall. Himalayan glaciers are an important source of fresh water for northern Indian rivers and water reservoirs (Kumar *et al*., 2005). Due to the rapid recession of glaciers, a number of catastrophic affects such as glacial lake outburst floods (GLOF) (WWF, 2005; Mool *et al*., 2007), water scarcity in the upper Himalayan villages and adverse effects on the flow of Himalayan rivers have been reported (Kulkarni *et al*., 2002; 2007). In the Himalayan region, major rivers are originating from glaciers and larger portion of the freshwater resources are locked up in ice and snow. It is reported, during the last few decades there has been a rapid retreat of glaciers which has created many precarious glacial lakes in the Himalayan region.

4.10.1 Glacial Lakes

A glacial lake is defined as water mass existing in a sufficient amount and extending with a free surface in, under, beside, and/or in front of a glacier and originating from glacier activities and/or retreating processes of a glacier. The isolated lakes found in the mountains and valleys far from the glaciers may not have a glacial origin. Due to the rapid rate of ice and snow melt, possibly caused by global warming, accumulation of water in these lakes has been increasing rapidly in Himalaya. The isolated lakes above 3,500 msl are considered to be the remnants of the glacial lakes left due to the retreat of the glaciers (Chambel, 2005).

The lakes located at the snout of the glacier are mainly dammed by the lateral or end moraine, where there is high tendency of breaching. Such lakes could be dangerous as they may hold a large quantity of water. Breaching and the instantaneous discharge of water from such lakes can cause flash floods enough to create enormous damage in the downstream areas. In order to assess the possible hazards from such lakes it is therefore essential to have a systematic inventory of all such lakes formed at the high altitudes. This is feasible by identifying them initially through satellite images (and aerial photographs, if available) and to assess their field setting subsequently. Besides making a temporal inventory, a regular monitoring of these lakes is also required to assess the change in their nature and aerial extent. The lakes are classified into Erosion, Valley trough, Cirque, Blocked, Moraine Dammed (Lateral Moraine and End Moraine Dammed lakes), and Supraglacial lakes (Chambel, 2005).

Erosion lakes

Glacial Erosion lakes are the water bodies formed in a depression after the glacier has retreated. They may be Cirque type and trough Valley type lakes and are stable lakes. These Erosion lakes might be isolated and far away from the present glaciated area.

Supraglacial lakes

The Supraglacial lakes develop within the ice mass away from the moraine with dimensions of 50 to 100 meters. These lakes may develop in any position of the glacier but the extension of the lake is less than half the diameter of the Valley glacier. Shifting, merging, and draining of the lakes are the characteristics of the Supraglacial lakes. The merging of lakes results in expansion of the lake area and storage of a huge volume of water with a high level of potential energy. The tendency of a glacial lake towards merging and expanding indicates the danger level of the GLOF.

Moraine Dammed lakes

In the retreating process of a glacier, glacier ice tends to melt in the lowest part of the glacier surrounded by Lateral Moraine and End Moraines. As a result, many supraglacial ponds are formed on the glacier tongue. These ponds sometimes enlarge to become a large lake by interconnecting with each other and have a tendency to deepen further. A Moraine Dammed lake is thus born. The lake is filled with melt water and rainwater from the drainage area behind the lake and starts flowing from the outlet of the lake even in the winter season when there is minimum flow. There are two kinds of moraine: an ice-cored moraine and an ice-free moraine. Before the ice body of the glacier completely melts away, glacier ice exists in the moraine and beneath the lake bottom. The ice bodies cored in the moraine and beneath the lake are sometimes called dead ice or fossil ice. As glacier ice continues to melt, the lake becomes deeper and wider. Finally, when ice contained in the moraines and beneath the lake completely melts away, the container of lake water consists of only the bedrock and the moraines.

Blocking lakes

Blocking lakes are formed through glacier and other factors, including the main glacier blocking the branch valley, the glacier branch blocking the main valley, and the lakes through snow avalanche, collapse and debris flow blockade.

Ice-dammed lakes

An Ice-dammed lake is produced on the side(s) of a glacier, when an advancing glacier happens to intercept a tributary/tributaries pouring into a main glacier valley. As such, an Ice coredammed lake is usually small in size and does not come into contact with glacier ice. This type of lake is less susceptible to GLOF than a moraine dammed lake. A glacial lake is formed and maintained only up to a certain stage of glacier fluctuation. If one follows the lifespan of an individual glacier, it is found that the Moraine Dammed glacial lakes build up and disappear with a lapse of time. The moraine dammed lakes disappear once they are fully destroyed or when debris fills the lakes completely or the mother glacier advances again to lower altitudes beyond the moraine-dam position. Such glacial lakes are essentially ephemeral and are not stable from the point of view of the life of glaciers. Generally, moraine dammed lakes pose a threat in the basin.

4.10.2 Glacial Lake Outburst Floods

A Glacial Lake Outburst Flood (GLOF) is created when water dammed by a glacier or a moraine is released. Some of the glacial lakes are unstable and most of them are potentially susceptible to sudden discharge of large volumes of water and debris which causes floods downstream i.e. GLOF. GLOFs are severe geomorphological hazards and their floodwaters can wreak havoc on all human structures located along their path. Much of the damage created during GLOF events is associated with large amounts of debris that accompany the floodwaters. GLOF events have resulted in many deaths, as well as the destruction of houses, bridges, entire fields, forests, and roads. Unrecoverable damage to settlements and farmland can take place at great distances from the outburst source. In most of the events livelihoods are disturbed for long periods. The lakes at risk, however, are situated in remote and often inaccessible areas. When they burst, the devastation to local communities could be tremendous, while those in far away cities downstream may be unaware of the catastrophe. Many glacial lakes are known to have formed in the Himalaya in the last half century, and a number of GLOF events have been reported in the region in the last few decades. Due to extreme hazard potential of GLOF events, it is necessary to take into account GLOF while planning, designing and constructing any infrastructure, especially water resources projects, as they are located on the path of glacial lake outburst flood wave and would be the prime target in case of GLOF.

Since the beginning of last century the number of glacial lake outburst floods (GLOFs) increased in the Himalaya (Richardson and Reynolds, 2000). Previous studies showed already that the risk of lake development is highest where the glaciers have a low slope angle and a low flow velocity or are stagnant (Quincey et al., 2007; Reynolds 2000). Whether glacial lakes become dangerous depends largely on their elevation relative to the spillway over the surrounding moraine (Benn et al., 2001; Sakai et al., 2007). Triggering events for an outburst can be moraine failures induced by an earthquake, by the decrease of permafrost and increased water pressure, or a rock or snow avalanche slumping into the lake causing an overflow (Buchroithner et al., 1982; Ives, 1985; Viuchard and Zimmerman, 1987).

Factors contributing to the hazard risk of moraine-dammed glacial lake include (a) large lake volume, (b) narrow and high moraine dam, (c) stagnant glacier ice within the dam, and (d) limited freeboard between the lake level and the crest of the moraine ridge. Potential outburst flood triggers include avalanche displacement waves from (A) calving glaciers, (B) hanging glaciers, and (C) rock falls; (D) settlement and/or piping within the dam; (E) melting ice-core; and (F) catastrophic glacial drainage into the lake from subglacial or englacial channels or supraglacial lakes. A schematic diagram of a moraine-dammed glacial lake is shown in **Figure 4.5**.

4.10.3 Criteria for the identification of Potential Glacial Lake Outburst Floods

In general, based on geo-morphological characteristics, glacial lakes can be grouped into three types: glacial Erosion lakes, glacial Cirque lakes, and Moraine Dammed lakes. The former two types of glacial lakes occupy the lowlands or emptying cirques eroded by ancient glaciers. These glacial lakes are more or less located away from present-day glaciers and the downstream banks are usually made of bedrock or covered with a thinner layer of loose sediment. Both of these glacial lakes do not generally pose an outburst danger. On the other hand, the Moraine Dammed glacial lakes have the potential for bursting. A standard index to define a lake that is a source of potential danger because of possible bursting does not exist. Moraine Dammed glacial lakes, which are still in contact or very near to the glaciers, are usually dangerous. These glacial lakes were partly formed between present-day glaciers and Little Ice Age moraine. The depositions of Little Ice Age moraines are usually about 300 years old, form high and narrow arch-shaped ridges usually with a height of 20–150 m, and often contain dead glacier ice layers beneath them. These End Moraines are loose and unstable in nature. The advance and retreat of the glacier affect the hydrology between the present-day glacier and the lake dammed by the moraines. Sudden natural phenomena with a direct effect on a lake, like ice avalanches or rock and Lateral Moraine material collapsing on a lake, cause moraine breaches with subsequent lake outburst events. Such phenomena have been well known in the past in several cases of Moraine Dammed lakes, although the mechanisms at play are not fully understood.

4.10.4 Literature Review

Various studies have focused on glacial lake outbursts. In Peru, for example, the problem has been fully recognized since 1941, when an outburst flood destroyed the city of Huaráz killing 4500 people (Lliboutry et al. 1977). A considerable number of mitigation works have been carried out since (e.g., Ames 1998; Reynolds et al. 1998). In the Himalayas, retreating glaciers have prompted the evolution of large and rapidly growing lakes in glacial forefields with extremely high damage potential (Reynolds 1998; Yamada 1998). In the past decades, several lakes caused outburst floods affecting human lives and infrastructure (Vuichard and Zimmermann 1987; Yongjian and Jingshi 1992; Hanisch et al. 1996). Glacier lake outbursts were also studied in detail in North America, mainly in western Canada (Clague and Evans 1992; Mathews and Clague 1993; Clague and Evans 2000) as well as in Central Asia (Popov 1997). In the Alps, and particularly in the Swiss Alps, the situation is different from the above regions because the lakes are generally smaller, and the infrastructure and settlements are situated much closer to the hazard sources. As a result, even small glacial and periglacial lakes have caused considerable damage (Haeberli 1980). As a result of a relatively high density and quality of documentation from historical sources and recent case studies in Switzerland, data on historical outburst catastrophes could be evaluated and compiled in a database forming a valuable background for empirical studies (Haeberli 1983; Huggel et al. 2000).

In Uttaranchal, India the sources of its major rivers and the bulk of its freshwater resources are locked up in ice and snow. During the last few decades there has been a rapid retreat of glaciers creating many moraine-dammed lakes. The formation of such lakes could be dangerous as these lakes may contain a large quantity of water and lakes can cause flash floods in the downstream areas. Compared to other basins of Himalaya there are quite a few numbers of such lakes in Uttaranchal. Even though to assess the possible hazards from such lakes, it has become essential to have the systematic inventory of all such lakes formed at the high altitudes. Besides making a temporal inventory, a close monitoring of these lakes is required to assess the change in their behavior.

The objective of this study is to study the Glacial Lake Outburst Flood at proposed dam site at Jelam Tamak.

4.10.5 The Study Area

The Jelam Tamak Hydro-electric project is a run of the river scheme proposed on the Dhauliganga River in Chamoli district of Uttarakhand. The project envisages construction of a 28 m high elevation structure across river Dhauliganga approximately 2.5 km downstream of the location of the power house of upstream Malari Jelam Hydroelectric project. The river bed level at the diversion site is a EL 2623.5m and the crest level of the main barrage bays is at EL 2624.50m. The diverted water shall be carried though a water conductor system to underground power house, harnessing a head of approximately 200m. Pertinent details of project are as follows:

State	Uttarakhand
District	Chamoli
Location of Diversion Site	Downstream of Jelam village about 3 km from Malari Power house
Latitude	30º 37’ 35.4” N
Longitude	79º 49’ 39.5” E
River Basin	Ganga
River	Dhauliganga
Catchment Area	1666 km²
Installed Capacity	126MW (as per FR)
River Bed Elevation	EL.2623.5 m
Full Reservoir Elevation	EL.2648.50 m
Diversion Structure	Barrage
Height of diversion structure above river bed	28 m
Crest level (Spillway bay)	2624.5 m
Crest level (Under sluice bay)	2623.5 m
Gross head	221.77 m

The total catchment area of river Dhauliganga up to the proposed diversions site is 1666 km². The rain fed catchment area is 787 km² (47%) and the snow fed area is 879 (53%). The catchment above the diversion site at Jelam is fan shaped.

4.10.6 Data Used

The basic materials used for the compilation of an inventory of glaciers and glacial lakes are different type of satellite images, topographic maps and published maps, field report and available literatures. Medium to high resolution satellite images of different dates are more useful in the inventory of glaciers and glacial lakes. The combination of satellite remote sensing data and the digital elevation model (DEM) were also used for better interpretations and more accurate results for the inventory of glaciers and glacial lakes in the three dimension geographic information system platform.

4.10.6.1 *Satellite data*

For glacier and glacial lake identification from satellite images, the images should be with least snow cover and cloud free. Least snow cover in the Himalaya occurs generally in the summer season (May-September). But during this session, monsoon clouds will block the views. If snow precipitation is late in the year, winter images are also suitable expect for the problem of long relief shadows in the high mountain regions. For the present study, most of the images are the winter season under the conditions of least seasonal snow cover and cloud free. The details of the satellite data is given in Table 4.5.

4.10.6.2 *Digital Elevation Model*

In the present study, DEM generated using ASTER has been used. ASTER (Advanced Spaceborne Thermal Emission and Reflection Radiometer sensor) is an imaging instrument that is flying on the TERRA satellite launched in December 1999 as part of NASA's Earth Observing System (EOS). ASTER represents a revolution in the remote sensing community because of the availability of its imagery and its superior resolution. ASTER resolution ranges from 15m to 90m, depending on the wavelength. The instrument records in three bands: the Visible and Near Infrared (VNIR), the Shortwave Infrared (SWIR), and the Thermal Infrared (TIR), oriented on the nadir and backward looking. There are 14 spectral bands all together spanning the visible and infrared spectra, so the sensor is susceptible to cloud cover and cannot record images at night. Because of its off-nadir sensor pointing capability, ASTER can collect the stereo pairs necessary to generate high resolution DEMS (using bands 3N and 3B).The ASTER onboard the Terra satellite has produced 30 m resolution elevation data. There is a fairly complete coverage of world at this high resolution and data are free. Japan’s Ministry of Economy, Trade and industry (METI) and NASA announced the release of the ASTER Global Digital Elevation Model (GDEM) on June 29, 2009. The GDEM was created by stereo-correlating the 1.3 million scene ASTER VNIR archive, covering the Earth’s land surface between 83N and 83S latitudes. The GDEM is produced with 30 meter postings, and is formatted in 1 x 1 degree tiles as GeoTIFF files. The GDEM is referenced to the WGS84/EGM96 geoid. The GDEM’s pre-production accuracy estimates were 20 meters at 95% confidence for vertical data, and 30 meters at 95% confidence for horizontal data.

Table 4.5 Satellite data used in this study

Year	Satellite	97/49	98/49
1999	IRS-1D	21 November	26 November
2004	IRS-1D	16 April, 7 September	21 April, 12 September
2005	IRS-1D	11 April, 13 November	16 April, 18 November
2006	IRS-1D	06 April, 15 October	05 May, 26 September
2007	IRS-P6	08 March, 27 November	06 April, 26 December
2008	IRS-P6	19 April, 10 September	24 April, 15 September

4.10.7 Methodology

4.10.7.1 *Creation of Data Base*

The ERDAS imagine 9.3 and Arc GIS 9.3 have been used for the processing of satellite data and GIS analysis. In the present study, digital elevation map of Dhauliganga basin up to Jelam Tamak H.E. Project has been prepared using ASTER DEM and shown in **Figure 3.3** and the same is shown as 3-dimensional in **Figure 3.8a**. The total area up to dam site is 4782.9 km^2. The brighter pixels in the DEM are with higher elevation values while the darker pixels are with lower elevation values. The mountain ridges and river valleys in the study area can be seen in the DEM. The elevation values ranges from a minimum of 2593 m to maximum of 7693 m within the study area. Drainage map of the study area has been prepared using the DEM and shown in **Figure 3.1**. The area of the catchment up to Jelam Tamak comes out to be 1685 Km2. All the streams show marked characteristics of mountain streams. They flow between high Rocky Mountains confining the channel in a narrow valley. As the gradient of the river falls markedly, the streams rush tumultuously over beds of huge boulders and rock masses. Satellite data browsing was done for selecting suitable satellite data covering the years 1999 to 2008 and given in previous chapter. Cloud free LISS- III image from IRS 1D and IRS-P6 satellite of different dates were purchased, NRSC, Hyderabad.

4.10.7.2 *Glacial Lake Mapping*

A glacial lake is a water mass existing in sufficient amount and extending with a free surface in, under, beside and/or in front of a glacier and originated by glacier activities such as the retreating processes of a glacier. For glacial lakes identification from the satellite images, the image should be with minimum snow cover and cloud free. The detection of glacial lakes using multispectral imagery involves discriminating between water and other surface types. Delineating surface water can be achieved using the spectral reflectance differences. Water strongly absorbs in the near- and middle-infrared wavelengths (0.8–2.5µm). Vegetation and soil, in contrast, have higher reflectance in the near- and middle-infrared wavelengths; hence water bodies appear dark compared to their surroundings when using these wavelengths (Pietroniro and Leconte 2000). When applying basic techniques of multispectral classification similar to those used for the normalized difference vegetation index, NDVI (Hardy and Burgan 1999), a normalized difference water index (NDWI) for lake detection was used (Huggel 1998). Applying the idea of two spectral channels with maximum reflectance difference for an object (i.e., water), a blue channel (maximum reflectance of water) and a near-infrared (NIR) channel (minimum reflectance of water) were chosen.

$$\text{NDWI} = \frac{\text{Green Band} - \text{NIR Band}}{\text{Green Band} - \text{NIR Band}}$$

As a result of spectral reflection, some self shadowed areas are misclassified as lakes. These areas have been found with the help of DEM, the DEM was over-laid on NDWI image. It could thus be assured that only lake appeared as black spots. After that, manual delineation of lakes has been carried out. Lake boundaries were digitized using ERDAS Imagine vector module tools. The digitized polygons have been assigned polygon ID’s. The area of the lake was calculated using the digital techniques by counting the number of pixels falling inside the water body polygon. The geographic latitude and longitude of the centre of the lake has been computed using attributes information of the polygon later. There may be a possibility of some lakes which are snow covered and can not be fully distinguishable in the satellite data. The lakes or water bodies which are partly snow covered or fully snow covered and could not be distinguishable are not reported.

4.10.7.3 *Glacial Lake Outburst Flood (GLOF) Simulation*

In order to get the maximum GLOF peak for Jelam Tamak H.E. Project, the outbursting or breaching of biggest glacial lake have been considered along with channel routing. Arc-GIS and ERDAS Imagine software were used to delineate cross-sections of the stream. For this purpose the vector layer of the stream and the buffer lines along the stream on the both side of stream at the distance of 1 km were created. The stream was divided at the distance of 5 Km from lake side and the cross-section layer was created. ERDAS Imagine Software was used to overlay DEM of basin and vector layer of cross-section. The Spatial Profile Viewer in ERDAS allows to visualize the reflectance spectrum of a polyline of data file values in a single band of data (one dimensional mode) or in many bands (perspective three-dimensional mode). This is being used to create a height cross-section profile along a route. This helps in interpreting changes in elevation along a planned route and in identifying sections of the route which are particularly steep or flat. Inquire cursor of ERDAS Imagine was used to extract the elevation values at each pixel.

There is no estimate available for volume of glacial lakes in Gharwal Himalaya from their water spread areas. However, some estimates are available for glacial lakes in Swiss Alps, as given by Huggel et al. (2002). In the absence of information on the volume of glacial lake, it is considered appropriate to use the same relationships developed for the lakes in Swiss Alps for estimating the water volume for the lakes in this area. The empirical relations as available in the study by Huggel et al. (2002) are:

The lake volume V = 0.104 A1.42 (3.1)
Where V is the lake volume in m3, A is the lake area in m2.
The lake depth D = 0.104 A0.42 (3.2)
Where D is the lake depth in m

Due to possible out bursting or breaching of largest lake existing in the study area may result a surge of flood at the project site. Therefore, in order to estimate the maximum GLOF peak at Jelam Tamak H.E. Project site, the outbursting or breaching of lake have to be considered along with channel routing. The scope of the present study is primarily to estimate the flood hydrograph just upstream of Jelam Tamak H.E. Project in the event of breaching of largest glacial lake. Thus, the estimation of GLOF is similar to a dam break study (Sharma et al.,2009), which provides the flood hydrograph of discharge from the dam breach and maximum water level at different locations of the river downstream of the dam due to propagation of flood waves along with their time of occurrence. The dam break modelling mainly consist of i) prediction of the outflow hydrograph due to dam breach ii) routing the hydrograph through the downstream valley to get the maximum water level and discharge along with the time of travel at different locations of the river downstream of the dam. Dam break flood simulation studies can be carried out by either i) Scaled physical hydraulic models or ii) Mathematical simulation models.

The essence of dam break modelling is hydrodynamic modelling, which involves finding solution of two partial differential equations originally derived by Barre De Saint Venant in 1871. These equations are:

$$(\partial Q/\partial X) + \partial(A + A_0) / \partial t - q = 0 \qquad \text{(continuity equation)} \qquad (3.3)$$

$$(\partial Q/\partial t) + \{ \partial(Q^2/A)/\partial X \} + g\, A\, ((\partial h/\partial X) + S_f + S_c) = 0 \text{ (Momentum equation)} \qquad (3.4)$$

where, Q = discharge; A = active flow area; A_0 = inactive storage area;
h = water surface elevation; q= lateral flow; x = distance along waterway; t = time;
S_f = friction slope; S_c = expansion contraction slope and g = gravitational acceleration

The mathematical models which approximately solve the governing flow equations of continuity and momentum by computer simulation are the cost effective modern tool for the dambreak analysis. MIKE11 and DAMBRK computer programs have been developed in the recent past; however these computer programs are dependent on certain inputs regarding the geometric and temporal characteristics of the dam breach. The state-of-art in estimating these breach characteristics is not as advanced as that of the computer programs, and therefore these are the limiting factors in the dam break analysis.

Hydrological data

In the beginning of the simulation, a steady state hydrological condition needs to be defined. The glacial lake outbursting may be associated with a flood event. Thus, to get a reasonable estimate of GLOF at the dam site, the outburst flood need to be routed in the channel along with flood event, say 100 years return period flood. Accordingly, the flood with return period of 100 years has been channel routed along with the flood hydrograph of different GLOF scenarios to get a reasonable GLOF peak for the Jelam Tamak H.E Project. The same flood has also been used to generate the hot-start file for all GLOF simulations. The 100 years return period flood value at project has been taken from the report of THDC.

As the above lateral inflows have been routed along with the GLOF, the flood peak obtained at any downstream location will be combined routed peak of 100 year flood and GLOF. Hence, the GLOF ordinate at any location should be worked out by subtracting the 100 year flood ordinate at that location from the total flood ordinate.

MIKE-11 Model

The MIKE 11 model has been used to model GLOF simulation in India (Sharma et al., 2009). MIKE11 is a professional engineering software package for the simulation of one dimensional flow in estuaries, rivers, irrigation systems, channels and other water bodies. It is a dynamic, user friendly one-dimensional modelling tool for the detailed design, management and operation of both simple and complex river and channel systems. The Hydrodynamic Module (HD) contains an implicit, finite difference computation of unsteady flows in river and estuaries. The formulation can be applied to branched and looped networks and flood plains.

The computational scheme is applicable to vertically homogeneous flow conditions ranging from steep river flows to tidally influenced estuaries. Both sub-critical and supercritical flow can be described by means of a numerical scheme which adapts according to the local conditions. The complete non-linear equations of open channel flow (Saint Venant) can be solved numerically between all grid points at specified time intervals for a given boundary conditions. Within the standard Hydro Dynamic (HD) module, advanced computational formulations enable flow over variety of structures such as broad crested weirs, culverts and user-defined structures to be simulated. A number of add-on modules such as Dam Break Module (DB), Structure Operation Module exist for the Hydrodynamic Module.

The dam break model set up consists of a single or several channels, reservoirs, dam break structures and other auxiliary dam structures such as spillways, sluices, etc. The river is represented in a model by cross sections at regular intervals. However, due to highly unsteady nature of dam break flood propagation, it is advisable that the river course is described as accurately as possible through the use of a dense grid of cross sections, particularly where the cross section is changing rapidly. Further, the cross sections shall extend as far as the highest modelled water level, which normally will be in excess of highest recorded flood level.

The reservoir is normally modelled as a single “h” water level point to describe the storage characteristic by the use of storage area at different levels. This point will often be the upstream boundary of the model where inflow hydrographs may be specified. However, in case of very long and wide reservoir routing of inflow flood has to be carried out and hence the reservoir itself would have to be represented by cross sections at regular intervals. The downstream boundary will be either a discharge water level relation or time series water level as in case of tidal waves.

The manner in which the failure is to commence can be specified as one of the following:

- Given number of hours after the start of the simulation
- At a specified time
- At a specified reservoir level

The breach may be specified as rectangular, triangular or trapezoidal in shape. The initial and \final breach widths and levels along with the side slopes of the breach are required to be specified. The model has the option to select either the linear failure mechanism or an erosion based formulation. The linear failure mode assumes a linear increase in the breach dimensions in the time between specified limits etc. For the erosion based failure additional data such as slopes of the upstream and downstream faces of dam, width of dam crest and density, grain size, porosity and critical shear stress of dam material are required

For assessing the damage potential of GLOF the main factors considered are:

- Glacial lake water storage
- Average bed slope of the river carrying the GLOF flow
- The distance of the lake from the proposed project site

Lake information

The detailed topographic information for the lake was not available. Therefore, only the surface area information and maximum depth were used. The analysis was based on the analysis of remote sensing data of different years while average water level and seasonal fluctuations were not taken into consideration.

Dam breach

The geometric data for the lake were taken from the DEM. As the information regarding geotechnical parameters for the lake was lacking, these parameters were adapted, similar to the other case studies carried out in the Himalayan region (Sharma et al., 2009). Energy Equation of MIKE 11 was used to simulate the outburst hydrographs.

Glacial Lake (reservoir) and dam

In the present study, the lake has been represented as dam break structures having certain crest level and crest length. The dam breach parameters have been specified as a time series and assigned to corresponding lake. The glacial lake has been represented as reservoir in the model by its elevation-surface area relation, at chainage "0" km of the reservoir branch.

Selection of dam breach parameters

In any dam break study, prediction of the dam breach parameters and timing of the breach are very important factors. But prediction of these parameters is extremely difficult. The important aspects to deal when considering the failure of dam are, time of failure, extent of overtopping before failure, size, shape and time of the breach formation. Estimation of the dam break flood depends on these parameters.

Important breach characteristics that are needed as input to the existing dam break models are i) initial and final breach width and level; ii) shape of the breach; iii) time duration of breach development, and iv) reservoir level at time of start of breach. The predominant mechanism of breach formation dependents on the type of dam and the cause due to which the dam may fail.

Breach Invert Level

Breach invert level is the final breach level, i.e., the breaching starts at top of the dam and continues up to the breach invert level. As the glacial lakes may generally outburst due to overtopping and/or by piping, the breach invert level should be taken as two-third to three-fourth of the height of the dam below its top level. In the instant case, accurate estimate of height of supra lake dams is not available. Thus, elevation area relationship has been evolved in such a way that assumed volume of the glacial lake gets released on outbursting.

Breach parameters for the lake

The other breach parameters, i.e., average breach width (B), and time of failure (t_f) has been estimated using the available empirical equations available for earth and rockfill dams, as similar estimates for supraglacial dam are not available. The available empirical equations available for earth and rockfill dams are given below:

i) *Froelich's formula (1995 B)*

$B = 0.1803\ V_w^{0.32}\ h_b^{0.19}$ (3.5)

$t_f = 0.00254\ V_w^{0.53}\ h_b^{-0.90}$ (3.6)

Where, V_w = reservoir volume in m3 and h_b is the height of water above breach invert level.

ii) *Federal Energy Regulatory Commission's formula* (FERC 1987)

$B = 2\text{-}4\ h_d$ (3.7)

$t_f = 0.1$ to 1 hr. (3.8)

where, h_d is the height of water above breach invert level.

iii) *Von-thun and Gillette's formula (1990)*

$B = 2.5\ h_w + Cb$ (3.9)

(C_b = 54.9 for reservoir storage greater than 12.8 Mcum)

$t_f = .02\ h_w + 0.25$ for erosion resistant material (3.10)

$t_f = .015\ h_w$ for easily erodible material (3.11)

where, h_w is the height of water above breach invert level.

4.10.8 Glacial Lakes

In this study, as discussed in last chapter, manual delineation of lakes has been carried out. The lake area in the years, 2004, 2006 and 2008 are given in the Table 4.10. In the year 2006, the data obtained was having some snow cover therefore in this year all the lakes could not be identified. The area of biggest lake varies from 0.192 to 0.203 km2 for the years 2004 to 2008. The distance of this lake from the project site is 44.2 km.

4.10.9 GLOF Simulation for Biggest Lake

As discussed in previous section that the area of the biggest lake is 0.203 km2 in 2008 and it is located on Dhauliganga River. The resulting dam breach flood, i.e., GLOF has been routed through Dhauliganga River along with 100 yr return period flood in the valley. The Dhauliganga River from glacial lake location down to the project site (total length 44.2 km) has been represented in the model by a number of cross sections at an interval of 5 km, developed from DEM. The classified DEM is shown in **Figure 3.8**. The total reach along with cross sections from lake to project site is shown in **Figure 4.6**. All the cross sections obtained at different interval are shown in **Figure 4.7**.

In this study, as discussed in last chapter, manual delineation of lakes has been carried out. The lake area in the years, 2004, 2006 and 2008 are given in the Table 4.6. The biggest lake in the study area is Lake No. 47 which is shown on FCC of the year 2008 in **Figure 4.8**. The area of this lake varies from 0.192 to 0.203 km_2 for the years 2004 to 2008. The altitude of the biggest lake is 4663 m. The surface area of the lake and altitude are given in Table 4.7. The volume of the lake is calculated using equation 3.1 and it comes out to be 3.578 Mm^3. The breach width has been taken as 40, 60 and 80 m and breach depth is taken as 10 m. The side slope has been taken as 0.75H: 1V. The breach development time has been taken as 1 hour. The Manning's roughness coefficient has been taken as 0.040 considering the bouldery beds and hilly terrain of Himalayan Rivers and large debris flow associated with GLOF.

Table 4.6 Glacier lakes in the study area

Lake Name	Latitude	Longitude	Elevation (m)	Area (km2) 2004	Area (km2) 2006	Area (km2) 2008
lake47	30 54 06.54 N	79 45 25.04 E	4663	0.192	0.200	0.203
lake48	30 49 07.05 N	79 55 06.33 E	5177	0.004		0.006
lake49	30 49 36.82 N	79 55 22.37 E	5336	0.008	0.013	0.005
lake52	30 54 31.98 N	79 44 05.51 E	4764	0.007		0.006
lake53	30 48 52.47 N	79 55 46.13 E	4914	0.059	0.057	0.060
lake54	30 48 42.89 N	79 55 26.36 E	4987	0.035	0.026	0.029
lake55	30 48 30.55 N	79 56 07.36 E	5138	0.004		
lake56	30 48 38.96 N	79 54 54.93 E	5124	0.006	0.005	0.007
lake57	30 48 33.98 N	79 54 42.08 E	5154	0.003		
lake58	30 48 35.42 N	79 54 06.51 E	5247	0.003		
lake59	30 51 46.19 N	79 54 44.88 E	5153	0.094	0.099	0.088
lake60	30 51 40.62 N	79 54 04.71 E	5355	0.004		0.004
lake61	30 52 48.91 N	79 56 51.03 E	5166	0.002		0.002
lake62	30 51 51.52 N	79 59 01.62 E	4745	0.006	0.003	0.006
lake63	30 51 52.04 N	79 58 45.35 E	4690	0.002	0.002	0.005
Gangpani	30 35 02.84 N	80 10 12.60 E	5104	0.056	0.045	
lake64	30 35 14.22 N	80 10 23.35 E	5122	0.003		
lake65	30 54 32.75 N	79 49 37.57 E	4904	0.095	0.108	0.085
lake66	30 54 04.62 N	79 44 57.87 E	4679	0.012		0.074
lake67	30 54 21.86 N	79 44 51.66 E	4677	0.024	0.010	
lake76	30 44 56.15 N	79 55 41.30 E	4862	0.004		0.004
lake85	30 46 29.78 N	80 05 30.47 E	4751	0.006	0.004	0.007
lake86	30 58 14.14 N	79 44 54.53 E	5440	0.005		0.024
lake87	30 56 17.10 N	79 45 21.77 E	5513	0.020		
l1	30 49 24.17 N	79 46 29.35 E	4856		0.008	
l3	30 56 46.88 N	79 50 20.62 E	4833		0.006	
l4	30 49 53.64 N	79 53 49.13 E	5219		0.024	
l6	30 38 54.28 N	80 07 11.61 E	4420		0.013	
l7	30 55 01.39 N	79 44 50.27 E	4771		0.006	
L3	30 53 54.33 N	79 45 35.31 E	4670			0.007
L4	30 59 21.79 N	79 45 09.32 E	5656			0.014
L15	30 53 33.66 N	79 42 59.03 E	4860			0.009

Table 4.7 Elevation-area relationship of glacial lakes

Glacial lake (volume 3.578 Mcum)	
Elevation (m)	*Surface area (m^2)*
4644.000	0.000
4645.000	194500.000
4663.000	203000.000

Table 4.8 Flood peak due to glacial lake outburst considering 40m breach width

Location	Distance (km) from Glacial Lake	Total flood peak (m^3/s)	100 yr flood peak (m^3/s)	GLOF peak (m^3/s)	Travel time (hr-min)
Just d/s of lake	0	1315.94	0	1315.94	00-00
Project Site	44.2	1826.66	790.00	1036.66	01-10

Table 4.9 Flood peak due to glacial lake outburst considering 60m breach width

Location	Distance (km) from Glacial Lake	Total flood peak (m^3/s)	100 yr flood peak (m^3/s)	GLOF peak (m^3/s)	Travel time (hr-min)
Just d/s of lake	0	1640.5	0	1640.5	00-00
Project Site	44.2	2153.23	790.00	1363,23	01-10

Table 4.10 Flood peak due to glacial lake outburst considering 80m breach width

Location	Distance (km) from Glacial Lake	Total flood peak (m^3/s)	100 yr flood peak (m^3/s)	GLOF peak (m^3/s)	Travel time (hr-min)
Just d/s of lake	0	1861.51	0	1861.51	00-00
Project Site	44.2	2261.11	790.00	1471.11	01-10

The 100 year return period flood value available at Jelam Tamak project site is available and its value is 790.0 cumec. MIKE 11 software was applied for generation of flood hydrograph for three cases (Breach width 40, 60 and 80 m). These flood hydrographs at just downstream of the lake and near project site are shown in **Figure 4.9** for breach width 80 m. The flood hydrograph at project site shows the flood ordinates as a sum of GLOF ordinates and 100 yr flood ordinates. The total flood peak, the flood peak due to 100 yr flood, the flood peak due to GLOF and its travel time from GLOF site is given in Table 4.8, 4.9 and 4.10 for breach width of 40, 60 and 80 m, respectively.

It can be seen from the Table-4.8, 4.9 and 4.10 that the GLOF peak for the above breach parameters is 1315.94, 1640.5 and 1861.51 cumec for breach width 40, 60 and 80 m respectively. The same get mitigated to 1036.66, 1363.23 and 1471.11 cumec for breach width 40, 60 and 80 m respectively at the project site. The time of travel of flood peak from the lake site to project location is about 50 minutes. It is inferred from the study that the outburst of glacial lake with peak flood of 1471.11 cumec at the project site gives the worst case scenario of GLOF and the same may be considered for the project. The resulting GLOF hydrograph at the Lake site and Project site is given in **Figure 4.9** for breach width 80 m.

4.10.10 Limitations

Glacial lake outburst flow modelling process is nothing but approximation of a physical phenomenon through which the physical phenomenon and its effects can be studied for water resources structure design and flood management. In GLOF modeling, assumptions are mainly associated with the breach parameters, especially, breach width and breach depth, which has impact on flood peak and arrival times. In general, glacial lake bursting mechanism and formation of breach in glacial lakes are not fully understood. Furthermore, the high velocity associated with GLOF can cause significant scour of channels associated with bed as well as bank erosion. Change in the channel cross section due to GLOF is neglected due to limitations in modelling such a complicated physical process. Generally, GLOF creates a large amount of transported debris and this may be accumulate at constricted cross sections, where it acts as a temporary dam and partially or completely restricts the flow, resulting variation in flood peak arrival time. This aspect has also been neglected due to limitations in modelling of such a complicated physical process. These limitations have an effect mainly on the conservative side. Even with the assumptions and limitations outlined above, hydrodynamic modelling serves very useful purpose, as it provides reasonable estimate of glacial lake outburst flood, thus enabling the appropriate estimation of design flood.

4.10.11 Conclusion

The Dhauliganga basin up to Jhelam Tamak H.E. Project site covers an area of 1685.00 km^2. The elevation values ranges from a minimum of 2593 m to maximum of 7693 m with in the study area. The biggest lake has been identified and the area of this lake is 0.203 km^2 in the year 2008. Though no lake is vulnerable to breaching, even then a GLOF study for this biggest lake has been carried out.

For GLOF study, MIKE 11 software has been used. In this study, 100 year return flood has also been considered in addition to GLOF peak at the project site. The flood peak at the lake site is 1315.94, 1640.5 and 1861.51 cumec for breach width of 40, 60 and 80 m respectively. The flood peak due to GLOF only is computed as 1036.66, 1363.23 and 1471.11 cumec at project site for breach width of 40, 60 and 80 m respectively. As earlier pointed out there is no danger of breaching of lake. But if in the worst case flood due to breaching of lake is to be considered then it is 1471.11 cumec.

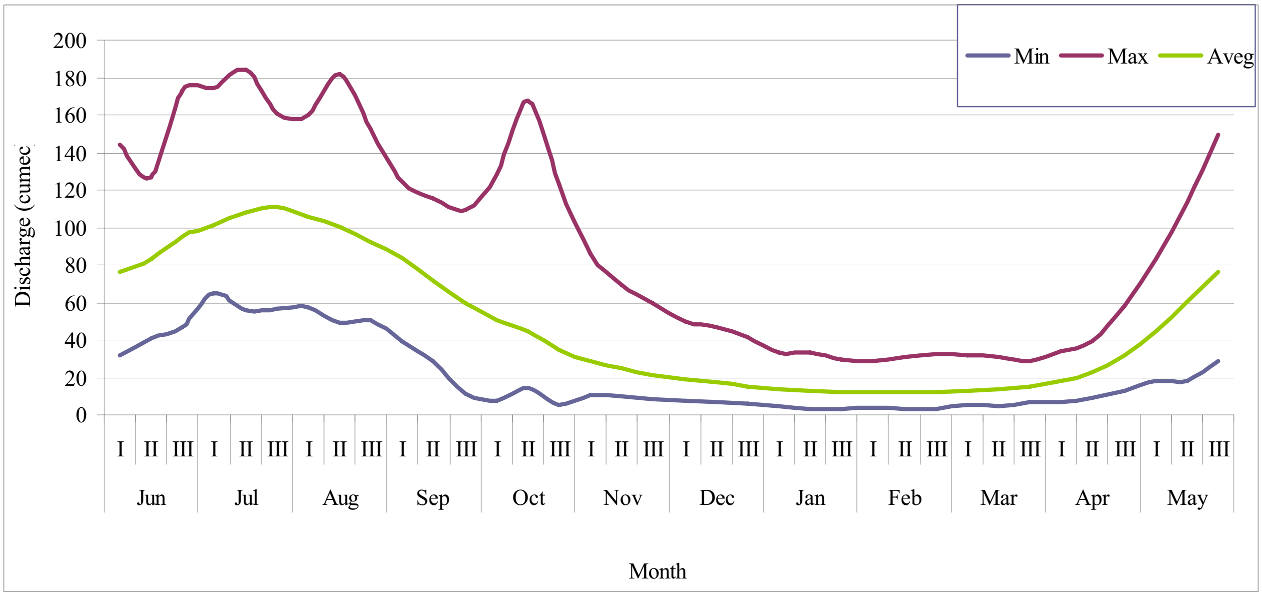


Fig. 4.1 Average, Maximum and Minimum for ten daily discharge extrapolated for 35 years

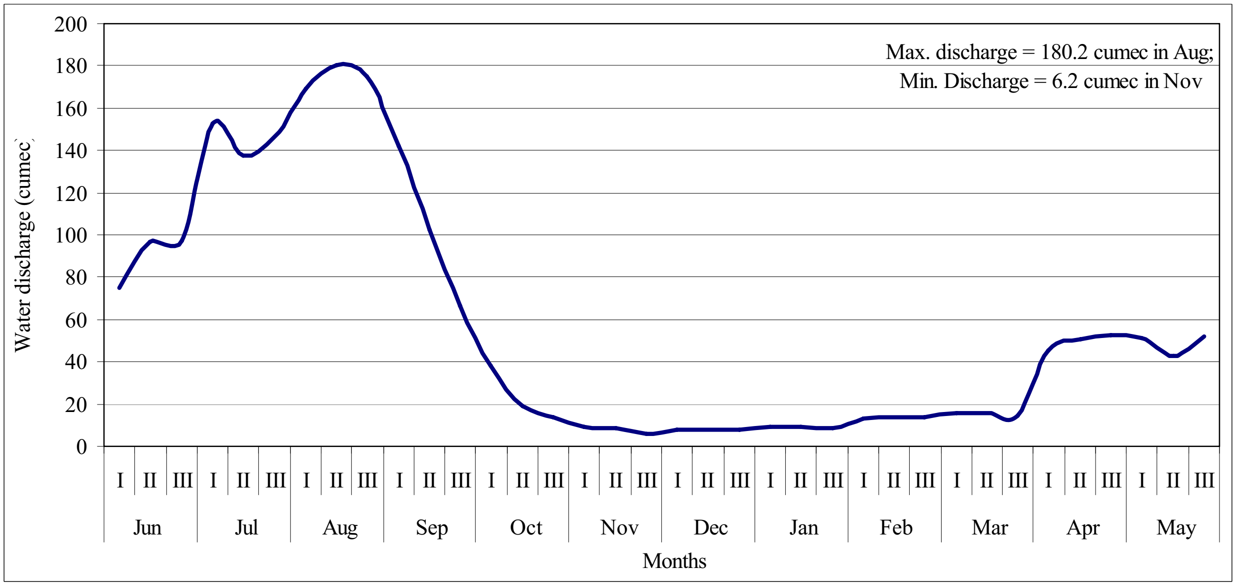


Fig. 4.2 Ten daily water discharge, recorded at Tamak (proposed powerhouse site) in Dhauliganga during 2007-2008

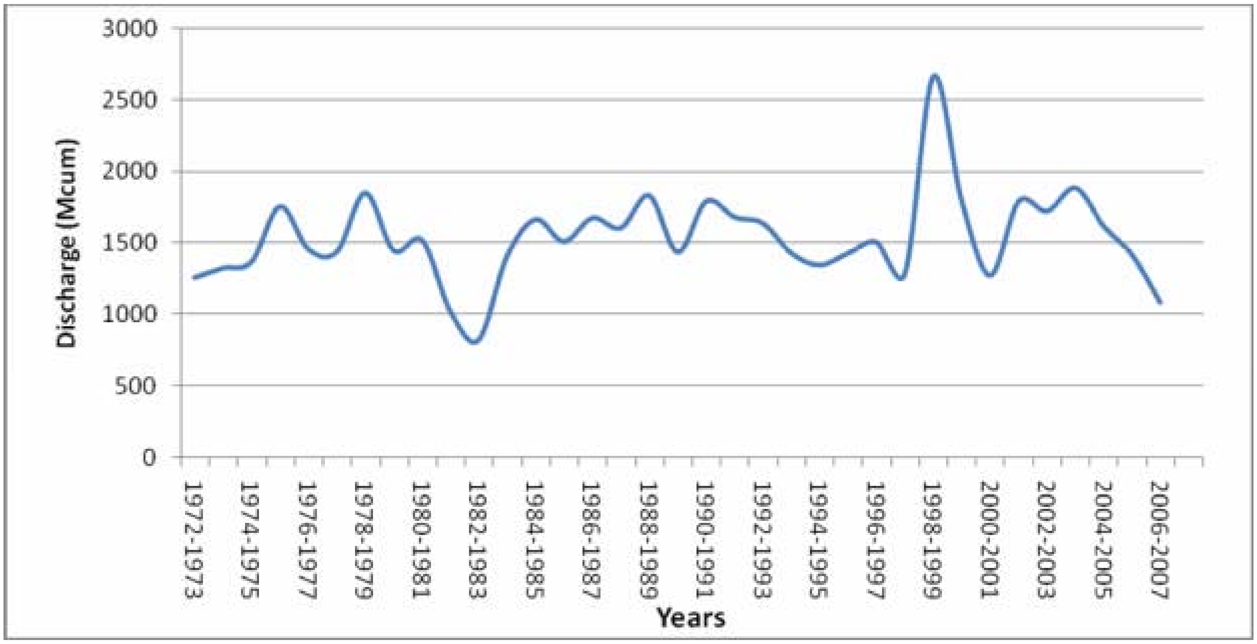


Fig. 4.3 Annual flow pattern in Dhauliganga river

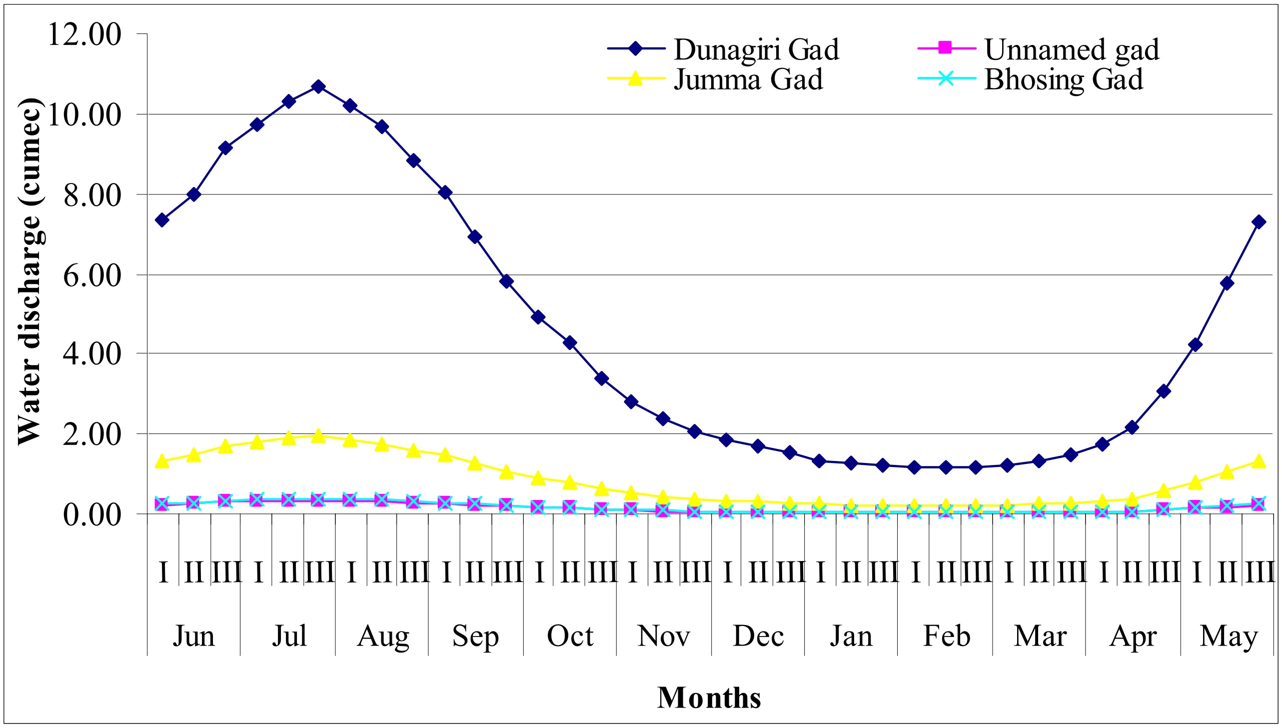


Fig. 4.4 10 daily water discharge pattern in downstream tributaries of Dhauliganga river

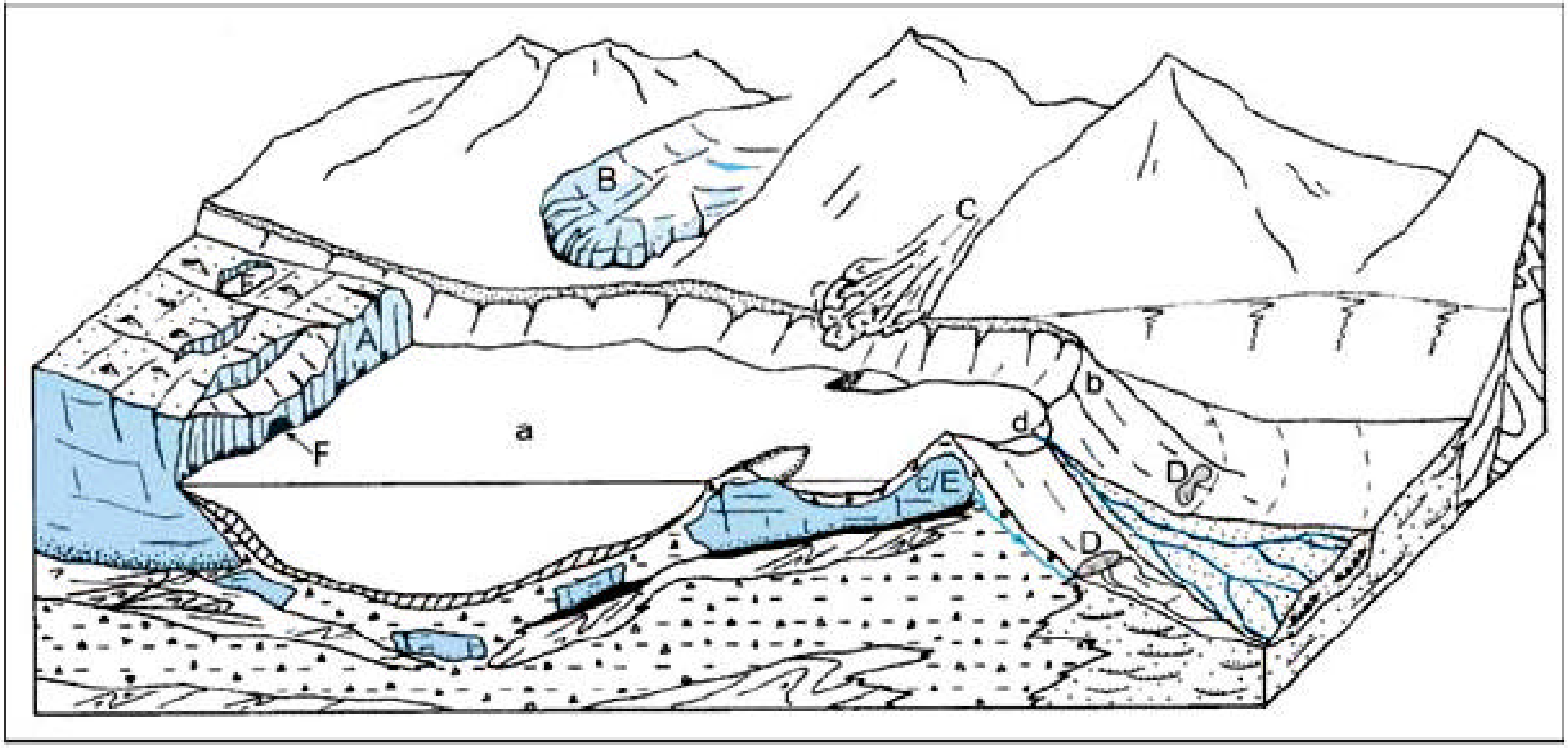


Fig. 4.5 Schematic diagram of a hazardous moraine-dammed glacial lake

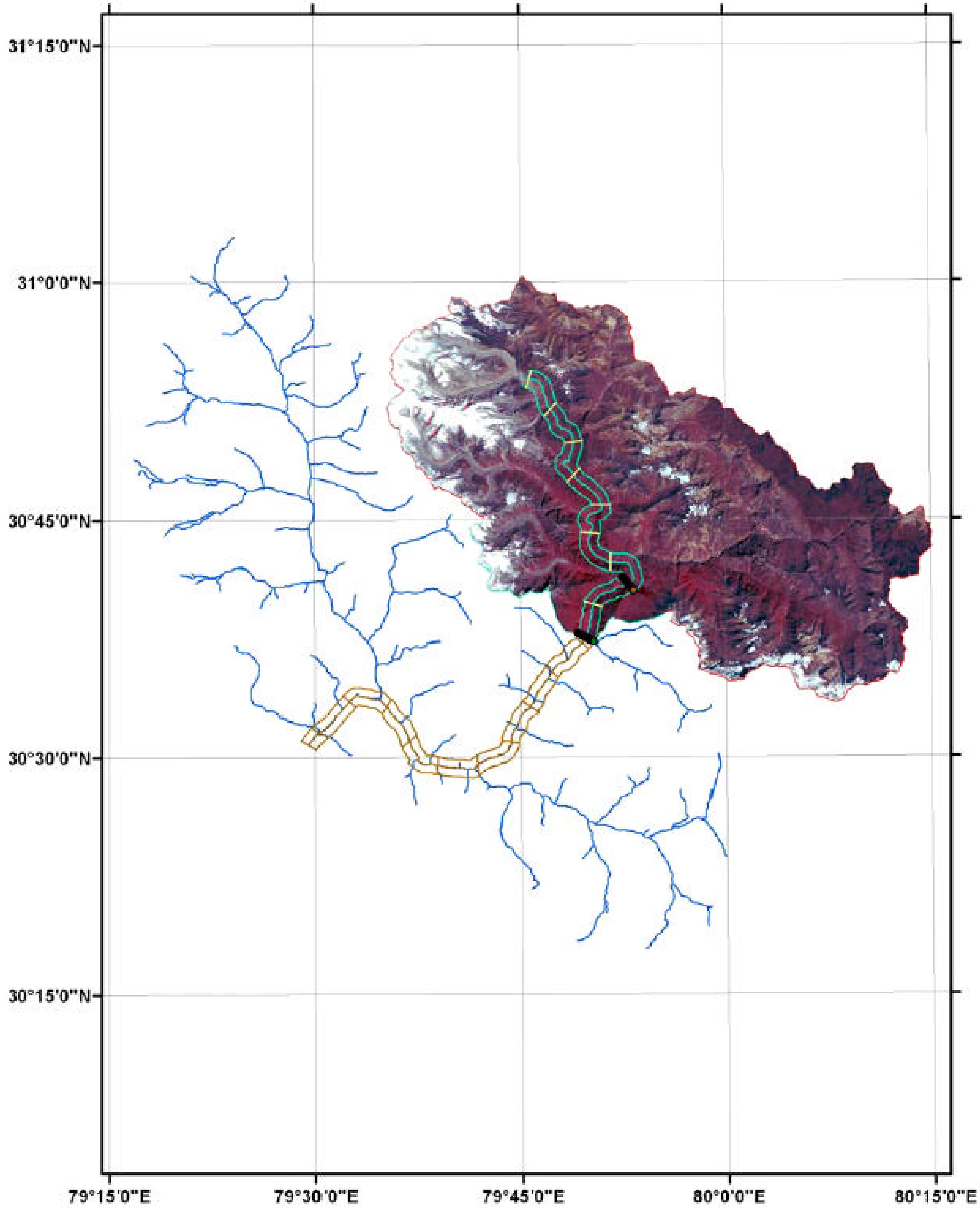


Fig. 4.6 Location of cross sections at 5 km interval downstream of lake

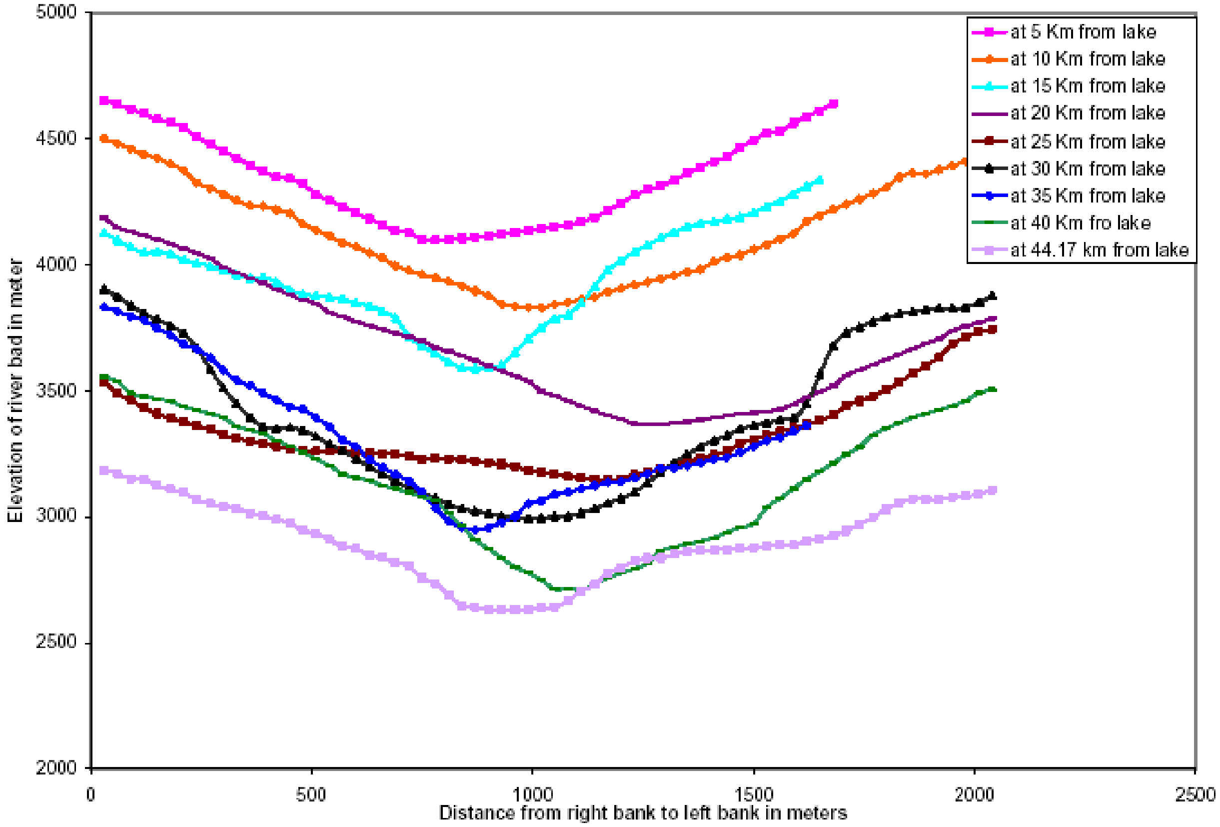


Fig. 4.7 Cross sections at 5 km interval downstream of lake

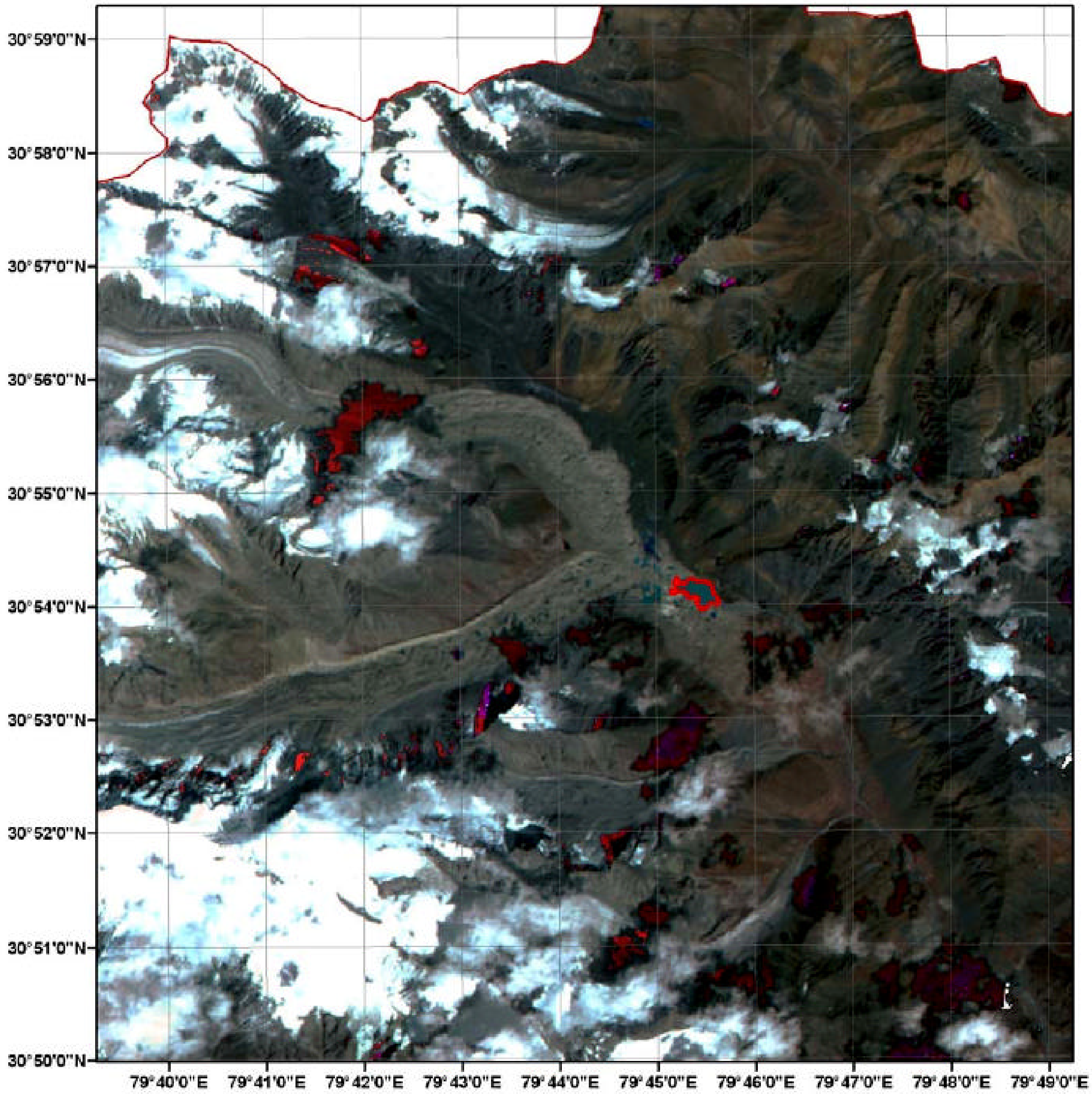


Fig.4.8 Biggest glacial lakes in the study area (September 2008)

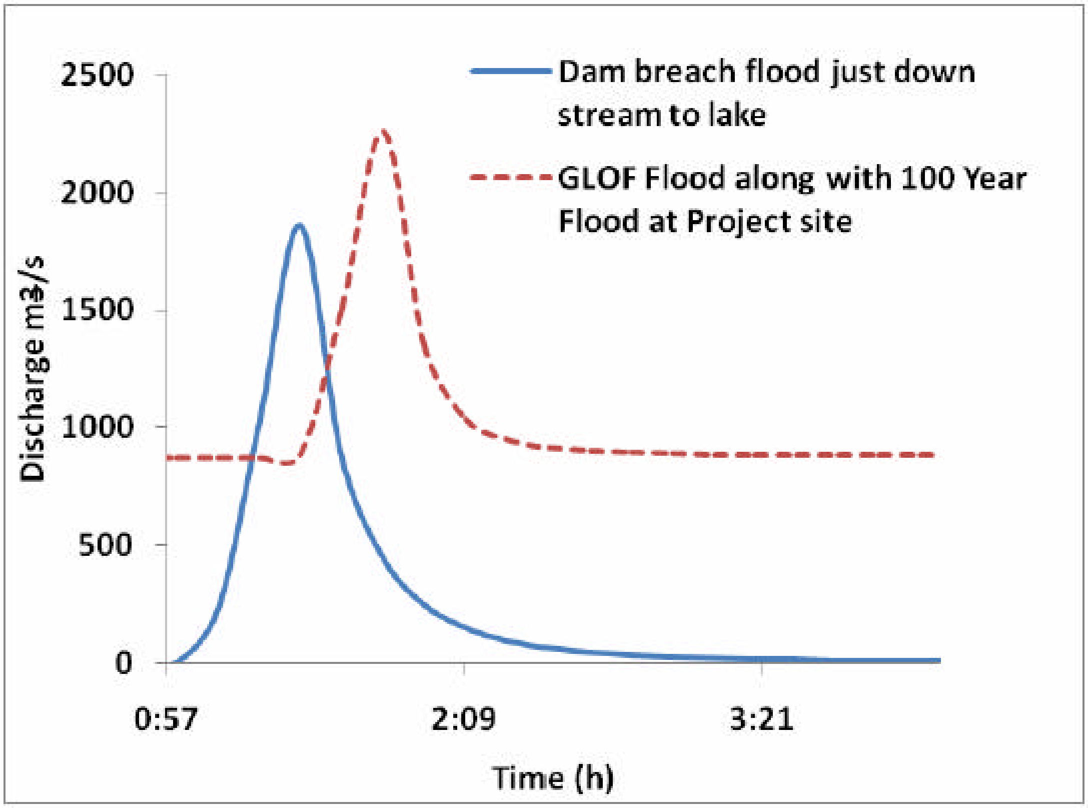


Fig. 4.9 GLOF hydrograph (including 100 year flood ordinates) at Jelam Tamak H.E. Project site considering 80 m breach width

Chapter 5

GEOLOGY AND SEISMICITY

5

GEOLOGY AND SEISMICITY

5.1 INTRODUCTION

Proposed Jelam Tamak H.E. Project is located across Dhauliganga river in Joshimath sub-division of Chamoli district in Uttarakhand. Dhauliganga is a largest head water tributary of Alakananda, originates from Kamet glacier. Kamet glacier lying above 6060 m is the source of this river. Proposed barrage is located between 30^0 37' 35.4"N latitude and 79^o49'39.5"E longitude while power house is located between 30º 36' 45" N latitude and 79º 47' 15" E longitude.

In order to understand the geophysical impacts and geo-environmental consequences a detailed geology of the project is addressed in this chapter. Present contribution highlights the regional geology, geology of the catchment and geology of the project area. Seismotectonic Environment in the chapter includes seismic history of Garhwal, seismic zoning in relation to the project sites and major earthquakes in Uttarakhand. Major land slides and thermal streams in the catchment and influence area were also discussed in this chapter.

5.2 REGIONAL GEOLOGY

5.2.1 Stratigraphy

Uttarakhand Himalaya is geologically divided into four parallel and longitudinal orogenic belts from south to north, namely Siwaliks, Lesser Himalaya, Greater Himalaya and Trans-Himalaya, each with characteristic physiographic features and distinct geological history. The rocks exposed are grouped into 15 Supersequences under in age from Archaean to Holocene (Kumar, 2005). Supersequence XV (Holocene), XIV (Middle to Late Pleistocene) and XIII (Early Miocene to Middle Pleistocene) are predominant in Shiwaliks. The Lesser Himalayan part of Uttarakhand is characterized predominantly by Supersequence III (Mesoproterozoic to Neoproterozoic II). The bulk of the Greater Himalaya is made up of Archaean Central Crystalline (Supersequence-I) to Paleoproterozoic (Supersequence-II). The dominant supersequences of Trans-Himalaya range from Ordovician to Early Carboniferous - Middle Jurassic to Early Paleocene (Supersequence - V to IX) (**Fig. 5.1**).

Catchment Area: In the Catchment area of Jelam Tamak, the rocks of the Central Crystalline are predominant and intrusive undifferentiated biotite granite (ca 500 Ma) and tourmaline granite (ca 21 Ma) are exposed. North part of Central Crystalline group is followed by Martoli Group (Rilkot/Dar formation), Sumna Group and Kanawar Group, Upper Lilang Group and Lagudarsi Group (Table 5.1; **Fig. 5.1**).

Table 5.1 Generalised stratigraphy in catchment area of Jelam Tamak H.E. Project (Kumar, 2005)

Geological Age	Group	Formation
Archaean	Central Crystalline	Ragsi-Bhilmgora-Joshimath-Pandukeshwar-Badrinath
Neoproterozoic III to Early Cambrian	Martoli	Bilju-Milam
Ordovician to Early Carboniferous	Sumna & Kanawar	-
Late Triassic to Early Jurassic	Upper Lilang	-
Middle Jurassic to Early Paleocene	Lagudarsi	-

5.2.1.1 *Central Crystalline*

This zone is continuously mapped from the Yamuna valley in the west to the Kali Valley in the east and farther east in the Nepal Himalaya. In the south its contact with the Garhwal Group (Super sequence II) represents a tectonic plane referred to as the Main Central Thrust (MCT). Central crystalline is the basement over which litho-sequences ranging in age from Mesoproterozoic to Quaternary were deposited. It has witnessed different Precambrian orogenies prior to the strong Himalayan orogeny, and much of the original composition is preserved. The gneisses, migmatites, crystalline schist, thick quartzite with conspicuous horizons of calc-silicates with psammite gneisses in the upper part form bulk of metasediments. Imprints of tectonothermal events, ca 2500, 2100 and 1900 Ma, probably related to Paleoproterozoic orogenic movements, are identifiable in the form of granite-gneisses. It also contains other younger granites (ca 21-500 Ma), which are related to younger tectonothermal events of which Tertiary granites are more conspicuous. The Central Crystalline is well exposed in the Alaknanda valley from Helang (south of Joshimath) to Badrinath (Table 5.2).

5.2.1.2 *Ragsi Formation*

This is the oldest litho-unit of the Central Crystalline Group named after a prominent peak SW of Tungnath (between Alaknanda and the Mandakini valleys). It is in tectonic contact (MCT) with the Garhwal Group, and is conformably overlain by the Bhimgora Quartzite. It is made up of crumbling green to silvery white kyanite-paragonite ± muscovite schist and gneisses well exposed 1.5 km NNE of Kalsir in the Nangol Gad. It is profusely intruded by tourmaline granite around Ragsi. In the Helang section, Alaknanda valley, para-amphibolite/ marble and gneisses are associated with it. It continues westwards to the Mandakini valley and beyond and is represented by quartzo-feldspathic schist and gneiss, kyanite-staurolite schist and cummingtonite-hornblende schist.

Table 5.2 Lithostratigraphy of the Central Crystalline Group (after Kumar, 2005) placed on Garhwal Group

Formation	Lithology	Metamorphic grade
Dar (Supersequence III)	Kyanite, sillimanite-staurolite, biotite schist; banded calcsilicates.	
....Unconformity..		
Badrinath	Garnet, sillimanite, muscovite and kyanite bearing gneiss, mica schist, migmatite, calc-silicate, leucogranite, pegmatite and garnet amphibolite.	Sillimanite zone
Pandukeshwar	Banded quartzitic gneiss and interbedded quartz mica schist, para-amphibolite.	Kyanite zone
Munsiari (Joshimath)	Garnet mica gneiss, garnet, staurolite and kyanite gneisses, tourmaline-mica gneiss, garnet amphibolite	Kyanite and staurolite zone
Bhimgora Quartzite	White quartzite with gneiss and schist	
Ragsi	Mica schist, gneiss, para-amphibolite	Kyanite zone
.....................................Main Central Thrust (MCT).....................................		

Geological Age	Group	Formation	Lithology
Paleoproterozoic	Garhwal	Berinag	Quartzite with/without penecontemporaneous mafic metavolcanic intruded by epidiorite.
		Deoban	Limestone, dolomite, and phyllite
		Rautgara	Quartzite with penecontemporaneous mafic metavolcanics intruded by epidiorite.
		Agastyamuni (=Uttarkashi)	Kurjan Phyllite : Chlorite phyllite, light grey to dark grey, carbonaceous at places with conspicuous bands of dolomite/marble intruded by Chandrapuri granite-gneiss and epidiorite.
			Thalassu Schistose Grit : Schistose grit and quartzite, greyish white, sericitic with lenticular penecontemporaneous mafic metavolcanic propfusely intruded by epidiorite now occurring as chlorite schist/feldspathic chlorite schist.
....Alaknanda Fault......................................			

5.2.1.3 *Bhimgora Quartzite*

It is named after Bhimgora Chatti along the Chamoli-Okhimath road and underlies the Joshimath Formation. It is traceable to the north of Helang in the Alaknanda valley and outcrops again near Tapoban in the Dhauliganga section, upstream of Joshimath. It is white in colour and comprises a recrystallised mosaic of fine-grained quartz with flakes of sericite. It contains abundant sub-rounded zircon, sphene and iron ore. In the Alaknanda valley, chloritic phyllite, possibly derived from amphibolites, is associated with this quartzite.

5.2.1.4 *Joshimath/ Munsiari (Valdiya, 1980) Formation*

The Joshimath Formation is well exposed from south of Joshimath to south of Pandukeshwar. It conformably overlies the Bhimgora quartzite in the south. In the north it is overlain by the Pandukeshwar formation and this contact is referred to as the Vaikrita thrust by Valdiya (1980). It is composed of regionally metamorphosed banded psammitic and pelitic sediments represented by interbedded sequence of garnet mica schist, staurolite-kyanite schist, sericite quartzite, quartz porphyry, amphibolite and associated coarse-grained biotite augen-gneiss.

5.2.1.5 *Pandukeshwar Formation*

This psammatic series of the Alaknanda at Pandukeshwar was first mapped by Heim and Gansser in 1939. It consists of 'regularly bedded quartzites'/banded quartzitic gneisses interbedded with quartizitic gneisses is garnet biotite schist. Current bedding and convolute bedding are preserved in these quartzites.

5.2.1.6 *Badrinath Formation*

In the Alaknanda valley this youngest formation of the Central crystalline Group, is well exposed between Hanuman Chatti and Badrinath. This formation is composed of garnet, sillimanite, muscovite and kyanite bearing gneiss, mica schist, migmatites, calcsilicates, and garnet amphibolite intruded by leucogranite and pegmatite.

5.2.1.7 *Martoli Group*

Resting over the Central Crystalline the Martoli Group is composed of the Rilkot, Bilju and Milam Formations. The Rilkot, also called as the Dar Formation, is made up of meta-sediments represented by kyanite-, sillimanite-, staurolite-, garnet- and mica-schist, calc-schist with bands of marble and quartzite. The Bilju is composed of dark grey to carbonaceous phyllite with bands of quartzite and the Milam formation contains thinly bedded phyllite-quartzite in basal part upwardly grading into massive quartzite in middle and greenish phyllite with calcareous lenses at the top. Lower Cambrian fossils are preserved in the Milam formation. In the Alaknanda Valley only Rilkot Formation is exposed in a synclinal trough and is profusely intruded by biotite and tourmaline granite.

5.2.1.8 *Granites*

Intrusive granites in the Martoli Group are exposed along the water divide between the Alaknanda and the Bhagirathi rivers, NW of Badrinath.

5.2.1.9 *Quaternary deposits*

Well-developed lateral moraines are seen along the glaciers, which stand out as high walls on either side of the glacier valley. These moraines were developed at one or two prominent levels indicating periods when glaciers had reached their best development in the Pleistocene period. In the Alaknanda valley, glacial deposits are found at Hanuman Chatti and in the upstream stretch. River terraces are seen at Pandukeshwar and other places along Alaknanda channel and other tributary streams downstream of Hanuman Chatti.

5.2.2 Structure

5.2.2.1 *Faults (*with special reference to project area)

The details of some of the important discontinuity surfaces present in the region around the project area are given below.

Main Central Thrust (MCT): The MCT is a steep north dipping major tectonic plane. It represents the contact between the Garhwal Group (Supersequence-II) and the Central Crystallines (Supersequence-I). It is traced from Helang in the Alaknanda valley to Munsiari in the Goriganga valley and farther east. In the west it extends upto Yamuna Valley. The MCT is nearly 40 km towards south of proposed barrage site (**Fig. 5.3**).

Dar-Martoli Fault: This is a major plane of dislocation mapped in the Kali valley at Dar separating the Dar formation from the Central Crystallines. It is traceable to the south of Martoli, and hence named as Dar-Martoli fault. At Martoli in Dhauliganga valley it is offset by the Niti Fault. In the Niti valley, the Dar Formation and Martoli Group (Mesoproterozoic to Early Cambrian) are not exposed but Sumna Group (Ordovician to Early Carboniferous) comes in direct contact with the Central Crystalline indicating the presence of a fault.

Niti Fault (NF): This is a major N-S trending cross-fault affecting the Central Crystallines and the Tethyan sequences ranging in age from Mesoproterozoic to Triassic. It steeply dips towards the east and has been mapped at Barmatiya in the Girthi valley uplifting the eastern block. Due to the presence of this fault, the Martoli Group is exposed as an inlier in the Girthi Valley. The NF is traced to the Niti Pass in the north and as an intraformational fault within the Central Crystalline in the south.

5.2.2.2 *Folds*

The Central Crystalline exhibits three phases of megascopic deformation as discussed below.

F_1 folds: These are symmetric to asymmetric, reclined, tight to isoclinal and recumbent folds having high amplitude: wave-length ratio with axial plane foliation and plunge generally towards NNE or NE at low to moderate angles. These are mostly preserved as rootless folds in quartzite and as lenses within quartz-mica schist and show thickening of hinges and attenuation of limbs defining flattened parallel folds. These are developed during 1st phase of deformation on bedding surfaces (S_1).

F_2 folds: These are developed during the second phase of deformation and refolded the earlier structures. The folds are generally upright with broad smooth rounded hinges, and are characterised by curving of both stratification and S_2 schistosity around the hinges. The axial plane is sub-vertical trending NE-SW to NNE-SSW with low amplitude:wave-length ratio. The axes plunge towards NE or SW at moderate angles. It is accompanied with development of axial-plane crenulation cleavage (S_3) in schistose rocks and fractures in quartzite.

F_3 folds: These are broad open folds on S_2 and S_3 surfaces with axes trending NW-SE with moderate dips towards northeast and are related to the third phase of deformation.

5.3 GEOMORPHOLOGY

The area around the proposed Jelam-Tamak Hydroelectric Project is located in the Great Himalaya in Alaknanda basin. It presents extremely rugged topography and has very high relief with altitudes going up to 6300m at Nanda Ghunti. The high ridges, which separate different river systems trend in NW-SE to WNW-ESE direction. In general, the northern slopes are gentler as compared to southern slopes due to influence of dip slopes. The valleys are V-shaped, steep and narrow gorges. River Alaknanda flowing south westerly is the principal draining agency in the northern part of the area. The tributaries of Alaknanda include Dhauli Ganga, Birahi Ganga and Mandakini. The river Dhauliganga, on which Jelam Tamak Project is planned, flows in southerly direction in general up to Malari downstream of its confluence with Girthi Ganga and follows southwesterly course downstream of it. Downstream of Malari it flows through a narrow valley with steep abutments. It is joined by Bhujgarh Gad and Kosa Gad in this reach. Both these Nala are reported to bring large amount of debris in the form of avalanches. The valley of the river opens up downstream of Jelam in general except for a few reaches and continues in similar fashion up to downstream of Tapoban. One significant feature observed in the valley of Dhauliganga in the reaches downstream of Jelam is existence of a number of sites where the river course has been blocked by either landslide resulting from failure of valley slopes or by the enormous amount of debris brought down by tributary nalas in the form of avalanches in recent past. This has resulted in reaches with very gentle gradient alternating with those having relatively steeper gradient. One such old blockade site is located within the project area at the confluence of Dronagiri Gad, a left bank tributary of Dhauliganga. It appears that the river Dhauliganga was blocked by the huge amount of debris brought down by Dronagiri Gad and the reservoir resulting from that extended up to Jelam village located about six kilometers upstream. The riverbed in this reach is wide and covered by thick sand and silt deposits that were deposited in lacustrine environs that resulted due to blockade of main river.

This observation is corroborated by the fact that bed gradient of the river upstream of Jelam is 1 in 30 and that goes down to 1 in 160 in the reach downstream. It is also observed that the bed gradient of the river again becomes relatively steeper in the reach downstream of confluence of Dronagiri. It appears from the above that Jelam Tamak Project is located in the reach where the river was blocked in the past and bedrock in the riverbed is not expected to be encountered at reasonable depth. The study carried out by National Institute of Hydrology (NIH) indicates that though there are many glacial lakes existing in the catchment of Dhauliganga and all of these are not big enough to hold the quantity of water that could much impact on downstream areas.

5.3.1 Land Slides

In Mana-Vishnu-Malari Central Crystalline, medium intensity landslide zone was noticed. Landslides were characterized with density ranging from 3 to 6 slides per sq. km in the villages of Lata, Jelam and Malari. These zones are consisting of schist, gneiss, granite and loose boulders, causing medium intensity of landslides (Saxena, 1982). In addition, Dhauliganga valley is characterized with slopes susceptible to high erosion and is marked by active landslides along the left bank of the river. Since the left bank hill slopes are predominantly composed of slid masses, the bank erosion basically causes a toe erosion of the slid material further aggravating erosion (Lakhera, 1982). In the close vicinity of project component area, no active landslide was observed.

5.4 GEOLOGY OF PROJECT AREA

5.4.1 General

The rocks exposed around the project area are regionally metamorphosed high grade metasediments, migmatites with Paleoproterozoic intrusive granite gneiss and younger granites.

Heim and Gansser (1939) referred to this sequence as Central Crystalline zone or crystalline series. Subsequently, Central Crystalline was given lithostratigraphic status. Different workers subdivided and named it differently in different areas. Gaur et al (1977) divided these rocks on the basis of lithology. Agarwal and Mukhopadhyay (1975) have subdivided the Central Crystallines into six formations viz Helang, Joshimath, Pandukeshwar, Rarang Chatti, Bamni and Mana whereas Pati and Rao (1979) have divided the same into five members that include Helang, Shelang, Joshimath, Pandukeshwar and Hanuman Chatti. Kumar (2005) based on the works of Kumar and Agarwal (1975), Agarwal and Mukhopadhyay (1983) and Thakur (1993) evolved following sequence for Central Crystalline Group.

Ragsi Formation is oldest formation of Central crystalline Group. It consists of green to silvery white kyanite-paragonite, muscovite schist and gneisses. In Alakananda valley around Helang, para amphibolite, marble and gneisses are associated with it. It appears to be equivalent to Helang Member of Pati and Rao (1979) and Helang Formation of Agarwal and Mukhopadhyay (1975). Helang Member of Pati and Rao (1979) is exposed immediately to the north of the Helang Thrust and extends from Helang in the Alaknanda Valley to Balan in Kali Ganga Valley. It shows much lateral lithological variation. The principal rock types are quartz-biotite schist, kyanite-biotite schist, biotite-muscovite schist, chlorite schist, phyllonite schist mylonitic gneisses, tourmaline granite gneiss, biotite gneisses, porphyroblstic biotite streaky gneiss, quartzite sericite, crystalline, limestone, hornblende schist and gneiss, etc. The gneisses alternate with schist bands and show lateral pinching and swelling.

Bhimgora Quartzite Formation conformably overlies the Ragsi Formation. It is traceable from Bhimgora in Nagol Gad in south to north of Helang in Alakananda valley and Tapoban in Dhauliganga valley. It comprises white quartzite. In the Alakananda valley, associated with it is chlorite phyllite that probably been derived from amphibolite. This formation is conformably overlain by Joshimath Formation. The rocks strike in general in NW-SE direction with 25° to 45° dips in NE direction. In Alaknanda valley, the contact between gneisses and garnetiferous carbonaceous schists is locally sheared It could probably correlated with Shelang Member of Pati and Rao (1979) and is included in Joshimath Formation of Agarwal and Mukhopadhyay (1975). Joshimath Formation conformably overlies the Bhimgora Quartzites in the south and is overlain by Pandukeshwar Formation in north. Valdiya (1980), however, considered the contact between these two formations as tectonic one and named id Vaikrita Thrust. It is well exposed from south of Joshimath to south of Pandukeshwar. Regionally, it comprises metamorphosed banded psammitic and pelitic sediments represented by an interbedded sequence of garnet mica schist, staurolite-kyanite schist, sericite quartzite, quartz porphyry, amphibolite and associated coarse grained biotite augen gneiss. This formation has been correlated with Munsiari Formation of Goriganga valley (Kumar, 2005) and appears to equivalent of the formation of same of Agarwal and Mukhopadhyay (1975) and of Pati and Rao (1979). These are highly puckered and thinly laminated. The limestone is crystalline in nature and occurs as impersistent bands and lenses. These have been recrystallised to marble at places. The lower part is predominantly gneisses whereas schists are dominant in upper part. The general strike of rocks varies from WNW-ENE to NW-SE with dips between 30° and 60° towards NE. Pandukeshwar Formation consists of bedded quartzite, banded quartzitic gneiss and interbedded garnet biotite schist. These are well exposed in Dhauliganga Valley between Surithota and Juma Gad. This formation has been given same name by Agarwal and Mukhopadhyay (1975) and of Pati and Rao (1979) and is extensively exposed in the project area in the downstream reaches of head race tunnel and powerhouse area (see **Fig.5.2**).

The general strike of rocks varies from NW-SE with 25° to 35° dips towards north. Badrinath Formation is the youngest formation of the Central Crystalline Group. It is well exposed between Hanuman Chatti in Alaknanda valley and has been named by Thakur (1993). It appears to be equivalent of Hanuman Chatti Member of Pati and Rao (1979). It includes a thick sequence of gneisses, schist, quartzites, limestone and granulites with meta basic rocks exposed north of Hanuman Chatti in Alaknanda Valley. In Dhauliganga Valley, rocks of this member are exposed from Juma to Malari. It overlies Pandukeshwar Member in the south and the northern contact of this member with Tethyan sediments is marked by a fault near Malari. Main rock types of this member include well foliated porphyroblastic migmatitic and occasionally banded gneisses and granulites alternating with schistose, banded grey quartzites and schists. The schists are highly puckered. Highly schistose meta basic rocks occur as thin sills along the foliation planes. The rocks in general strike in NW-SE direction and have 30° to 60° dips towards NE. Three distinct tectonic units have been observed in the area. These are Garhwal Group, Central Crystallines and Ghat Formation. The Central Crystalline Group is separated from the Garhwal Group of rocks by a low angle thrust locally designated as Helang Thrust.

The Garhwal Group of rocks underlies the rocks of Ghat Formation with tectonic contacts on either side. At least three planar surfaces have been recognised in the area. S1 surfaces are represented by bedding planes indicated by original compositional and lithological banding. S2 surface are foliation planes marked by schistosity and cleavage in the rocks. These two planes are parallel to sub parallel at most of the planes. S3 surfaces are represented by fracture cleavage planes. At least three phases of folding have been recognised in the area. The first phase of folding F1 is represented by tight, reclined interfolial folds plunging in NE and SW directions. These are not traceable on regional scales and S1 surfaces have been folded by these folds. The S2 surface have been folded by the second phase of folding F2 into very broad, open to tight isoclinal folds and minor drags and puckers trending in NW-SE and N-S directions.

These are represented by series of folds in Pipalkoti and Wan areas; Maithana synformal structure in Garhwal Group of rocks; a series of inverted isoclineal folds in Dhauliganga section from Suritho to Juma in Pandukeshwar Formation. The third phase of folding F3 is represented by E-W trending folds as observed near Chinchini Binayak, north of Wan along Kali Ganga valley etc. Pipalkoti antiformal structure extends from Pipalkoti in the Alaknanda valley to Pindar Valley. In the core of this, Pipalkoti Formation is exposed which is flanked by Chamoli Formation on either side. This antiformal structure closes to the west to the west of Pipalkoti. A major anticline trending NW-SE can be traced from Ramni to Wan and further beyond Kali Ganga Valley. It plunges NW in the north of Ramni. Mailthana synformal structure is supplementary to Pipalkoti antiformal structure. It trends in NW-SE direction and can be traced from Maithana in the Alaknanda Valley to Pindar valley and beyond. It closes in NW of Maithana. A number of NE-SW trending vertical faults have been observed along the Bhadra Gad, near Gauna along Birhi Ganga and near Jhinji north of Josjhimath. Helang Thrust separating Joshimath Formation from the Garhwal Group of rocks passes through little south of Helang Village in Alaknanda Valley. It may be representing Main Central Thrust (MCT) in this area. It dips due north at 30° - 35° and runs almost in NW-SE direction and passes little north of Pana, Chinchini Binayak and extends up to north of Balan.

5.4.2 Reservoir

The reservoir resulting due to impoundment of water by a 28m high (above the deepest foundation level) barrage with FRL at 2648.5 m is expected to spread over an area of 37.92 Ha. It is expected to extend for a length of about 3.3 km along the river Dhauliganga upstream of barrage.

The geological map of the reservoir area indicates that the river Dhauliganga upstream of the barrage site flows through slightly wider valley for a distance of about 1.8 km and then the valley narrows down considerably towards upstream. In most cases, the right bank slopes are covered by slopewash deposits. Exposures of bedrock are seen along river edge at few locations and at higher reaches. No slide or unstable zone has been observed along the right flank.

Bedrock is extensively exposed all along the left bank upto a height varying from 25m to more than 80m above riverbed. Occurrence of slopewash deposits has been observed in patches. No avalanche and/or slide zone has been observed along the left bank. The bedrock exposed in the area includes Grantic gneiss, migmatite and quartzitic gneiss with bands of quartzite and mica schist. The bedrock is slightly weathered on the surface. The bedrock is foliated and jointed. Foliation, the most prominent discontinuity, strikes in general NNW to SSE direction with dip 40^0 to 60^0 towards E-EEN direction. The area is traversed by two other prominent joint sets.

No evidences of distress were observed on the valley slopes on both the banks even on overburden materials in the area around reservoir. So, the small pondage due to the impoundment of reservoir and small fluctuation of reservoir level between MDDL and FRL will not make any adverse impact on the reservoir rim stability in general. However, possibility of sloughing of slopewash deposits resting on steep slopes at lower elevations during initial filling and operation of reservoir can not be ruled out.

5.4.3 Headrace Tunnel (HRT)

Alternative layouts considered during feasibility stage studies included two alternative alignments for HRT. The HRT in case of Alternative-II, a left bank development, was envisaged on the left bank of the river Dhauliganga. However, the appraisal of this alternative alignment indicated that the HRT could be day-lighted while negotiating Dronagiri Nala, a left bank tributary of Dhauliganga.

The HRT in case of Alternative-I at feasibility stage was envisaged on the right bank of Dhauliganga River. The intake in this case was proposed in hard and massive gneissic rock exposed on the right bank of the river just upstream of the proposed barrage axis. The proposed HRT was to negotiate only one major cross drainage, Juma Gad where availability of adequate vertical rock cover was established through a drill hole drilled in the nala bed. The length of HRT as per this proposal was 6141.91m. However, based on detailed studies, the alternative barrage axis B4 was selected for locating diversion structure and the HRT was realigned on the right bank of Dhauliganga accordingly. The length of the HRT along this proposed alignment works out to 4870.63m. After detail study, the barrage axis has been finalized as Alternative-2 near B4 axis and a 4428.79m long and 5.2m finished diameter horse shoe shaped HRT with a view to convey 67.38 cumecs of designed discharge to powerhouse has been proposed on the right bank of the river Dhauliganga.

5.4.4 Construction Adits

In order to facilitate the construction activities and maintain the construction schedule, the 4428.79m long HRT has been provided with three construction adits. Out of these 3 adits, two have been provided at upstream and downstream ends of HRT and one at intermediate location. Upstream Construction Adit is located on the right bank slope of the river Dhauliganga in the initial reaches of HRT. Geological map of the area indicates that the bedrock exposed in the area comprises gneiss. The bedrock is foliated and jointed. It is traversed by four sets of discontinuities of which those parallel to foliation are most prominent. It is observed from geological section along the adit that this 387.32m long adit is aligned askew to the strike of foliation (S1) by 47° which is not ideal.

Inlet portal of 604.85m long Intermediate Construction Adit-3 is proposed on right bank of Dhauliganga above Joshimath - Malari Road. Geological map of the area indicates that the hill slopes around the proposed adit alignment are in general covered by slopewash deposits at lower elevations below the road and isolated exposures of quartzite are present within the overburden. The hill slopes above the road expose the bedrock, after about 15-20m, comprising quartzite belonging to Pandukeshwar Formation overlain by gneisses belonging to Badrinath Formation extensively. Gneisses are exposed in the upstream areas while quartzites are confined to downstream areas. The bedrock is foliated and traversed by three sets of discontinuities of which foliation joints are most prominent. Foliation plane dips towards valley by 39^0.

For construction facility, Inlet portal of 284.46m long Downstream Construction Adit is proposed on right bank slope of the river Dhauliganga above Joshimath - Malari road at El 2589.00m. Geological map of the area indicates that the hill slopes surrounding the adit alignment expose bedrock extensively. However, patches of slopewash covering the bedrock are also observed in the area. Bedrock exposed in the area comprises quartzite with thin bands of schist and occasional bands of basic rocks disposed as sills and dykes have also been observed. The bedrock is foliated and traversed by three prominent sets of discontinuities of which the joints aligned parallel to foliation are most prominent.

5.4.5 Powerhouse Complex

Geological map of the area around the powerhouse complex indicates that bedrock is exposed right from riverbed/road level in the downstream part on this bank. Right bank in general is occupied by overburden between riverbed and Joshimath – Malari road. Depositional fluvial terraces at two levels are observed on right bank in the area. The right bank slope above the terrace rises moderately up to a height of about 30m and is relatively steep beyond it. It is observed from geological map of powerhouse complex that hill slope in the area on the right bank expose bedrock in the upstream portion whereas these, in the downstream are covered extensively by slope wash deposits. It is observed that bedrock exposed on both banks of the river comprises quartzite with thin schistose bands. It belongs to Pandukeshwar Formation of Central Crystalline Group. The bedrock comprising quartzite is foliated and jointed. The foliation in general strikes in N03°W – S03°E and dips on an average by 39° towards east. The rock mass in the area is traversed by two major sets of joints in addition to those parallel to foliation plan.

5.5 GEOTHERMICS

Geothermal Atlas of India published by Geological Survey of India (1991) reveals that there are 62 thermal spring location in Uttarakhand Himalaya that are restricted between 1000m and 4000 m altitudes and occupy a 10 to 40 km wide zone all along the major river valleys. Of the 62 thermal spring localities recorded in this part of Himalaya, 37 are located in the area north of Main central thrust exposing the rocks belonging to Central Crystallines, the zone in which the proposed project is located and 22 are located in lesser Himalaya exposing the rocks belonging to Garhwal Group. The remaining three such localities are located in Tethys Himalaya zone. The thermal springs occurring within the Central Crystallines show high temperatures varying between 55°C and 94°C where as majority of those located in the area exposing the rocks belonging to Garhwal Group show low temperatures varying between 22°C and 38°C.

The proposed Jelam -Tamak Hydroelectric Project is located in Dhauliganga valley in the area that exposes the rocks belonging to Central Crystalline Group in the vicinity of Tapoban Geothermal area in the Himalayan Geothermal Province. This geothermal province is characterised by temperature gradients in excess of 100°C/km and heat flow in excess of 200mW/m2. As per Heat Flow Map of India and Adjoining Areas (1996) the project area is located in Heat Flow Zone-II which is characterised by heat flow ranging between 100 and 80mW/m2. It may also be mentioned here that the proposed project is located in the vicinity of Tapoban Geothermal area in Higher Himalaya. The highest temperature recorded in the springs is 65°C and discharge varies between 0.83 and 9.22 lits/sec. One of the springs indicated gaseous emanations. Two drill holes drilled in this area encountered thermo-artesian conditions at 79m and 431m depths respectively. The drill hole AGW-2 has discharge of 11 lit/sec flowing at 80°C. The other hole AGW-3 drilled about 1.5 km ESE of AGW-2 had 13lit/sec discharge at 90°C when blowout occurred in the hole and jet of water rose to 10m above ground. The discharge subsequently came down to 1.7lit/sec. The distribution pattern of thermal springs in the area around the proposed project indicates that following springs in addition to those in the Tapoban Geothermal area have been recorded (Table 5.3).

Table 5.3 Hot springs located in the influence area

S.N.	Site	Coordinates	Temperature	Location
1	Yong	30° 44’ 45”N: 80° 01’ 56” E	52°C	u/s of the proposed project
2	Sumna	30° 43’ 40”N: 80° 01’ 30” E	36°C	u/s of the proposed project
3	Bhapkund	30° 40’ 05”N: 79° 50’ 50” E	28°C	vicinity of the project area
4	Bhapkund*	30° 40’ 05”N: 79° 50’ 50” E	11°C	vicinity of the project area
5	Juma	30° 36’ 00”N: 79° 48’ 10” E	62°C	vicinity of the project area
6	Juma*	30° 36’ 00”N: 79° 48’ 10” E	15°C	vicinity of the project area

*Represent cold Waters

Table 5.3 indicates that two of the six springs recorded i.e. Yong and Sumna are located further up stream in the valley of Dhauliganga and may not have much influence on the geothermal conditions in the project area. It is also observed from the above table that out of the four springs located either within the project area or in its immediate vicinity, two are cold water springs whereas two of these indicate temperatures of 28°C and 62°C.

5.6 SEISMOTECTONICS

5.6.1 Seismotectonic Environment

Uttarakhand falls in the Himalaya region, which is seismically active zone. The regional seismotectonic map of Uttarakhand Himalaya is shown in **Figure 5.3**. It is continuously under stress field and undergoing crustal adjustments since the last phase of Himalayan Orogeny Movement (HOM-4) in Middle Pleistocene when the Sub-Himalaya and the Himalaya gained the present heights. These crustal movements, referred to as the neotectonic activity, are identifiable in the form of reactivation of some of the existing major tectonic lineaments and development of cross-faults (**Fig.5.3**) along which block movements are taking place.

A large number of cross-faults have been mapped which subdivide the Himalaya into several blocks (**Figs 5.3 and 5.4**). These faults, in general, trend in north-south to northeast-southwest directions in the north-western part of the Himalaya. Some of these cross faults are traceable up to the Indo-Gangetic plain. These cross-faults have also controlled the drainage and development of wide river terraces in some areas. The neotectonic activity along the Foot Hill Fault, Main Boundary Fault and Ramgarh Thrust has been recorded. The seismic epicenters are concentrated in the vicinity of the MCT. In the Barkot-Bhatwari sector they are concentrated in the south of MCT, but in the Bhatwari-Okhimath sector they cluster in the north of MCT. However, in the Okhimath-Gopeshwar sector the epicenters are clustered on either side of MCT.

Five distinct seismic zones have been demarcated in the northwest Himalaya taking into account i) the seismicity patterns and tectonic set up, ii) the contemporary deformation style evaluated on the basis of manifestations of neo-tectonic activity, as well as iii) direction of crustal shortening in Quaternary sediments and source mechanism of discrete seismic events. Those zones are i) Foot-hill Seismic Zone, ii) Main Himalayan Seismic Zone, iii) High Himalayan Seismic Zone, iv) High Plateau Seismic Zone, and v) Kashmir Syntaxial Seismic Zone. Of these, the first three Seismic zones are further subdivided into six blocks/segments with well-defined transverse boundaries marked by interpretative fundamental faults (Narula et al., 2000) that are believed to play a significant role in the generation and modification of source parameters. These segments are named as Kashmir, Chamba-Kishtwar, Kangra, Shimla, Garhwal and the Kumaon blocks (**Fig. 5.4**). These block boundaries can act as earthquake nucleation sites with rupture propagation only in one direction along the longitudinal (Himalayan trend) seismic source

(Acharyya and Narula, 1998) The Garhwal and the Kumaon blocks (**Fig. 5.4**) lie in Uttarakhand Himalaya. The Garhwal Block of the Main Himalayan Seismic Zone is bounded by the Kaurik-Chango Fault (transverse cross-fault) in the west, the Main Central Thrust on the north, the Alaknanda Fault in the south, and the Niti Fault, a transverse cross-fault, in the east. Like seismic epicenters the hot springs are concentrated in the MCT zone in Uttarakhand Himalaya.

Table 5.4 Chronological listing of Earthquakes of magnitude expressed in magnitude > 5.5, Uttarakhand (Source: Narula *et al.* 2000; Khattri, 2000)

Ref.	Year	M	Dt.	Hr	Min.	Sec.	Lat. N	Long. E	Ms	Mb	Depth	Source No.
1.	1803	09	01	--	--	--	30.30	78.80	8.0	--	--	--
2.*	1816	05	26	22	--	--	30.90	79.00	6.5	--	--	IMD
3.*	1842	03	05	21	10	--	30.70	78.00	5.5	--	--	IMD
4.*	1902	06	16	--	--	--	31.00	79.00	6.0	--	--	IMD
5.*	1906	06	13	--	--	--	31.00	79.00	6.0	--	--	IMD
6.	1911	10	14	23	24	00.0	31.00	80.50	6.7	--	--	GR
7.	1916	08	28	--	--	--	30.00	81.00	7.5	--	--	--
8.	1926	07	27	--	--	--	30.50	80.05	6.0	--	--	IMD
9.	1927	10	08	07	23	36.0	30.50	80.50	6.0	--	-	IMD
10.	1935	03	05	10	34	28.0	29.75	80.25	5.8	--	--	GR
11.	1945	06	04	22	12	53.0	30.30	80.0	6.5	--	60	IMD
12.	1947	08	19	12	08	55.0	31.20	79.09	5.9	--	--	IMD
13.	1949	02	05	20	07	06.0	31.20	79.05	5.5	--	--	IMD
	1955	06	27	10	14	09.0	32.00	78.50	5.7	--	-	IMD
14.*	1958	12	28	08	55	20.0	29.50	80.00	6.0	--	--	CGS
15.	1958	12	31	--	--	--	30.10	80.70	6.0	--	--	--
16.*	1961	12	24	05	34	36.0	29.43	80.83	5.6	--	59	ISS
17.	1962	07	13	07	13	30.0	30.50	79.60	5.5	--	25	IMD
18.	1962	07	14	05	01	08.6	30.40	79.50	5.5	--	40	IMD
19.	1963	01	30	15	58	53.7	29.50	80.90	5.5	--	--	IMD
20.*	1964	09	26	10	33	50.0	29.56	80.46	--	5.8	50	ISC
21.*	1966	03	06	00	46	02.6	31.50	80.50	--	6.0	50	ISC
22.*	1966	06	27	02	15	57.2	29.62	80.83	--	6.0	06	ISC
23.	1966	06	27	10	41	08.1	29.71	80.89	--	6.0	36	ISC
24.	1966	12	16	10	59	18.1	29.62	80.79	--	5.7	19	ISC
25.	1979	05	20	20	52	16.3	29.93	80.27	--	5.6	16	ISC
26.*	1991	10	19	22	59	11.6	30.77	78.79	--	6.4	15	ISC

27.*	1997	01	05	21	23	15.0	29.80	80.50	--	5.5	16	IMD/ISC

*Earthquakes located in the Garhwal block (Source: EIA report Alaknanda HEP)

The fault-plane solution for five events (**Table 5.5, Fig.5.3**) indicate that in the Kaurik-Chango fault region strike-slip mode of failure is predominant and in other parts of the Kumaun-Garhwal Himalaya thrust fault mechanism prevails**.**

5.6.2 Seismic Zoning

5.6.2.1 *Seismic Zoning Map of India*

The revised Seismic zoning map of India (BIS: 2002), encompasses four zones namely II, III, IV and V (**Fig. 5.5**). The zone factors are also shown in Table 5.6. On the seismic zoning map of India, Uttarakhand Himalaya lies within the ambit of the Seismic Zone V (zone factor 0.36) of I.S. code 1893-1984/1998/2002 (see **Fig. 5.5**). Therefore, there is always a necessity to consider the factor of safety for highest earthquake intensity while designing an engineering construction.

5.6.2.2 *Isoseismals of important earthquakes*

Important recent earthquakes which struck the Uttarakhand Himalaya are listed in **Figure 5.6**. The epicenters of most of the earthquakes of varying intensity lie on the surface trace of MCT, a ~50 km wide weak zone, in Uttarakhand Himalaya. In this tract at least 36 events of magnitude >5 have occurred in the Garhwal Division alone in the past one and a half centuries. The recorded historical catastrophic event dates back to 1803. This event accounts for a toll of 200-300 people in Uttarkashi. Besides, Badrinath area was also severely affected. About 24 earthquakes at magnitude >5.5 are recorded between Long. 78°-81° N and Lat. 29° -31.3° E in this zone (see Table 5.4).

Table 5.5 Focal Mechanism solutions for selected events in the Uttarakhand Himalaya

Plot No.	Year	Month	Date	Bulk Magnitude	NP 1		NP 2		P- Axis		T-Axis		B-Axis		Source
					Strike	Dip	Strike	Dip	Plunge	Azimuth	Plunge	Azimuth	Plunge	Azimuth	
1	1958	12	28	5.8	102	54	282	36	10	192	80	12	0	282	Tandon & Srivastava' 75
2	1964	09	26	5.8	305	17	114	73	28	207	62	19	03	115	Chandra, 1978
3	1979	5	20	5.7	282	15	102	75	30	190	60	10	0	100	Ni & Barazangi '84
4					274	7	105	83	38	194	52	16	1	285	HRV
5	1986	7	16	5.6	278	17	152	80	33	231	53	79	14	330	HRV
6					288	34	165	70	21	244	54	108	26	334	DAS Gupta, '97
7	1991	10	19	6.4	317	14	12	78	32	207	57	14	6	113	HRV
8					349	26	100	80	30	210	50	342	23	105	Das Gupta, ' 97*

Source : Narula *et al*. (2000)

Table 5.6 Seismic zones of India with corresponding zone factors

Seismic Zones of India	Hazard Intensity	Z(g)
II	Low Damage Risk Zone	0.10
III	Moderate Damage Risk Zone	0.16
IV	High Damage Risk Zone	0.24
V	Very High Damage Zone	0.36

Z(g) = zone factor

Uttarkashi Earthquakes of 20 October, 1991: An earthquake of magnitude 6.6 occurred at 02h 23m 16s IST on 20th October, 1991 in the Inner Lesser Himalaya in the Gharwal block (see **Fig.5.4**). The strong ground motions lasting for over 45 seconds, led to a toll of 768 human lives, injured 5066 persons and caused severe to partial damages to about 0.1 million houses. There were a number of aftershocks, the frequency of which showed rapid fall from more than 150 on the 21st October, 1991 to less than 10 by the end of November 1991. The main shock and aftershocks induced numerous landslides of rockfall type, overburden failures, slumps, rock dislodgement and ground fissures. The focal depth of the earthquake was worked out to 13.3 km. Utilising MSK-64 intensity scale, isoseismals were drawn (**Fig. 5.6**). The maximum intensity in the epicentral tract is IX and encompasses an area of about 20 sq km (Narula *et al*. 1995; Rastogi and Chadha, 1994). On the basis of the disposition of the epicentral tract, isoseismal patterns and the plot of the after shocks, an N60°W-S60°E alignment of the source plane was indicated. The trend of the inferred plane corresponds to the surface trace of the MCT, which is located about 7km north of the epicentral tract.

Chamoli Earthquake of March 29, 1999: The epicenter of this event is located in the Kumaon block at the boundary of Garhwal block (see **Fig. 5.6**). This earthquake of magnitude 6.8 mb with epicenter at Lat. 30.41°N and Long. 79.42°E caused extensive damage to life and property. A toll of 103 human lives, extensive damage to 4495 buildings, and partial damage to more than 25,000 buildings are recorded (Narula *et al*., 2000). The macroseismic survey indicated maximum intensity of VIII on MSK-64 scale around Chamoli. An area of about 1200 sq km. was included in an almost E-W elongated epicentral tract of isoseismal VII of almost uniform and same grade damages; the long axis to short axis ratio being 9:2. According to Narula *et al*. (2000), the earthquake nucleated at the intersection of a transverse fault and the rupture propagated towards west along the detachment surface. After this earthquake, 338 active landslides, including 56 earthquake-induced landslides were mapped downstream of Joshimath up to Chamoli (Barnard *et al*., 2001). These landslides are mainly comprised of the shallow failures in regolith and highly weathered bedrock involving avalanches, slides and flows.

5.6.2.3 *Seismic maps and spatial disposition of the project area*

The spatial disposition of the project area in the regional seismotectonic setup of Uttarakhand is shown in Figs 5.3 and 5.6. It is evident from these figures that the project area is very close to seismically active zone in the vicinity of MCT. Since the project area forms a part of the seismic zone V, which corresponds to a zone factor of 0.36 (Effective Peak Ground Acceleration in terms of 'g' as per IS 1893: Part 2002). The north dipping Main Central Thrust (MCT) lies about 2 km northeast of the proposed barrage site and the seismic status of this thrust is not properly known. The Alaknanda fault, and Srinagar thrust (NAT) are located about 32 km and 45 km southwest respectively of the proposed barrage site. A number of other less prominent structural dislocations are also present in the area.

5.7 GEOENVIRONMENTAL ASPECTS

The considerable thickness of overburden precludes the construction of a barrage at either location, since it would need to be founded on rock. Geotechnical aspects that will need to be addressed for alternative design solutions will include settlement of the structure and forming an adequate cut off to prevent seepage and piping. Due to fear of snow avalanches and glacial outburst flood large reservoir is also not preferred. Therefore, the site is suitable for a barrage. However, at the present barrage site snow avalanches are slightly expected on the left abutment.

The intake in this case was proposed in hard and massive gneissic rock exposed on the right bank of the river just upstream of the proposed barrage axis. The proposed HRT was to negotiate only one major cross drainage, Juma Gad where availability of adequate vertical rock cover was established through a drill hole drilled in the nala bed. Much of the gneiss is expected to have a strength greater than 150 MPa, some sections, for example within schist, foliated gneiss and faulted zones could be expected to show evidence of stress problems, either in terms of instability and/or excavation profile and overbreak. Depositional fluvial terraces at two levels are observed on right bank in the area of proposed Power house. The right bank slope above the terrace rises moderately up, to a height of about 30m and is relatively steep beyond it. It is possible therefore that squeezing ground may be experienced, beneath sections of the headrace tunnel where the cover is high and schist or fault zones are encountered.

The area lies in the seismically active zone–V of the seismic zoning map of India and is in proximity with the MCT zone along which micro-seismic activity is witnessed in this part of Himalaya. Therefore, it is essential to adopt suitable seismic coefficient in the design for various appurtenant structures of the project. Suitable design for the barrage, tunnel, surge shaft and power house be adopted. The offices and colonies be suitably designed to withstand any future devastating earthquake. The old and new landslides in the project area must be taken into consideration during the construction of tunnel and safety measures, if required, be taken.

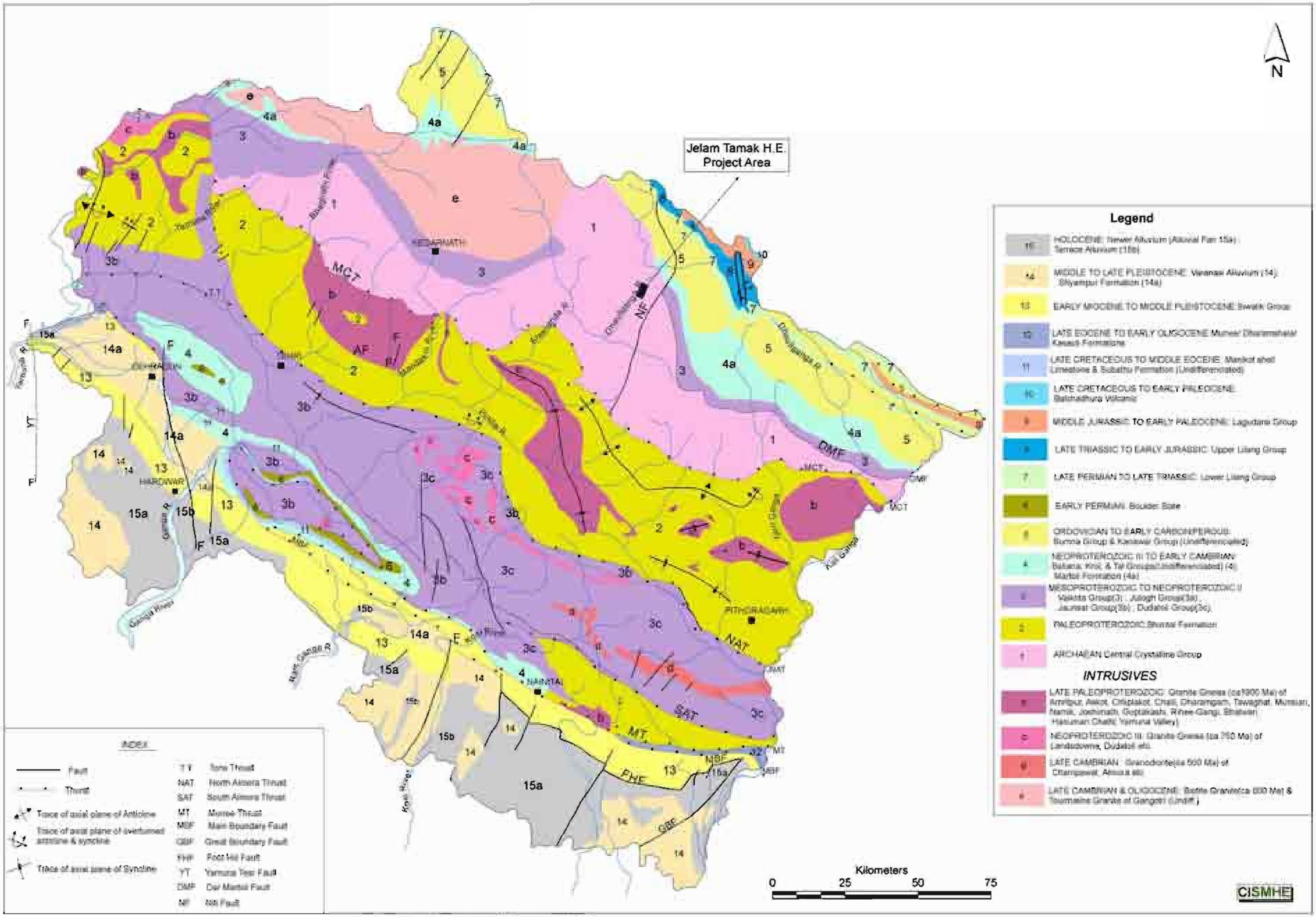


Fig.5.1 Regional geological map of Jelam Tamak H.E. Project (Source: Kumar, 2005)

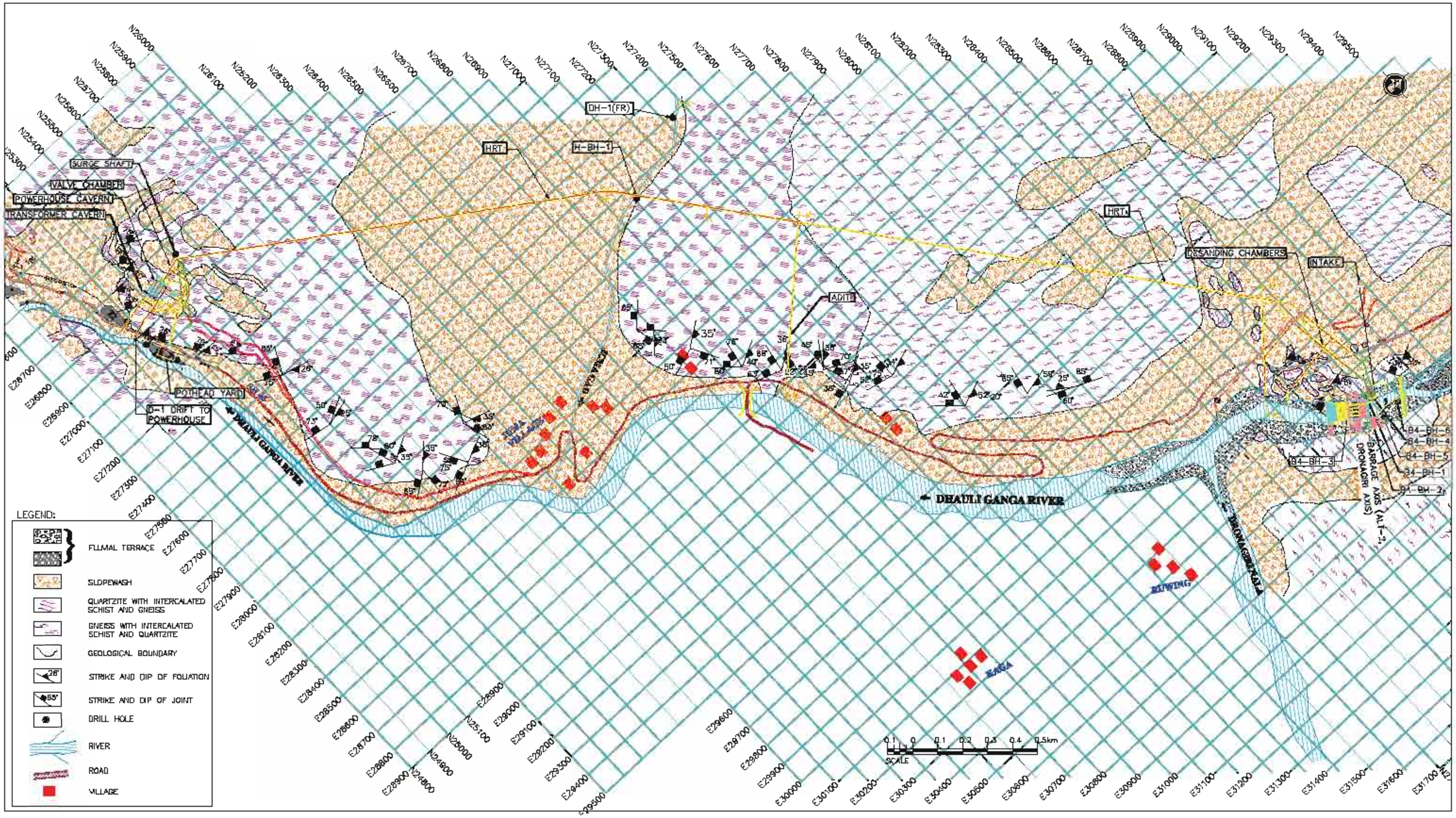


Fig.5.2 Geology map of the Jelam Tamak H.E. Project area

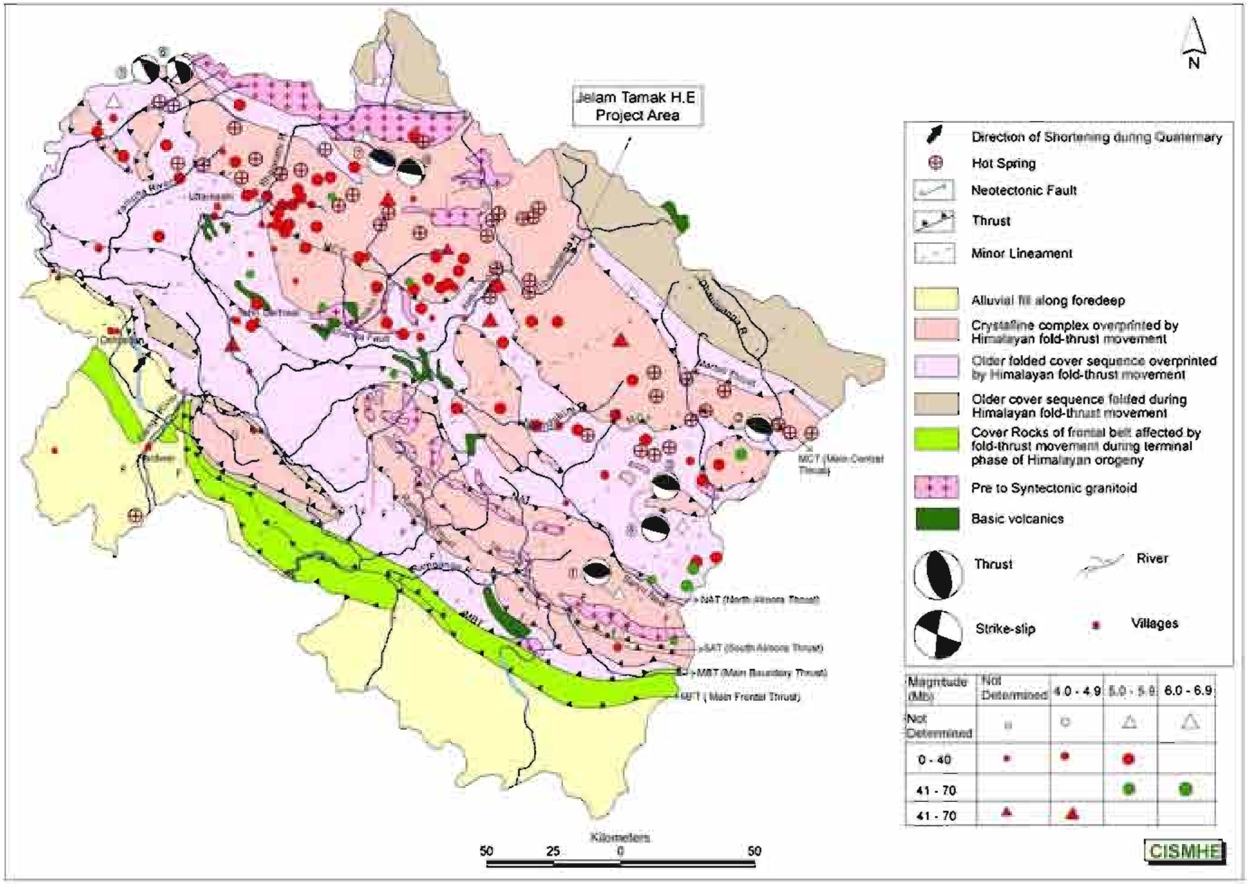
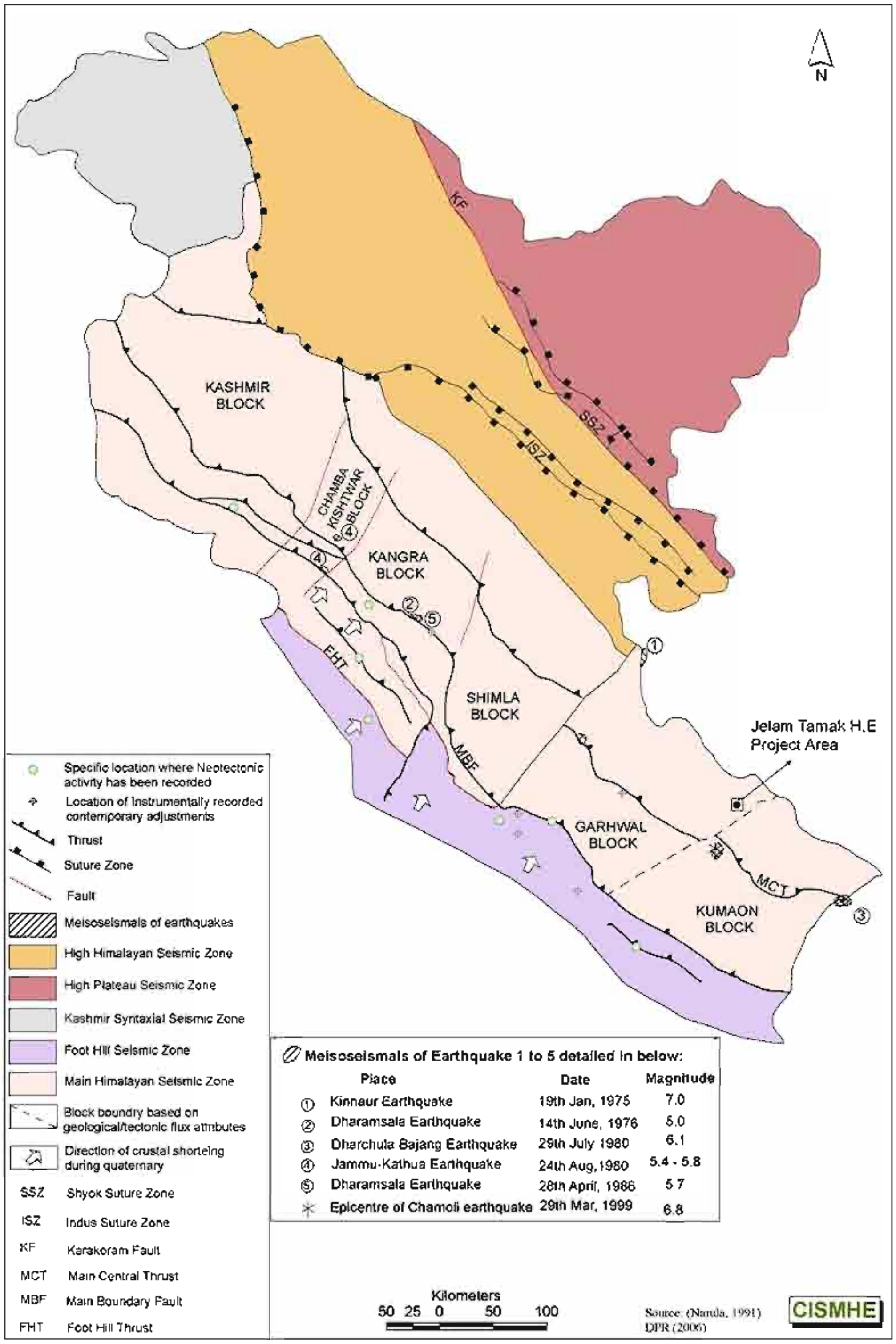


Fig.5.3 Seismotectonic map of the Uttarakhand Himalaya and the spatial disposition of the project area (Source : Narula et al.2000; CISMHE, 2006)



Meisoseismals of Earthquake 1 to 5 detailed in below:

	Place	Date	Magnitude
①	Kinnaur Earthquake	19th Jan, 1975	7.0
②	Dharamsala Earthquake	14th June, 1976	5.0
③	Dharchula Bajang Earthquake	29th July 1980	6.1
④	Jammu-Kathua Earthquake	24th Aug,1980	5.4 - 5.8
⑤	Dharamsala Earthquake	28th April, 1986	5 7
✳	Epicentre of Chamoli earthquake	29th Mar, 1999	6.8

Fig 5.4 Seismotectonic domains of N.W. Himalaya (Source : Narula,1991; CISMHE 2006)

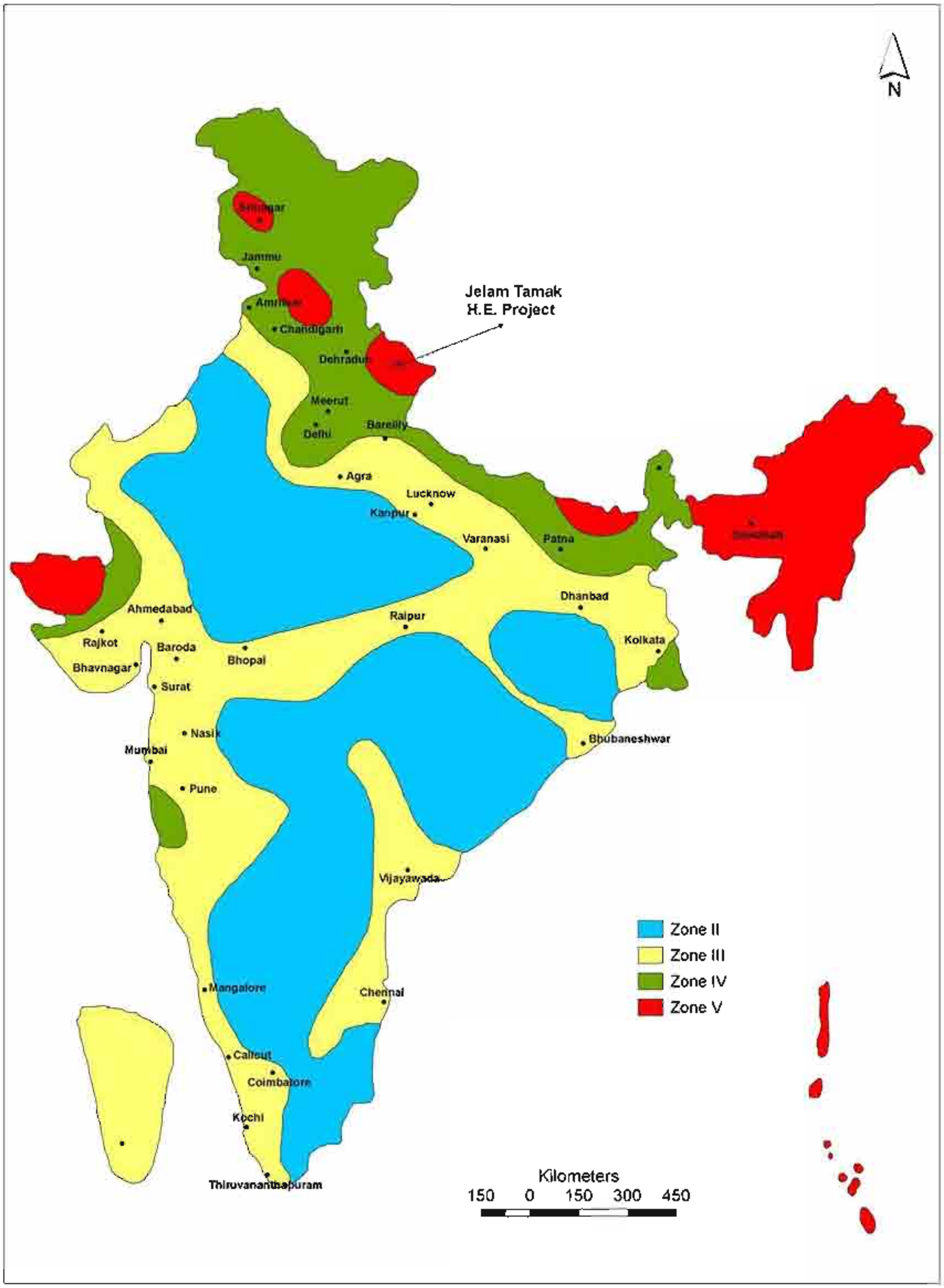


Fig. 5.5 Seismic zoning map of India (Source : BIS, 2001, New Delhi)

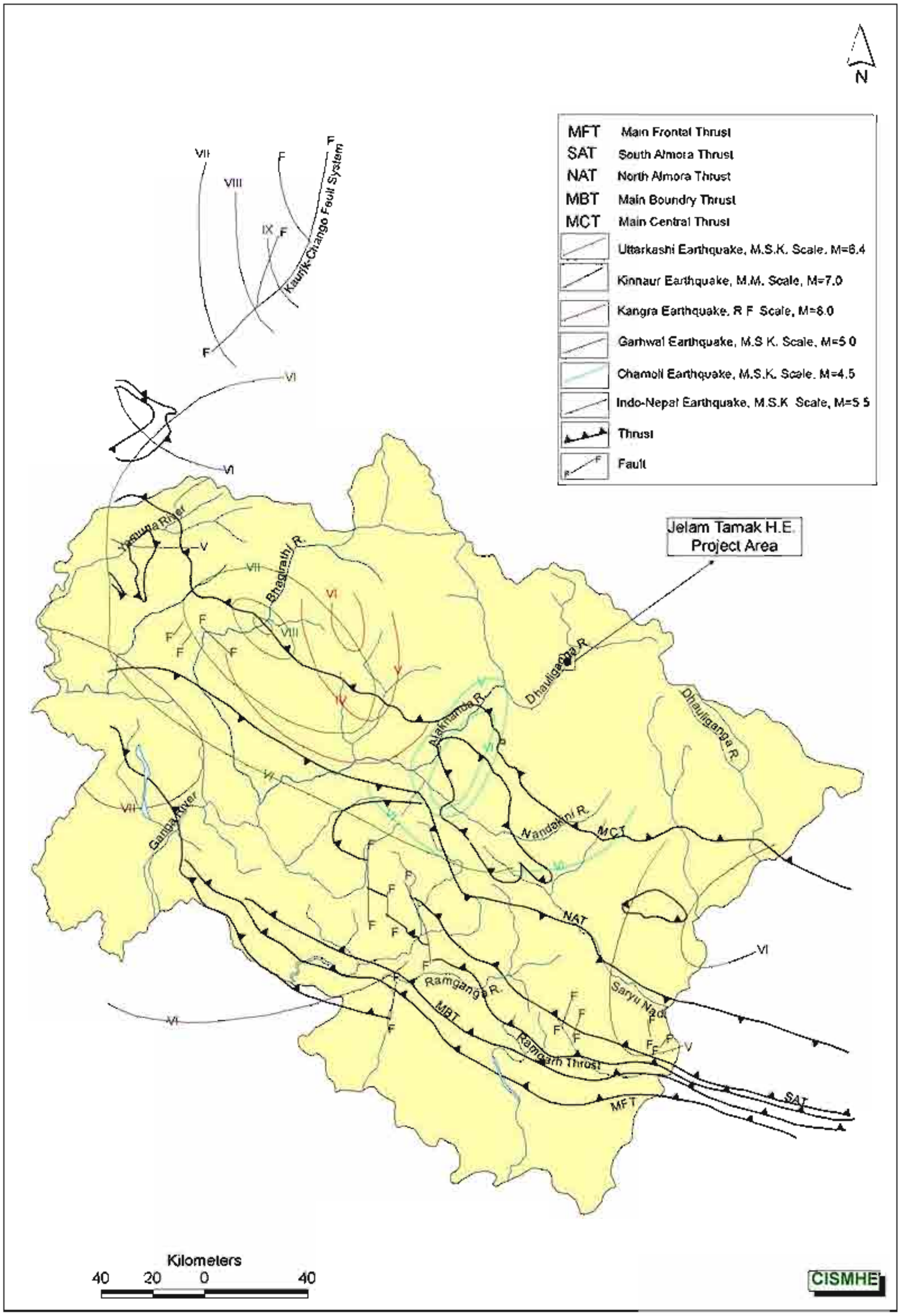


Fig.5.6 Isoseismal map of Kumaon-Garhwal-Kinnaur-Himalaya

Chapter 6
SOIL

6

SOIL

6.1 INTRODUCTION

Soils are one of most important components of ecosystem that controls the process of ecosystem through physical, chemical and biological properties. It is derived from the weathering of primary, sedimentary and metamorphic rocks, and conversion of raw materials. Soil formation depends on the climate, topography or relief, rock types and time.

Soil is primarily focused in the assessment studies of developmental projects especially in hydro-electric projects; many actions of the project are likely to deteriorate the soil quality and some of the properties of soils like erosion and sedimentation are closely related to the life of the project. The collection of the baseline data of the soil types and characteristics would be helpful in formulating the Catchment Area Treatment Plan of Jelam Tamak H.E. Project. This contribution highlights the soil profiles of catchment area, influence zone and the project areas.

6.2 SOIL TYPES

6.2.1 Catchment Area

Soils of the catchment area of Jelam Tamak H.E. Project comprises of 6 soils associations (**Fig. 6.1**; Tables 6.1 & 6.2). Soil association Lithic Cryorthents – Lithic Cryorthents is predominant in the catchment, covering an area of 24.9% of total catchment. It is very shallow, excessively drained, loamy soils on very steep slopes with loamy surface and very severe erosion. A large area of the catchment is covered with glacier associated soils.

Table 6.1 Soil associations of the catchment area of Jelam Tamak H.E. Project

Soil Unit	Main Group	Sub Group
1	Glaciers; *associated with*	Rock outcrops
2	Glaciers	-

3	**Lithic Cryorthents** Rock outcrops; *associated with:*	**Lithic Cryorthents** Very shallow, excessively drained, sandy-skeletal soils on very steep slopes with sandy surface, very severe erosion and strong stoniness.
4	**Lithic Cryorthents** Rock outcrops; *associated with:*	**Lithic Cryorthents** Shallow, excessively drained, sandy-skeletal soils on very steep slopes with sandy surface, very severe erosion and strong stoniness.
5	**Lithic Cryorthents** Very shallow, excessively drained, loamy soils on very steep slopes with loamy surface and very severe erosion; *associated with:*	**Lithic Cryorthents** Shallow, excessively drained, loamy-skeletal soils with loamy surface, very severe erosion and moderate stoniness.
7	**Typic Cryorthents** Moderately shallow, excessively drained, coarse loamy soils on steep slopes with loamy surface, severe erosion and moderate stoniness; *associated with:*	**Lithic Cryorthents** Shallow, excessively drained, loamy skeletal soils on very steep slopes with loamy surface, very severe erosion and moderate stoniness.
8	**Typic Cryorthents** Moderately shallow, excessively drained, sandy-skeletal soils on moderate slopes with sandy surface, moderate erosion and strong stoniness; *associated with:*	**Typic Cryorthents** Rock outcrops.
9	**Lithic Cryorthents** Rock outcrops; *associated with:*	**Lithic Cryorthents** Very shallow, excessively drained, sandy-skeletal soils on very steep slopes with sandy surface, very severe erosion and strong stoniness.

6.2.2 Influence Zone

Soils of influence zone comprise of 5 soil association with an area of 41195 ha. Typic Cryorthents – Lithic Cryorthents is most predominant soil group in the influence zone (**Fig. 6.2**; Table 6.1 & 6.2), covering an area of 48.8% of the total area. These soils are moderately shallow, excessively drained, coarse loamy soils on steep slopes with loamy surface and prone to severe erosion. Nearly 22% area of influence zone is covered with the glaciers.

Table 6.2 Different soil associations and their areas in the catchment area and influence zone

Soil Unit	Catchment area	Influence zone
Glacier	30057.18	10000.2
S2	15418.04	1765.73
S3	45245.99	4148.61
S4	8475.73	-
S5	24546.35	-
S7	37969.61	22175.71
S8	1698.70	3633.58
S9	7055.52	3648.19
Total	**170467.12**	**45372.02**

6.2.3 Project Areas

Proposed barrage site is located on the Typic Cryorthents – Typic Cryorthents soil group (see **Fig. 6.2**). Soil is moderately shallow, excessively drained, sandy-skeletal on moderate slopes with sandy surface, moderate erosion and strong stoniness; associated with Rock Outcrops. Proposed power house and HRT are located on the Typic Cryorthents – Lithic Cryorthents soil association. The soil is moderately shallow, excessively drained, coarse loamy soils on steep slopes and loamy skeletal soils on very steep slopes with loamy surface. Soils are prone to severe erosion to very severe erosion.

6.3 SOIL PROPERTIES

6.3.1 Physical and Chemical characteristics

No definite pattern was observed in the soil profile; medium sand, very coarse, coarse sand and very fine sand are predominant at all sites (Table 6.3). Fine silt with clay ranged from 0.83% to 4.4.3% with maximum at site S1 and minimum at S3. Clay particle is important reservoir of plant nutrients, thus, clay play an important role in the growth of plants. Soil bulk density was measured to be more than 1 gm/cc at all sites. The optimum range of water holding capacity was recorded at all sites with maximum in monsoon season. Soils were slightly acidic in nature; the available range of the pH is adequate to hold the maximum concentration of nutrients. Soils are characterized by the low organic carbon, organic matters and nutrients. The poor nutrients and organic matters can be attributed to the types and magnitude of vegetation cover in the project areas. Scrub forests are predominant in and around the project area.

6.3.2 Microbes

Microbes were analyses for bacteria and fungi. They play important role in decomposition, nitrogen fixation and nitrogen cycle. The majority of the bacterial are decomposers and a few are pathogen in general. Upstream of proposed dam site (near Malari Jelam power house site) recorded high concentration of bacteria and lowest number of fungal colony. Generally monsoon season recorded high concentration of soil bacteria and fungi, which can be correlated to wet soils and new grasses enhancing the bacteria and fungi (Table 6.4; **Plate 6.1**).

6.4 CONCLUSION

Major part of the catchment is covered with glacier associated soils while remaining parties dominated with Lithic Cryorthents –Lithic Cryorthents association. Most of the project components are located on moderately shallow, excessively drained, sandy-skeletal soils which are prone to severe to very severe erosion. Very coarse, coarse sand; medium sand and very fine sand contribute more or less equal proportion to the soil texture. Soils are poor in nutrient concentration and microbes.

Table 6.3 Physical and chemical characteristics of soil in Jelam Tamak H.E.P. Soil sampling were carried out from the project area. Soils were retrieved from many locations from left bank, which were grouped into S1 (upstream of proposed barrage site), S2 (proposed barrage site) and S3 (powerhouse site).

	Post- Monsoon			**Pre- Monsoon**			**Monsoon**		
Physical Characteristics	**S1**	**S2**	**S3**	**S1**	**S2**	**S3**	**S1**	**S2**	**S3**
Soil Pore Size Measurement (%)									
Gravels and pebbles	2.46	0.00	0.00	0.00	0.43	0.00	1.24	1.94	1.50
Very coarse, coarse sand	31.46	16.85	22.65	23.65	17.8	19.93	40.63	35.09	20.22
Medium sand	37.27	28.63	39.96	24.49	40.81	38.62	25.32	31.63	40.44
Very fine sand	23.87	46.19	33.77	46.84	39.15	36.36	27.14	29.78	34.70
Coarse, medium silt	2.70	3.92	2.76	0.14	0.21	2.64	3.48	0.45	1.62
Fine silt with clay	2.22	4.38	0.83	4.43	2.01	2.44	2.16	1.09	1.48
Bulk Density	1.56	1.23	1.08	1.11	1.61	1.42	1.28	1.04	1.28
Water Holding Capacity	33.13	47.95	46.00	43.57	28.44	36.75	64.00	48.00	55.00
Chemical Characteristics									
pH	6.87	6.98	6.91	6.76	6.29	6.97	6.66	7.18	6.98
Electrical Conductivity (μS)	98.66	289.00	43.33	186.50	163.00	103.50	167.00	236.00	201.00
Chloride (mg/g)	0.10	0.22	0.10	0.03	0.03	0.02	0.04	0.03	0.03
Organic Carbon (%)	0.25	0.78	0.48	2.20	0.33	0.36	1.43	2.36	0.58
Organic Matter %	0.43	1.35	0.83	3.79	0.56	0.62	2.47	4.08	1.00
Phosphate (mg/g)	0.92	0.84	1.50	1.16	0.18	0.24	0.91	0.77	3.56
Nitrate (mg/g)	0.03	0.00	0.012	0.033	0.009	0.02	0.008	0.048	0.07

Table 6.4 Concentration of bacteria and fungi at different sites of Jelam Tamak H.E. Project

Sampling Sites	Bacteria (MPNB/gm)			Fungi (CFU/gm)		
	PM	**PrM**	**M**	**PM**	**PrM**	**M**
Proposed Dam site	36,000	44,000	52,000	1700	6000	14,000
Upstream of dam site	2,40,000	2,55,000	1,10,000	80	700	2600
Proposed PH site	11,900	15000	32,000	8000	-	-

PM = Post monsoon; PrM = Pre-monsoon; M = Monsoon

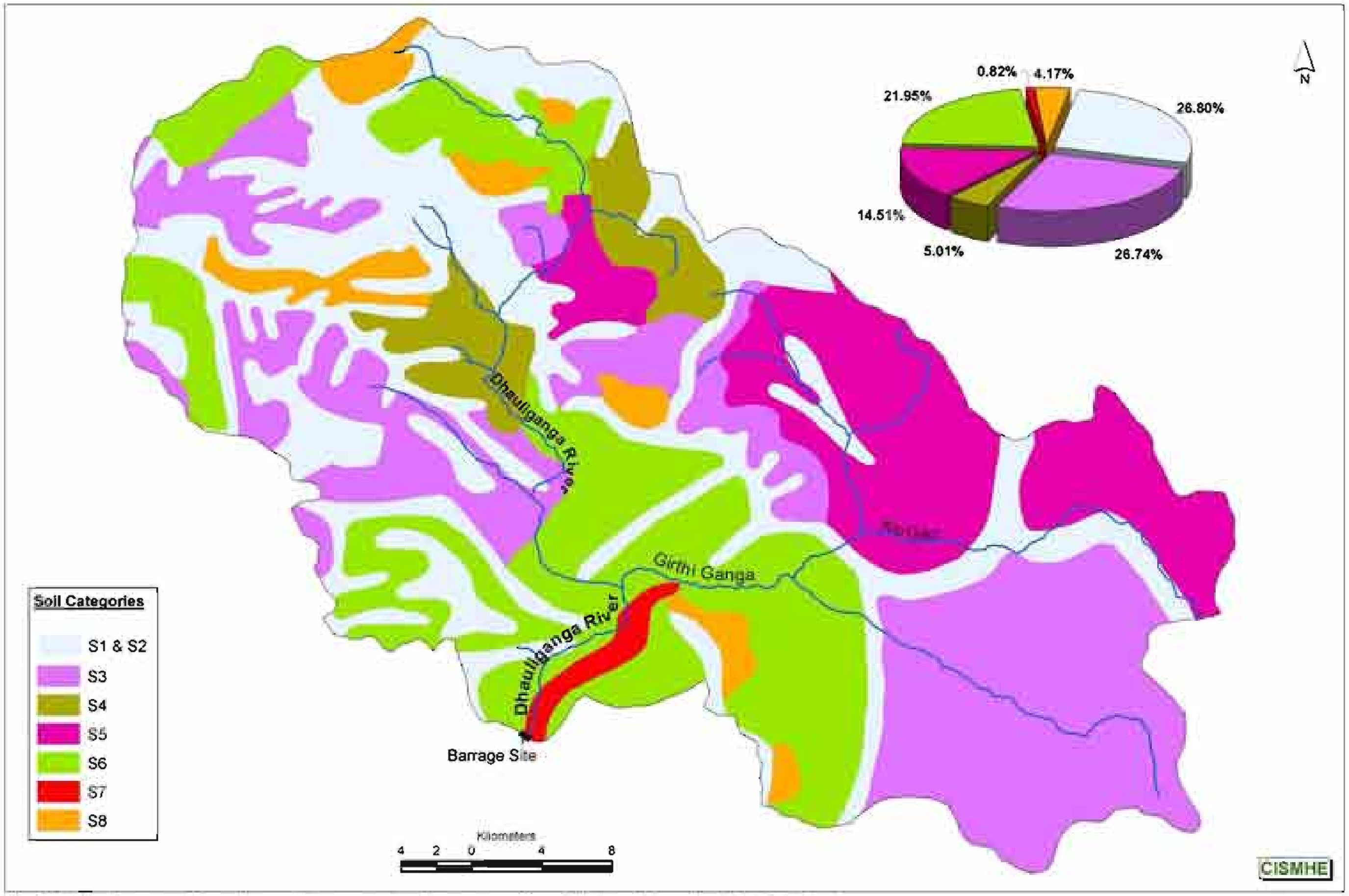


Fig.6.1 Soil map of catchment area up to barrage site of Jelam-Tamak H.E. Project

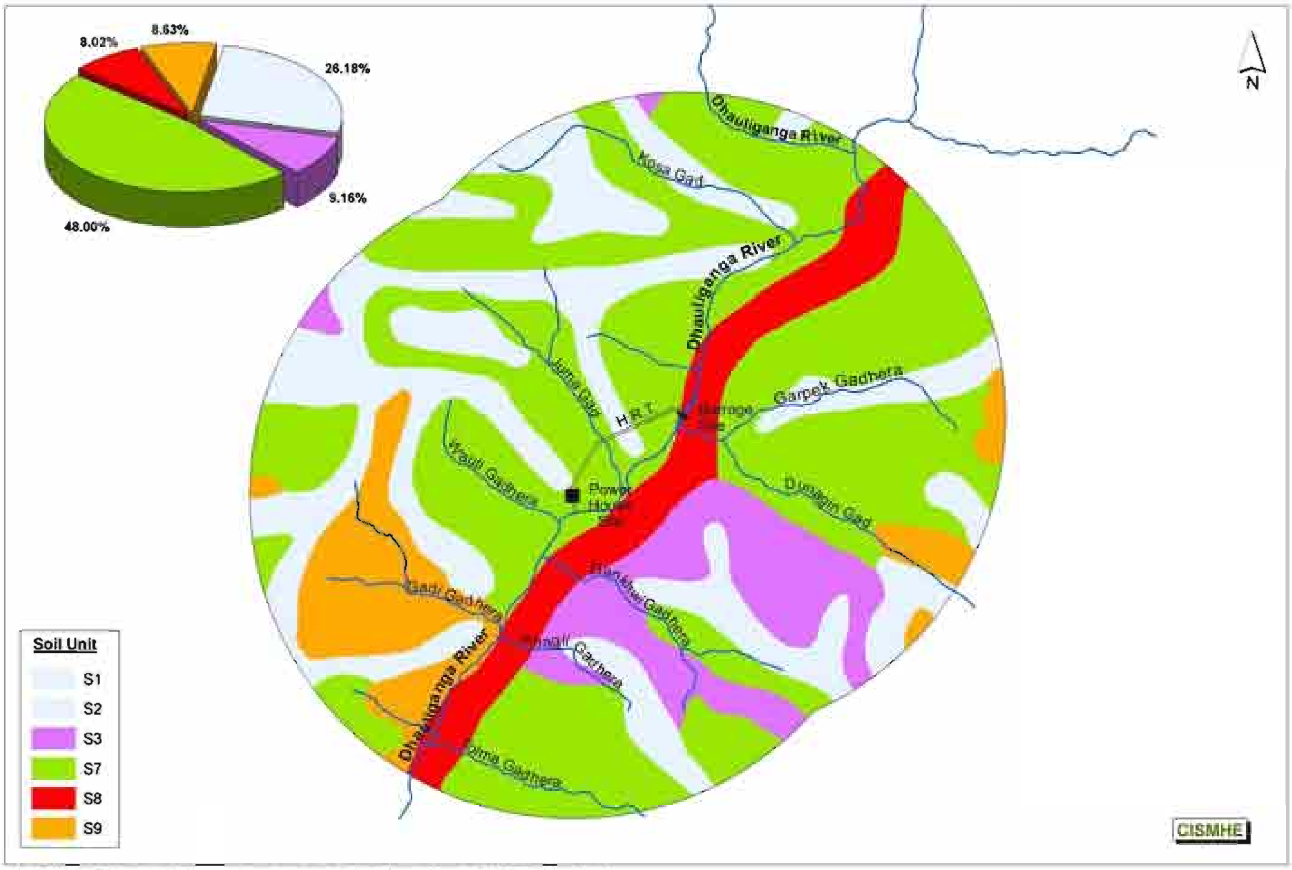
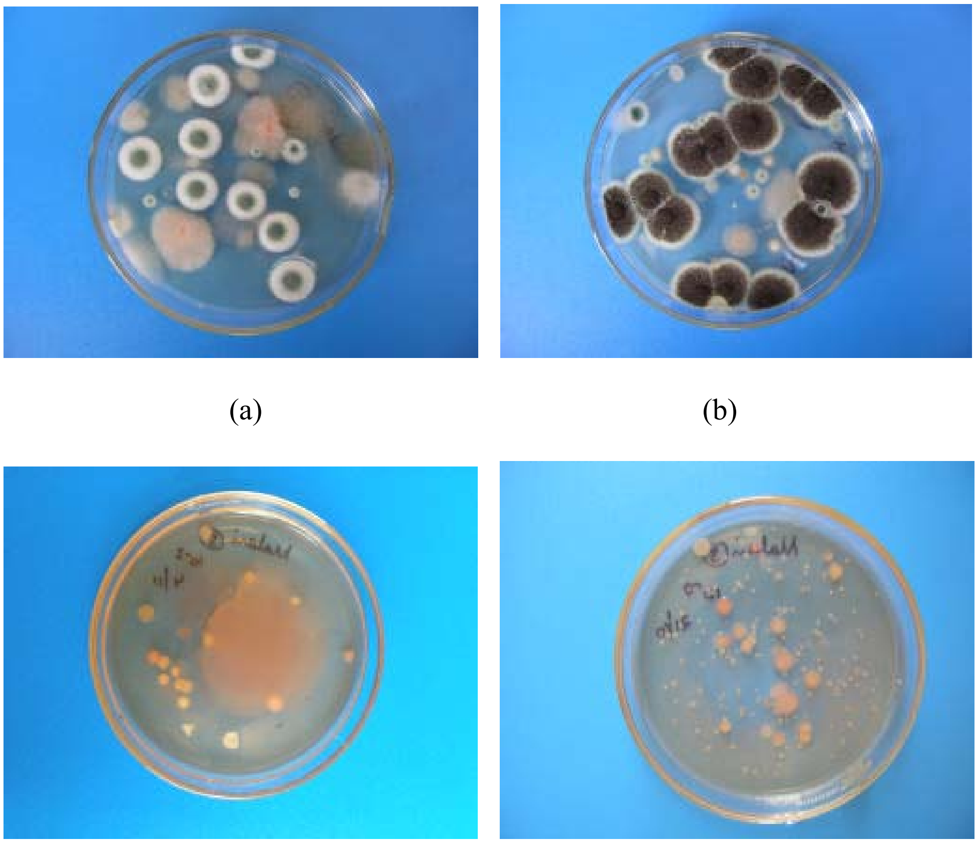


Fig.6.2 Soil map of influence zone of Jelam-Tamak H.E. Project



(a) (b)

(c) (d)

Plate 6.1 **Fungal colonies (a,b) and bacterial numbers (c,d) recorded from proposed barrage site and power house site of Jelam Tamak H.E. Project**

Chapter 7

LAND USE AND LAND COVER

7

LAND USE AND LAND COVER

7.1 INTRODUCTION

Land use is defines as any human activity or economical related processes associated with a specific piece of land, while the term land cover relates to the type of feature present on the surface of the earth (Lillesand and Kiefer, 2000). Land cover/ Land use map also shows the spatial distribution of identifiable earth surface features; it provides an information description over a given area, rather than a data description. Land cover classification or Image classification is the process used to produce thematic maps from satellite imagery. The knowledge of land use and land cover is important for many planning and management activities as it is considered as an essential tool for modeling and understanding the earth feature system. Land cover maps are presently being developed from local to regional and national to global scales. The use of panchromatic and medium scale aerial photographs to map land use has been an accepted practice since the 1940s. More recently, small scale aerial photographs and satellite images have been utilized and enhanced the land use and land cover mapping. The satellite remote sensing technology has found its acceptance worldwide for rapid resource assessment and monitoring, particularly in the developing world. National Aeronautical and Space Administration (NASA) of USA has made most significant contributions with satellite based remote sensing techniques. Since 1972, after the Landsat–1 was launched, remote sensing technology and its application has undergone a tremendous change in terms of sensing development, aerial flights with improved sensors, satellite design development and operations including data reception, processing, interpretation, and utilization of satellite images. All these advancement have widened the applicability of remotely sensed data in various areas, like forest cover, vegetation type mapping, and land cover changes on a regional scale. If this remotely sensed data is judiciously used along with the sufficient ground data, it is possible to carry out detailed forest inventories, monitoring of land use, and vegetation cover at various scales. The present work is an attempt to make the same for the Jelam Tamak H.E. Project.

Digital image processing (DIP) and classification of these satellite imageries and the analysis of interpreted maps were carried out using ERDAS Imagine 8.7. In this chapter we describe the objective of land cover thematic map generation and the methodology used for the image classification, followed by land cover/ land use description of Jelam Tamak catchment. Subsequently, detail study of the power house and barrage site will also be undertaken with in 10 km radii from both the sites.

7.2 OBJECTIVE

The objective behind land use/land cover classification is to produce land use and land cover map using hybrid digital classification technique. The land cover/ land use map will depict the state of the land features and land use pattern of the study area. Therefore, it will exhibit the naturalness and anthropogenic activities being carried out in the catchment. In addition, land cover/ land use thematic map will also be used in studying the 10 km radii of power house and barrage site, besides, wide variety of applications of this thematic map are used in the Environmental Management Plan like Catchment Area Treatment (CAT) planning to mitigate the soil erosion.

7.3 GENERAL DESCRIPTION

The Jelam Tamak H.E. project is located on Dhauliganga river, a tributary of Alaknanda joining from the north at Joshimath. Dhauliganga is majorly a glacier fed river and it originates from the Kamat Glaciers which flows south to north-westwards before it joins Alaknanda. The catchment area of the proposed schemes spreads between latitude of 30º 36’ 45” N to 30^0 37’ 35.4”N latitudes 79º 47’ 15” E to 79^o 49’39.5”E longitudes. The terrain has highly undulating peaks with complex mountain topography. The rivers and streams along the higher reach flows through the steep valleys, steep gradients. The catchment consideration forms the inner parts of the lesser Himalayas and outer parts of the Greater Himalayas. It presents extremely rugged topography with very high altitude mountain systems. The high altitudes are snow covered, whereas medium altitudes are largely covered with pine trees. The high ridges, which separate different river systems trend in NW-SE to WNW-ESE direction. The northern slopes in the catchment are gentler as compared to southern slopes due to influence in dip slope. The valleys are V-shaped, steep and narrow gorges. The river Alaknanda flowing south westerly is the principal draining agency in the Northern part of the area. The tributaries of Alaknanda include Dhauliganga, Birahi Ganga and Mandakini (modify after land use has to be done and Drainage).

7.4 METHODOLOGY

Land use and land cover mapping of the Jelam Tamak project was carried out by standard methods like digital image processing (DIP). Field survey and ground truthing were also carried out to support the image processing from the remotely sensed data. To carry out digital image processing, digital data (satellite imageries) on CDROMs was procured from National Remote Sensing Agency (NRSA), Hyderabad. DIP of the satellite data, preparation of various thematic maps, and their interpretation were achieved at Computer GIS Lab, CISMHE using ERDAS Imagine 9.0 of Leica Geosystems. Prior to digital processing, image enhancement, transformation, classification and pre-processing was done for band separation using existing Geostatistics algorithm. All the bands were uploaded into the workstation using ERDAS Imagine 9.0. The images were checked for occasional shortcomings in the quality of radiometric and line dropouts. Band separation and windowing of the study area with the help of Survey of India (SOI) toposheets was performed. The registration of image was performed using the nearest neighbour resampling algorithm (Jensen, 1996). The scene was geometrically corrected with toposheets using proper identification of GCPs with a root-mean-square (RMS) error of 0.0002 to 0.003 pixels. Indian Remote Sensing data was radiometrically corrected using dark pixel subtraction technique. They were then co-registered with SOI toposheets using UTM Zone – 44 N WGS84 projection systems. Geo-referencing of the composite image was done using digital vector layer of drainage, road network, water bodies, and other permanent ground features extracted from SOI toposheet. Distinguishable Ground Control Points (GCPs) both on image and vector database were identified. By using these GCPs the image was resample and geo-coded. Sub-pixel image to map registration accuracy was achieved through repeated attempts. The image enhancement techniques like edge detection, filters, manipulation of contrast and brightness, histogram equalization etc. was performed by using different combinations for best image contrast. Standard false color composite (FCC) image of the influence zone was prepared using bands 2, 3 and 4 of IRS-1D (**Fig. 7.2**) and discrimination of features was made by visual interpretation on this image. The interpretation key was based on the relationships between ground features and image elements like texture, tone, shape, location and pattern. A flow chart indicating the general procedure for land use and land cover classification is shown in the **Figure 7.3**.

In order to provide higher resolution of base image (IRS-P6 LISS III), panchromatic (PAN) image was fused with MSS LISS –III image. In this process, a portion of high resolution PAN band, which corresponds to an area of interest (AOI) in the multi-spectral LISS – III image was extracted. Thereafter, both the images were co-registered and LISS-III image was resampled for merging with PAN image. Merging or image fusion was done by special enhancement module in ERDAS Imagine 9.0.

The digital vector layers like contour, drainage network, forest, settlements etc. of the Jelam Tamak H.E site were prepared from the SOI toposheet in 1:50,000 scale. The vector layers were also prepared for nearby free-draining catchment areas. Further, the drainage network was classified into various sub-watersheds based on stream order (Horton, 1945, Strahler, 1952, 1957). Major morphomotric parameters like drainage length, density, area etc. were calculated in each sub-watershed for determining basin characters. These parameters will be significant during the Catchment area treatment plan.

In the preliminary analysis, image classification was done by unsupervised classification method by performing ISODATA training. It helped in assigning the classification of the image into land use categories. However, the boundaries of water bodies were separately mapped from SOI toposheets for image classification. The doubtful areas or wrongfully interpreted areas owing to various physical features controlling the study area were marked for ground truth collection. After ground truth collection, supervised classification was assigned for the final image classification. The classified map was regrouped and merged. The classified raster map thus, prepared was then converted to vector format for GIS analysis, and the preparation of required thematic maps using ArcGIS 9.1 and GeoMedia Professional 5.2.

7.4.1 Database

The detail of primary data in the form of digital data on CDROMs for interpretation and analysis is given in Table 7.1. The mask of the entire Dhauliganga catchment area including the project site was generated from the IRS as shown in the **Figure 7.1**. For the secondary data, Survey of India (SOI) toposheets on 1:50,000 scales were referred to for the preparation of base map and drainage map.

Table 7.1 Database used for land use and land cover mapping of the Dhauliganga catchment

Satellite	Sensor	Path/Row	Date	Data type & Bands
IRS P6	LISS-IV	99/50	23-11-2007	Digital (1,2,3,4)
LANDSAT 7	ETM+	145/39	16-11-2005	Digital (1,2,3,4,5,7)

7.4.2 Classification Scheme

Keeping in mind the objectives of preparation of Environment Management Plan (EMP), action plan for catchment area treatment (CAT) plan, the classification scheme adopted for the preparation of land use/land cover maps on 1:50,000 scale is described below. Density classification was made by Normalized Difference Vegetation Index (NDVI) technique. Different forest classes were identified and the degraded areas and scrubs were also delineated for the purpose of erosion mapping. The scrub/ alpine scrub and agricultural areas were also identified and delineated. Settlement areas were classified under the built-up and impervious areas. The non-forest land cover in the form of rocky land, moraines, rivers. etc. were also delineated for the calculation and classification of erosion intensity.

7.5 LAND USE/ LAND COVER

7.5.1 Catchment Area

The total area of the proposed project up to the dam site is about 166600 hectares. The project site lies under Dhauliganga catchment which includes its major tributaries like the Girthi Ganga, Amrit Ganga and Janti Gad. As shown in the **Figure 7.4**, the land use/land cover of the catchment area consists of 10 categories (Table 7.2), out of which maximum area of about 37.97% of the catchment is covered with snow capped mountains and 6.96% is covered with glaciated mountains (see Table 7.2). Dense forest and open forest amounts to 10% and 10.31% of the catchment respectively (see **Fig. 7.4**). However, barren land and moraines together amounts to 26.21% of the total catchment area much larger than the total forest area. Therefore the catchment is characterized with less forest cover and but more barren land and moraines. It is due the fact that most of the higher reaches are highly elevated and less covered with forest and vegetation. For the land use/ land cover area coverage please see Table 7.2 and **Figure 7.4**.

Table 7.2 Land use / Land cover area coverage of Jelam Tamak H.E.P. catchment

Land use/Land cover	Area (ha)	Per cent
Dense Forest	16660.00	10.00
Open forest	17309.74	10.39
Scrub	1499.40	0.9
Alpine scrub	5797.68	3.48
Cultivation Settlement	33.32	0.02
Barren land	26689.32	16.02
Moraines	17009.86	10.21
River	6747.30	4.05
Snow	63258.02	37.97
Glacier	11595.36	6.96
Total	**166600.00**	**100**

7.5.2 Influence Zone

A influence zone was demarcated from the dam site and power house site to 10 km radius. Distance calculation in GIS was to demarcate the influence zone with 10 km radius. Land use and land cover mapping of project area falling within 10 km radius of Dhauliganga catchment from the proposed barrage site to the proposed powerhouse site was carried out by standard methods using remotely sensed data followed by ground truth collection and interpretation.

As shown in the **Figure 7.5** dense forest and open forest covers maximum area of 22.61% and 31.24% respectively. Moreover these land covers are spread along the left bank of the river. Second predominant land cover is Snow which is spread on an area of 14.2% of the influence zone and it is spread on the higher reaches along the right bank of the river. Details of other land classes and land cover is given in Table 7.3 and **Figure 7.5**.

Table 7.3 Land cover/ Land use of influence zone

Land use/Land cover	Area in percent
Dense Forest	22.61
Open forest	31.24
Scrub	7.10

Alpine scrub	4.57
Cultivation Settlement	0.46
Barren land	9.44
Moraines	5.57
River	0.86
Snow	14.25
Glacier	3.9

7.5.3 Submergence Area

The reservoir area of Jelam Tamak H.E. Project is 37.92 ha at Full Reservoir Level (FRL) 2648.5 m. It consists seven categories of land use/ land cover classes. The reservoir area has covered open forest (24.12%) followed by river channel (26.54%). The scrub/ alpine scrub capture the reservoir area is 5.49 ha (14.32%). The moraines class is covered very less area at 2.11% of the submergence (see **Fig. 7.6**). Most of the cultivation and settlement area along the river on the left bank of Dhauliganga river is covered 10.80% of the land in the reservoir.

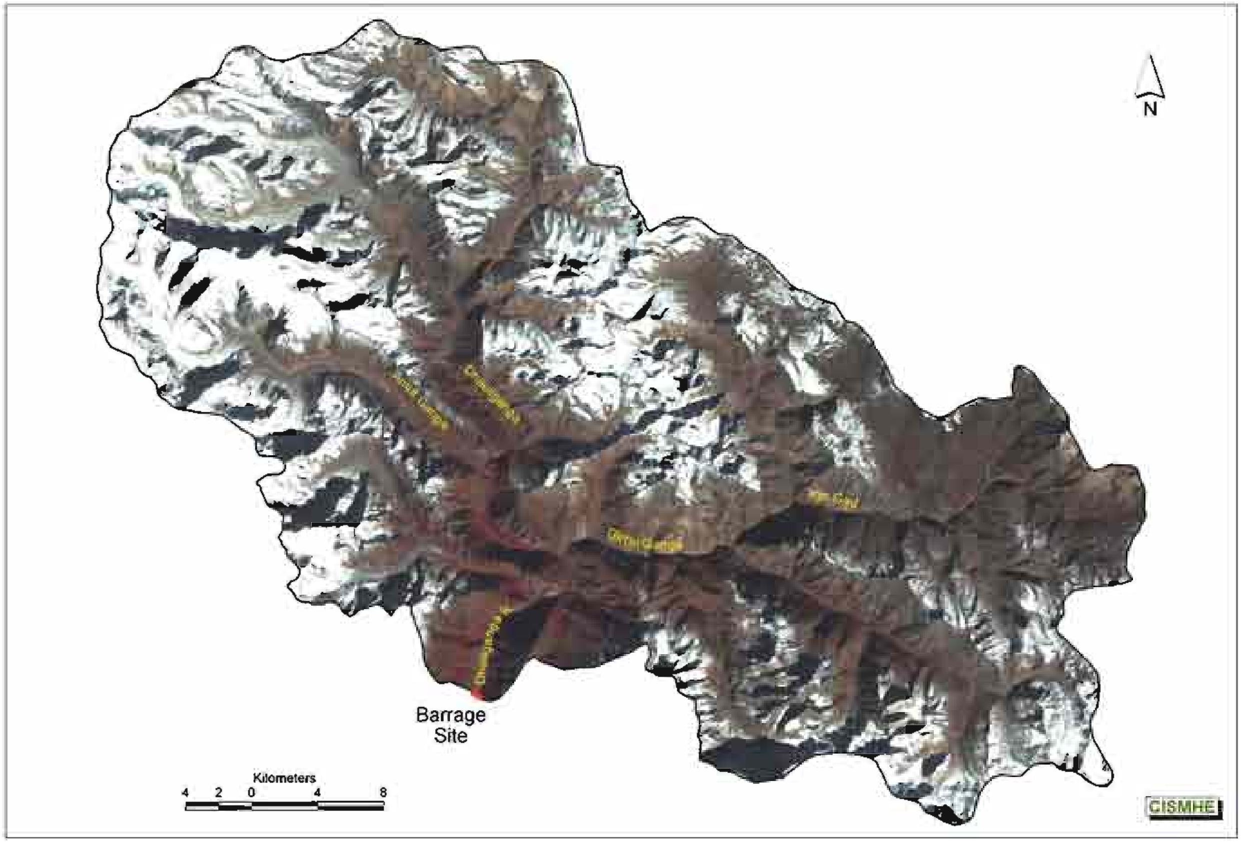


Fig.7.1 False Colour Composite (FCC) generated from IRS-P6 LISS-III, November, 2006 of the Jelam Tamak H.E. project catchment area

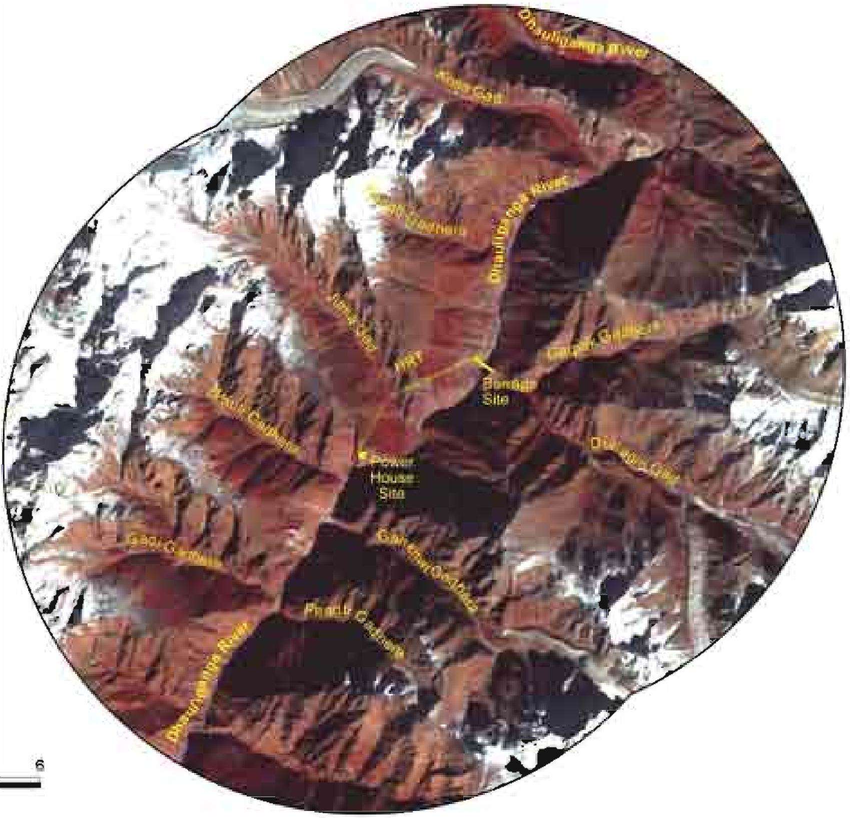


Fig.7.2 False Colour Composite (FCC) generated from IRS-P6 LISS-III, November, 2006 of influence zone of the Jelam Tamak H.E. project

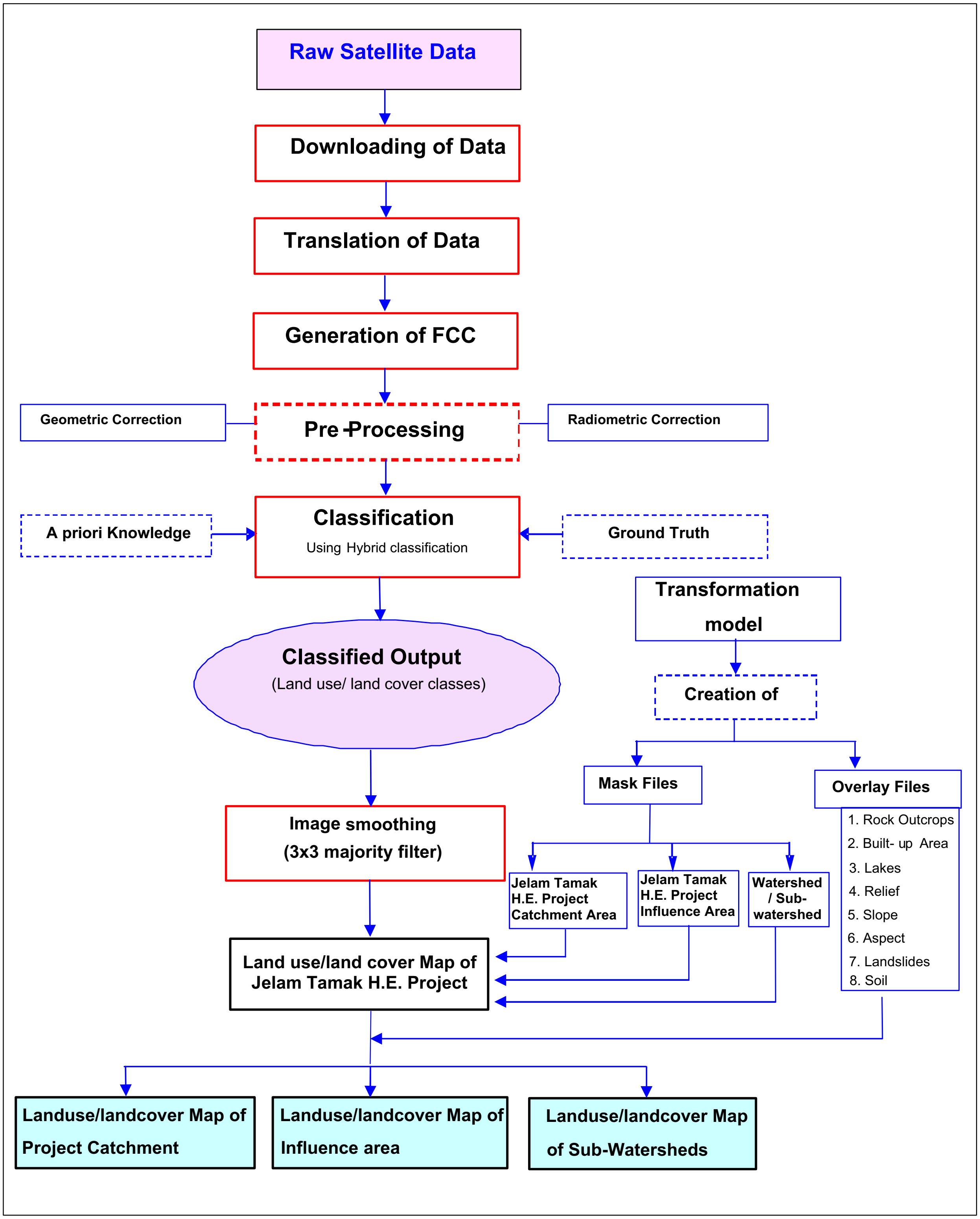


Fig.7.3 Flow diagram for Land use/ land cover classification

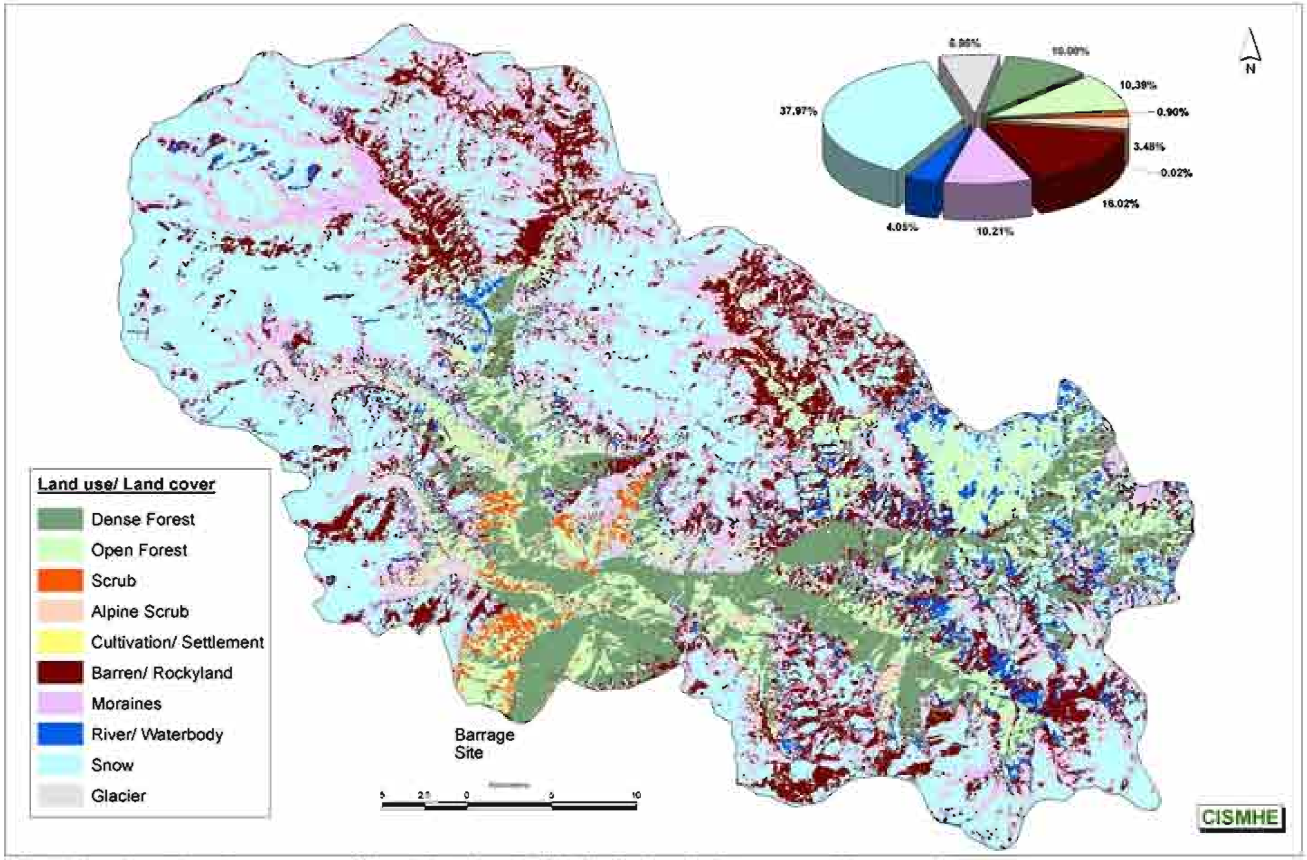


Fig.7.4 Land use/ Land cover map of the Jelam Tamak H.E. Project up to the proposed barrage site

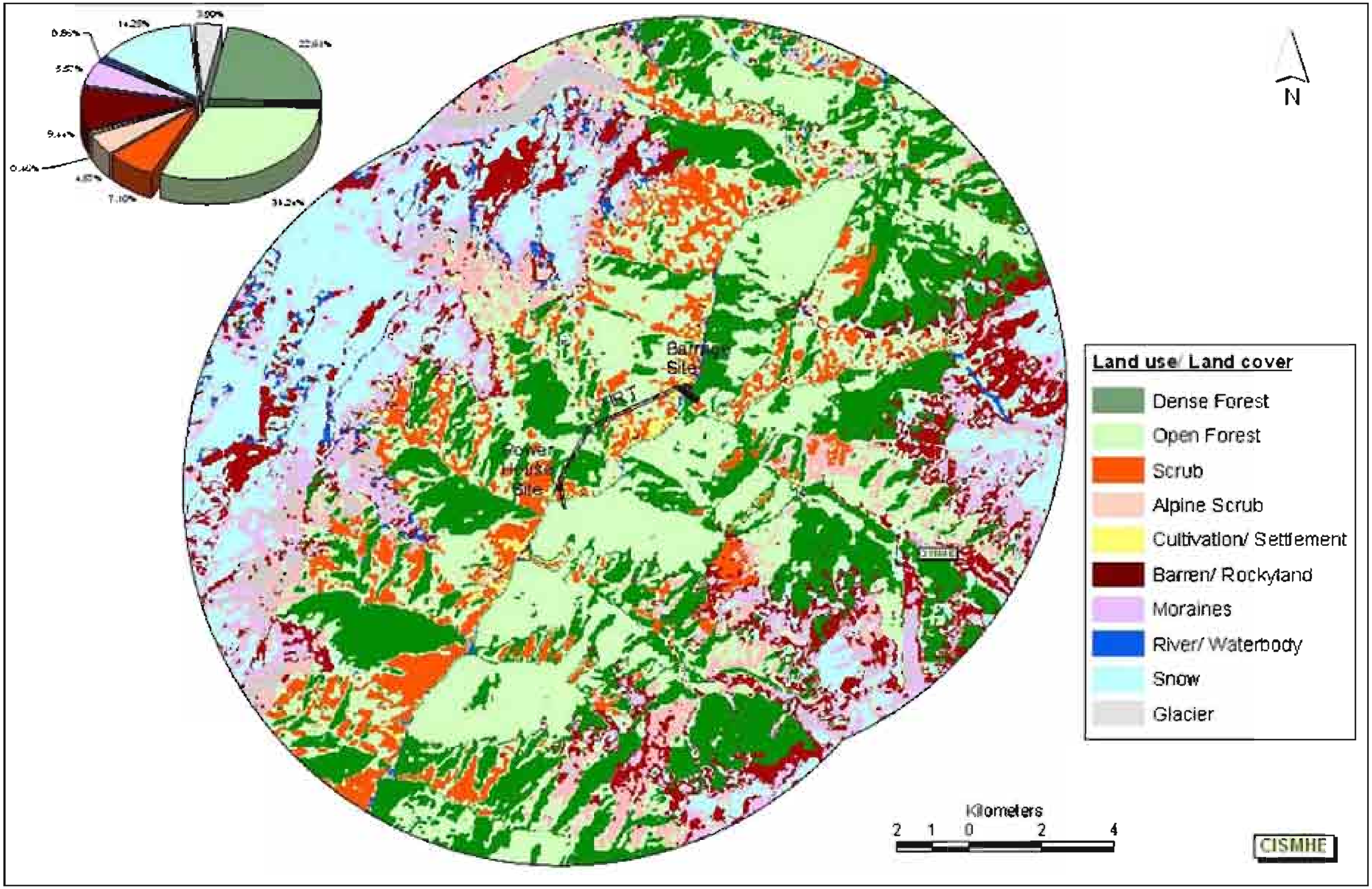


Fig.7.5 Land use/ Land cover map of influence zone of Jelam-Tamak H.E. project

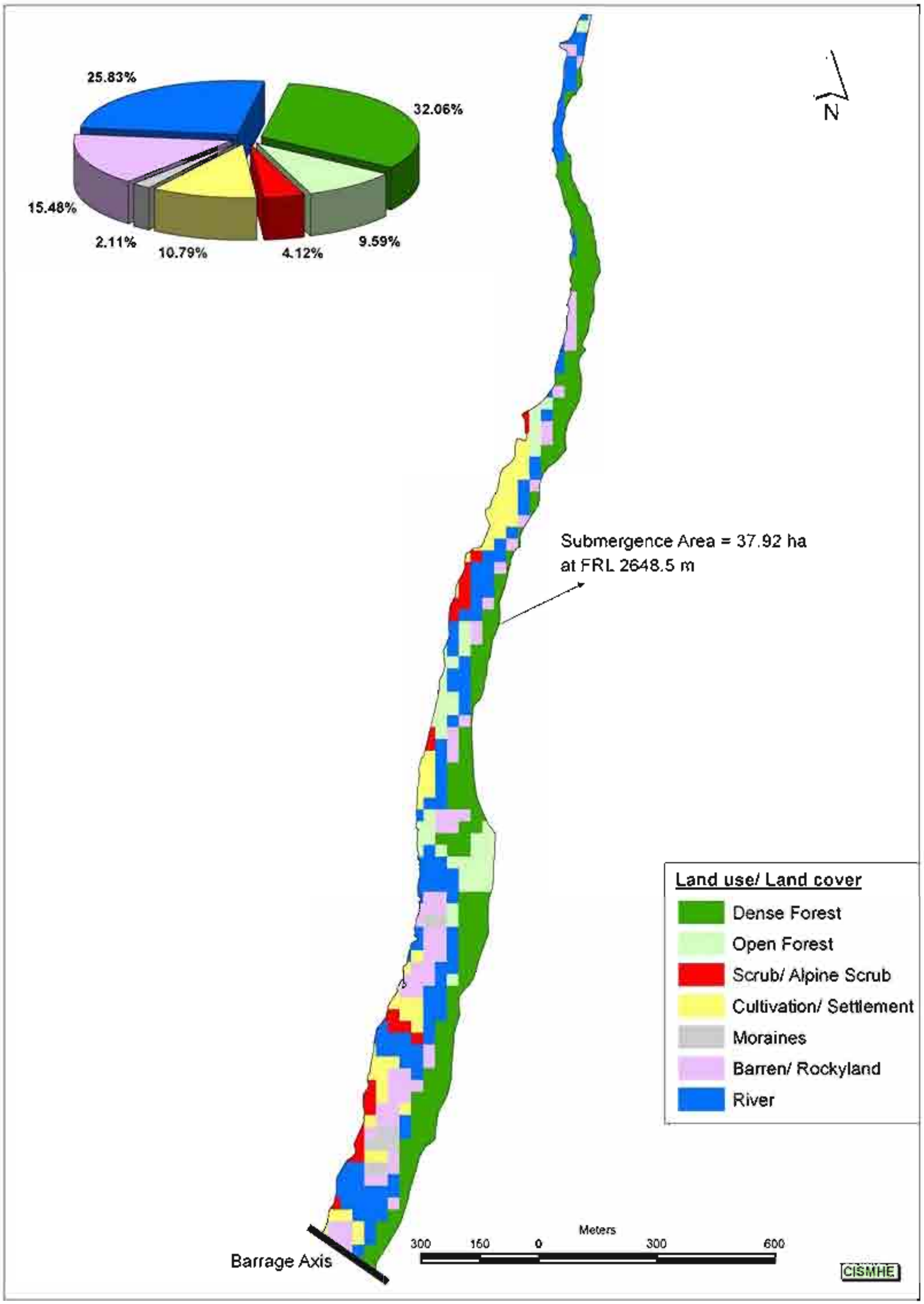


Fig.7.6 Land use/ land cover map of submergence area of Jelam Tamak H.E. Project

Chapter 8

FOREST TYPES & FLORISTICS

8
FOREST TYPES & FLORISTICS

8.1 INTRODUCTION

Uttarakhand, 27th state of the Republic of India, in northern portion of India covering an area of 53,483 sq km. It is surrounded in the north by Tibet, in west by and Himachal Pradesh, east by Nepal, south by Uttar Pradesh. The entire terrain is mountainous and the elevation of the hills ranges from 250m in the foot hills to 7817m along Tibet border. The climate varies from sub-tropical in south to temperate in north. The lower valleys are usually hot during summer and record maximum temperature up to 45^0C while cooler climate is experienced in middle zone (Srivastava and Singh, 2005). The winters are very severe at higher elevations and snow falls occurs even down to 1600m. The region is well known for its lofty peaks like Nanda Devi, Kameth, Neelkanth, Trishul, Dronagiri, Kedarnath and many others. The great rivers like Ganga, Yamuna, Tons and Ramganaga, etc. all originate from the glaciers from this part of Himalaya. The famous Nanda Devi Biosphere Reserve is located in this part of state of Uttarakhand. The varied topographic and phytoclimatic conditions met within the state has resulted into a rich floristic diversity. The state represents one of the four hyperdiversity states in the Indian Himalayan region with about 4248 species in angiosperms and 18 species in gymnosperms (Srivastava & Singh, 2005). The vegetation of Uttarakhand ranges from tropical deciduous to alpine.

Based on the collections from hills of Garhwal and Kumaon the vegetation of Uttarakhand has been dealt with by different workers. General Thomas Hardwicke (1787-1835) was the first European to collect plants from North-Western Himalaya from Alkananada valley. Sir Richard Strachey and J.E. Winterbottom traveled extensively the hills of Kumaon and collected over 2000 plant species which were finally transfererred to Hooker's Herbarium. A list of these plants (1852-1853) was published in 1882 and later supplemented by Duthie in 1918. A. E. Osmaston (1927) also extensively surveyed the Kumaon and adjoining portions of Garhwal and succeeded in bringing out "Forest flora of Kumaon". Holdsworth and Smythe who were members of the British Kamet Expedition in 1931, also collected plants in the Bhyundar valley and included the lists of plants in their work "Kamet Conquered" (1932). Smythe again visited the valley in 1937 and collected more than 250 species and included all plants in his book named “Valley of Flowers”. After the establishment of Northern Circle, Botanical Survey of India (BSI) in 1956, M. A. Rau, T. A. Rau, U. C. Bhattacharya, S.K. Mehrotra, R.R. Rao, B. P Uniyal, Surindra Singh, Bipin Balodi have extensively explored the different parts of Kumaon and Garhwal. Among the recent workers include Ghildyal (1957), Gupta (1968), Rau (1974), Mehrotra *et. al.* (1979), Gaur (1982), Kala & Gaur (1982), Hajra (1983), Naithani (1984 -1985), Uniyal, Surinder Singh and D.K. Singh (1994) and many others. Apart from the above a number contributions have also been made on vegetation, medicinal, ethnobotanical and ecology (Sundriyal, 1994; Rawat et. al., 1994; Mudgal and Hajra, 1999; Pande and Samant, 2001; Srivastava and Singh, 2005).

8.2 FOREST TYPES

Uttarakhand is reported to have 45.80 per cent of its total geographic area under forest cover, which includes very dense, moderately dense, open forest and scrub (FSI, 2009). The forest in the state can be divided into sixteen types which are characterized by Northern tropical dry deciduous forests (Dry sal-bearing forest and dry plain forest), Himalayan sub-tropical pine forests (Himalayan chir-pine and sub-tropical scrubs and Euphorbia scrub), Himalayan moist temperate forests (Lower Western Himalayan temperate and Upper west Himalayan temperate forests), Himalayan dry temperate forest (Dry temperate coniferous and West Himalayan dry juniper forest), Sub-alpine forests (West Himalayan birch/fir forest and pastures) and Moist and dry alpine scrub forests. The catchment area of the proposed Jelam Tamak H.E. Project covers Himalayan dry temperate forests (Dry temperate coniferous forest and West Himalayan dry juniper forest (*J. macropoda*) and West Himalayan birch/fir forests. However, the project area which is directly concerned with is stretched around 10 km along the Dhauli river and covers an approximate area of 43235.25 ha (includes the area within 10 km radius from the barrage site and power house and the stretch between these two sites). The forests in project area fall in the buffer zone of Nanda Devi Biosphere Reserve.

The vegetation in these forests comprises dry deodar forest in the lower reaches. In the upper reaches dry juniper forest and sub-alpine birch-fir forest occurs. In the entire valley of the catchment, the area is either covered by patchy coniferous forest along the ridges or degraded open forests interspersed with Apple orchards in lower reaches. The forests present in the catchment area have been grouped into different forest types following the classification of Champion & Seth (1968), Negi (1989, 1996), Chowdhery (1996) and Muddgal & Hajra (1999). The major forest types found in this catchment are discussed below.

13/C2 Dry temperate coniferous forest

This is an open pure coniferous forest with a little proportion of few broad-leaved trees and shrubs in the lower storey. Important tree associates found in the forests are *Cedrus deodara, Fraxinus xanthoxyloides, Hippophae salicifolia, Pinus wallichiana* and *Populus ciliata*. Shrubs are few and represented by *Berberis aristata, Cotoneaster bacillaris, Ephedra gerardiana, Jasminum officinale, Prinsepia utilis, Rabdosia rugosa* and *Sorbaria tomentosa*. Climbers are almost absent (with a few exceptions like presence of *Clematis* spp.). This type of forest is found in Lata, Tamak, Juma and Jelam areas between 1800-2600m elevations. *Drynaria mollis* and *Lepisorus kashyapii* are important epiphytic ferns which occurred on trunks of *Hippophae salcifolia, Salix wallichiana* and *Prunus cornuta*. Some lichens like species of *Bulbothrix, Cladonia, Ramalina, Usnea,* etc. occur on trunks and rocks in the forest. Other non flowering plants belonging to the group musci are *Andreaea rupestris, Pogonatum thomsonii, Fissidens grandifrons, Bryum cellulare, Mnium marginatum,* etc. The common terrestrial ferns are species of *Adiantum, Athyrium, Dryopteris, Pteris,* etc.

13/C5 West Hiamlayan dry juniper forest

This is an open evergreen forest of low height with a different type of xerophytic undergrowth. This type of forest occurs above Malari especially in Niti area between 2800-4300m. *Juniperus macropoda* form either scattered or pure patches with some evergreen shrubs like *Berberis petiolaris, Cotoneaster microphyllus, Hippophae salicifolia, Lonicera hypoleuca, Rosa sericea, Ribes orientale, Salix denticulata* and *Viburnum nervosum*.

14/C I b West Himalayan birch/fir forests

This is an irregular forest consisting mainly of fir, birch and Rhododendron bushes. This type of forest is found above 3000m altitudes in Dronagiri and Malari areas. The important tree associates include *Abies pindrow, Betula utilis* and *Taxus baccata*. Other woody associates are *Cotoneaster microphyllus, Lonicera* spp., *Ribes orientale, Rosa sericea, Rubus niveus* and *Salix wallichiana.* Climbers are almost absent. Terrestrial ferns are not common but species of *Dryopteris, Osmunda* and *Pteris* are seen growing with other herbs and grasses. Epiphytes are few consisting of lichens and musci. Some lichens species of *Cladonia, Ramalina, Usnea,* etc. occur on the trunks and rocks in the forest.

14/ DSI Sub-alpine pastures

These are meadows lying below timber line in the sub-alpine area. The predominating herbs and grass species are *Aconitum atrox, Agropyron longearistatum, Arctium lappa, Artemisia gmelinii, Danthonia catchymeriana, Geranium wallichianum, Hieracium umbellatum, Ligusticum roylei, Melica persica, Pedicularis hoffmeisteri, Poa* spp., *Potentilla cuneata, Taraxacum officinale,* etc.

8.3 VEGETATION PROFILE IN THE INFLUENCE ZONE

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

i) Area between Surai Thota and Juma
ii) Area beyond Juma up to Dunagiri
iii) Area between Juma and Jelam
iv) Area above Kosha village up to Malari

8.3.1 Area between Surai Thota and Juma

This area has predominantly open mixed dry coniferous forest interspersed with terrace cultivation in the lower reaches. Trees of *Cedrus deodara, Juniperus macropoda* and *Pinus wallichiana* are quite conspicuous on ridges along the river course. Few broad-leaved tree species like *Fraxinus xanthoxyloides, Populus ciliata, Salix wallichina,* etc are also seen growing along roadside. *Berberis aristata, Cotoneaster microphyllus, Incarvilea arguta, Olea ferruginea, Rosa sericea, Sorbaria tomentosa,* etc. are common woody shrubs in the understorey. Ground flora comprises *Artemisia nilagirica, Bidens bipinnata, Bromus japonicus, Conyza stricta, Echinops cornigerous, Oryzopsis munroi, Oxalis corniculata, Rumex nepalensis, Saccharum rufipilum,* and *Urtica ardens.*

8.3.2 Area beyond Jumma up to Dunagiri

The lower reaches in this zone are characterized by a patchy dry coniferous forest especially in the Jumma area, whereas areas of upper reaches lying in adjoining Dunagiri are characterized by sub-alpine birch fir and sub-alpine pastures. The prominent trees of upper ridges include *Abies pindrow, Betula utilis, Pinus wallichina* and *Taxus baccata.* The shrub elements are represented by species of *Berberis*, *Cotoneaster, Daphne, Lonicera, Rosa, Rubus, Sorbaria* and *Viburnum*. On left bank, Kaga, Kargam and Dunagiri areas are abounds in many life saving herbs since ancient times. *Aconitum atrox, Artemisia gmelinii, Astragalus candolleanus, Caragana gerardiana, Danthonia catchymeriana, Geranium wallichianum, Hieracium umbellatum, Ligusticum roylei, Nepeta discolor, Dactylorhiza hatagirea, Polygonatum verticillatum, Potentilla fulgens,* and *Smilacina purpurea* are sub-alpine herbs.

8.3.3 Area between Jumma and Jelam

The right bank of this area from Jumma to the bank of Jelam Nala is a gentle slope interspersed with terrace cultivation. The lower reaches in this zone are characterized by some mixed broad-leaved tree species like *Fraxinus xanthxyloides, Populus ciliata, Salix wallichina,* etc. with scattered growth of *Cedrus deodara*. This area has many fruit tree orchards of *Prunus armenica* and *Pyrus malus*. At Tamak, the vegetation is sparse and shrubby interspersed with agricultural fields in the lower reaches. Dense vegetation of *Hippophae salicifolia* can be seen all along the roadside towards Jelam Nala. The areas lying in the upper reaches are characterised by dry coniferous forests. *Cedrus deodara, Cupressus torulosa, Pinus wallichiana,* etc important tree associates. The shrub vegetation is comprised of *Abelia triflora*, *Berberis aristata, Cotoneaster microphylla, Jasminum multiflorum, Indigofera heterantha, Olea cuspidate* and *Rabdosia rugosa*. The notable parasite *Scrrula elata* can be seen on branches of *Pyrus malus*. Herbaceous flora represented by species of *Anaphalis, Artemisia, Bupleurum, Circium, Conyza, Festuca, Oryzopsis, Oxalis, Phleum, Rumax* and *Setaria*.

8.3.4 Area above Jelam up to Malari

Beyond Jelam (2600 m), a more or less open coniferous forest with little proportion of other tree species in lower reaches of the valley. The upper reaches of these forest pass into West Hiamlayan dry juniper and birch fir forest. *Abies pindrow, Cedrus deodara, Juniperus macropoda, Pinus wallichiana, Taxus baccata,* etc. are important associates in upper reaches of these forests. The vegetation around Pangti Nala and Kosha Nala is characterized by patchy dry temperate coniferous forest with few evergreen broad-leaved evergreen species. Around Malari village, sparse sub-alpine vegetation interspersed with terrace orchards occurs, while stunted birch/fir forests are seen on upper reaches. Important constituents of the area are *Acer laevigatum, Betula utilis, Berberis petiolaris, Cotoneaster micophyllus, Ephedra gerardiana, Juniperus macropoda, Lonicera hypoleuca, Rosa sericea,* and *Salix wallichiana*. *Ephedra gerardiana* forms dense bushy mats of 30-40 cm height along the moraines and meadows. Some fruit trees like *Prunus armenica, P. persica* and *Juglans regia* are seen cultivated on the gentle slopes in the Malari village. Herbaceous vegetation is represented by *Artemisia gmelinii, Astragalus candolleana, Carum carvi, Caragana gerardiana, Fagopyrum dibotrys, Geranium pratense, Pleurospermum stellatum, Rumex nepalensis* and *Viola biflora*. On the left bank, from Malari village to Burans Bada, slopes of upper reaches are covered with birch/ fir forest, while patchy dry coniferous forest occur along the river course. Still higher above, the vegetation is characterized by *Hippophae*/ *Myricaria* sub-alpine seral or degraded alpine scrubs.

8.4 FLORISTICS OF PROJECT AREA

The present ecological study in the project area of Jelam Tamak HEP was undertaken with the objectives of preparing a checklist of flora in the submergence area and locations where project components are proposed; listing of rare/ endangered, economically important and medicinal plant species; determination of frequency, density and IVI of different vegetation components. An inventory of plant species has been prepared from 96.27 ha of land including 92.44 ha forest land.

8.4.1 Vegetation in Submergence Area

The submergence area is located upstream of Jelam Nala on Dhauli river near Jelam village. The area in the vicinity of proposed project comprised of patchy scrub forest along the lower reaches. Dry temperate coniferous forest in the middle of submergence area, while Birch/fir forest occurs in the top of upper ridges. On the right bank, the vegetation is comprised of open mixed forest consists of few small trees like *Cupressus torulosa, Fraxinus xanthoxyloide, Hippophae salicifolia, Populus ciliata* and *Salix wallichiana*. Understorey is represented by a few shrubs like *Berberis petiolaris, Cotoneaster microphyllus, C. integrima, Jasminum humile, Rabdosia rugosa,* etc. On the left bank, a fairly dense dry coniferous forest (Ceder and blue pine) occurs in the middle reaches and stunted birch forest at the top of ridge. Climbers and epiphytes are few (**Plate 8.1**). *Clematis orientalis, Cynachum auriculatum* and *Cuscuta reflexa* are important twiners in the area. A total of 45 species of flowering plants (angiosperms and gymnosperms) including trees, shrubs, climbers and herbs were recorded during survey in submergence area (Table 8.1a). Rich diversity of some corticolous and saxicolus lichens like *Bulbothrix, Cladonia,* and *Usnea longissima* were noticed on right bank of Dhauliganga. Among moss species are *Andreaea rupestris, Distichium capillaceum, Bryum cellulare, Funaria wallichii, Entodon myurus*, *Thuidium assimile*, etc. Terrestrial ferns are few and represented by *Adiantum incissum, Lepisorus contortus, Athyrium falcatum,* etc. Herbaceous flora is represented by some tall grasses and many herbs. Among commonly occurring species are *Artemisia gmelinii, Brachypodium sylvaticum, Bromus japonicus, Bupleurum falcatum, Calamagrostis emodensis, Chrysopogon gryllus, Festuca polycolea, Oryzopsis munroi, Oxalis corniculata, Phleum alpinum, Saccharum rufipilum, Themeda anathera,* etc.

There are few apple orchards in the middle of right bank near Jelam village. Cultivation of Ban Oagal (*Fagopyrum dibotrys*), millet (*Panicum miliaceum*), spices like fern (*Allium humile, A. corolianum* and *A. wallichii*) and ginjar (*Zingiber officinale*), are common in the surrounding areas.

Table 8.1a List of plant species recorded in the submergence area under Jelam Tamak H.E. Project

Plant species	Local Name	Uses
Trees :		
Cupressaceae		
Cupressus torulosa	Surai	Timber
Pinaceae		
Cedrus deodara	Deodar	Timber
Pinus wallichiana	Blue pine	Timber
Rosaceae		
Pyrus malus	Seb	Fruit
Prunus nepalensis	Bhang Bhalu	Fuel-wood
Oleaceae		
Fraxinus xanthoxyloides	Repchu	Fire-wood
Salicaceae		
Populus ciliata	Poplar	Timber
Salix wallichianas	Willow	Fuel
Shrubs :		
Berberidaceae		
Berberis aristata	Rasut	Medicinal

B. petiolaris	Rasut	Medicinal
Rhamnaceae		
Rhamnus virgatus	-	Fuel-wood
Papilionaceae		
Caragana nubigena	-	Medicinal
Rosaceae		
Cotoneaster microphyllus	-	Fuel-wood
Rosa macrophylla	-	Medicinal
Sorbaria tomentosa	-	Fuel-wood
Grossulariaceae		
Ribes orientale	-	Fuel-wood
Caprifoliaceae		
Lonicera hypoleuca	-	Fir-wood
L. webbiana	-	Fir-wood
Oleaceae		
Jasminum humile	-	Medicinal
Olea cuspidata	-	Fuel-wood
Lamiaceae		
Rabdosia rugosa	-	Fuel-wood
Elaeagnaceae		
Hippophae salcifolia	Tarwa	Medicinal
Climbers :		
Ranunculaceae		
Clematis orientalis	-	
Asclepiadaceae		
Cynanchum auriculatum	-	
Cuscutaceae		
Cuscuta reflexa	AmarBel	Medicinal
Herbs :		
Brassicaceae		
Arabis pterosperma	-	Fodder
Violaceae		
Viola betonicifolia	Vanfsa	Medicinal

Oxalidaceae		
Oxalis corniculata	Khati-buti	Medicinal
Apiaceae		
Bupleurum falcatum	-	Fodder
Asteraceae		
Artemisia gmelinii	Kala Parcha	Medicinal
Echinops cornigerus	Kandaru	Medicinal
Taraxacum officinale	-	Fodder
Polygonaceae		
Bistorta vivipara	-	-
Persicaria nepalensis	-	Fodder
Rumax nepalensis	Kholia	Medicinal
Fagopyrum esculentum	Ban ogal	Vegetables
Poaceae		
Cymbopogon jwarancusa	-	Fodder
Saccharum rufipilum	Kans	-
Stipa jacquemontii	-	Fodder
S. sibirica	-	Fodder
Cynodon dactylon	Doob	Medicinal
Brachypodium sylvaticum	-	Fodder
Bromus japonicus	-	Fodder
Calamagrostis emodensis	-	Fodder
Festuca polycolea	-	Fodder

8.4.2 Vegetation around Barrage site

The proposed barrage site is located in the downstream of Jelam Nala near the Jelam village. The area in the vicinity of proposed project comprised of patchy or open coniferous forest in the lower and middle reaches and birch fir forest on the upper reaches. On the right bank, the vegetation is sparse and patchy. Important associates of tree layer include *Cedrus deodara, Cupressus torulosa, Fraxinus xanthoxyloides, Populus ciliata* and *Salix wallichiana*. Understorey is represented by a few shrubs like *Berberis aristata, Cotoneaster integrima, C. mirophyllus, Lonicera hypoleuca, Prinsepia utilis, Rabdosia rugosa* and *Sorbaria tomentosa.* Climbers are few and represented by species of *Clematis, Cynanchum* and *Cuscuta*. Herbaceous flora is represented by pteridophytes, grasses and many other herbs. *Adiantum venustum, Artemisia gmelinii, Athyrium falcatum, Bupleurum falcatum,* *Calmagrostis emodensis, Festuca polycolea, Poa annua, Saccharum rufipilum, Stipa jacquemontii, Themeda anathera* and *Traxacum officinale.*

At left bank, the vegetation is patchy or open dry coniferous forest (**Plate 8.2**). At many places especially on upper reaches tall blue pine tree is also seen mixed with ceder forest. Under storey is very open and represented by few shrubs like *Berberis aristata, Fraxinus xanthoxyloides, Rabdosia rugosa* and *Sorbaria tomentosa* (**Plate 8.4**).

8.4.3 Vegetation at Power House Site

An underground powerhouse is proposed on the right bank of Dhauli river near village Tamak. A fairly mixed dry coniferous forest occurs in the vicinity of project areas. On the right bank, the tree canopy is represented by trees like *Cedrus deodara, Cupressus torulosa* and *Fraxinus xanthoxyloides*. Shrubs are represented by *Berberis aristata, Caragana nubigena, Cotoneaster bacilaris, Prinsepia utilis, Rabdosia rugosa* and *Sorbaria tomentosa*. There are very few climbers and epiphytes in the area. *Atylosia platycarpa, Clematis orientalis* and *Cuscuta reflexa* are found trailing in the forest. Some lichen species are also found on stones and rocks. The ground floor is occupied by many herbs and grasses like *Artemisia gmelinii, Bupleurum falcatum, Cymbopogon caesius, Erigeron alpinus, Galinsoga parviflora, Galium asperifolium, Incarvillea arguta, Lepidium arguta, Oxalis corniculata, Sacharum rufipilum, Senecio alatus, Themeda anathera, Viola betonicifolia* and *Verbascum thapsus.* Left bank has also sparse and patchy coniferous forest on steep slopes. Undergrowth is open and scant.

8.4.4 Vegetation at Quarries RBM sites, Colony, HRT, Road side and Power house Site

The project has identified 2 rock quarry sites and 5 RBM borrow sites and Colonies are proposed on the right bank of Dhauliganga river along the Border road which is connected to National Highway 58. Two rock quarry sites i.e. rock quarry 1 upstream of submergence area near Bhapkund and another rock quarry downstream of submergence area near THDC Colony are proposed for the requirement of coarse and fine aggregates. While these areas dominated by dry coniferous forests, other broad-leaved plant associates around the sites are: *Berberis aristata, Ephedra geradiana, Fraxinus xanthoxyloides, Prinsepia utilis, Rosa macrophylla,* etc (Table 8.1b).

Table 8.1b List of plant species recorded in quarry, colony and HRT sites of Jelam Tamak HE Project.

Species	Local name	Uses
Quaries and RBM sites		
Trees :		
Cupressaceae		
Juniperus macropoda	Dhoopi	Fuel-wood
Pinaceae		
Cedrus deodara	Devdar	Timber
Grosulariaceae		
Ribes orientale	-	Fuel-wood
Oleaceae		
Fraxinus xanthoxyloides	Repchu	Fuel-wood
Salicaceae		
Populus ciliata	Poplar	Fodder/Fuel-wood
Shrubs :		
Ephedraceae		
Ephedra gerardiana	Som valli	Medicinal
Berberidaceae		
Berberis aristata	Daru Haridra	Medicinal
Rosaceae		
Prinsepia utilis	Bhenkal	Medicinal
Rosa macrophylla	Jangli gulab	Medicinal
Oleaceae		
Jasminum humile	-	Fodder
Lamiaceae		
Rabdosia rugosa	-	Fuel-wood
Herbs :		
Violaceae		
Viola betonicifolia	Vanfsa	Medicinal
Asteraceae		
Artemisia gmelinii	Kala parcha	Medicinal
Poaceae		
Saccharum rufipilum	Kans	-
Oryzopsis munroi	-	Fodder

Phleum alpinum	-	Fodder
Calamagrostis emodensis	-	Fodder
Cynodon dactylon	Doob	Medicinal
Loxogrammaceae		
Loxogrammme involuta	-	Fodder
Pteridaceae		
Pteris aspericaulis	-	Fodder/cushion
Colony area		
Trees :		
Pinaceae		
Cedrus deodara	Devdar	Timber
Oleaceae		
Fraxinus xanthoxyloides	Repchu	Fuel wood
Salicaceae		
Populus ciliata	Poplar	Timber
Salix wallichiana	Willow tree	Fuel wood
Shrubs :		
Berberidaceae		
Berberis aristata	Daru Haridra	Medicinal
Papilionaceae		
Indigofera heterantha	Sain	Fuel wood
Rosaceae		
Cotoneaster integerrima	-	Fuel wood
Rubus niveus	Kali Hisalu	Fodder
Sorbaria tromentosa	Barun	Fuel- wood
Oleaceae		
Olea ferruginea	-	Fuel wood
Lamiaceae		
Rabdosia rugoa	-	Medicinal
Herbs :		
Rubiaceae		
Galium asperifolium	-	Medicinal
Asteraceae		
Anaphalis busua	Kabasi	Fuel- wood
Conyza stricta	Malchu	-

Arctium lappa	Kut	Medicinal
Bidens bipinnata	Kuru	-
Polygonaceae		
Aconogonum affine	-	Fodder
Rumex nepalensis	Kholya	Fodder
Scrophulariaceae		
Veronica anagallis-aquatica	-	Fodder
Poaceae		
Calamagrorstis emodensis	-	Fodder
Athyriaceae		
Athyrium falcatum	-	-
Aspleniaceae		
Asplenium indicum	-	-
Dryopteridaceae		
Dryopteris chrysocoma	-	-
HRT site		
Trees :		
Cupressaceae		
Cupressus torrulosa	Surai	Timber
Pinaceae		
Cedrus deodara	Devdar	Timber
Pinus wallichiana	Kail	Timber
Rosaceae		
Pyrus malus	Seb	Fruit
Oleacece		
Fraxinus xanthoxyloides	Repchu	Fuel-wood
Elaeagnaceae		
Hippophae salicifolia	Tarwa	Medicinal
Salicaceae		
Populus ciliata	Poplar	Timber
Shrubs :		
Berberidaceae		
Berberis aristata	Daru Haridra	Medicinal
Caprifoliacaeae		
Lonicera hypoleuca	-	Fuel-wood

Rosaceae		
Cotoneaster integerrima	-	Fuel-wood
Prinsepia utilis	Bhenkal	Medicinal
Sorbaria tomentosa	Barun	Fuel-wood
Oleacece		
Olea ferruginea	-	Fuel-wood
Lamiaceae		
Rabdosia rugosa	-	Medicinal
Loranthaceae		
Scurrula elata	-	Parasitic
Liliaceae		
Asparagus filicinus	Satavari	Medicinal
Herbs :		
Asteraceae		
Arctium lappa	Kut	Medicinal
Artemisia gmelinii	Kala parcha	Medicinal
Polygonaceae		
Rumex nepalensis	Kholya	Medicinal
Poaceae		
Calamagrostis emodensis	-	Fodder
Cynodon dactylon	Doob	Medicinal
Oryzopsis munroi	-	Fodder
Pteridaceae		
Pteris aspericaulis	-	Fodder
Hymenophyllaceae		
Mecodium exsertum	-	Fodder
Dryopteridaceae		
Dryopteris wallichiana	-	cushion
Road side		
Trees :		
Pinaceae		
Cedrus deodara	Devdar	Timber
Pinus wallichiana	Kail	Timber
Oleacece		
Fraxinus xanthoxyloides	Repchu	Fuel-wood

Elaeagnaceae		
Hippophae salicifolia	Tarwa	Medicinal
Salicaceae		
Populus ciliata	Poplar	Timber
Shrubs :		
Berberidaceae		
Berberis aristata	Daru Hridra	Medicinal
Papilionaceae		
Indigofera heterantha	-	Fuel-wood
Rosaceae		
Cotoneaster integerrima	-	Fuel-wood
Rubus niveus	Kali Hisalu	Fodder
Sorbaria tromentosa	-	Fuel-wood
Oleaceae		
Olea ferruginea	-	Fuel-wood
Lamiaceae		
Rabdosia rugoa	-	Medicinal
Herbs :		
Brassicaeae		
Arbidopsis mollisisma	-	Fodder
Asteraceae		
Anaphalis busua	Kabasi	Fuel
Bidens bipinnata	Kuru	-
Conyza stricta	Malchu	-
Bignoniacerae		
Incarvillea arguta	-	Fodder
Lamiaceae		
Nepeta discolor	-	Fodder
Polygonaceae		
Rumex nepalensis	Kholya	Fodder
Poaceae		
Calamagrorstis emodensis	-	Fodder
Oryzopsis munroi	-	Fodder
Adiantaceae		
Adiantum venustum	-	-

Dryopteridaceae		
Polystichum bakerianum	Fern	-
Polypodiaceae		
Lepisorus contortus	Fern	-

8.4.5 Community Structure in the Project Area

Community is an assemblage of organisms living in a particular area or physical habitat or it is an aggregation of organisms which form a distinct ecological unit. Before going to expel any idea related to numerical strength of the species in the community, it is prerequisite to understand the community quantitatively. Thus the phytosociological data gives an idea about the numerical strength of the species in a particular community. In order to understand the community structure, vegetation sampling was carried out at different locations in the project area. During our surveys in Nov., 2008, March, 2009, Sept., 2012 six sites viz., proposed barrage site, submergence site, u/s of submergence site, d/s of barrage site, powerhouse site, and d/s of powerhouse site were selected for vegetation structure study on the basis of the presence of forest patches in the area.

8.4.5.1 *Density and Basal area*

The maximum number of tree species was recorded from the proposed barrage site (V4, right bank of Dhauliganga). The powerhouse site, submergence site and u/s of submergence area did not show as many tree species due to past and on-going land use changes and extensive felling of trees for various purposes including timber (Table 8.2). The number of herb species was higher during monsoon and post-monsoon seasons (Table 8.3).

On the powerhouse site, the tree strata was dominated by *Cupressus torulosa* having maximum frequency (70%) and density (280 trees/ha). The associated species in the tree canopy were *Fraxinus xanthoxyloides* and *Cedrus deodara*. In the shrub layer *Berberis aristata* was found as the most dominant species having density. The dominance of *Berberis aristata* may be due to its non palatable nature and capability to grow in cold areas. Other competing species in the understorey were *Rabdosia rugosa, Prinsepia utilis, Sorbaria tomentosa* and *Colquhounia coccinea* (Table 8.2). Absence of saplings and seedlings of all major species in a forest shows severe biotic pressure.

At the barrage site, *Cupressus torulosa* and *Salix wallichiana* were found to be the most dominant species having maximum frequency (50%) and density (110 trees/ha). The associated species of the tree layer were *Fraxinus xanthoxyloides, Hippophae salcifolia, Salix acmophylla, Prunus nepalensis* and *Pinus wallichiana*. Absence of saplings and seedlings of all major species in a forest shows severe biotic pressure. In the shrub layer *Berberis aristata* was found to be the most dominant species having high frequency and density. Other competing species of the layer were *Sorbaria tomentosa, Rabdosia rugosa, Lonicera hypoleuca, Cotoneaster bacillaris, Olea ferruginea, Rosa sericea, R. macrophylla, Jasminum humile* and *Rhamnus virgatus* (Table 8.2).

At the submergence site (u/s of Jelam, right bank Dhauliganga), the tree strata was dominated by *Cedrus deodara* having maximum frequency (90%) and density (200 trees/ha). The associated species in the tree canopy were *Fraxinus xanthoxyloides* and *Ribes orientale*. In the shrub layer *Berberis aristata* was found to be the most dominant species having high density. Other competing species in the layer were *Rabdosia rugosa, Jasminum officinale, Sorbaria tomentosa, Lonicera hypoleuca,* and *Rosa sericea*. The complete absence of saplings and seedlings of all dominant trees in forest can be attributed to high human encroachment.

On upstream site (Buransbara, right bank of Dhauliganga), the tree strata was dominated by *Fraxinus xanthoxyloides* having maximum frequency (90%) and density (270 trees/ha). The associated species in the tree layer were *Juniperus macropoda* and *Cedrus deodara*. In the shrub layer *Lonicera hypoleuca* was found to be the most dominant species with high density. Other competing species in the layer were *Berberis petiolaris, Caragana spinosa, Cotoneaster bacillaris,* and *Ephedra gerardiana.* The complete absence of saplings and seedlings of all dominant tree species in a forest is attributed to high human encroachment in the area.

On d/s of barrage site, the tree strata was dominated by *Fraxinus xanthoxyloides* having maximum frequency (30%) and density (80 trees/ha). The associated species in the tree canopy were *Salix wallichiana, Hippophae salicifolia,* and *Cedrus deodara*. In the shrub layer *Sorbaria tomentosa* was found as the most dominant species having high frequency and density. Other competing species in the understorey were *Rabdosia rugosa, Berberis aristata, Cotoneaster bacillaris* and *Ephedra gerardiana*. The presence of *Fraxinus xanthoxyloides, Hippophae salicifolia*, *Berberis aristata* and *Ephedra gerardiana* as throny species shows biotic disturbance in the area due to grazing and lopping.

At the d/s of powerhouse site (Tamak, right bank of Dhauliganga), *Juniperus macropoda* was found to be the most dominant tree species having maximum frequency (40%) and density (80 trees/ha). The associated species of the tree layer were *Fraxinus xanthoxyloides, Cedrus deodara* and *Pinus wallichiana*. Absence of saplings and seedlings of all major species in a forest shows severe biotic pressure. In the shrub layer *Rabdosia rugosa* was found to be the most dominant species having high frequency and density. Other competing species of the layer were *Berberis aristata, Lonicera hypoleuca, Prinsepia utilis* and *Olea ferruginea* (Table 8.2).

Across all the sites/stands the total tree density ranged from 160 trees/ha at the d/s of barrage site (Jelam, right bank of Dhauliganga) to 420 trees/ha at upstream site (Buransbara, right bank of Dhauliganga). Absence of saplings and seedlings of all major species in a forest indicates heavy anthropogenic pressure in the area. The total density for shrubs varied from 2120 to 5560 individuals ha^{-1}. It was comparatively higher at the barrage site (5560 individual ha^{-1}) as compared to powerhouse and other sites. The maximum individual shrub density was recorded for *Lonicera hypoleuca* (2080 individual ha^{-1}) at the upstream site (Table 8.2). This species may help in restoration of soil.

The total basal area ranged from 15.86 m^2/ha at d/s of barrage site to 461.36 m^2/ha at submergence site (Table 8.2). The lowest mean basal area (0.0754 m^2/tree) was recorded for *Salix wallichiana* at d/s of barrage site, while the highest values were recorded for *Cedrus deodara* (5.9798 m^2/tree) at powerhouse site. *Cedrus deodara, Cupressus torulosa* and *Fraxinus xanthoxyloides* were the dominant species with an IVI of 232.79, 188.19 and 152.28 at submergence site, powerhouse site and upstream area, respectively.

Among the herbaceous species, *Themeda anathera* was the dominant species having maximum density (92000 plants/ha) during post-monsoon at powerhouse site. It was followed by *Pennisetum flavidum, Cynodon dactylon, Cymbopogon caesius* and *Micromeria biflora* in term of density. Whereas *Cymbopogon caesius* (68000 plant/ha) and *Cynodon dactylon* (44000 plant/ha) was the most dominant species in pre-monsoon and monsoon sampling (Table 8.3). As per IVI values, *Urtica dioica* was the dominant species (45.91) followed by *pennisetum flavidum* (38.39), *Themeda anathera* (29.02), *Cynodon dactylon* (25.65), *Cymbopogon caesius* (18.97), *Malva rotundifolia* (16.95) and *Artemisia gmelinii* (15.03) during post-monsoon. The lowest IVI of 3.40 was recorded in *Rumex nepalensis* during post-monsoon.

At the proposed barrage site, *Themeda anathera* was found to be most dominant species having maximum density (36000 plants/ha) during post-monsoon, pre-monsoon (68000 plants/ha) and monsoon (70000 plants/ha). It was followed by *Bromus japonicus* and *Calamagrostis emodensis* in terms of density (Table 8.3). Maximum value of IVI was observed in *Themeda anathera* during post-monsoon (48.58) and monsoon (63.60). It was followed by *Bromus japonicus* (40.45) and *Calamagrostis emodensis* (37.11) during post-monsoon. The minimum IVI of 5.10 was noted for *Bupleurum falcatum* during pre-monsoon.

At the submergence site, again *Themeda anathera* was the most dominant species having maximum density (22000 plants/ha) during post-monsoon. It was followed by *Calamagrostis emodensis, Conyza stricta, Oryzopsis munroi* and *Origanum vulgare* in terms of density. *Oryzopsis munroi* and *Festuca polycolea* were the dominant species in pre-monsoon and monsoon sampling. Maximum IVI was observed in *Conyza stricta* (59.00) followed by *Themeda anathera* (29.05) and *Artemisia gmelinii* (26.84) during post-monsoon. The minimum IVI of 4.23 was recorded in *Erigeron multiradiatus* during post-monsoon.

At the upstream site (Buransbara, right bank of Dhauliganga), *Artemisia maritima* was the most dominant species having maximum density (298000 plants/ha) during post-monsoon. It was followed by *Festuca polycolea, Thymus linearis, Oryzopsis munroi* and *Poa himalayana* in terms of density. Maximum IVI was observed in *Artemisia maritima* (173.15) during post-monsoon. The lowest IVI of 3.72 was recorded in *Impatiens brachycentra* during pot-monsoon sampling.

At d/s of barrage site (u/s of Juma), *Themeda anathera* was the most dominant species having maximum density (25000 plants/ha) during post-monsoon. It was followed by *Calamagrostis emodensis, Oryzopsis munroi, Rumex nepalensis, Festuca polycolea* and *Brachypodium sylvaticum.* Maximum value of IVI was observed in *Themeda anathera* (30.68) followed by *Conyza stricta*

(28.06), *Saccharum rufipilum* (27.92) and *Calamagrostis emodensis* (23.84). The minimum IVI of 4.96 was noted for *Geranium nepalense.*

At d/s of power house site (Tamak, right bank of Dhauliganga), *Cynodon dactylon* was the most dominant species having maximum density (30000 plants/ha). It was followed by *Cymbopogon caesius, Bidens bipinnata, Fragaria nubicola, Oryzopsis munroi* and *Aster molliusculus* in term of density (Table 8.3). As per IVI values, *Verbascum thapsus* was the dominant species (34.59) followed by *Cynodon dactylon* (22.87), *Artemisia gmelina* (17.42), *Cymbopogon caesius* (16.92) and *Polystachyum nepalense* (15.75). The lowest IVI of 3.64 recorded in *Erigeron multiradiatus* (Table 8.3).

8.4.5.2 *Species Diversity*

The diversity index value (H) in the tree layer ranged from 0.582 at power house (Tamak, right ban of Dhauliganga) to 1.679 at barrage site (Jelam, right bank of Dhauliganga). The species diversity for shrub strata ranged from 1.396 to 1.816 (see Table 8.4). The occurrence of shrubs in large numbers at the barrage site can be attributed to the anthropogenic disturbances that arrest further succession. The value of species diversity (H) in the herbaceous layer ranged from 1.835 (barrage site) to 2.800 (power house site), respectively (Table 8.4).

Table 8.2 Vegetational attributes of woody vegetation in Jelam Tamak HE Project

	Species	Frequency (F%)	Density(ha^{-1})	TBC (m^2ha^{-1})	IVI
V1	**Powerhouse site(Tamak, right bank of Dhauliganga)2200m**				
	Trees				
1	*Cupressus torulosa*	70	280	67.95	188.19
2	*Fraxinus xanthoxyloides*	40	60	8.55	56.75
3	*Cedrus deodara*	10	10	59.80	55.06
	Total	**120**	**350**	**136.29**	
	Shrubs				
1	*Prinsepia utilis*	60	920	25.39	78.62
2	*Berberis aristata*	80	1200	44.56	115.72
3	*Colquhounia coccinea*	20	80	1.81	12.84
4	*Rabdosia rugosa*	60	1080	9.35	65.57
5	*Sorbaria tomentosa*	10	400	11.10	27.25
	Total	**230**	**3680**	**92.21**	

V2	**Barrage site(Jelam, right bank)2600m**				
	Trees				
1	*Cupressus torulosa*	50	110	32.66	99.64
2	*Fraxinus xanthoxyloides*	40	60	20.08	64.08
3	*Salix wallichiana*	50	110	10.52	70.08
4	*Hippophae salcifolia*	20	30	2.34	21.75
5	*Salix acmophylla*	10	30	2.41	16.59
6	*Prunus nepalensis*	10	20	5.10	17.48
7	*Pinus wallichiana*	10	10	1.81	10.38
	Total	**190**	**370**	**74.92**	
	Shrubs				
1	*Lonicera hypoleuca*	20	440	15.41	27.80
2	*Cotoneaster bacillaris*	30	280	3.43	21.63
3	*Rabdosia rugosa*	50	1200	10.39	52.38
4	*Berberis aristata*	20	1640	32.96	61.18
5	*Olea ferruginea*	20	280	3.17	16.69
6	*Rosa sericea*	10	160	1.96	8.96
7	*Rosa macophylla*	10	120	3.96	9.58
8	*Sorbaria tomentosa*	30	1320	73.87	87.70
9	*Rhamnus virgatus*	10	40	2.84	7.39
10	*Jasminum humile*	10	80	0.73	6.69
	Total	**210**	**5560**	**148.72**	
V3	**Submergence site(u/s of Jelam, right bank of Dhauliganga)2700m**				
	Trees				
1	*Cedrus deodara*	90	200	447.88	232.79
2	*Fraxinus xanthoxyloides*	40	70	12.70	56.32
3	*Ribes orientale*	10	10	0.78	10.88
	Total	**140**	**280**	**461.36**	
	Shrubs				
1	*Berberis aristata*	70	1800	40.21	135.98
2	*Rabdosia rugosa*	60	1080	9.53	69.34
3	*Jasminum officinale*	30	640	5.75	38.47
4	*Lonicera hypoleuca*	20	160	7.23	24.30
5	*Rosa sericea*	10	160	1.46	10.91

6	*Sorbaria tomentosa*	10	400	4.52	21.01
	Total	**200**	**4240**	**68.71**	
V4	**Upstream site(Buransbara, right bank of Dhauliganga)2800m**				
	Trees				
1	*Juniperus macropoda*	40	90	66.47	66.13
2	*Fraxinus xanthoxyloides*	90	270	103.17	152.28
3	*Cedrus deodara*	20	60	198.90	81.59
	Total	**150**	**420**	**368.55**	
	Saplings				
1	*Fraxinus xanthoxyloides*	80	1600	70.85	198.75
2	*Juniniperus macropoda*	60	520	28.07	92.33
3	*Cedrus deodara*	10	40	0.40	8.92
	Total	**150**	**2160**	**99.31**	
	Shrubs				
1	*Lonicera hypoleuca*	90	2080	22.66	149.60
2	*Cotoneaster bacillaris*	20	240	16.40	49.36
3	*Olea ferruginea*	10	120	1.22	11.00
4	*Berberis petiolaris*	30	560	5.13	41.41
5	*Caragana spinosa*	20	360	3.12	26.64
6	*Ephedra gerardiana*	20	240	2.45	22.00
	Total	**190**	**3600**	**50.97**	
V5	**D/s of barrage (U/s of Juma, right bank of Dhauliganga)2400m**				
	Trees				
1	*Cedrus deodara*	20	20	3.93	57.25
2	*Fraxinus xanthoxyloides*	30	80	7.26	125.77
3	*Salix wallichiana*	30	30	2.26	63.02
4	*Hippophae salcifolia*	20	30	2.41	53.96
	Total	**100**	**160**	**15.86**	
	Shrubs				
1	*Ephedra gerardiana*	10	80	0.69	13.93
2	*Cotoneaster bacillaris*	30	200	1.76	38.78
3	*Rabdosia rugosa*	30	560	6.33	71.98
4	*Berberis aristata*	20	240	2.20	34.51
5	*Sorbaria tomentosa*	40	1040	17.16	140.80

	Total	**130**	**2120**	**28.15**	
V6	**D/s of powerhouse site (d/s of Tamak, right bank of Dhauliganga) 2180m**				
	Trees				
1	*Juniperus macropoda*	40	80	12.16	92.91
2	*Cedrus deodara*	30	50	23.88	94.11
3	*Fraxinus xanthoxyloides*	40	50	4.27	63.03
4	*Pinus wallichiana*	20	30	10.26	49.96
	Total	**130**	**210**	**50.57**	
	Shrubs				
1	*Lonicera hypoleuca*	50	440	16.72	76.04
2	*Berberis aristata*	50	640	17.19	85.34
3	*Olea ferruginea*	30	120	1.36	22.04
4	*Rabdosia rugosa*	50	880	7.62	75.92
5	*Prinsepia utilis*	30	320	6.43	40.66
	Total	**210**	**2400**	**49.32**	

Table 8.3 Vegetational attributes of herbaceous vegetation in jelam tamak HE project

	Species	**Pos-tmonsoon**		**Pre-monsoon**		**Monsoon**	
		Density	**IVI**	**Density**	**IVI**	**Density**	**IVI**
V1	**Powerhouse site(Tamak, right bank of Dhauliganga)2200m**						
1	*Cynodon dactylon*	86000	25.65	22000	20.28	44000	30.45
2	*Pennisetum flavidum*	88000	38.39	20000	21.92	28000	29.00
3	*Urtica dioica*	26000	45.91	-	-	-	-
4	*Malva verticillata*	20000	16.16	6000	10.54	12000	13.58
5	*Oxalis corniculata*	12000	8.14	4000	5.46	8000	7.75
6	*Elsholtzia flava*	5000	5.39	-	-	-	-
7	*Roripa nastrutium-aquaticum*	16000	6.08	-	-	-	-
8	*Poa annua*	12000	8.19	-	-	4000	5.43
9	*Artemisia capillaris*	12000	15.03	10000	18.50	8000	17.30
10	*Salvia lanata*	12000	6.03	1000	3.63	2000	4.37
11	*Cypsella bursa-pastorius*	6000	7.50	-	-	-	-
12	*Scrophularia decomposita*	5000	5.39	2000	4.77	2000	5.68

13	*Rumex nepalensis*	2000	3.40	14000	17.42	4000	6.77
14	*Geranium nepalense*	4000	3.64	4000	5.57	6000	9.19
15	*Galium asperifolium*	4000	3.64	4000	5.57	8000	8.16
16	*Saccharum rufipilum*	8000	7.99	-	-	4000	11.35
17	*Brachypodium sylvaticum*	4000	3.66	4000	5.63	2000	4.12
18	*Themeda anathera*	92000	29.02	40000	33.52	26000	20.42
19	*Oryzopsis munroi*	8000	7.67	14000	16.18	4000	5.90
20	*Bidens bipinnata*	4000	5.34	4000	6.76	2000	5.68
21	*Micromeria biflora*	28000	9.09	-	-	-	-
22	*Verbascum thapsus*	2000	14.91	2000	8.44	2000	6.88
23	*Cymbopogon caesius*	48000	18.97	68000	63.70	30000	30.38
24	*Echinops cornigerus*	2000	4.80	-	-	1000	6.40
25	*Anaphalis busua*	-	-	2000	4.41	4000	9.47
26	*Adiantum incisum*	-	-	4000	5.34	6000	8.92
27	*Eragrostis nigra*	-	-	8000	12.10	12000	17.61
28	*Bupleurum falcatum*	-	-	4000	10.73	2000	5.68
29	*Dracocephalum heterophyllum*	-	-	2000	4.03	4000	4.96
30	*Elsholtzia eriostachya*	-	-	8000	11.39	7000	10.57
31	*Selaginella kashmiriana*	-	-	2000	4.12	-	-
32	*Erigeron multiradiatus*	-	-	-	-	2000	3.83
33	*Muhlenbergia himalayensis*	-	-	-	-	8000	9.76
V2	**Barrage site(Jelam, right bank of Dhauliganga) 2600m**						
1	*Themeda anathera*	36000	48.58	68000	63.60	70000	41.17
2	*Bupleurum falcatum*	4000	12.62	1000	5.10	-	-
3	*Oxalis corniculata*	8000	16.52	4000	7.12	-	-
4	*Bromus japonicus*	30000	40.45	24000	26.65	28000	24.35
5	*Viola betonicifolia*	2000	6.69	-	-	-	-
6	*Oryzopsis munroi*	18000	27.60	4000	7.34	4000	6.33
7	*Festuca polycolea*	14000	23.32	-	-	-	-

8	*Geranium nepalense*	2000	6.55	4000	7.98	-	-
9	*Calamagrostis emodensis*	22000	37.11	44000	57.17	60000	49.28
10	*Artemisia gmelinii*	12000	29.73	4000	15.08	20000	59.86
11	*Saccharum rufipilum*	2000	9.63	2000	13.23	5000	9.00
12	*Brachypodium sylvaticum*	4000	8.45	4000	7.34	8000	8.31
13	*Taraxacum officinale*	4000	8.64	8000	15.15	-	-
14	*Persicaria nepalensis*	4000	9.02	-	-	-	-
15	*Geranium nepalense*	4000	8.45	-	-	28000	24.85
16	*Anaphalis busua*	2000	6.69	10000	17.77	-	-
17	*Conyza stricta*	-	-	12000	14.82	20000	17.04
18	*Nepeta discolor*	-	-	4000	8.43	-	-
19	*Origanum vulgare*	-	-	22000	33.00	22000	25.74
20	*Salvia hians*	-	-	-	-	4000	6.89
21	*Artemisia nilagirica*	-	-	-	-	4000	8.07
22	*Epilobium angustifolium*	-	-	-	-	4000	6.66
23	*Galium asperifolium*	-	-	-	-	8000	12.66
V3	**Submergence site (u/s of Jelam, right bank of Dhauliganga)2700m**						
1	*Androsace rotundifolia*	6000	9.95	-	-	-	-
2	*Campanula latifolia*	5000	8.99	-	-	-	-
3	*Salvia hians*	2000	5.94	-	-	-	-
4	*Origanum vulgare*	12000	16.20	-	-	-	-
5	*Conyza stricta*	17000	59.00	-	-	-	-
6	*Geranium nepalense*	5000	9.37	-	-	-	-
7	*Brachypodium sylvaticum*	8000	11.51	-	-	-	-
8	*Themeda anathera*	22000	29.05	40000	30.98	-	-
9	*Thymus lineris*	8000	11.22	8000	11.14	8000	10.93
10	*Bupleurum falcatum*	5000	10.78	7000	12.98	7000	15.29
11	*Bistorta affinis*	8000	12.00	-	-	-	-
12	*Micromeria biflora*	10000	9.32	-	-	-	-
13	*Oryzopsis munroi*	14000	17.37	44000	42.65	24000	25.40

14	*Festuca polycolea*	10000	10.08	40000	34.48	40000	34.06
15	*Calamagrostis emodensis*	20000	20.89	-	-	-	-
16	*Thalictrum foetidum*	2000	4.66	5000	9.82	-	-
17	*Saccharum rufipilum*	4000	6.48	10000	14.10	-	-
18	*Erigeron multiradiatus*	2000	4.23	-	-	-	-
19	*Artemisia gmelinii*	8000	26.84	18000	38.27	18000	55.08
20	*Arisaema jacquemontii*	2000	9.33	-	-	-	-
21	*Stachys tibetika*	5000	6.74	-	-	-	-
22	*Oxalis corniculata*	-	-	10000	9.38	15000	18.29
23	*Phleum alpinum*	-	-	4000	10.96	4000	14.52
24	*Rumex nepalensis*	-	-	22000	21.84	22000	19.47
25	*Urtica hyperborea*	-	-	18000	32.37	-	-
26	*Cynodon dactylon*	-	-	15000	15.58	15000	15.35
27	*Setaria viridis*	-	-	6000	9.87	6000	9.67
28	*Polygonum aviculare*	-	-	4000	5.57	4000	13.62
29	*Arisaema tortuosum*	-	-	-	-	2000	8.28
30	*Silene conoidea*	-	-	-	-	3000	5.34
31	*Fragaria nubicola*	-	-	-	-	14000	15.12
32	*Pteris* sp.	-	-	-	-	4000	5.91
33	*Ephedra gerardiana*	-	-	-	-	10000	22.25
34	*Arabidopsis mollisisma*	-	-	-	-	4000	7.10
35	*Potentilla fulgens*	-	-	-	-	2000	4.26
V4	**Upstream site (Buransbara, right bank of Dhauliganga) 2800m**						
1	*Festuca polycolea*	92000	26.60	44000	37.54	28000	29.02
2	*Poa himalayana*	30000	8.93	20000	18.23	10000	12.27
3	*Artemisia maritima*	298000	173.15	53000	107.86	34000	96.77
4	*Thlaspi griffithianum*	7000	4.55	5000	9.18	4000	8.34
5	*Thymus linearis*	60000	15.49	60000	46.05	20000	20.28
6	*Astragalus graveolens*	3000	4.55	18000	26.77	5000	16.18
7	*A. leucocephalus*	10000	5.34	18000	26.77	-	-

8	*Oryzopsis munroi*	42000	22.12	22000	33.98	28000	38.14
9	*Pedicularis hoffmeisteri*	1000	3.92	1000	7.30	1000	8.70
10	*Carum carvi*	12000	8.63	-	-	-	-
11	*Geranium wallichianum*	6000	7.47	-	-	-	-
12	*Impatiens brachycentra*	2000	3.72	-	-	-	-
13	*Rumex nepalensis*	8000	8.08	-	-	10000	19.18
14	*Asplenium ensiforme*	6000	7.44	-	-	-	-
15	*Arcteum lappa*	-	-	-	-	4000	11.01
16	*Calamagrostis emodensis*	-	-	-	-	22000	26.41
17	*Anaphalis busua*	-	-	-	-	10000	13.73
V5	**D/s of barrage (U/s of Juma, right bank of Dhauliganga) 2400m**						
1	*Lepidium apetalatum*	5000	10.85				
2	*Conyza stricta*	6000	28.06				
3	*Themeda anathera*	25000	30.68				
4	*Bupleurum falcatum*	4000	10.09				
5	*Oxalis corniculata*	4000	6.59				
6	*Rumex nepalensis*	10000	18.87				
7	*Circium wallichii*	6000	13.35				
8	*Oryzopsis munroi*	12000	14.16				
9	*Festuca polycolea*	10000	12.32				
10	*Geranium nepalense*	8000	14.84				
11	*Calamagrostis emodensis*	18000	23.84				
12	*Artemisia gmelinii*	6000	20.41				
13	*Saccharum rufipilum*	4000	27.92				
14	*Brachypodium sylvaticum*	10000	15.44				
15	*Taraxacum officinale*	2000	5.08				
16	*Arctium lappa*	4000	7.56				
17	*Geranium nepalense*	2000	4.96				
18	*Anaphalis busua*	8000	14.57				
19	*Poa annua*	5000	7.72				

20	*Senecio chrysanthemoides*	6000	12.69				
V6	**D/s of powerhouse site (d/s of Tamak, right bank of Dhauliganga)2180m**						
1	*Geranium nepalense*	4000	7.28				
2	*Artemisia gmelina*	9000	17.42				
3	*Cynodon dactylon*	30000	22.87				
4	*Ajuga bracteosa*	6000	8.81				
5	*Polystachyum nepalense*	7000	15.75				
6	*Saccharum rufipilum*	8000	16.21				
7	*Rumex nepalensis*	11000	16.18				
8	*Viola canescens*	4000	7.45				
9	*Selaginella kashmiriana*	6000	8.60				
10	*Oxais corniculata*	10000	10.69				
11	*Bidens bipinnata*	14000	12.58				
12	*Verbascum thapsus*	2000	34.59				
13	*Cymbopogon caesius*	20000	16.92				
14	*Erasimum hiersifolium*	4000	7.50				
15	*Fragaria nubicola*	14000	13.27				
16	*Echinops cornigera*	5000	15.35				
17	*Bupleurum candolii*	4000	5.34				
18	*Oryzopsis munroi*	12000	12.60				
19	*Polystachyum bakerianum*	4000	11.09				
20	*Lespdeza gerardiiana*	4000	5.06				
21	*Aster molliusculus*	12000	11.13				
22	*Galium asperifolium*	4000	7.28				
23	*Urtica hyperborea*	4000	12.51				
24	*Erigeron multiradiatus*	2000	3.64				

Table 8.4 Species Diversity Indices (H) for different vegetation components at different sampling sites in Jelam Tamak HE Project

Vegetation component	Shannon's Diversity Index (H)		
	Post-monsoon	Pre-monsoon	Monsoon
Power House site (Tamak)			
Trees	0.58	0.58	0.58
Shrubs	1.39	1.39	1.39
Herbs	2.54	2.51	2.80
Barrage site (Jelam)			
Trees	1.67	1.67	1.67
Shrubs	1.81	1.81	1.81
Herbs	2.34	2.11	2.21
Submergence site (U/s of Jelam)			
Trees	0.71	0.71	0.71
Shrubs	1.47	1.47	1.47
Herbs	2.82	2.42	2.56
Upstream site (Jelam)			
Trees	0.89	0.89	0.89
Shrubs	1.31	1.31	1.31
Herbs	1.63	1.87	2.20
D/s of Barrage site (u/s of Tamak)			
Trees	1.23		
Shrubs	1.29		
Herbs	2.79		
D/s of Powerhouse site (Juma)			
Trees	1.33		
Shrubs	1.45		
Herbs	2.94		

Table 8.5 Number of herb species observed on project sites in different seasons

Seasons	No. of species					
	V1	V2	V3	V4	V5	V6
Post-monsoon	33	16	21	14	20	24
Pre-monsoon	24	15	15	9		
Monsoon	27	14	18	12		

8.4.5.3 *Plant Biodiversity*

A total of 113 species of plants were recorded under the ecological investigation during different sampling seasons. Out of which 10 were trees, 16 shrubs and 87 herbs. The ground vegetation comprised of ephemeral, annual, and perennial species of grasses, sedges, legumes and non-legume forbs.

8.4.5.4 *Lower Plant Diversity (Cryptogams)*

Cryptogamic flora of Uttarakhand is very rich with a diverse species composition. However, studies on this component of the flora are largely lacking. Lichens are unique group of plants consisting of algae and fungi living together in symbiotic association. The state represents 521 species, 2 sub-species and 18 varieties belonging to 125 genera under 45 families. The area is rich both in crustose and fruticose lichens. The most commonly found lichens species are *Bulbothrix meizospora, Cladonia cartilaginea, Heteroderma diademata, Parmelinella wallichiana, Ramalina sinensis* and *Usnea longissima*. Pteridophytes form an important constituents of the vegetation and their study is important from their morphological as well as their unique position between non seed bearing and seed bearing plants. Dixit and Kumar (2001) listed 487 species belonging to 108 genera and 50 families from India, of these 10 species and 2 varieties confined their distribution only to Uttarakhand. A list of some common pteridophytes, mosses and lichens of influence zone are given in Table 8.6. A detailed account on algal flora is given in chapter 11 of EIA report.

Table 8.6 List of some common pteridophytes, bryophytes and lichens from different zones of influence area of Jelam Tamak HEP

Species	Habit	Altitude (m)
Pteridophytes		
Selaginellaceae		
Selaginella kashmiriana	terrestrial herb	1200-2600
Osmunndaceae		
Osmunda claytoniana	terrestrial fern	1500-3000
Loxogrammaceae		
Loxogramme involuta	terrestrial herb	1200-2400
Polypodiaceae		
Lepisorus contortus	epiphytic fern	1500-2700
Drynariaceae		
Drynaria mollis	epiphytic fern	1600-2800
Peridaceae		
Pteris aspericaulis	terrestrial fern	1000-2500

Adiantaceae		
Adiantum venustum	terrestrial fern	1000- 3000
Hymenophyllaceae		
Mecodium exsertum	terrestrial fern	1200-2400
Aspleniaceae		
Asplenium indicum	terrestrial fern	Up to 2600
Athyriaceae		
Athyrium attenuatum	terrestrial fern	1200-2800
A. f*alcatum*	terrestrial fern	Up to 2500
Dryopteridaceae		
Dryopteris chrysocoma	terrestrial fern	1600-2600
Polystichum bakerianum	terrestrial fern	1400- 2600
Liverworts		
Marchantiaceae		
Marchatia paleacea		
Plagiochilaceae		
Plagiochila chinensis		
Anthocerotaceae		
Anthoceros angustus		
Mosses		
Andreaeaceae		
Andreaea rupestris		
Polytrichaceae		
Pogonatum thomsonii		
Funariaceae		
Funaria wallichii		
Grimmiaceae		
Grimmia apiculata		
Fissidentaceae		
Fissdens grandifrons		
Ditrichaceae		
Ditrichum homomallum		
Dicranaceae		
Anisothecium molliculum		
Bryaceae		

Bryum cellulare

B. recurvulum

Mniaceae

Mnium marginatum

Thuidiaceae

Thuidium assimile

Liverworts

Marchantiaceae

Marchantia paleacea

Ricciaceae

Riccia fluitans

Lichens

Parmeliaceae

Bulbothrix meizospora

Cladoniaceae

Cladonia cartilaginea

Physciaceae

Heteroderma diademata

Ramalinaceae

Ramalina sinensis

Parmeliaceae

Usnea longissima

Source: Srivastava & Singh, 2005 ; Dandotiya et al, 2011

8.4.5.5 *Taxonomic Diversity*

The proposed Jelam Tamak H.E. Project area extends from Juma to Jelam village, along the Dhauliganga. Out of about 17,000 flowering plant species estimated to occur in India (Karthikeyan, 2000) about 4248 species of flowering plants are reported from Uttarakhand (Srivastava & Singh, 2005). There are nearly 196 species of angiosperms have been recorded in the free-draining catchment of Jelam Tamak H.E. project encompassing the valleys of Dhauliganga and its major tributaries Jelam Nala, Pangti Nala and Kosa Nala (Table 8.7). These species belong to 147 genera and 59 families. Out of 59 families represented in the area, 50 are dicots and 9 are monocots. The dicotyledons are represented by 146 species belonging to 110 genera 50 families, while the monocotyledons are represented by 37 genera and 50 species. Gymnosperms are represented by 4 families, 7 genera and 7 species. The ratio of monocot to dicot species is 1:2.92. For monocots, family to genera, family to species and genera to species ratios are 1: 4.11, 1: 5.55 and 1:1.35, respectively. The genera to species ratio for this region is around 1:1.35 which is nearly similar to that of Uttarakhand 1: 3.25 (Srivastava & Singh, 2005). However, this ratio is much less in comparison to the corresponding ratio 1:13 for the world and 1: 6 for India (Raizada and Saxena, 1978; Mudgal & Hajra, 1999). This result confirms the general view that within the same floral region flora of smaller areas have lower genus-species ratio.

Poaceae with 25 genera and 30 species and Asteraceae with 14 genera and 20 species are the largest families of monocots and dicots, respectively. Among gymnosperms Pinaceae is the dominant family represented by 3 genera and 3 species. The dominating genera represented by 3 or more species in the project area are *Allium* (4), *Astragalus* (3) and *Prunus* (3). Many of these species were observed during our field visits conducted between Nov., 2008, March, 2009 and Sept., 2012.

Table 8.7 List of plant species in the free-draining catchment of Jelam Tamak H.E. Project

Family	**Genus**	**Species**	**Habit**	**Alt.(m)**
Gymnosperms				
Cupressaceae	*Cupressus*	*torulosa*	tree	2200-3000
	Juniperus	*macropoda*	tree	2100-3300
Pinaceae	*Abies*	*pindrow*	tree	2800-3300
	Cedrus	*deodara*	tree	2000-3300
	Pinus	*wallichiana*	tree	2900-3000
Taxaceae	*Taxus*	*baccata*	tree	3000-3500
Ephedraceae	*Ephedra*	*gerardiana*	shrub	3500-4500
Angiosperms				
Dicots				
Ranunculaceae	*Aconitum*	*atrox*	herb	3500-4000
Ranunculaceae	*Anemone*	*obtusiloba*	herb	3200-4000
		polyanthes	herb	3200-4000
	Clematis	*montana*	climber	1500-2500
		acuminata	climber	up to 2400
	Delphinium	*cashmerianum*	herb	2800-3000
	Ranunculus	*hirtellus*	herb	2000-4500
	Thalictrum	*foetidum*	herb	ca 2600
Berberidaceae	*Berberis*	*edgeworthiana*	shrub	up to 3500
		petiolaris	shrub	2800-3500

		aristata	shrub	up to 3000
Papaveraceae	*Meconopsis*	*aculeata*	herb	3000-4500
		paniculata	herb	3500-4000
Fumariaceae	*Corydalis*	*cashmeriana*	herb	3000-3500
		vaginans	herb	2500-4500
Brassicaceae	*Arabidopsis*	*mollissima*	herb	2500-3000
	Arabis	*pterosperma*	herb	2700-3000
	Lepidium	*apetalum*	herb	2000-2500
	Thlaspi	*griffithianum*	herb	2700-5500
Violaceae	*Viola*	*betonicifolia*	herb	2400-3400
Caryophyllaceae	*Arenaria*	*griffithii*	herb	2600-3600
		serpyllifolia	herb	1600-2000
	Sagina	*saginoides*	herb	2000-3500
	Silene	*kumaonensis*	herb	2500-3000
		viscosa	herb	2500-3500
Hypericaceae	*Hypericum*	*oblongifolium*	herb	1500-2500
		japonicum	herb	Up to 2500
Malvaceae	*Malva*	*verticillata*	herb	2000-3000
Geraniaceae	*Geranium*	*nepalense*	herb	Up to 2400
		wallichianum	herb	Up to 3000
Balsaminaceae	*Impatiens*	*brachycentra*	herb	2500-3000
Celastraceae	*Euonymus*	*pendulus*	tree	1500-2500
Rhamnaceae	*Rhamnus*	*procumbens*	shrub	2000-3000
		prostrata	shrub	3000-4500
	Sageretia	*filiformis*	shrub	1000-2500
Aceraceae	*Acer*	*laevigatum*	tree	1500-2500
Papilionaceae	*Astragalus*	*leucocephalus*	herb	ca 2600
		candolleanus	herb	2600-3000
	Atylosia	*platycarpa*	climber	2500
	Caragana	*nubigena*	herb	3000-400
	Indigofera	*gerardiana*	shrub	2000-3500
Rosaceae	*Cotoneaster*	*duthieana*	shrub	3000-4000
		bacillaris	shrub	1800-300
		microphyllus	shrub	1500-4000
	Potentilla	*cuneata*	herb	3000-4500
		fulgens	herb	up to 2500
	Prunus	*Jacquemontii*	shrub	3000-3500
		nepalensis	tree	1800-2500
		persica	tree	2500-3500
	Prinsepia	*utilis*	shrub	1200-2400
	Rosa	*sericea*	shrub	3000-4000
		webbiana	shrub	3000-4500

	Rubus	*pentagonus*	shrub	2500-3500
		rosaefolius	shrub	2000-2500
	Sorbaria	*tomentosa*	shrub	2000-3500
	Sorbus	*microphylla*	shrub	3500-4200
	Spiraea	*arcuata*	shrub	2000-3500
Saxifragaceae	*Saxifraga*	*brachypoda*	herb	3000-4500
	Sedum	*multicaule*	herb	1500-2500
Grossulariaceae	*Ribes*	*orientale*	shrub	2100-3500
Onagraceae	*Epilobium*	*angustifolium*	herb	2500-4000
Apiaceae	*Bupleurum*	*falcatum*	herb	1800-4000
	Carum	*carvi*	herb	1800-2500
	Ligusticum	*elatum*	herb	1500-3000
	Pleurospermum	*stellatum*	herb	3000-4000
Caprifoliaceae	*Abelia*	*triflora*	shrub	2000-3500
	Lonicera	*hypoleuca*	shrub	3000-3500
		microphylla	shrub	3000-4000
	Viburnum	*grandiflorum*	shrub	2700-3600
		nervosum	shrub	1800-3600
Rubiaceae	*Galium*	*asperifolium*	herb	2000-3000
Valerianceae	*Valeriana*	*hardwickii*	herb	2500-4000
Dipsacaceae	*Morina*	*coulteriana*	herb	3000
Asteraceae	*Anaphalis*	*contorta*	herb	2500-4000
		busua	herb	1500-3000
		margratisea	herb	1800-3000
	Bidens	*bipinnata*	herb	to 2600
	Arctium	*lappa*	herb	3000
	Artemisia	*gmelinii*	herb	3000-5000
		maritima	herb	3000-4000
		nilagirica	herb	1000-2500
	Conyza	*stricta*	herb	1500-3000
	Aster	*thomsonii*	herb	3900
	Erigeron	*multiradiatus*	herb	2200-3000
	Hieracium	*umbellatum*	herb	3400
	Ligularia	*arnicoides*	herb	2500-4000
	Picris	*hieracioides*	herb	2500-3000
	Echinops	*cornigerus*	herb	Up to 2800
	Saussurea	*atkinsoni*	herb	3000-4500
		costus	herb	2500-3800
	Senecio	*pedunculatus*	herb	2500-4000
		chrysanthemoides	herb	2000-3000
	Youngia	*glauca*	herb	3800
Campanulaceae	*Campanula*	*alsinoides*	herb	2500-3500

Ericaceae	*Rhododendron*	*arboreum*	tree	1500-3600
		campanulatum	shrub	3000-4000
Oleaceae	*Fraxinus*	*xanthoxyloides*	tree	1800-2800
	Jasminum	*humile*	shrub	1500-3500
		officinale	shrub	2500-3500
	Olea	*ferruginea*	shrub	to 2600
Asclepiadaceae	*Vincetoxicum*	*hirundinaria*	herb	2300-3600
Boraginaceae	*Cynoglossum*	*zeylanicum*	herb	Up to 2800
Gentianaceae	*Gentiana*	*crassuloides*	herb	3800
Cuscutaceae	*Cuscuta*	*europaea*	climber	2800-3800
Scrophulariaceae	*Euphrasia*	*himalaica*	herb	2700-4200
		laxa	herb	2900
	Pedicularis	*hoffmeisterii*	herb	3000-4000
	Veronica	*cephaloides*	herb	2400-2700
		anagallis- aquatica	herb	2000-4500
Bignoniaceae	*Incarvillea*	*arguta*	herb	2000-2800
Acanthaceae	*Goldfussia*	*bracteata*	shrub	2000-2800
	Pseudaechmanthera	*glutinosa*	shrub	700-2500
	Pteracanthus	*angustifrons*	shrub	600-2500
Lamiaceae	*Elsholtzia*	*strobilifera*	herb	2000-3000
	Salvia	*hiniana*	herb	2200-3200
	Mentha	*lanatum*	herb	4800
	Nepeta	*discolor*	herb	ca 2600
		distans	herb	ca 2500
		leucophylla	herb	ca 2600
	Colquhounia	*coccinea*	herb	1200-3000
	Scutellaria	*bracteosa*	herb	ca 3000
	Amaranthus	*linearis*	herb	1800-4500
Chenopodiaceae	*Chenopodium*	*album*	herb	600-5000
		botrys	herb	1800-3800
Polygonaceae	*Fagopyrum*	*dibotrys*	herb	2000-2800
		esculentum	herb	1500-3000
	Oxyria	*digyna*	herb	2500-4500
	Polygonum	*aviculare*	herb	2500-4500
		delicatula	herb	3000-4000
	Aconogonum	*campanulatum*	herb	21000-3000
	Bistorta	*emodi*	herb	2200-3500
		amplexicaulis	herb	2100-3500
		vaccinifolium	herb	3000-4000
	Periscaria	*capitata*	herb	1000-3000
	Rumex	*acetosa*	herb	up to 3000
		nepalensis	herb	1000-2600

Aristolochiaceae	*Aristolochia*	*griffithii*	herb	1800-2900
Elaeagnaceae	*Hippophae*	*salcifolia*	shrub	2500-3000
Loranthaceae	*Arceuthobium*	*minutissimum*	shrub	3000-4000
	Scurrulla	*elata*	shrub	Up to 2800
Euphorbiaceae	*Euphorbia*	*hirta*	herb	Up to 2000
Buxaceae	*Sarcococca*	*saligna*	shrub	1200-2400
Urticaceae	*Urtica*	*dioica*	herb	1000-2500
Cannabaceae	*Cannabis*	*sativa*	herb	1000-3000
Juglandaceae	*Juglans*	*regia*	tree	1600-3000
Betulaceae	*Betula*	*utilis*	shrub	3000-4500
Corylaceae	*Corylus*	*ferox*	tree	1800-3000
Salicaceae	*Salix*	*acmophylla*	tree/shrub	1800-3500
		wallichiana	tree	2000-3500
Monocots				
Orchidaceae	*Eulophia*	*herbacea*	herb	1500-2500
	Goodyera	*repens*	herb	2000-4000
	Habenaria	*diphylla*	herb	2500-
	Liparis	*rostrata*	herb	3900
	Dactylorhiza	*hatagirea*	herb	3000-3500
Zingiberaceae	*Zingiber*	*officinale*	herb	up to 2600
Amaryllidaceae	*Allium*	*stracheyi*	herb	3000-3500
		carolinianum	herb	3000-4500
		wallichii	herb	3400-4200
Liliaceae	*Asparagus*	*filicinus*	shrub	2500-3000
	Polygonatum	*verticillatum*	herb	1800-4500
	Smilacina	*purpurea*	herb	2500-3500
Juncaceae	*Juncus*	leucanthus	herb	2800-3500
Araceae	*Arisaema*	*flavum*	herb	2500-3500
		Jacquemontii	herb	2000-3000
Acoraceae	*Acorus*	*calamus*	herb	2500-3000
Cyperaceae	*Carex*	*hirtella*	herb	300-3500
		notha	herb	3000
	Kobresia	*vulpinaris*	herb	3500
		capilifolia	herb	3600
Poaceae	*Chrysopogon*	*gryllus*	herb	2600
	Cymbopogon	*caesius*	herb	2600
	Panicum	*miliaceum*	herb	3000
	Pennisetum	*flaccidum*	herb	2500-3000
	Setaria	*italica*	herb	3000
		viridis	herb	2500-3500
	Agrostis	*Gigantea*	herb	ca 2800
		pilosula	herb	2400-3000

	Calamagrostis	*emodensis*	herb	2600
	Cynodon	*dactylon*	herb	up to 3000
	Muhlenbergia	*himalayensis*	herb	2500
	Koeleria	*macrantha*	herb	2500
	Brachypodium	*sylvaticum*	herb	2000-2500
	Bromus	*japonicus*	herb	3000
	Danthonia	*cachemyriana*	herb	3000-4000
		schneidri	herb	2000-4000
	Eleusine	*coracana*	herb	up to 3000
	Eragrostis	*nigra*	herb	2500-2800
	Dactylis	*glomerata*	herb	ca 2900
	Eremopoa	*persica*	herb	2500-5000
	Poa	*nemoralis*	herb	4000-4500
	Stipa	*Jacquemontii*	herb	2000-3500
		sibirica	herb	ca 3000
	Festuca	*polycolea*	herb	2200-3000
		leucophylla	herb	2400-3000
	Phleum	*alpinum*	herb	2000-3000
	Elymus	*nutans*	herb	3500-5000
	Hordeum	*vulgare*	herb	1700-3800
	Leymus	*secalinus*	herb	3500-4000
	Triticum	*aestivum*	herb	Upto 4000

8.4.5.6 *Physiognomic Diversity*

The diversity of vegetation in Jelam Tamak and its adjacent areas in the catchment was assessed in terms of the physiognomy of its floral elements. The herbaceous species (72.90%) constitute bulk of the flora followed by shrubs (15.76%), trees (7.88%), climbers (2.46%) and parasites (0.98%). About 62% families of the flowering plants are comprised of only herbaceous species of which Ranunculaceae, Apiaceae, Asteraceae, Polygonaceae, Cyperaceae and Poaceae are the dominant ones, each represented by more than 5 species. Comparatively, there are only a few families (12.69%) which are comprised of entirely shrubby species and are largely represented by Berberidaceae, Rhamnaceae, Rosaceae, Caprifoliaceae, Thymelaceae, Elaeagnaceae and Loranthaceae. Similarly, Aceraceae, Betulaceae, Juglandaceae, Salicaceae Cupressaceae and Pinaceae are some of the families present in the area which are represented exclusively by tree species. Members of Cuscutaceae, Asclepiadaceae and Aristolochiaceae are exclusively climbers. The analysis indicated that majority of the families in the catchment area are characteristically exhibit only one specific habit form. Comparatively, only a few families in the catchment show diverse habit forms among their species. Rosaceae is among such families which exhibits all the diverse habit forms of herb (*Potentilla fulgens*), shrub (*Cotoneaster integerrima*), climber (*Rubus foliolosus*) and tree (*Prunus nepalensis*). Similarly, Ranunculaceae, Brassicaceae, Caryophyllaceae and Asteraceae are also largely represented by herbaceous species. This type of physiognomic diversity observed in Jelam Tamak free draining area is typical of high altitude Himalayan vegetation where a large number of meadows are dominated by herbaceous species and at lower altitudes in temperate and sub-temperate areas the forests are coniferous mixed with deciduous elements. Severe biotic pressures in the form of human habitation, cultivation and extensive grazing further contribute to the growth of a large number of herbaceous species which are responsible for arresting of woodland formation.

8.4.5.7 *Endemic Species*

There are reports of nearly 116 endemic species of flowering plants found in Uttarakhand. Some of these endemic species are found in the catchment as well. Species like *Arenaria ferruginea*, *Berberis petiolaris, Calamagrostis garhwalensis Carex nandadevensis,* etc. are reported from the catchment area (Nanda Devi Biosphere Reserve) (Table 8.8).

Table 8.8 Some of the endemic plants of high hills likely to be found in the influence area of Jelam Tamak HE project

Plant species	Altitude (m)	Habit
Berberidaceae		
Berberis petiolaris	above 2700	Shrub
Caryophyllaceae		
Arenaria curvifolia	3300-3650	Herb
A. ferruginea	above 3000	Herb
Geraniaceae		
Geranium polyanthes	2500-4500	Herb
Rosaceae		
Cotoneaster garhwalensis	2700-3700	Shrub
Cyperaceae		
Carex nandadeviensis	2000-3000	Herb
Poaceae		
Calamagrostis garhwalensis	2500-3500	Grass
Festuca nandadevica	3500-3550	Grass

8.4.5.8 *Threatened Flora*

As per Red Data Book of India, only two plant species (*Allium stracheyi* and *Taxus baccata*) are recorded from the project and catchment area. Destruction of habitats and unsustainable harvest in wild and its product have severely threatened many useful species. There are around 30 species of flowering plants from the state that have entered the Red Data Book of Indian Plants (Nayar and Sastry 1987, 1988 and 1990). Some threatened plants like *Arenaria curvifolia, Cypripedium himalaicum, C. cordigerum, Dioscorea deltoidea, Nardostachys grandiflora* and *Picrorhiza kurroa* are reported from the core and adjoining buffer areas of Nanda Devi National Park and Valley of Flowers (Naithani, 1984, 1985; Hajra & Balodi, 1995; Uniyal, 2001). The possibility of wiping out of any species from the ecosytem is not expected, since aerial distance of proposed project from nearest point of these pristine areas is around 16-17 km. As far as forest area (92.44 ha) proposed for the direct project activities are concerned only *Allium stracheyi* could be located in submergence area and barrage area.

8.4.5.9 *Parasitic Flora*

A few parasitic species belonging to the families Cuscutaceae and Loranthaceae were observed growing on a few shrubs and trees in the region. *Arceuthobium minutissimum* is a minute and leafless parasite observed growing on *Pinus wallichiana* and *Scurrula elata* was observed growing as a parasite on trees of *Prunus* and *Pyrus. Cuscuta reflexa,* the twining parasite, were also observed growing on some small shrubs and trees in the project area.

8.4.5.10 *Phytogeography*

The floral elements in Jelam Tamak H.E. Project were analysed for their floristic similarities with other regions of the world and to find out the nature and composition of the flora. These elements are admixture of various floristic elements which migrated and occupied the area from different phytogeographical zones. Various floristic elements found in the Dhauliganga catchment area belong to the following zones. *Hippophae salcifolia* and *Artemisia maritimai* are characteristic of semi-arid zone of Pamir and Turkestan are found in the project area. Europe and sub-arctic species is represented by *Anaphalis, Berberis, Clematis, Fragaria, Spiraea,* etc. The genera which represent the north-east temperate zone with only minor representation in Europe are *Acer, Alnus, Rubus,* etc. There are genera which are common to the mediterranean region and temperate regions of Eurasia and north America are *Acer, Clematis, Fraxinus, Juniperus, Pinus, Rosa, Rhus* and

Rubus. There are a few genera occurring in the catchment which are restricted to Himalaya, China, Nepal and Tibet are Euphrobia stracheyi, *Geranium nepalense, Juniperus macropoda* and *Viola biflora* (Clarke, (1898), Hooker, (1904), Willis, (1982), Takhtajan, (1986).

8.4.5.11 *Economically Important Plants*

The economic dependence of local people is essentially on the plant resources growing in the adjoining areas. These include plant of medicinal value, food, fodder, fuel, timber, etc. by the local people. Some of these species are also cultivated by the local communities. However, a number of these species are still harvested from the wild for their use, particularly for medicinal purposes (Table 8.7).

8.4.5.11.1 *Medicinal Plants*

Uttarakhand region is very rich in medicinal plant diversity. Several tribal populations and local people inhabited in the pockets of forest areas use these plants in various ailments for curing their diseases. Though the project area is a degraded dry semi arid type but offers diverse habitats for a number of plants of great medicinal value. Some of the medicinal plants along with their medicinal uses in the area are given in Table 8.9 & **Plate 8.3**. Most of these were observed during the survey in the project area.

Table 8.9 Economically important plant species in the Jelam Tamak project area

Plant species	Local name	Altitude	Part used
Berberidaceae			
Berberis aristata	Daru-haridra	Up to 2500	Stem, roots
Violaceae			
Viola biflora	Vanfsa	2500-3500	Flower
Papilionaceae			
Astragalus candolleanus	Rudravanti	2600-4000	Whole plant
Rosaceae			
Potentilla fulgens	Vajar-danti	1600-2600	Roots
Prinsepia utilis	Bhenkla	1500-2800	Fruit
Asteraceae			
Artemisia gmelinii	Kala- parcha	1600-3000	Leaves
Saussurea costus	Kut	2600-3000	Root

Cuscutaceae			
Cuscuta reflexa	Akas- bel	Up to 2200	Stem
Polygonaceae			
Fagopyrum dibotrys	Ban-Ogal	1800-3000	Whole plant
Rumex nepalensis	Kholya	1500-3500	Leaves
Cupressaceae			
Juniperus macropoda	Dhoop	2600-3600	Leaves
Ephederaceae			
Ephedra gerardiana	Som valii	2500-3500	Whole plant

8.4.5.11.2 *Food Plants*

Parts of many plants are used by local people as vegetables or eaten raw. These include fruits of *Prunus armenica, P. persica, Pyrus malus, Rosa sericea*,etc which are eaten raw. Leaves of certain wild plant species provide good source of minerals in the diet of the local people. *Amaranthus paniculatus*, *Chenopodium album, Rumex nepalensis,* and *Urtica ardens* are important plant source of minerals.

8.4.5.11.3 *Fodder Plants*

Fodder requirement in the region is fulfilled mainly by some wild herbs and grasses. *Brachypodium sylvaticum, Bupleurum falcatum, Calamagrostis emodensis, Chenopodium album*, *Cybopogon caesius, Dactylis glomerata, Elymus nutans, Eragrostis nigra, Festuca polycolea, Dactylis glomerata, Oryzopsis munroi, Panicum miliacum, Poa annua, Stipa sibirica, Themeda anathera,* etc. are used for feeding the livestock.

8.4.5.11.4 *Timber Trees and Fuelwood*

Most important timber yielding species of the area include *Abies pindrow, Cedrus deodara, Cupressus torulosa, Pinus wallichiana* and *Taxus buccata.* Among angiosperms are are *Acer laevigatum*, *Fraxinus xanthoxyloides, Hippophae salcifolia, Salix acmophylla, S. wallichiana,* etc. Besides timber, the trunks and branches of *Acer laevigatum, Fraxinus xanthoxyloides, Hippophae salcifolia, Juniperus macropoda* and *Salix acmophylla* are used for carvings and fuelwood purposes.

8.4.5.11.5 *Fruit Trees*

Naspati (*Pyrus communis*), plum (*P. domestica*), seb (*Pyrus malus*), apricots (*P. armanica*), Kagzi nimbu (*Citrus* sp.), Akhrot (*Juglans regia*), etc. are some fruit yielding cultigens.

8.4.5.11.6 *Plants of Miscellaneous Uses*

The local people have been traditionally using several plant species for the purpose of food, medicine, drinks, spices and condiments. Many of these plants are easily available in the wild and local villagers do not buy these edible commodities from the adjacent market. A list of some commonly occurring plant species and their miscellaneous uses are given in Table 8.10.

Table 8.10 Some of the common useful plant species of project area

Sl.No.	Plant species	Miscellaneous uses
1.	*Allium wallichii*	Young shoots and leaves are eaten raw and added in the food dishes.
2	*Berberis aristata*	Roots and twigs are source of yellow dye.
3	*Bupleurum falcatum*	Roots are used for making alcoholic drinks with grains of *Eleusin coracana* (Mandua).
4	*Eleusine coracana*	Seeds are used for making local beverages.
5	*Hippophae rhanoides*	Fruits juice are taken as soft drinks as substitute for tea.
6	*Fagopyrum esculentum*	Young leaves are eaten as vegetables.
7	*Origanum vulgare*	Young shoots and leaves are added in food dishes for flavour
8.	*Panicum miliacum*	Seeds are eaten after roasting and also cooked for food.
9	*Prinsepia utilis*	Seeds are source of yielding aromatic oil
10	*Rumex nepalensis*	Leaves are used in preparing pakora and also eaten as vegetables.

8.5 CONCLUSION

The Influence area of proposed Jelam Tamak HE Project comprised of patchy vegetation including many economically important plants such as timber trees, medicinal herbs, and also some horticulturally important species like apple, apricot and spices (Amaryllidaceae). In addition to these, the area has a rich crop plant diversity like millets (buckwheat, finger millets), french beans and ginger.

The submergence area has a patchy scrub forest at lower reaches, dry temperate coniferous forest in middle and *Betula utilis* and *Abies pindrow* at top of upper reaches. On mid of the ridge, there are few apple orchards on the right bank near Jelam village. Cultivation of Ban Oagal (*Fagopyrum dibotrys*), millet (*Panicum miliaceum*), spices like fern (*Allium corolianum* and *A. wallichii*) and ginger (*Zingiber officinale*) are common in the surrounding areas. However, there are many flowering plants found wild in diverse localities of influence area and may consume as edible fruits, vegetables, medicines, etc. These include fruits of *Hippophae rhamnoides* (Tarwa), *Berberis aristata* (Daru Hridra), *Prunus nepalensis* (Bhang Bhalu); leaves of *Chenopodium album* (Bhetu), *Fagopyrum esculentum* (Ban ogal), *Urtica ardens* (Kandali), etc are used for vegetables. *Artemisia gmelinii* (leaves), *Astragalus candolleanus* (roots), *Berberis aristata* (roots, stem), *Ephedra gerardiana* (whole plant), *Juniperus macropoda* (leaves), *Prinsepia utilis* (seeds), *Taxus baccata* (bark, leaves), *Viola biflora* (whole plant), etc are important medicinal plants in Dhauliganga valley. *Abies pindow, Cedrus deodara, Cupressus torulosa, Pinus wallichiana* and *Taxus baccata* are commonly used timber species for construction purposes like building, furniture, domestic implements, etc. These species along with many other woody species are also used as fire-wood. As there is no rare, threatened or endangered plant species observed in the project areas, no impact is anticipated on such plants.

Plate 8.1 Vegetation in submergence area

Plate 8.2 Ceder forest (*Cedrus deodara*) at left bank of barrage site

Plate 8.3 *Ephedra gerardiana* (medicinal herb)

Plate 8.4 *Fraxinus xanthoxyloides* (shrub)

Chapter 9

FAUNAL ELEMENTS

9
FAUNAL ELEMENTS

9.1 INTRODUCTION

Faunal composition and distribution pattern are primarily governed by the altitude, climatic conditions, forest composition, topography, human settlements etc. Altitude is the key factor, which is highly specialized in many ways. With a steady increase in elevbation, the climate, topography and forest composition change gradually and affect the faunal composition. The proposed area of the study extends from temperate to alpine zones, the faunal forms are adapted to high altitude environment, inhabiting cliffs, alpine meadows, forested slopes and valleys.

The catchment area of the proposed project above timber line remains covered with snow during the winter season while the valley areas of the catchment are predominant with terrace cultivation and settlements. The area is dominated with coniferous forest and many rare and threatened species like Blue Sheep, Musk deer, Snow Leopard, Monal Pheasant, Crested Kaleej Pheasant, Himalayan Griffon Vulture. The wildlife inhabiting the high mountain zone above timber line is highly adapted to the deep fragile conditions. These animals, living permanently in these areas and rarely descend to lower. The present account highlights the composition, zoo-geographical distribution and conservation status of the fauna in the catchment and surrounding areas of proposed Jelam Tamak H.E. Project to predict the likely impacts of the project. The various literature (CISMHE, 2007, 08; Arora et al. 1995; Ray, 1995; Husain and Ray, 1995; Tak, 1995; Sinha, 1995; Uniyal, 2002) have been consulted to complete this contribution.

AFFINITIES: The fauna of Western Himalaya shows its affinities partly with oriental fauna and partly with palaearctic forms. To some extent Mediterranean, Ethopian, Indo-chinese and Malayan elements are also represented in this region (Mani, 1974). Dhauliganga basin largely affected by the palaearctic features which increase towards north-west Himalaya. However, some of the oriental elements also make their presence in the region especially in the lower reaches and southern part of the basin.

9.2 CATCHMENT AREA AND INFLUENCE ZONE

9.2.1 Mammal

Of 390 mammalian species in India, 75 species are known to inhabit Garhwal Himalaya. It comprises of Macaque, Langur, Jackal, Fox, Wolf, Wild dog, Bear, Jungle cat, Leopard, Tiger, Snow leopard, Marten, Weasel, Otter, Civets, Mongoose, Wild boar, Deer, Sambar, Goral, Argali, Porcupine, Rats, Shrews and Bats. The proposed area (Dhauliganga basin) forms a small part of Garhwal Himalaya in upper reaches. Coniferous forest, sub alpine birch/fir and alpine meadows are prevalent in the catchment of Jelam Tamak H.E. Project. Climatic conditions become harsh to mammalian fauna. The catchment area harbours about 17 species of mammals belonging to 8 families (Table 9.1). Surrounding area (10 km radius of project site), expands from sub tropical to alpine zones, is relatively rich in the mammalian diversity. It harbours around 30 species of 14 families.

9.2.2 Distribution

Rhesus macaque (*Macaca mulatta*) and Common langur (S*emnopithecus entellus*) are widely distributed in the region. Rhesus macaque can ascend up to 2500 m. while Common langur is distributed up to 3500 m. Both species move in the troops of variable size. They inhabit open areas and near settlements and raid agricultural and horticultural crops. Wild boar (*Sus scrofa*), Musk deer (*Moschus chrysogaster*), Barking deer (*Muntiacus muntjak*), Sambar, (*Cervus unicolor*), Goral (*Naemorhedus goral*), Blue sheep (*Pseudois nayaur*) and Argali (*Ovis ammon*) represent order Artiodactyla in the region. Wild boar is distributed up to 1500 m. It inhabits open areas and raids agricultural fields. The niche of goral and barking deer is between 2100 – 3000 m and 1500 – 2400, respectively. Musk deer is restricted to the catchment and distributed between 3000 – 4000 m. Nanda Devi National Park is well known habitat of Musk deer. Argali and Blue sheep are found over 4000 m. between tree line and trans-Himalayan tracts. Nanda Devi Biosphere Reserve is well known habitat of Blue sheep and Argali in the basin.

Common leopard (*P. pardus*) is very common in the region, distributed between lowermost reaches to 3000 m. They sometimes, enter in the human habitation and kill domestic animals. Snow leopard (*P. uncia*) inhabits upper part of the basin (above 3000 m.). It lives in the caves of stunned forest lying near the snow line. In winter season it can descend up to 2000 m. Snow leopard preys on deer and blue sheep. Jungle cat (*Felis chaus*) prefers to inhabit scrubs areas. It is distributed up to 2000 m. in the basin.

Dog family includes Wolf (*Canis lupus*), Asiatic Jackal (*C. aureus*), Red fox (*Vulpes vulpes*) and Indian wild dog (*Coun alpinus*). Wolf is found in the lower and middle part of Himalaya. Jackal is very common between 1200-2100 m. They live in dense and open forests. Jackal can ascend up to 3500 m. in Himalaya. It comes out in search of food at dusk and return to the shelter at down. Red fox and Indian wild dog are not very common in the area. They inhabit high altitudes over 2500 m to trans-Himalayan tracts. Bear family is represented by Asian black bear (*Ursus thibetanus*) and Brown bear (*Ursus arctos*). Brown bear is found rarely in the upper catchment of the proposed project (above 3000 m.). Black bear is altitudinal migrant and move to elevations over 3500 m. near snow line in summer season. In winter season they can descend up to 1500 m. Family Musteliade is represented by Yellow throated marten (*Martes flavigula*) and Common otter (*Lutra lutra*). They are widely distributed in surrounding area. Marten is distributed between 1200 – 2700 m. They normally live in pair and avoid human habitation. Common otter can ascend up to 3600 m. It lives near the water bodies and prey on crabs, frogs and fish.

House shrew (*Suncus murinus*) inhabits all possible settlements areas in the surrounding area. Bat family includes only two species - Indian flying fox (*Pteropus giganteus*) and Horse shoe bat (*Rhinolophus ferrumequinum*) in Alaknanda basin, former niches up to 2100 m. and later above 2500 m. Rodentia includes Indian porcupine and rats in the Alaknanda basin. Indian porcupine is found up to 2400 m. House rat (*Rattus rattus*), House mouse (*Mus musculus*) and Indian field mouse (*M. buduga*) are common species in the basin in which later two are widely distributed.

Table 9.1 Composition, distribution and status of mammals in the catchment and surrounding areas of Jelam Tamak H.E. Project

		Status				
Common name	**Scientific name**	**IUCN (2006)**	**ZSI (1994)**	**WPA (1972)**	**Distribution**	
Cercopithecidae						
Common langur	*Semnopithicus entellus*	LC	-	II	-	S
Rhesus macaque	*Macaca mullata*	LC		II		S
Bovidae						
Bharal	*Pseudois nayaur*	LC	VU	I	C	S
Argali	*Ovis ammon*					
Himalayan tahr	*Hemitragus jemlahicus*	VU	EN	I	C	S
Goral	*Nemorhaedus goral*	LC	-	III	C	S

Serow	*Capricornis sumatraensis*	VU	VU	I	C	S
Cervidae						
Himalayan musk deer	*Moschus chrysogaster*	LC	EN	I	C	S
Barking deer	*Muntiacus muntjak*	-	-	III	-	S
Suidae						
Wild boar	*Sus scrofa*	-	EN	III	-	S
Felidae						
Jungle cat	*Felis chaus*	LC	-	I	-	S
Snow leopard	*Panthera uncia*	EN	EN	I	C	S
Common leopard	*P. pardus*	VU	VU	I	C	S
Canidae						
Wolf	*Canis lupus*	LC	-	II	C	S
Asiatic Jackal	*C. aureus*	LC	-	II	C	S
Red fox	*Vulpes vulpes*	LC	-	II	-	S
Ursidae						
Himalayan black bear	*Selenarctos thibetanus*	VU	-	I	C	S
Brown bear	*Ursus arctos*	LC	EN	I	C	S
Viverridae						
Himalayan palm civet	*Paguma larvata*	-	-	-	-	S
Mustellidae						
Yellow throated martin	*Martes flavigula*	LC	-	II	C	S
Common otter	*Lutra lutra*	-	-	I	-	S
Himalayan Weasal	*Mustela sibirica*	-	-	-	C	S
Ochotonidae						
Himalayan mouse hare	*Ochotona roylei*	LC	-	IV	C	S
Family: Hystricidae						
Indian porcupine	*Hystrix indica*	VU	-	II	-	S
Muridae						
Vole	*Altocola* sp.	LC	-	V	C	S
House rat	*Rattus rattus*	-	-	-	C	S
House mouse	*Mus musculus*	-	-	-	C	S
Field mouse	*M. buduga*	-	-	-	C	S
Soricidae						
House shrew	*Suncus murinus*	-	-	-	-	S
Pteropodidae						

Indian flying fox	*Pteropus giganteus*	-	-	-	-	S
Horse shoe bat	*Rhinolophus ferrumequinum*	-	-	-	-	S

EN = endangered, VU = vulnerable, LC = Least concerned; C = catchment area; S = surrounding area (10 km radius)

Source: compiled from Tak & Lamba, 1985; Sinha, 1995; Arora et al., 1995, Uniyal, 2001

9.2.3 Avifauna

9.2.3.1 *Species composition and distribution*

The avifauna in the catchments and project vicinity of proposed Jelam Tamak H.E. Project is comprised of hawks, vultures, falcons, eagles, partridges, pheasants, pigeons, doves, cuckoos, swifts, barbets, drongoes, mynas, tits, sparrows, tree pies, magpies, thrushes, laughing thrushes, bulbuls, flycatchers, finches, wagtails, forktails, etc. (Table 9.2). Most of the species listed in the Table 9.2 are common in influence zone (predominantly lower part of the influence zone) while a few of them like Snow partridge (*Lerwa lerwa*), Himalayan snowcock (*Tetragallus himalayensis*), Monal pheasant (*Lophophorus impejanus*), Cheer pheasant (*Catreus wallichii*), Wood pigeon (*Columba hodgsonii*), Yellow billed chough (*Pyrrhocorax graculus*), Common chough (*Pyrrhocorax Pyrrhocorax*) and Rock bunting (*Emberiza cia*) are restricted in the catchment area above 2500 m.

Nearly 54% of the species in catchment area and influence zone are widespread resident while 35.4% are sparse resident (Table 9.2).

Table 9.2 Species composition, habit and status of avifauna in the catchment and surrounding areas of Jelam Tamak H.E. Project

Common name	Scientific name	Status		
		Habit	ZSI (1994)	WPA (1972)
Accipitridae				
Sparrow Hawk	*Accipiter nisusi*	rw	-	I
Himalayan golden eagle	*Aquila chrysaetos*	r	-	I
Griffon vulture	*Gyps fulvus*	r	-	IV
Himalayan griffon	*Gyps himalayensis*	r	-	I
Lammergeier	*Gypaetus barbatus*	r	EN	I
Falconidae				
Falcon	*Falco* sp.	-	-	I

Phasianidae				
Snow partridge	*Lerwa lerwa*	r	-	IV
Himalayan snowcock	*Tetraogallus himalayensis*	r	-	I
Monal pheasant	*Lophophorus impejanus*	r	EN	IV
Koklas pheasant	*Pucrasia macrolopha*	r	VU	IV
Whitecreasted Kaleej pheasant	*Lophura leucomelana*	r	-	-
Cheer pheasant	*Catreus wallichi*	r	EN	I
Chukar partridge	*Alectoris chukar*	R	-	-
Columbidae				
Snow pigeon	*Columba leuconota*	R	-	IV
Rock pigeon	*Columba livia*	R	-	IV
Wood pigeon	*Columba hodgsonii*	r	-	IV
Rufous turtle dove	*Streptopelia orientalis*	R	-	IV
Strigidae				
Brawn hawk owl	*Ninox scutulata*	AM	-	IV
Cuculidae				
The cuckoo	*Cuculus canorus*	R	-	IV
Common hawk cuckoo	*Hierococcyx various*	r	-	IV
Apodidae				
Himalayan swiftlet	*Collacalia* sp.	R	-	I
White rumped swift	*Apus pacificus*	R	-	IV
Upupidae				
Hoopoe	*Upupa epops*	RW	-	IV
Capitonidae				
Great hill barbet	*Megalaima virens*	R	-	IV
Picidae				
Sapsucker	*Hypopicus hyperythrus*	r	-	IV
Dicruridae				
Ashy drongo	*Dicrurus leucophaeus*	R	-	IV
Sturnidae				
Common mynah	*Acridotheres tristis*	R	-	IV
Lanidae				
Long tailed shrike	*Lanius schach*	R	-	IV
Corvidae				
Red billed blue magpie	*Cissa erthrorhyncha*	R	-	IV

Himalayan tree pie	*Dendrocitta formosae*	R	-	IV
Nutcracker	*Nucifraga caryocatactes*	R	-	IV
Yellow billed chough	*Pyrrhocorax graculus*	R	-	IV
Common chough	*Pyrrhocorax Pyrrhocorax*	R	-	IV
Jungle crow	*Corvus macrorhynchos*	R	-	IV
Pycnonotidae				
White cheeked bulbul	*Pycnonotus leucogenys*	R	-	IV
Red-vented bulbul	*P. cafer*	R	-	IV
Turdidae				
Blue whistling thrush	*Myophonus caeruleus*	R	-	IV
Black bird	*Turdus merula*	r	-	IV
Timalidae				
Black-caped sibia	*Heterophasia capistrata*	R	-	IV
Tranidae				
White-browed flycatcher	*Ficedula superciliaris*	R	-	IV
Verditer flycatcher	*Eumyias. thalassina*	R	-	IV
Muscicapidae				
Bush robin	*Ertithacus cyanurus*	r	-	IV
Blue fronted redstart	*Phoenicurus frontalis*	r	-	IV
White caped redstart	*Chaimorrornis leucocephalus*	r	-	IV
Sylviidae				
Red headed laughing thrush	*Garrulax erythrocephalus*	r	-	IV
Varieg. laughing thrush	*Garrulax variegates*	r	-	IV
Streaked laughing thrush	*Garrulax lineatus*	R	-	IV
Grey-hooded warbler	*Seicercus xanthoschistos*	R	-	IV
Large-billed leaf warbler	*Phylloscopus magnirostris*	rw	-	IV
Greenish leaf warbler	*P. trochiloides*	rW	-	IV
Crowned leaf warbler	*P. occipitalis*	r	-	IV
Jungle babbler	*Turdoides striatus*	R	-	IV
Cinclidae				
Brown dipper	*Cinclus pallasi*	R	-	IV
Prunellidae				
Alpine accentor	*Prunella collaris*	r	-	IV
Paridae				
Green backed tit	*Parus monticolus*	R	-	IV

Crested black tit	*P. melanolophus*	r	-	IV
Motacillidae				
Vinaceous breasted pipit	*Anthus roseatus*	R	-	IV
Grey wagtail	*Motacilla caspica*	R	-	IV
Passeridae				
House sparrow	*Passer domesticus*	R	-	IV
Tree sparrow	*P. montanus*	R	-	IV
Fingillidae				
Common rosefinch	*Carpodacus erythrinus*	rW	-	IV
Pink browed rose finch	*Carpodacus rhodopeplus*	r	-	IV
Emberiziade				
Rock bunting	*Emberiza cia*	R	-	IV
Crested bunting	*Melophus lathami*	R	-	IV

Source: compiled from Tak, 1995; Uniyal, 2001

9.2.4 Herpetofauna

Catchment area of Jelam Tamak H.E. Project is very poor in harbouring the herpetofauna. Influence zone (lower reaches) is expected to harbour nearly 4 species of amphibian, viz. *Rana annadalei*, *R. blandordii*, *R. leibigii* and *R. minica*. Reptiles comprise of *Hemidactylus brooki*, *H. flaviviridis*, *Agama tuberculata*, *Japalura major*, *Scincella himalayanum*, *Amphiesma stolata*, *Xenochrophis piscator*, *Ptyas mucosus* and *Agkistrodon himalayanus* (see Husain and ray, 1995; Ray, 1995).

9.2.5 Conservation Status

Based on the IUCN criterion a total of 3 species (*Panthera uncia, Cuon alpinus, Moschus chrysogaster*) of mammals are endangered in the catchment area. Except *Cuon alpinus* all of them are distributed above 3000 m and are not common in the surroundings (Table 9.3). *Ursus thibetanus* is only mammalian species categorized as 'Vulnerable'. The criterion of ZSI included 6 species under the threatened category, of which 3 are endangered and 3 are vulnerable. WPA (1970) categorize 6 species under Schedule I. Except *Felis chaus* all are restricted to the catchment area of proposed project.

In the bird species four species namely *Gypaetus barbatus*, *Catreus wallichii, Lophophorus impejanus* and *Pucrasia macrolopha* have been identified as threatened species as per criterion of ZSI

(1994). Among these species *Catreus wallichii* is placed under ‘vulnerable’ of IUCN and Schedule I of WPA (1972). None of the herpetofaunal species in the catchment area and influence zone is threatened, however, three species are categorized as Schedule II.

Table 9.3 Distribution and conservation status of vertebrates fauna within 10 km radius of Jelam Tamak H.E. project

		Conservation status		
Taxa	**Distribution range (m)**	**IUCN (2012)**	**ZSI (1994)**	**WPA (1972)**
MAMMALS				
Macaca mulatta	up to 2500	LC	-	II
Semnopithecus entellus	up to 3500	LC	-	II
Panthera uncia	> 3000	EN		I
P. pardus	up to 3000	NT	VU	
Felis chaus	up to 2000	LC	-	I
Canis lupus	<1500	LC	VU	
C. aureus	1200-2100	LC		II
Cuon alpinus	-	EN	-	-
Ursus thibetanus	1500-3500	VU		
Ursus arctos	>3000	LC	EN	I
Martes flavigula	1200-2700	LC	-	II
Moschus chrysogaster	3000-4000	EN	EN	I
Hemitragus jemlahicus	above 3000	NT	EN	I
Pseudois nayaur	>4000	LC	VU	I
Hystrix indica	-	LC	-	II
BIRDS				
Gypaetus barbatus	1200-3300	LC	EN	I
Catreus wallichi	1500-2500	VU	EN	I
Lophophorus impejanus	above 2300	LC	EN	
Pucrasia macrolopha	above 2000	LC	VU	
REPTILES				
Xenochrophis piscator	up to 3000 or over	-	-	II
Ptyas mucosus	up to 3000 or over	-	-	II
Agkistrodon himalayanus	up to 3000 or over	-	-	II

EN = endangered; VU = vunerable

9.2.6 Invertebrate Fauna

Invertebrate fauna of the catchment area and influence zone including aquatic and terrestrial forms comprises of Oligochaeta, Odonata, Lepidoptera, Hymenoptera, Coleoptera, orthoptera, Diptera, Ephemeroptera, etc. There is a brief account of invertebrates except Lepidoptera. Lepidoptera is described under the separate section of this chapter.

Oligochaeta is represented by *Amyntha cortis*, *Metaphire houlleti*, *Dendrodrillus rubidus*, etc. These species are predominant in the lower reaches of the influence zone. Group Odonata comprises of *Rhinocypha quadrimaculata*, *Bayadera indica*, *Anisogomphus occipitalis* and *Orthretrum* spp. The most common Coleopteran species of the catchment and influence zone are *Pheropsophus catoiree*, *Amara batesi*, *Calathus punctyastriatus*, *C. pulcher* etc. Hymenoptera is represented mainly by *Campsomeriella collaris*, *Megacampsomeris prismatica*, *Labus* sp. *Polistes maculipennis*, *Vespula flaviceps*, *Podalonia hirticeps*, *Pimpla vidua*, *Netalia* sp. etc. In addition, there are many other species belonging to the groups Ephemeroptera, Trihoptera, Diptera sharing terrestrial and aquatic ecosystems.

9.3 PROJECT AREAS

Primary surveys were carried our in the surrounding of the project area to inventorize the mammals, avifauna, herpetofauna and butterflies for different seasons. A detailed account on the direct and indirect evidences of the presence of fauna in and around the proposed project is described below.

9.3.1 Mammals

During the pre-monsoon season Goral (*Nemorhdaedus goral*) was spotted between proposed barrage and powerhouse sites (left bank of river Dhauliganga) of the project (**Plate 9.1a**). Local inhabitants confirmed the presence of Himalayan tahr (*Hemitragus jemlahicus*) near the proposed project activities area. In monsoon season Himalayan weasel (*Mustella sibirica*) was spotted near the proposed power house while Asiatic Jackal (*Canis aureus*) was sighted upstream of barrage site (right bank). Group of Rhesus Macaque (*Macaca mulatta*) was observed for all seasons in the surroundings. Pellets and tracks of deer were recorded at bank of river near proposed barrage site in winter season.

9.3.2 Avifauna

Inventorization of avifauna indicated that the area is not rich in bird species. A total of 34 species (including 3 unidentified species) were recorded during three season surveys with the help of general surveys and point count methods. Out of 34 species 28 species were also covered in the point count sampling. Point count method indicated that lower most survey area (Surai Thoda) was relatively rich in bird density (Table 9.4). Species density of bird ranged from 1.7 to 3.0 per point while individual density was recorded to be 3.0 to 5.4 per point

Table 9.4 Statistics of bird species recorded during the sampling in influence area of Jelam Tamak H. E. Project

	Winter				Pre-monsoon				Monsoon			
	ML	DG	PS	ST	ML	DG	PS	ST	ML	DG	PS	ST
No of Points	5.0	5.0	5.0	5.0	6.0	6.0	6.0	6.0	5.0	5.0	5.0	5.0
No of species	9.0	11.0	13.0	14.0	11.0	12.0	10.0	12.0	8.0	12.0	15.0	10.0
No of individuals	21.0	19.0	21.0	22.0	18.0	23.0	21.0	27.0	17.0	24.0	27.0	22.0
No of sp/point	1.8	2.2	2.6	2.8	1.8	2.0	1.7	2.0	1.6	2.4	3.0	2.0
No of indiv/point	4.2	3.8	4.2	4.4	3.0	3.8	3.5	4.5	3.4	4.8	5.4	4.4

ML = Malari; DG = Dunagiri; PS = Project sites ; ST = Surai Thoda

Rock pigeon, Common myna, White cheeked bulbul, Tree sparrow, Greenish warbler and Rock bunting were most common and abundant species in the project area. Majority of the species were widespread and sparse resident. None of the species was threatened and scheduled (Table 9.5).

Table 9.5 Occurrence of bird species in the project areas during winter, pre-monsoon and monsoon seasons

		Winter				Pre-monsoon				Monsoon			
Common Name	**Scientific Name**	ML	DG	PS	ST	ML	DG	PS	ST	ML	DG	PS	ST
Himalayan griffon	*Gyps himalayensis*			++									++
Kaleej pheasant	*Lophura leucomelana*			++									+
Chukar partridge	*Alectoris chukar*	+				+							
Rock pigeon	*Columba livia*	+	+	+	+	+	+	+	+	+	+	+	+
Rufous turtle dove	*Streptopelia orientalis*	+	+	+	++	+	+	+	+	+	+	+	+
Wood pigeon	*Columba hodgsonii*		++			++		++			++		

Common hawk cuckoo	*Hierococcyx various*			++								++	
Hoopoe	*Upupa epops*						+	+		+		+	+
Ashy drongo	*Dicrurus leucophaeus*	+	+	+		+	+	+	+	+	+	+	+
Common mynah	*Acridotheres tristis*	+		+	+			+	+				+
Long tailed shrike	*Lanius schach*	++		+	+	++	+	+	++		+	+	
Red billed blue magpie	*Cissa erthrorhyncha*		+		+			+	++	++			
Jungle crow	*Corvus macrorhynchos*	++		++	+	++		++	++		++	++	
Himalayan tree pie	*Dendrocitta formosae*	++	+					++	++		++		
White cheeked bulbul	*Pycnonotus leucogenys*		+	++				+	+	+	+	+	+
Redvented bulbul	*P. cafer*	+	+	+	+	+	+	+	+			+	+
Blue whistling thrush	*Myophonus caeruleus*			+	+	+	+	+				+	
Blue fronted redstart	*Phoenicurus frontalis*		++	++			+			++	+	+	+
White caped redstart	*Chaimorrornis leucocephalus*			+				++	+				+
Alpine accentor	*Prunella collaris*	+	+				+			++	++	+	
Bush robin	*Ertithacus cyanurus*				+		+				+		
Greenish leaf warbler	*Phylloscopus trochiloides*		++	+	+	+		++	+	+	+	+	++
Crowned leaf warbler	*P. occipitalis*			+	+	+		++	+			+	++
Streaked laughing thrush	*Garrulax lineatus*		+				+						
Brown dipper	*Cinclus pallasi*				+				+			+	
Grey wagtail	*Motacilla caspica*		++	+	+		++				+		
Tree sparrow	*Passer montanus*	+	+	+	+	+			+	+	+	+	
House sparrow	*P. domesticus*				++				++			++	++
Common rosefinch	*Carpodacus erythrinus*		+		+	++		++					
Rock bunting	*Emberiza cia*	+	++			+	++			+	+	+	
Crested bunting	*Melophus lathami*		++	+		+	++		+		+		++

ML = Malari; DG = Dunagiri; PS = Project sites ; ST = Surai Thoda

(+) = Species recorded in point; (++) = species not recorded in point

9.3.3 Herpetofauna

Rana annadalei, *Hemidactylus brooki*, *H. flaviviridis*, *Agama tuberculata* and *Vipera russell* were common herpetofauna in the surroundings of the proposed project. A carcass of *V. russell* was observed downstream area of proposed power house confirming its presence in the region. *Hemidactylus* spp. were common in households near the project area. *A. tuberculata* was most abundant species among the herpetofauna in and around the project area (**Plate 9.1b**). Herpetofaunal richness decreased with increasing elevation.

9.3.4 Butterfly

Climatic conditions of the project area are not conducive for the rich Lepidopteran diversity, which generally decreases gradually with increasing elevation. During the field survey we observed 17 species of butterflies belonging to 6 families with maximum (17) in monsoon season. Lowest density and diversity were recorded in Malari site (2800 m asl) while maximum density and diversity were recorded in Surai Thoda area. The species density and individual density ranged from 0.0 to 2.0 per transact and 0.0 to 3.0 per transact, respectively (Table 9.6).

Table 9.6 Statistics of butterfly species recorded during the sampling in influence area of Jelam Tamak H. E. Project

	Winter				**Pre-monsoon**				**Monsoon**			
	ML	**DG**	**PS**	**ST**	**ML**	**DG**	**PS**	**ST**	**ML**	**DG**	**PS**	**ST**
No of transact	5.0	5.0	5.0	5.0	6.0	6.0	6.0	6.0	5.0	5.0	5.0	5.0
No of species	0.0	0.0	1.0	3.0	0.0	1.0	3.0	5.0	1.0	2.0	6.0	10.0
No of individuals	0.0	0.0	3.0	7.0	0.0	1.0	5.0	9.0	3.0	5.0	8.0	15.0
No of sp/transact	0.0	0.0	0.2	0.6	0.0	0.2	0.5	0.8	0.2	0.4	1.2	2.0
No of indiv/transact	0.0	0.0	0.6	1.4	0.0	0.2	0.8	1.5	0.6	1.0	1.6	3.0

ML = Malari; DG = Dunagiri; PS = Project sites; ST = Surai Thoda

During the winter season only 4 species (Himalayan Fivering, Indian Red Admiral, Dark Clouded Yellow and Sapphire) were observed far below the project area (**Plate 9.1c, d**). Majority of the species were sighted in the lower reaches of influence zone. Common Fourring, Cabbage White and Indian Red Admiral were most common species of butterflies around the project areas (Table 9.7).

Table 9.7 Occurrence of butterfly species in the surrounding area of Jelam Tamak H.E. project

		Winter				**Pre-monsoon**				**Monsoon**			
Common Name	**Scientific Name**	ML	DG	PS	ST	ML	DG	PS	ST	ML	DG	PS	ST
Paplionidae													
Common Mormon	*Princes polytes*							+	+				
Pieridae													
Large Cabbage White	*Pieris brassicae nepalensis*								+	+			

Indian Cabbage White	*P. canidia indica*										+
Dark Clouded Yellow	*Colias electo fieldi*		+				+	+		+	+
Satyridae											
Common Forester	*Lethe insana*								+		+
Common Fourring	*Yupthima asterope*						+			+	
Himalayan Fivering	*Y. sacra*		+								+
Nymphalidae											
Indian Red Admiral	*Vanessa indica*		+							+	
Blue Admiral	*Kaniska canace*									+	+
Broad-banded Sailer	*Neptis sankara*					+				+	+
Studded sergent	*Parathyma asura*								+		+
Chocolate soldier	*Precis iphita iphita*						+				
Large Silver Strip	*Childrena childreni*									+	
Lycaenidae											
Common copper	*Lycaena phalaeas*										+
Sapphire	*Heliophorus sena*	+			+						
Hesperiidae											
Dart	*Potanthus dara*										+

9.4 CONCLUSION

The catchment area and influence zone of the proposed project area is sparsely populated, therefore, less affected of anthropogenic activities. Topographical features like cliffs, gorges etc and climatic conditions of the region do not seem suitable to harbour high species richness as compared to tropical and sub tropical areas. However, the faunal species especially mammals and birds are unique and specific to high altitudes. Many of them are rare, threatened and scheduled. The species are shy in nature, adapted to calm conditions. No considerable difference in the presence and occurrence of faunal elements were recorded between different seasons except butterfly. The proposed project may lead to the adverse impact on the shelters, habits and habitats of these animals.

(a) Nemorhaedus goral (b) Agama tuberculata

(c) Indian Red Admiral (d) Himalayan Five Ring

Plate 9.1 Common faunal species in the surrounding area of the Jelam Tamak H.E. Project area

Chapter 10

PROTECTED AREAS

10

PROTECTED AREAS

10.1 INTRODUCTION

The proposed project lies within the buffer zone of Nanda Devi Biosphere Reserve. Nanda Devi National Park forms one of the core zones of the biosphere Reserve having a total area of about 624.62 sq km. The other core zone subsequently added to it is the Valley of Flowers National Park (VONP), which covers an area of 87.50 sq km. The total area of Nanda Devi Biosphere Reserve is 5,860.69 sq km. The area covered under buffer zone is 5148.57 sq km. The biosphere reserve is situated between 30^0 16’ to 30^0 41’ N latitude and 79^0 40’ to 80^0 05’ E longitude. Nanda Devi Biosphere Reserve is bordered by the upper catchment areas of Saraswati and Ganesh and the Malari-Lapthal zone in the north; village Khati and Sunderdhunga river in the south; Bam Padhura, Kala glacier and catchment area of Girthiganga in the east; and by upper catchment of Alaknanda, Nanda Ghunti peak, Homkund and Roopkund in the west. The Rishi Ganga is the major river that flows through the National Park which is joined by various tributaries at different locations inside the park. Core zones do not fall within 10 km radius of the proposed H.E. project. A detail Map of Nanda Devi Biosphere Reserve is given in **Figure 10.1**.

People living in the 47 villages of the buffer zone of Nanda Devi Biosphere Reserve belong to two ethnic groups viz., Indo-Mongoloid (Bhotiya) and Indo-Aryan with their indigenous culture, tradition and religious beliefs. The Bhotia reside in the higher mountains near the area of the reserve. No human habitation exists in the core zones of the Nanda Devi Biosphere Reserve. Out of 47 villages, 34 villages are in Chamoli, 10 in Pithoragarh and 3 in Bageshwar districts. Inaccessibility and remoteness coupled with short working season makes any development initiatives difficult in the area. Most of the villages transmigrate seasonally to the lower Himalaya during winter. The principal occupation is agriculture and sheep rearing although tourism is coming up as an important industry in the region.

The threat to biodiversity caused in the decades of sixties and seventies by ever increasing human and animal population of the surrounding villages led the government to close the Rishi Ganga basin as Nanda Devi National Park in 1983.

Nanda Devi National Park: Nanda Devi National Park is one of the core zones of NDBR and recognized as World Heritage site of UNESCO. It is located between $30^0$16' – $30^0$32' N latitude to $79^0$44' – $80^0$02'E longitude in Rishiganga Catchment of Chamoli district of Uttarakhand. Total geographic area of the Park is 630 sq km. Altitudinally the area extends from 1900 m – 7817 m. Nanda Devi National Park is included in the 1a strict nature reserve category of IUCN and Himalayan Highland of Biogeographical Province (2.38.12). Forests are restricted largely to the Rishi Gorge and are dominated by West Himalayan fir *Abies pindrow* and *Rhododendron campanulatum* with Himalayan birch *Betula utilis* and *Juniperus pseudosabina* etc. up to about 3,350m.A floristic analysis of the area based on the 1993 Nanda Devi Scientific and Ecological Expedition is given by Balodi (1993). A total of 312 species, distributed over 199 genera and 81 families, has been recorded and preserved in the herbarium of the Northern Circle Botanical Survey of India. A total of 8 nationally threatened species recorded include *Nardostachys grandiflora*, *Picroehiza kurrooa* (VU), *Cypripedium elegans*, *C. himalaicum*, *Dioscorea deltoidea* (VU) and *Allium stracheyi* (VU). An account of the 14 species of mammals, 114 species if birds and 28 species of butterflies are known in the National Park (e.g. Tak & Lamba, 1985; Lamba, 1987).

The aerial distance of proposed project Jelam Tamak H.E. Project from nearest point of Nanda Devi National Park is around 17 km. Thus, direct impacts of the project activities are not anticipated on the park because aerial distance passes through various ridges.

Valley of Flowers: Valley of Flowers National Park is other core zone of NDBR. It is located between $30^0$41' – $30^0$48' N latitude to $79^0$33' – $79^0$46'E longitude in the Bhyundar valley of Chamoli district of Uttarakhand. Total area of the park is 8.75 sq km. It extends from 3350 m to 6708 m and has been categorized as Himalayan Highland of Biogeographical Province (2.38.12). The valley is rich in floral diversity, harbouring over 600 species including higher and lower plants. with many rarities. It lies in a transitional area between the Great Himalaya and Zanskar Mountains, also between the eastern and western Himalayan phytographic regions. The park is dominated by the uncommon Himalayan maple *Acer caesium* (VU), west Himalayan fir *Abies pindrow*, Himalayan white birch *Betula utilis*, and *Rhododendron campanulatum* with Himalayan yew *Taxus wallichiana*, *Syringa emodi* and *Sorbus lanata*. Some of the common herbs of the area are *Arisaema jacquemontii*, *Boschniakia himalaica*, *Corydalis cashmeriana*, *Polemonium caerulium*, *Polygonum polystachyum*, *Impatiens sulcata, Geranium wallichianum, Helinia elliptica, Galium aparine, Morina longifolia, Inula grandiflora,* *Nomochoris oxypetala, Anemone rivularis, Pedicularis pectinata, P. bicornuta, Primula denticulate and Trillidium govanianum*, The dominant herbs of alpine zone are. There are also several colourful herbs like Saussurea simpsoniana, Potentilla argyrophylla, Geum elatum, Senecio spp., Bistorta affinis, Bergenia stracheyi, Mecanopsis aculeate etc.

The aerial distance of proposed project Jelam Tamak H.E. Project from nearest point of Valley of Flowers National Park is around 16-18 km. Thus, direct impacts of the project activities are not anticipated on the park because aerial distance passes through various ridges.

10.2 TOPOGRAPHY AND CLIMATE

The topography of the biosphere reserve is quite varied from up hills to the snow-clad mountains with altitude ranges from 2000 m to 7817 m. Climatically, the area is dry with low annual precipitation but in some of the area of buffer zone there is heavy monsoon rainfall from late June to early September. Prevailing mist and low cloud during the monsoon keeps the soil moist, hence the vegetation is lusher than is usual in the drier inner Himalayan valleys. In Valley of flowers there is often dense fog and rain especially during the late summer monsoon. The park remains snow covered almost throughout the year except from mid May to mid October when highest temperature record is around 25 ^{0}C. Being an inner Himalayan valley,

10.3 FOREST TYPES

Geographical location, climate and topography have all contributed to the characteristic vegetation and forest types of the area. In general, Core zones are predominated by Silver fir (*Abies pindrow*) and birch (*Betula utilis*) forests. Buffer zone follows more or less broad pattern of forests types of north-west Himalaya. They are temperate forests, upper West Himalayan temperate forests, sub-alpine birch-fir and moist and dry alpine scrubs and pastures. The following forest types have been demarcated in the biosphere reserve based on Champion & Seth (1968).

10.3.1 Lower Western Himalayan Temperate Forests

The forests are represented by mixed forests of evergreen and deciduous trees and the top canopy is comprised of coniferous or broad-leaved species. The forests may be of the following types.

a) Moru -Oak forests

These forests occur in narrow belt between 2,100 m and 2,800 m elevation. Important associates are *Abies pindrow, Aesculus indica, Ilex dipyrena, Lyonia ovalifolia, Prunus cornuta, Quercus dilatata* and *Rhododendron arboreum*. Among shrubs are *Berberis aristata, Daphne papyracea, Rosa macrophylla* and *Thamnocalmus spathiflora.*

b) Moist deodar forests (*Cedrus deodara*)

The forest is a hardly pure but often mixed with *Pinus wallichiana*. The deodar forests occur between 1,700 and 2,700 m on cool aspects and extending up to the 3,000 m on sunny ridges.

c) Western mixed coniferous forest

This is mixed coniferous forest of the temperate areas comprised of fir and blue pine. *Abies pindrow, Aesculus indica, Betula alnoides, Cedrus deodara, Juglans regia, Lyonia ovalifolia, Pinus wallichiana, Rhododendron arboreum,* etc. found in the tree canopy. These forests occur Deodar forests between 2400 m -3000 m. Dense thickets of small bamboos like *Thamnocalamus spathiflora* is found in the understorey. Others shrubs are species of *Berberis, Cotoneaster, Desmodium, Hippophae, Rhododendron, Rubus, Salix* and *Viburnum*.

d) Moist temperate deciduous forest

This is a deciduous forest and found between 1,800 and 2,700 m elevation. *Acer caesium, Aesculus indica, Betula alnoides, Carpinus viminea, Jugalns regia* and *Quercus semecarpifolia* are found in the tree canopy. Shrubs are *Berberis aristata, Daphne papyracea, Spiraea canescens* and *Viburnum foetens*.

e) Low level Blue pine forest (*P. wallichiana*)

This forest is dominated by blue pine (*Pinus wallichiana*) but there are also some deciduous species are mixed with it. Other tree associates are *Acer pictum, Aesculus indica, Juglans regia, Lyonia ovalifolia* and *Rhododendron arboreum.* These forests are found between 1,800 and 2,400 m.

f) Kharsu oak (*Quercus semecarpifolia*) forest

Kharsu is found between 2500 m and 3300 m elevation. It replaces coniferous forest at higher altitudes. Other scattered trees found in the forest are *Abies pindrow, Acer caesium, Betula* *alnoides, Quercus dilatata* and *Rhododendron arboreum*. Shrubs include *Cotoneaster acuminatus, Rosa macrophylla, Ribes* sp., *Viburnum cotinifolium,* etc.

10.3.2 West Himalayan Sub-alpine Birch/Fir Forests

These forests are typically of dense growth of mixed small trees and large shrubs and found between 2900 m and 3500 m elevations. Abies pindrow, Betula utilis, Quercus semecarpifolia, Rhododenron campanulatum, etc occur in the forest.

a) Hippophae / Myricaria brakes

A more or less pure thicket of Hippophae with some under growth of Salix spp. and Myricaria spp. occur from 2300 m and 3200 m elevations.

b) Deciduous sub-alpine scrub

A low deciduous scrub formation mainly of Betula utilis and dwarf Rhododendrons occurs in sub-alpine region above 3000 m.

C Sub-alpine pasture

The important predominating herbs and grass species of sub-alpine and alpine pasture are Agropyron longearistatum, Animone obtusiloba, Danthonia catchymeriana, Geranium wallichianum, Pedicularis hoffmeisteri, Poa spp., Potentilla cuneata, Saxifraga spp., etc.

10.3.3 Birch-Rhododendron Alpine Scrub Forest

This type forms a low evergreen forest dominated by species of Rhododendron, birch and some deciduous trees. Important associates include Betula utilis, Rhododendron campanulatum, Salix denticulata and Sorbus foliolosa.

a) Dwarf Rhododendron scrub

The forest form consociations in the Rhododendron-Lonicera associations. Lonicera obovata, Rhododendron hyperanthum, R. lepidotum and R. campanulatum occur in more or less dense patches along rocky slopes.

b) Alpine pastures

The meadows lying below the snowline are composed of perennial mesophytic herbs with some grasses. Among the herbs are species of Aconitum, Anemone, Gentiana, Iris, Pedicularis, Poa, Primula, Ranunculus, etc.

c) Dwarf Juniper scrub

Juniperus communis and *J. wallichiana* are found on dry sites in more or less compact patches.

10.4 FLORISTIC DIVERSITY

Nanda Devi Biosphere Reserve is represented nearly by 739 species of angiosperms belonging to 378 genera and 98 families. In addition to this, there are 11 species of gymnosperms and 51 species of pteridophytes in the area. Among the angiosperm dicotyledons are represented by 600 species belonging to 301 genera and 86 families, while the monocotyledons are represented by 139 species belonging to 77 genera and 12 families. Gymnosperms are represented by 4 families, 8 genera and 11 species. In dicots, Asteraceae shows maximum diversity with 44 genera and 82 species. Similarly, *Carex* is the largest genus in monocots consisting of 14 species. Status of different groups of vascular plants, dominant families of dicots and monocots and the number of their genera and species observed in the Nanda Devi Biosphere Reserve are given in Table (10.1). There are new species have been described from the area which have not shown extended distribution from other areas. These are *Carex nandadeviensis, Festuca nandadevica, Listera nandadeviensis* and *Saussurea sudhanshui*. Due to various biotic and abiotic factors some plants have become rare and threatened from the biosphere reserve. *Aconitum balfouri, A. falconeri, A. ferox, A. violaceum, Allium stracheyi, Arnebia benthamii, Cypripedium elegans, Dioscorea deltoidea, Megacarpaea polyandra, Nardostachys grandifllora, Picrorhiza kurooa, Saussurea gossypiphora,* etc. are threatened due to overexploitation for various purposes. The tribal communities of the surrounding villages who live in fringe areas of the biosphere reserve have a good knowledge of wild plants. They are dependent on them for their food, shelter, medicines, fodder, insecticides, etc.

Table 10.1 Status of different groups of vascular plants in Nanda Devi Biosphere Reserve

Group	Family	Genera	Species
Angiosperms	86	301	600
Dicots	86	301	600

Monocots	12	77	139
Gymnosperms	4	8	11

In addition to vascular plant, the predominant species of lower plants are described in following paragraphs.

a) Pteridophytes

Pteridophytes of Biosphere Reserve comprise of 52 species belonging to 28 genera and 18 families. Predominant species are *Dryopteris*, *Polystachyum*, *Pteris, Asplenium*, *Osmunda* etc.

b) Bryophytes

Common bryophytes are *Bryum argentium, Barbula tenuirostris, Junjerrmannia subulata* and *Thuidium tamariscellum* in the Biosphere reserve.

c) Lichens

Some of the lichens with their preferred habitat in the area are:

On trunk, branch and twig are *Cladonia coniocraea, Parmelia* spp.*, Usnea orientalis, U. longissima, Ramalina himalayensis* and *Heterodermia leucomela*.

Rocks: *Dermatocarpon* sp., *Parmelia* sp., *Ramalina himalayensis*, *Stereocaulon foliolosum,* etc.
Ground: *Cladonia coccifera*, *C. pyxidata*, *Sterocaulon* sp., *Thamnolia vermicularis,* etc.

10.5 FAUNA DIVERSITY

Nanda Devi Biosphere Reserve (NDBR), comprised of two core zones - Nanda Devi National Park and Valley of Flowers National park, is well known for its unique high altitude floral and faunal diversity; many of them are nationally and globally threatened. The most of the parts of the NDBR is restricted to the sub-alpine and alpine zones, where human population is sparse and anthropogenic stresses are low. The distribution of animals depends mainly on the same factors. There is a brief description of fauna of Nanda Devi National Park and Valley of Flowers National Park.

10.5.1 Mammals

Mammalian fauna of Nanda Devi Biosphere reserve is comprised of more than 18 species belong to 9 families. In the Nanda Devi National Park an account of the 14 known species of mammals has been reported by Tak and Lamba (1985) Himalayan musk deer (*Moschus chrysogaster)*, mainland serow (*Capricornus sumatrensis*), and Himalayan tahr (*Hemitragus jemlahicu*) are common but density is not plentiful. Bharal (*Pseudois nayur*) and Snow leopard (Panthera uncial) inhabit high altitude and are not common species. The Goral (*Naemorhaedus goral*) does not inhabit core zones but relatively high density occurs in the buffer zone, and is occasionally found near human settlements. Other large carnivores are Black bear (*Selenarctos thibetanus*), Brown bear (*Ursus arctos*) and Common leopard (*Panthera pardus*). Sometimes Black bear and Common leopard invade agricultural fields and settlements in the buffer zone. Small carnivores include Red fox (*Vulpes vulpes*). It is comparatively common species among the carnivores. Among the primates Hanuman langur (*Semnopithecus entellus*) and Rhesus macaque (*Macaca mullata*) are very common species in the parks, especially in buffer zones. Mammalian fauna of other core zone -Valley of Flowers National Park is more or less similar to the Nanda Devi National Park. A total of 13 species have been recorded from the Valley of Flowers National Park. Blue sheep, Himalayan tahr, Musk deer, Serow, Snow leopard, Common leopard and Red fox are 'threatened' species.

10.5.2 Avifauna

Arora *et. al*. (1995) recorded about 175 species of birds in the buffer and core zones of Nanda Devi Biosphere Reserve (NDBR). An inventory of 114 species was made by Sankaran (1993) in Nanda Devi National Park. The avifaunal composition is almost similar in the Nanda Devi National Park and Valley of Flowers National Park. These areas are well known for the pheasants, partridges and quails. Himalayan monal (*Lophophora impejanus*), Koklas pheasant (*Pucrasia macroplopha*) Snow partridge (*Lerwa lerwa*), Himalayan snowcock (*Tetraogallus himalayensis*) and Chukar partridgte are important Galliformes of the core zones. Among the Falconiformes Himalayan golden eagle (*Aqiula chrysaetos*), Himalayan griffon (*Gyps himalayensis*) and Lammergeier (*Gypaetus barbatus*) are the most common species. Crested black tit (*Parus melanolophus)*, Yellow-bellied fantail flycatcher (*Rhipidura hypoxantha)*, Orange-flanked bush robin (*Erithacus cyanurus*), Bluefronted redstart (*Phoenicurus frontalis*), Indian tree pipit (*Anthus hodgsoni*), Vinaceous breasted pipit (*A. roseatus*), Common rosefinch (*Carpodacus erythrinus*) and Nutcracker (*Nucifraga *caryocatactes)* are abundant species of these national parks. Species richness is highest in the temperate forests, with a significant decline in richness as elevation increased. Himalayan monal, Himalayan snowcock, Himalayan golden eagle and Himalayan griffon are the threatened species of parks.

10.5.3 Butterflies

About 80 species of butterflies are known to inhabit NDBR (Arora *et al*. 1995). The important species of core and buffer zones are: Dark clouded yellow (*Colias electo fieldii*), Painted lady (*Cynthia cardui*), Indian tortoiseshell (*Aglais cashmirensis*), Indian fritillary (*Argyreus hyperbius*), Queen of Spain fritillary (*Issoria lathonia*), Comma (*Polygonia album*), Common sailer (*Neptis hylas varmona*), Himalayan sailer (*Neptis mahendra*), Chocolate soldier (*Precis iphita iphita*), Blue admiral (*Kaniska canace*), Large silverstripe (*Childrena childreni*), Common tiger (*Danaus genutia*) and Plain tiger (*Danaus chrysippus*).

10.6 VILLAGES IN BUFFER ZONE

The buffer zone, constituting the area immediately surrounding the core zone of Nanda Devi, is home to 19 communities. While five of the communities reside in permanent year-round settlements, 14 have traditionally moved residences in the summer and winter months with one even shifting location three times a year. Lata and Reni situated near the West entrance of the reserve and the confluence of the Rishi and Dhauli Ganga, are the most prominent villages in the buffer zone. Other large settlements include Malari, Jelum, Jumma, Dronagiri, Gamshali, and Tolma. Furthest north along the Dhauli lies the village of Niti at the Indo-Tibetan frontier, from which the entire valley has traditionally drawn its name.

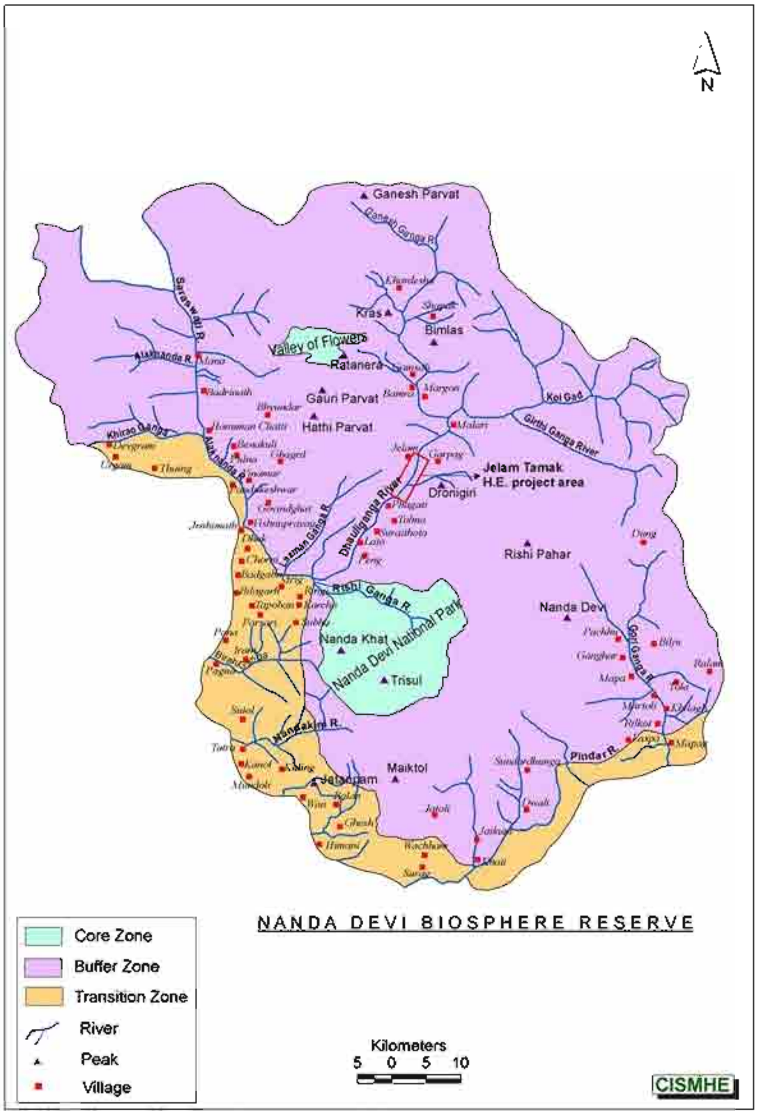


Fig.10.1 A map showing Jelam Tamak H.E. project vis-a-vis Nanda Devi Biosphere Reserve

Chapter 11

WATER ENVIRONMENT & AQUATIC ECOLOGY

11

WATER ENVIRONMENT & AQUATIC ECOLOGY

11.1 INTRODUCTION

Dams represent one of the most significant human interventions in the hydrological cycle. A dam regulates the flow of the river, which prior to dam building, exists as a continuum of linked surface and groundwater flow paths providing important natural corridors for the flows of energy, matter and species (McCartney, 2009). Hydropower is the energy that comes from the natural flow of water. The water's energy is being harnessed increasingly for the purpose of generating electricity to fulfill the requirement of households, industries etc. It is considered as a renewable, nonpolluting, and reliable energy source. Hydropower plants can also start up and shut down quickly and economically, giving the network operator the vital flexibility to respond to wide fluctuations in demand across seasons and at different times of the day. This flexibility is particularly important in a highly-populated country like India where household electricity demand is a significant portion of total demand and this demand in concentrated in a short period of time (usually in the evening). When developed in accordance with good environmental and social practices, hydropower plants have the advantage of producing power that is both renewable and clean, as they emit less greenhouse gases than traditional fossil fuel plants and do not emit polluting suspended particulate matter (from the high ash-content of indigenous coal).

Hydropower is still the only means of storing large quantities of electrical energy for almost instant use. However, Dams have both intended and unintended impacts, which can be positive or negative. It is unlikely to find intended negative impacts, though positive impacts can be both intended and unintended. Each of these types of impacts can be inevitable in their entirety, reducible or totally avoidable. Dams change the hydrology of the river as it alters the flow regime and disturb the seasonal fluctuations. This can be particularly damaging in seasonal floodplains as dam also holds back sediments that would naturally replenish downstream ecosystems. Thus, dams create obstacles in the longitudinal exchanges along fluvial systems. The most significant consequence of this disruption is that, it tends to fragment the riverine ecosystem, isolating population of species living up and downstream of the dam and cutting off migrations and other species movements (McCully, 2000; Dynesius and Nilsson 1994 and Postel, 1998).

To assess these ecological impacts, EIA/ EMP studies are being carried out prior to developing hydro electric projects. These studies help in formulating methods to avoid or mitigate the adverse environmental impacts caused by the projects. The present study was conducted in Dhauliganga River in Uttarakhand to assess the aquatic ecology and water quality with special reference to hydro- electric project.

Dhauliganga River is one of the five Source Rivers that make up the Ganga River. The river has its origin from the glacier clad and snow capped peak of Ganesh Parvat at 6531 m. Amrit Ganga, Girthi Ganga and Rishi Ganga are some of the major tributaries joining the river before it merges with Alaknanda at Vishnu Prayag. Dhauliganga is a perennial river like most of the Himalayan Rivers. The river is fed by glaciers in its upper reaches and the monsoon phenomenon adds huge volume of discharge which results in the swelling of stream. The present study highlights the physical, chemical and biological including fish and fisheries characteristics of the river water to predict the likely impacts of proposed project on the river water quality.

11.2 WATER QUALITY

The present study to assess the water quality in Dhauliganga river stretch from Jelam to downstream Vishnu Prayag was conducted in three seasons, Post- monsoon (November, 2008), Pre-monsoon (March, 2009) and Monsoon (August, 2009). Sampling was done at following five sites: W1 (proposed barrage site), W2 (proposed power house site), W3 (downstream of proposed power house site), W4 (Dhauliganga upstream of Vishnu Prayag) and W5 (Alaknanda downstream of Vishnu Prayag). Sampling was also conducted at Jelam Nala (Jn) in post- monsoon season. Sites W4 and W5 were not included in the study in post- monsoon season.

11.2.1 Surface Water

11.2.1.1 *Physical and chemical characteristics*

The quality of lotic waters should ideally be assessed by the use of physical, chemical, and biological parameters in order to provide a complete spectrum of appropriate management of water resources (Ilipoulou- Georgudaki, et al., 2003). The water quality - the physical, chemical and biological characteristics of the lotic systems depend on the seasonal fluctuations in the water discharge. In deed, stream flow, which is strongly correlated with many critical physicochemical characteristics of rivers, such as water temperature, channel geomorphology, and habitat diversity, can be considered as a "master variable" that limits the distribution and abundance of riverine species (Power et al. 1995 and Resh et al. 1988) and regulates the ecological integrity of flowing water systems. A number of important stream flow characteristics such as the daily, seasonal and annual pattern of flows, timing of extreme flows, frequency and duration of floods and droughts and intermittent flows etc. are critical for the survival of communities of animals and plants living downstream (Poff and Allan, 1997).

As water levels rise and fall, river and stream habitats expand and contract, resource availabilities shift, certain habitats become more or less isolated from others and flow regimes change, altering other physical gradients (Fisher 1983). Water discharge showed seasonal fluctuations with lowest discharge recorded in post- monsoon season (6.13 cumecs) at W1, while the highest values were recorded in monsoon season (263.55 cumecs) at W5. One of the most important factors regulated by the water discharge is the water current velocity. High water current velocity was recorded at all sites, although marked seasonal fluctuations were observed (Table 11.1). High current velocity can be correlated with high gradients, slopes and deep gorges prevalent in the river continuum. Water current velocity ranged from 0.92 m/s at W1 in pre- monsoon season to 3.27 at W2 in monsoon season. Velocity gradients in rivers play a vital role in determining the supply of nutrients and food particles to aquatic organisms and removal of wastes or allelochemicals (Vogel, 1981). Water temperature is another physical factor which influences important physical, chemical and biological processes (McCartney, 2009). Water temperature also showed seasonal variations with lowest temperature recorded in post- monsoon season (5º C) at site W2, while the highest temperature was recorded in monsoon season (13º C) at W5. River water recorded very low turbidity in pre-monsoon and post-monsoon seasons. In monsoon season rivers swell greatly due to rainfall and snow melt. They triggers surface runoff and increase turbidity (Table 11.1).

Water in Dhauliganga River is alkaline as indicated by the pH values. The pH values showed seasonal variations with lowest values (7.7) being recorded in post- monsoon season at three sites viz. W1, W2 and W3. The highest values for pH were recorded in monsoon season. All sites recorded pH above 8.5 in monsoon season and maximum pH was recorded at W2 (8.76). Dissolved oxygen content varied temporally and spatially; maximum values observed in post- monsoon season (12.60 mg/ lit.) at W2 , while lowest values were recorded in monsoon season W3 (7.86). Low concentration of BOD and COD in Dhauliganga and its tributaries can be attributed to the absence of organic pollution and water deteriorating agents in the surrounding areas. Electrical conductivity and Total dissolved solids (TDS) showed similar patterns as, the maximum values for both the parameters were recorded in pre- monsoon season and the minimum values were recorded in monsoon season. The minimum value for Electrical Conductivity was recorded at 76 mg/l at W5 and maximum value was recorded at 362 mg/l at W5, while for TDS, minimum value (81 mg/ lit.) was recorded at W5 and maximum value (226 mg/ lit.) was recorded at W1. Total Alkalinity values ranged from 52 mg/ lit. in monsoon season at W5 to 92 mg/ lit. in pre-monsoon season at W1. Total hardness values ranged between 94 mg/ lit. (W5 in pre- monsoon season) to 224 mg/ lit (W2 in post-monsoon season).

Calcium was the important component of hardness. Calcium hardness values were higher than the Magnesium hardness at all sites during the study except at W3 in post- monsoon season, where Magnesium hardness was recorded higher than Calcium hardness. Calcium hardness values ranged from 63 mg/ lit at W5 in pre- monsoon season to 140 mg/ lit at W2 in post- monsoon season. Calcium ion concentration ranged between 25.23 mg/ lit (W5 in pre-monsoon season) to 56 mg/ lit. (W2 in post-monsoon season). Magnesium hardness ranged from 31 mg/ lit. at W5 in pre- monsoon to 136 mg/ lit at W3 in post- monsoon season. Magnesium ions ranged from 7.52 mg/ lit. at W5 in pre- monsoon season to 22.35 mg/ lit at W1 in post- monsoon season. Chloride concentration was recorded higher in monsoon season at all sites than the other two seasons (pre- monsoon and post-monsoon season). Chloride concentration ranged from 5.99 mg/ lit. to 9.92 mg/ lit. Nitrate concentration ranged from 0.13 µg/ lit at W5 in pre- monsoon season to 4.52 µg/ lit at W3 in monsoon season. Nitrate concentration was not detectable at W1 and W2 in pre- monsoon season. Phosphate concentration ranged from 0.20 µg/ lit at W1 in pre- monsoon season to 1.62 µg/ lit at W1 in post- monsoon season. Phosphate was not detectable at W1 in post- monsoon season, W3 and W4 in post- monsoon season and W4 and W5 in monsoon season.

Jelam nala was included in the study only in post- monsoon season. It recorded the minimum values for pH, Electrical Conductivity, TDS, Total alkalinity, Total hardness, Ca hardness and Mg hardness.

Table 11.1 Physico-chemical characteristics of Dhauliganga river near Jelam Tamak H.E. project area

	Post-monsoon				Pre-monsoon					Monsoon				
Parameters	**W1**	**W2**	**W3**	**Jn**	**W1**	**W2**	**W3**	**W4**	**W5**	**W1**	**W2**	**W3**	**W4**	**W5**
Physical Characteristics														
Water current velocity (m/s)	1.40	1.30	1.10	NR	0.92	1.34	1.28	2.72	1.25	2.24	3.27	2.43	2.89	2.40
Water discharge (Cumecs)	6.10	11.60	11.90	NR	19.97	21.51	30.67	41.61	44.79	70.32	86.57	98.83	174.8	263.55
Temperature (ºC)	6.00	5.00	6.00	6.50	5.83	6.00	6.00	9.00	9.00	10.00	10.00	12.00	10.00	13.00
Turbidity (ntu)	3.00	3.00	2.00	3.00	1.00	1.00	2.00	1.00	2.00	45.00	52.00	53.00	64.00	72.00
Chemical Characteristics														
pH	7.70	7.70	7.70	7.10	7.85	8.06	8.28	8.12	8.18	8.67	8.76	8.69	8.66	8.67
Dissolved Oxygen (mg/l)	11.2	12.60	11.50	NR	8.05	10.05	10.00	10.05	9.85	8.93	8.43	7.86	9.60	9.40
BOD (mg/l)	0.22	0.12	0.36	-	1.23	1.02	1.22	1.41	2.21	0.21	0.23	0.29	0.21	0.23
COD (mg/l)	1.25	1.29	1.25	-	2.56	2.43	2.68	3.21	1.21	1.12	1.34	1.21	1.46	1.53
E. Conductivity (µs)	136.6	135.00	139.00	58.66	354.70	353.00	362.00	330.00	269.30	152.00	146.00	131.00	169.00	76.00
Salinity (mg/l)	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
TDS (mg/l)	156.60	160.00	160.00	30.00	226.70	198.00	220.00	201.30	162.00	112.70	185.66	102.33	116.30	81.00
Total alkalinity (mg/l)	76.00	80.00	78.00	24.00	92.00	86.00	84.00	84.00	68.00	56.00	68.00	66.00	60.00	52.00
Total hardness (mg/l)	208.00	224.00	220.00	40.00	138.00	134.00	128.00	112.00	94.00	136.00	136.00	136.00	148.00	128.00
Ca hardness (mg/l)	116.00	140.00	84.00	28.00	81.90	79.80	77.70	75.60	63.00	100.00	100.00	96.00	112.00	88.00
Ca++ (mg/l)	46.40	56.00	33.60	11.20	32.79	31.95	31.11	30.27	25.23	40.00	40.00	38.40	44.80	35.20

Mg hardness (mg/l)	92.00	84.00	136.00	12.00	56.40	54.20	50.30	36.40	31.00	36.00	36.00	40.00	36.00	40.00
Mg++ (mg/l)	22.35	20.41	33	2.91	13.7	13.16	12.22	8.84	7.52	8.74	8.74	9.72	8.74	9.72
Chloride (mg/l)	8.99	5.99	5.99	7.99	8.99	6.99	5.99	5.99	6.99	8.50	9.92	8.50	9.92	9.92
Nitrate as NO_3-N (µg/l)	0.33	0.91	0.73	0.00	0.82	0.63	0.86	0.56	0.13	0.00	0.00	4.52	2.98	3.52
Phosphate as PO_4-P (µg/l)	0.00	1.05	0.30	0.16	0.20	0.22	0.00	0.00	0.26	1.62	0.614	1.07	0.00	0.00
Iron (mg/l)	1.10	1.13	1.14	1.10	1.26	1.24	1.21	1.24	1.24	1.11	1.23	1.11	0.98	1.11
Heavy metal (mg/l)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL

Heavy metal included Mercury (Hg), Cadmium (Cd), Lead (Pb), Chromium (Cr)

11.2.1.2 *Biological characteristics*

The biological community of a river is the product of the various physical and geomorphologic forms and processes of the river. Biological quality can be assessed by different kinds of organisms: diatoms, riparian and aquatic vegetation, invertebrates and fishes (Kelly and Whitton, 1995). The advantage of monitoring with the use of bio-indicators is that the biological communities reflect overall ecological quality and integrate the effects of different stressors providing a broad measure of their impact and an ecological measurement of fluctuating environmental. Varieties in diatom assemblage could be detected through changes in components of the community, functional groups, species diversity, and relative abundance (Zhu & Chang, 2008 and Van Dolah et al., 1999). They are also important part of environmental assessments, as conservation and management of these organisms is the prime objective of the EIA studies (Smol, 1999). Therefore, in this study, density and abundance of these bio indicators is recorded to provide holistic information regarding the water quality of Dhauliganga river.

Total coliform estimation test is considered to be one of the most important parameter to determine the water quality. Presence of coliform indicates the contamination of water due to sewage outfall. In the present study, total coli form were absent from the study area indicating good water quality in the present stretch. In the plankton communities, zooplanktons accounted for minor part (Table 11.2). Their density was higher in pre- monsoon season than in monsoon season. Density of zooplanktons ranged from 12 indiv./ lit at W3 in monsoon season to 672 indiv./ lit in pre-monsoon season in pre- monsoon season. Density of suspended algae was highest in post- monsoon season and lowest in monsoon season. Density of suspended algae ranged from 9 cells/ lit. at W4 in monsoon season to 40864 cells/ lit at W1 in post- monsoon season. Phytobenthos recorded highest density in pre- monsoon season. The density of Phytobenthos ranged from 5 cells/ cm² to 842887 cells/ cm². Density of Phytobenthos was found nil at W2 in monsoon season. High densities of suspended algae and phytobenthos indicate healthy status of the river, though, high density in the suspended form of algae can not be attributed to accurate measures of productivity as they may be resultant of scouring and turbulent flow in the river.

Benthic macro invertebrates are the most widely used biological assemblage for water quality monitoring. These organisms make good indicators of watershed health because they differ in their tolerance to amount and types of pollution and are integrators of environmental conditions.

Minimum density of benthic macro invertebrates was recorded at W5 (33 Indiv. /m^2) in monsoon season, while maximum density was recorded at W2 (5810 Indiv./m^2) in pre- monsoon season. Monsoon season recorded minimum density for all the biotic communities recorded, as the high discharge during the season washes away the suspended as well as benthic organisms.

11.2.1.3 *Community structure*

11.2.1.3.1 *Algae*

A total of 101 diatom taxa were found during the study, in which 44 taxa were common in both communities (benthic and suspended) while 30 were specific to suspended form and 27 to benthic form (Table 11.3). *Gomphonema* was the genera with maximum number of taxa (25 taxa) followed by *Achnanthidium* (24 taxa), *Cymbella* (22 taxa), *Fragilaria* (10 taxa) and *Diatoma* (6 taxa). Diatom assemblage composition of *Achnanthidium, Cymbella, Fragilaria* and *Diatoma* indicates good water quality, as these genera are generally characteristics of oligotrophic streams (Hieber, 2001). *Cyclotella, Melosira, Planothidium* and *Reimeria* were monotypic taxa. Species richness was found maximum (30 taxa) at W1 in pre- monsoon season in benthic form and minimum (11) was found at W2 in monsoon season. In suspended form, maximum numbers of taxa (32 taxa) were found at W3 and minimum numbers of taxa (17 taxa) were found at W2 in pre- monsoon season.

Achnanthidium affinis, Achnanthidium fragilaroides, Achnanthidium Grimmei, Achnanthidium microcephala, Cocconeis placentula, Cymbella affinis, Cymbella tumidula, Cymbella ventricosa, Fragilaria capucina, Fragilaria construens, Fragilaria leptostauron, Gomphonema olivaceum, Gomphonema parvulum, Planothidium lanceolata and *Reimeria sinuata* were the most abundant taxa. Most of the taxa which occurred exclusively either in suspended form or in benthic form were found only at one or two sites in one season only. Taxa like *Achnanthidium conspicua, Achnanthidium Boyei, Achnanthidium minutissima* var. *cryptocephala, Achnanthidium suchlandti, Cyclotella sp., diatoma vulgare* var. *brevis, Fragilaria pinnata, Gomphonema angustatum, Gomphonema lanceoltaum, Gomphonema olivaceum* var. *calcarea, Hannaea arcus* var. *amphioxys* and *Navicula cryptocephala* were found exclusively in suspended forms. *Achnanthidium nodosa, Achnanthidium fragilaroides, Cocconeis placentula* var. *lineate, Cymbella maharashtrensis, Diatoma vulgare* var. *ehrenbergii, Fragilaria bicapitata, Fragilaria leptostauron* var. *rhomboids, Fragilaria vaucherae, Gomphonema acuminatum* var. *trigonocephala, Gomphonema longiceps* var. *montana, Hannaea arcus* var. *linearis and Navicula reichardtiana* were found in benthic form only.

Table 11.2 Density of various biotic communities Dhauliganga river near Jelam Tamak H.E. project area

	Post- monsoon				Pre-monsoon					Monsoon				
Biological Characteristics	**W1**	**W2**	**W3**	**Jn**	**W1**	**W2**	**W3**	**W4**	**W5**	**W1**	**W2**	**W3**	**W4**	**W5**
Total Coliforms test	A	A	A	A	A	A	A	A	A	A	A	A	A	A
Zooplankton (indi./lit.)	NR	NR	NR	NR	164	94	672	196	288	23	34	12	26	21
Suspended algae (cells/ lit.)	40864	20229	7020	NR	82	225	244	42	72	22	31	10	9	16
Phytobenthos (cells/ cm²)	96212	197900	34983	8801	680932	175897	842887	794722	170	5	0	21	NR	NR
Macro invertebrates (indiv / m²)	266	465	154	NIL	3144	5810	3833	433	1344	177	122	221	NR	33

11.2.1.3.2 *Macro-invertebrates*

Benthic fauna in the studied river stretch was represented by four Orders viz., Ephemeroptera, Plecoptera, Tricoptera and Diptera (Table 11.4). Order Ephemeroptera showed maximum species richness with 8 genera belonging to three families (Heptageniidae, Baetidae and Tricorythodes), followed by Order Diptera with 7 genera belonging to five families (Chironomidae, Simuliidae, Tipulidae, Tendipedidae and Rhagionidae**).** Order Tricoptera was represented by 3 genera belonging to two families (Hydroptilidae and Hydropsychidae) followed by Order Plecoptera with 2 genera belonging to two families (Perilidae and Periodidae). Mixed assemblage of Ephemeroptera, Plecoptera and Tricoptera with dominance of Ephemeroptera indicates good water quality.

Heptageniidae was the most represented family with seven taxa, and the most abundant family was Chironomidae with maximum density 1722 indiv. / m² at site W2 in pre- monsoon season. Marked seasonal variations were found in the Macro invertebrate assemblage composition with only a few taxa appearing in two seasons. None of the taxa was found in all three seasons. Taxa *Cinygmula, Epeorus, Ephemerella, Hydroptila, Acroneuria* and *Ablabesmyia* were found in more than one season. Maximum density of macro invertebrates was found in pre- monsoon season. *Stenonema, Baetis* and *Chironomus* were recorded in pre- monsoon season. Monsoon season recorded minimum density of macro invertebrates. *Cinygmula* and *Epeorus w*ere recorded in monsoon season only. Epeorous, Cinygmula, Hydroptila and Tendipes were the most abundant taxa in post monsoon season. Taxa *Tricorythodes, Hydropsyche* and *Atherix variegate* were recorded from single sites in one season only.

11.2.2 Drinking Water Quality

Villagers do not directly use the river water for drinking purpose but the water of spring or nallahs in a few cases is tapped and supplied to the villages. We sampled the tap water and analyzed for their potability. The villages are located on right bank of Dhauliganga, therefore, the samples were collected only for right bank. Samples were collected from Jumma (W1), Jelam (W2), Longsagiri (W3) and Suraithoda (W4) villages.

Tap water recorded high water temperature and low turbidity as compared to that of surface water. The taste of waters was agreeable. Water is alkaline, with low oxygen contents. Biochemical oxygen demand and salinity was below detectable limit. The water was slightly hard. Hardness, alkalinity, calcium and magnesium were considerable low than surface water. Heavy metals were below detectable limit. Total coliforms were absent in all water samples during all seasons (Table 11.5).

Table 11.3 Algal taxa composition in phytoplankton and phytobenthos of Dhauliganga River

	Phytoplankton								Phytobenthos								
	Pre- Monsoon					Post- Monsoon			Pre- Monsoon					Post- Monsoon			
Taxa	**W1**	**W2**	**W3**	**W4**	**W5**	**W1**	**W2**	**W3**	**W1**	**W2**	**W3**	**W4**	**W5**	**W1**	**W2**	**W3**	**WN**
Achnanthidium affinis	2.77	-	3.7	3.8	-	4	1.85	1.09	1.1	-	-	-	2.17	2.9	3.4	-	5.06
A. biasolettiana	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.26
A. Boyei	-	-	0.61	-	-	-	-	-	-	-	-	-	-	-	-	-	-
A. conspicua	-	-	-	-	-	-	-	1.09	-	-	-	-	-	-	-	-	-
A. exilis	3.7	-	1.85	0.92	-	-	1.85	2.19	2.76	-	-	-	-	1.16	-	-	-
A. fragilaroides	0.92	-	-	-	1.96	-	3.7	1.09	-	-	-	10	-	-	4.1	14.28	1.26
A. gibberula	-	-	-	-	-	2	12.96	4.39	-	-	-	-	-	2.32	0.7	12.85	1.26
A. Grimmei	0.92	-	0.61	0.92	-	-	-	4.39	1.65	-	-	-	-	-	0.7	-	-
A. hauckiana									-	-	-	-	-	-	-	-	1.26
A. hungarica	-	-	-	-	-	-	3.7	-	-	-	-	-	-	-	-	-	-
A. lapidosa	-	-	-	-	3.92	-	-	-	-	-	-	-	-	-	-	-	-
A. lavenderi	-	-	-	-	-	-	1.85	-	-	-	-	-	-	-	-	-	-
A. linearis	1.85	-	3.7	2.85	-	-	1.85	3.29	1.65	12	-	-	4.34	-	0.7	-	1.26
A. linearis var. pusila	-	-	-	-	-	-	1.85	-	1.65	-	0.51	-	-	-	-	-	-
A. microcephala	-	1.2	1.85	5.71	1.96	-	-	-	-	-	-	3.33	-	2.9	2.1	2.84	2.53
A. minutissima	-	-	-	-	-	-	1.85	3.29	0.55	-	-	3.33	6.52	-	0.7	-	5.06
A.minutissima																	

var. *cryptocephala*	-	-	-	-	-	-	-	-	1.65	-	-	-	-	1.16	-	-	-
A. nodosa	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.7	-	-
A. plonenesis	-	-	0.61	-	-	-	-	-	-	-	-	-	-	-	-	-	-
A. saxonica	-	-	-	-	-	-	-	3.29	-	-	-	-	-	-	-	-	-
Achnanthudium sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.42	-
A. suchlandti	-	-	-	-	-	-	3.7	-	-	-	-	-	-	-	-	-	-
A. fragilaroides	-	-	-	-	-	-	-	-	-	-	-	-	2.17	-	-	-	-
A. linearis	-	-	-	-	1.96	-	-	-	-	-	-	-	-	-	-	-	-
Cocconeis placentula	1.85	4.81	-	-	-	2	1.85	1.09	0.53	-	-	-	8.69	-	-	2.85	7.59
C.placentula																	
var. *euglypta*	-	-	1.23	6.66	5.88	-	-	-	-	-	-	19.99	21.7	-	-	-	-
C. placentula																	
var. *lineata*	-	-	-	-	-	-	-	-	-	-	-	10	-	-	-	-	-
Cyclotella sp.	-	-	-	-	-	-	-	1.09	-	-	-	-	-	-	-	-	-
Cymbella affinis	-	-	3.7	-	5.88	4	-	-	1.65	4	5.18	-	-	0.58	-	-	-
C. amphicephala	0.92	-	0.61	0.92	-	4	-	-	-	-	0.51	-	-	-	-	-	-
C. delicatula	-	2.4	1.23	-	-	-	-	-	-	-	-	3.33	-	-	-	-	-
C. gracilis	0.92	-	6.79	2.85	1.96	-	-	-	-	-	2.59	-	-	-	-	-	-
C. herbicida	-	-	-	-	-	-	-	-	0.55	-	-	-	-	-	-	-	1.26
C. hungarica	-	-	3.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-
C. Hungarica																	
var. *signata*	0.92	-	-	-	-	2	-	-	-	4	6.73	-	-	-	-	-	-
C. kerkevarensis	-	-	-	-	-	4	-	-	-	-	-	-	-	-	-	-	-

C. lacustris	-	-	-	-	-	-	-	-	-	-	-	6.66	-	-	-	1.42	-
C. laevis	4.62	7.22	-	-	1.96	-	1.85	-	2.2	4	6.73	3.33	-	-	0.7	2.85	2.52
C. leptoceros	-	-	3.08	-	-	-	-	-	-	-	-	-	-	-	-	-	-
C. maharashtrensis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.42	-
C. microcephala	-	-	1.23	-	-	-	1.85	-	-	-	-	-	-	-	-	-	-
C. nagpurensis	3.7	3.61	3.08	-	-	-	-	-	2.76	-	4.14	-	-	0.58	-	-	-
C. perpusila	0.92	-	-	-	-	-	1.85	-	-	-	-	-	-	-	-	1.42	1.26
C. prostrata	-	-	-	-	1.96	-	-	-	-	-	-	-	-	-	-	-	-
C. pusila	-	1.2	-	-	-	4	-	-	0.55	-	5.69	-	2.17	-	-	-	-
Cymbella sp.	-	-	1.23	-	-	-	-	-	-	-	-	-	-	-	-	-	-
C. tumidula	1.85	1.2	2.46	0.92	-	6	-	-	11.04	40	8.8	3.33	4.34	-	-	1.42	1.26
C. turgida	-	-	-	0.92	-	6	-	-	1.65	-	-	-	-	-	-	1.42	2.53
C. turgidula	9.25	10.8	22.22	2.85	-	2	-	-	2.76	-	-	-	-	-	-	-	-
C. ventricosa	-	-	1.85	4.76	-	2	-	6.59	-	-	-	-	2.17	1.16	0.7	2.85	6.32
Diatoma elongatum var. *tenuis*	-	-	-	-	-	16	7.4	1.09	-	-	-	-	-	5.81	6.8	-	1.26
D. heimale	1.85	2.4	0.61	3.8	-	6	-	1.09	1.04	4	-	-	4.34	1.74	4.1	-	-
D. hiemale var. *mesodon*									-	-	-	-	-	11	2.7	1.42	18.98
D. vulgare	-	-	-	-	-	4	-	-	-	-	-	-	-	0.58	0.7	-	-
D. vulgare var. *ehrenbergii*	-	-	-	-	-	-	-	-	-	-	-	-	-	1.74	-	-	-
D. vulgare var. *brevis*	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-

Fragilaria bicapitata									-	-	-	-	-	-	-	-	1.26
F. capucina	0.92	-	-	5.71	3.92	2	9.25	3.29	8.28	4	10.4	13.33	13	1.74	4.8	-	3.79
F. construens	-	-	-	1.9	1.96	6	14.81	2.19	-	-	-	-	-	-	0.7	4.28	-
F. leptostauron	10.2	-	-	-	1.96	2	7.4	18.68	4.41	4	5.18	-	-	0.58	2.1	2.85	8.86
F.leptostauron																	
var. *rhomboides*									-	-	-	-	-	-	1.4	-	-
F. pinnata	-	-	-	3.8	-	-	-	-	-	-	-	-	-	-	-	-	-
F. rumpens	-	-	-	-	1.96	-	-	-	-	-	-	-	-	-	-	-	1.26
Fragilaria sp.	20.4	33.7	16.04	27.61	39.2	-	-	17.58	15.45	-	15.5	-	2.17	-	-	7.14	-
Fragilaria sp.(2)	-	-	-	2.85	-	-	-	-	-	-	-	-	-	-	-	-	-
F. vaucherae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7.59
Gomphonema acuminatum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.7	-	
G.acuminatum																	
var. *trigonocephala*	-	-	-	-	-	-	-	-	-	-	-	-	-	0.58	-	-	-
G. angustatum	-	-	-	-	-	-	-	1.09	-	-	-	-	-	-	-	-	-
G. apicatum									-	-	-	-	-	0.58	-	-	-
G. augur	-	-	0.61	-	-	-	-	-	-	-	-	-	-	-	-	-	-
G. bohemicum	-	1.2	-	-	-	-	-	-	1.65	-	-	3.33	2.17	-	0.7	1.42	-
G. gracile																	
var. *auritum*	-	-	-	-	-	-	-	-	-	-	-	-	-	0.58	-	-	-
G. herbidense	-	-	0.61	-	-	-	-	-	-	-	-	-	-	-	-	-	-
G. intricatum	-	-	-	0.92	-	-	-	-	3.31	-	2.59	-	-	-	0.7	1.42	1.26
G.intricatum																	

var. *pumila*	7.4	13.3	2.46	0.95	3.92	-	-	3.28	8.21	-	-	-	4.34	-	-	-	-
G.intricatum																	
var. *pumilum*									2.2	-	-	-	-	-	-	-	-
G. lanceolatum	-	-	-	-	-	2	-	-	-	-	-	-	2.17	-	-	-	-
G. longiceps var.montana	-	-	-	-	-	-	-	-	-	-	-	-	-	1.16	-	-	-
G. longiceps																	
var. *subclavata*	-	-	0.61	-	-	-	-	-	-	-	-	-	-	-	-	-	-
G. olivaceoides	5.55	-	0.61	-	3.92	-	-	-	4.41	-	2.59	-	-	1.16	-	2.85	-
G. olivaceum	5.55	4.81	2.46	2.85	-	-	1.85	3.29	8.83	4	3.62	9.99	2.17	-	4.8	1.42	-
G. olivaceum																	
var. *calcarea*	-	1.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
G. olivaceum																	
var. *minutissima*	-	-	-	-	3.92	-	-	1.09	1.1	-	-	-	-	-	-	-	-
G. parvulum	10.2	6.02	3.08	-	-	8	3.7	4.39	2.76	4	-	-	8.69	14.5	14	17.14	-
G. parvulum																	
var . *exilissimum*	-	-	-	-	-	-	-	-	-	-	-	6.66	-	-	-	1.42	1.26
G. parvulum																	
var. *lagemula*	-	-	-	-	-	-	-	-	-	-	-	-	-	1.16	-	-	-
G. parvulum																	
var. *micropus*	-	-	-	-	-	-	-	-	-	-	-	-	-	1.16	-	1.42	-
Gomphonema sp.	-	-	-	-	-	2	9.25	5.49	-	-	-	-	-	0.58	0.7	8.57	3.79
G. sphaerophorum	0.92	-	-	0.92	1.96	-	-	1.09	1.65	-	1.55	-	-	9.3	6.8	-	1.26
G. tenuis	-	-	0.61	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Hannaea arcus	-	-	-	-	-	8	-	-	-	-	-	-	-	32	18	-	-
Hannaea arcus var. *amphioxys*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4.8	-	
Hannaea arcus var. *linearis*	-	-	-	-	-	-	-	-	-	-	-	-	-	1.16	10	-	-
Melosira junergensii	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.42	1.26
Navicula cryptocephala	-	-	-	-	-	-	1.85	-	-	-	-	-	-	-	-	-	-
Navicula reichardtiana	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.26
Planothidium lanceolata	-	3.61	4.93	11.42	3.92	-	1.85	3.29	-	-	-	3.33	2.17	-	-	-	2.53
Reimeria sinuata	6.48	1.2	1.85	0.92	1.96	-	-	-	1.1	16	0.51	-	4.34	-	-	-	-
Synedra ulna aequalis	0.92	-	-	1.9	-	-	-	-	-	-	-	-	-	-	-	-	-
Synedra ulna var. *amphirhynchus*	-	-	-	-	1.96	-	-	-	-	-	-	-	-	-	-	-	2.53
Total	**25**	**17**	**32**	**25**	**21**	**23**	**23**	**26**	**30**	**11**	**17**	**14**	**19**	**27**	**28**	**25**	**30**

Table 11.4 Macro-invertebrate composition in Dhauliganga River near Jelam Tamak H.E. project

	Post- Monsoon			Pre-Monsoon					Monsoon			
Taxa	**W1**	**W2**	**W3**	**W1**	**W2**	**W3**	**W4**	**W5**	**W1**	**W2**	**W3**	**W5**
Heptageniidae												
Adult*	-	-	-	11	-	-	-	-	-	-	-	-
Aneopeorus	-	-	11	-	-	-	-	-	-	-	-	-
Cinygmula	55	55	33	-	-	-	-	-	22	22	33	-
Epeorus	-	211	11	-	-	-	-	-	111	89	144	11
Ephemerella	-	-	33	-	-	-	-	-	-	-	-	-
Ephemerillidae												
Stenonema	-	11		333	700	256	144	56	-	-	-	-
Baetidae												
Baetis	-	-	-	156	211	278	67	555	-	-	-	-
Tricorythidae												
Tricorythodes	-	-	-	-	33	-	-	-	-		-	-
Perlidae												
Acroneuria	-	-	-	733	1811	1122	-	11	-	-	22	-
Periodidae												
Isoperla	-	-	-	-	-	-	-	-	-	-	11	22
Hydroptilidae												
Hydroptila	-	66	33	-	11	33	22	-	-	-	-	-
Orthotrichia	-	11	-	-	-	-	-	-	-	-	-	-
Hydropsychidae												
Hydropsyche	33	-	-	-	-	-	-	-	-	-	-	-
Chironomidae												

Ablabesmyia	-	-	-	644	1300	944	111	478	11	11	-	-
Chironomus	-	-	-	1255	1722	1144	78	244	-	-	-	-
Tendipedidae												
Tendipes tentans	-	-	-	-	11	56	-	-	-	-	-	-
Simuliidae												
Simulium pictipes	-	-	-	-	-	-	-	-	33	-	11	-
Tipulidae												
Antocha Saxicola	-	-	-	11	-	-	11	-	-	-	-	-
Tendipedidae												
Tendipes	133	111	33	-	-	-		-	-	-	-	-
Rhagionidae												
Atherix variegata	-	-	-	-	11	-	-	-	-	-	-	-
Density (Indiv. /m^2)	**221**	**465**	**154**	**3143**	**5810**	**3833**	**433**	**1344**	**177**	**122**	**221**	**33**

Table 11.5 Physical, chemical and biological characteristics of tap water collected from the villages located in the surroundings of proposed project.

Parameters	W1	W2	W3	W4	W1	W2	W3	W4	W1	W2	W3	W4
Physical Characteristics												
Temperature (ºC)	11	8	9.5	11	12	10.5	12	11	12.5	10.5	11.5	12.5
Turbidity (ntu)	2	0	3	3	5	4	2	4	5	10	10	12
Chemical Characteristics												
pH	7.12	7.23	7.26	7.56	7.85	7.16	7.17	7.12	7.1	7.08	6.98	7.2
Dissolved Oxygen (mg/l)	7.2	6.6	7.5	7.45	6.05	6.12	7.12	7.05	7.85	7.12	7.48	8.86
BOD (mg/l)	BDL	0.11	BDL	BDL	BDL	0.12	BDL	BDL	BDL	0.32	BDL	BDL
E. Conductivity (µs)	110	112	95	112	126	146	112	108	132	152	106	123
Salinity (mg/l)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
TDS (mg/l)	72	79	64	74	84	93	71	72	89	102	70	75
Total alkalinity (mg/l)	32	41	33	26	29	42	32	32	32	24	31	32
Total hardness (mg/l)	**125**	**120**	**134**	**124**	**110**	**112**	**124**	**98**	**123**	**116**	**107**	**114**
Ca hardness (mg/l)	80	82	90	28	75	76	80	66.5	88.4	70	72	76
Ca++ (mg/l)	32	32.8	36	11.2	30	14.4	32	26.6	35.3	28	28.8	30.4
Mg hardness (mg/l)	45	38	44	12	35	8.7	54	31.5	34.6	46	35	38
Mg++ (mg/l)	10.9	9.2	10.6	2.91	8.5	13.16	13.2	7.65	8.4	11.17	8.5	9.23
Chloride (mg/l)	6.44	5.25	5.84	6.42	6.79	6.82	7.12	5.56	5.78	7.14	5.67	6.66
Nitrate as NO_3-N (µg/l)	0.12	0.12	0.06	0.09	0.15	0.22	0.09	0.09	0.14	0.33	0.21	0.14
Phosphate as PO_4-P (µg/l)	0.1	0.12	0.1	0	0	0.12	0.04	0.02	0.09	0	0.08	0.01
Heavy metal (mg/l)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL

11.3 WATER QUALITY ASSESSMENT

Quality of water can be assessed by physical, chemical and biological characteristics of the water. The present investigation reveals that quality of surface water and drinking water is good and stand under the desirable limit as per IS:10500 except turbidity (Table 11.6). The surface runoff in monsoon season increases the water turbidity as result river water is not potable, though it is not used for drinking purpose. The majority of the algal species and most common species like *Achnanthidium linearis*, *A. affinis*, *A. exilis*, *Cymbella laevis*, *C. tumidula*, *Fragilaria* species etc. are pollution tolerant indicating good water quality in Dhauliganga and its tributaries.

The water quality was also assessed using the Biological Monitoring Working Party Score (1978) and Average Score per Taxon (Armitage et al., 1983). BMWP score ranged from 18 to 50 with minimum in monsoon season while Average per Taxon score ranged from 4.5 -9.5. These scores also confirmed the unpolluted state of the water.

Table 11.6 Drinking water quality standards (as per IS:10500)

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

There was no point source triggering the organic pollution in the vicinity. None of the effluent was recorded that measured the various parameters as per Table 11.7. Inland surface water standards indicate that the water of Dhauliganga and its tributaries are conducive for drinking, agricultural and fisheries purpose.

Table 11.7 Tolerance Limits for Inland Surface Waters (as per IS:2296)

SN	Parameter and Unit	Class-A	Class-B	Class-C	Class-D	Class-E
1.	Colour (Hazen Units)	10300	300	-	-	
2.	Odour	Unobject	-	-	-	-
3.	Taste	Tasteless	-	-	-	-
4.	pH (max) (min:6.5)	8.5	8.5	8.5	8.5	8.5
5.	Conductivity (µS/cm)	-	-	-	1000	2250
6.	Do (mg/L) (min)	6	5	4	4	-

7.	BOD (3 days at 27^{o}C) (mg/L)	2	3	3	-	-
8.	Total Coliforms (MPN/100 mL)	50	500	5000	-	-
9.	TDS (mg/L)	500	-	1500	-	2100
10.	Oil and Grease (mg/L)	-	-	0.1	0.1	-
11.	Mineral Oil (mg/L)	0.01	-	-	-	-
12.	Free Carbon Dioxide (mg/L CO_2)	-	-	-	6	-
13.	Free Ammonia (mg/L as N)	-	-	-	1.2	-
14.	Cyanide (mg/L as CN)	0.05	0.05	0.05	-	-
15.	Phenol (mg/L C_6H_5OH)	0.002	0.005	0.005	-	-
16.	Total Hardness (mg/L as $CaCO_3$)	300	-	-	-	-
17.	Chloride (mg/L as CI)	250	-	600	-	600
18.	Sulphate (mg/L as SO_4)	400	-	400	-	1000
19.	Nitrate (mg/L as NO_3)	20	-	50	-	-
20.	Fluoride (mg/L as F)	1.5	1.5	1.5	-	-
21.	Calcium (mg/L as Ca)	80	-	-	-	-
22.	Magnesium (mg/L Mg)	24.4	-	-	-	-
23.	Copper (mg/L as Cu)	1.5	-	1.5	-	-
24.	Iron (mg/L as Fe)	0.3	-	50	-	-
25.	Manganese (mg/L as Mn)	0.5	-	-	-	-
26.	Zinc (mg/L as Zn)	15	-	15	-	-
27.	Boron (mg/L as B)	-	-	-	-	2
28.	Barium (mg/L as Ba)	1	-	-	-	-
29.	Silver (mg/L as Ag)	0.05	-	-	-	-
30.	Arsenic (mg/L as As)	0.05	0.2	0.2	-	-
31.	Mercury (mg/L as Hg)	0.001	-	-	-	-
32.	Lead (mg/L as Pb)	0.1	-	0.1	-	-
33.	Cadmium (mg/L as Cd)	0.01	-	0.01	-	-
34.	Chromium (VI) (mg/L as Cr)	0.05	0.05	0.05	-	-
35.	Selenium (mg/L as Se)	0.01	-	0.05	-	-
36.	Anionic Detergents (mg/L MBAS)	0.2	1	1	-	-

Class-A:	Drinking water source without conventional treatment but after disinfection.
Class-B:	Outdoor bathing.
Class-C:	Drinking water source with conventional treatment followed by disinfection.
Class-D:	Fish culture and wild life propagation.
Class-E:	Irrigation, industrial cooling and controlled waste disposal.

11.4 FISH & FISHERIES

Regarding the hydro-electric projects, fish is most vulnerable group, suffers habitat degradation in downstream as well as upstream stretches of the river. In the central Himalaya, large and medium-sized dams on the Chenab at Salal and on the various source rivers of the Ganga at Tehri, Rudraprayag, Vishnuprayag and Lachmanjhula, are likely to have an impact, especially on the mahseer and schizothoracines (Sehgal, 1990). Inventorization of fish species and their status in the river, likely to be regulated is most important environmental parameter as it is an area of direct impact. Based on the baseline data, a sustainable plan for the fisheries management including hatchery, fish pass, fish lift, downstream management can be formulated.

In order to record the fish data of Dhauliganga river, detailed surveys were conducted in the stretch between Raini village to Malari village for three seasons. In addition, secondary literature was consulted to know the status of fish in Dhauliganga river. The local inhabitants were interviewed on the presence of fish, fishermen and fishing methods. The issues are discussed in light of the climatic condition in Dhauliganga river, fish species distribution pattern in Himalaya and any other possibility of fish occurrence in the river.

11.4.1 Fish Composition

None of the fish species was encountered during the fish surveys in Dhauliganga river. There are no traditional fishermen communities in region and local inhabitants also denied any possibility of fish species in the Dhauliganga river stretch between Raini to Malari villages. Also, fish fry and fingerlings from the pools and ditches were not observed. A detailed account on the geographical distribution of fish of Garhwal Himalaya was given by Singh et al. (1987). Their study area included all major tributaries of river Ganga, viz. Alaknanda, Bhagirathi, Birahi, Nadakini, Pindar, Mandakini, Bhagirathi, Yamuna, Nayar, Bhilangana, Hinwal, Khoh, Rawansan and Song. Dhualiganganga was not included in this report probably due to absence of fish species. Earlier report also confirms that the altitude above 2400 m is fishless zone in Garhwal Himalaya. Other reports (WII, 2012; IIT Roorkee, 2011) also identified the river stretch under discussion as no fish zone.

11.4.2 Climatic Condition of Dhauliganga River and Probability of Fish Occurrence

The Himalayan streams are well known for their cold water fisheries, also altitudinally vary in their physical, chemical and biological characteristics. The fish production gradually decreases from lower to upper reaches, because it mainly depends on the water current velocity, water temperature, dissolved oxygen and food availability. On the basis of fish species Sehgal (1988) divided Himalayan stream broadly into (i) head water zone dominated by loaches and exotic trout if introduced (ii) large stream zone dominated by *Schizothorax* spp. and *Schizothoraicthys* spp. and (iii) slow moving meandering zone, dominated by mahseer and carp species.

The proposed Jelam Tamak H.E. project is located in the head water zone, characterized by very low temperature 5 ^{0}C to 13 ^{0}C, high water current velocity (0.92 to 3.27 m/s), high dissolved oxygen concentration and rough river bed surface. The vicinity of river Dhauliganga in this zone retains coniferous temperate forest and alpine meadows, river flows through deep gorges and steep slopes. These characteristics of river make an adverse climatic condition for the survival of aquatic flora and fauna. The physical and chemical characteristics of river water seem to be conducive for the exotic trout viz. *Salmo trutta fario* and *S. gairdneri gairdneri*, which are not introduced in the upper stretches of Dhauliganga river. However, the presence of a rheophilic species like *Noemacheilus, staliczkae, Noemacheilus gracilis* and *Glyptosternum reticulatum* is expected to inhibit this head water zone (e.g. Sehgal, 1988). These species are bottom dwellers and do not take upstream or downstream migration to cope the climatic condition or for the purpose of spawning.

11.4.3 Fish species in downstream

As earlier stated that none of fish species was recorded from the influence zone of the proposed project. Alaknanda river can be considered as nearest fish zone. The important fish species in the nearest area are listed in Table 11.8.

Table 11.8 Fish species of Alaknanda river near river stretch of 700 – 1400 m

Species	Status
Schizothorax richardsonii Gray	VU
Schizothoraicthys progastus McClelland	VU
Tor tor Hamilton	EN
Tor putitora Hamilton	EN
Garra gotyla gotyla	LR
Garra lamta (Hamilton)	-
Barilius bendelisis Hamilton	-
B. bola (Hamilton)	-
B. vagra Hamilton	-

B. barna Hamilton	-
Puntius sophore Hamilton	LR
P. chillinoides McClelland	LR
Glyptothorax pectinopterus McClelland	-
G. madraspatanum Day	LR
Pseudecheneis sulcatus McClelland	VU
Nemacheilus montanus McClelland	-
N. bevani Gunther	-
N. multifasciatus Day	-
N. zonatus McClelland	-

EN = endangered; VU = vulnerable; LR = Low risk

Source: Consolidated Environmental Assessment Report of Vishnugad Pipalkoti H.E. project

11.5 WATER USE PATTERN

The villagers use drinking water from the nearby springs or brooks. The water is tapped and supplied to a common post in the villages. In a village or a hamlet a group of families uses water from a common stand post. The group comprises of 5 to 10 families. The individual water supply is generally not common in the area. The drinking water is not treated. The river water of Dhauliganga is not used for drinking purpose because all villages and hamlets are located at uphills.

11.6 CONCLUSION

No point source of organic pollution is available in the surroundings of Dhauliganga river especially in the project area. Also, diffuse source is negligible. The good health of river water quality is reflected by the physical and chemical characteristics of the water and species composition. High diversity and densities of algal and macro-invertebrate communities indicate healthy state of the river water. Majority of the algal species and macro-invertebrates species are pollution intolerant. River impoundment due to proposed project may lead to the changes in species composition in downstream and upstream sections of the river.

No major threats are foreseen on fisheries of the present stretch because the river stretch is already very poor in fish diversity and density. Due to the absence of migratory fish, the hampering of migration is not foreseen. In contrary, creation of a reservoir would provide a possibility of fish culture. The reservoir would provide a semi lacustrine environment, large surface area and warm condition as compared to that of running waters. Either indigenous species *Schizothorax* spp., *Schizothoraicthys* spp. etc or exotic trout *Salmo trutta fario* can be reared in the proposed reservoir.

Chapter 12

AIR ENVIRONMENT

12

AIR ENVIRONMENT

12.1 INTRODUCTION

The air environment includes primary gases (oxygen, nitrogen, carbon dioxide, etc.) and various secondary gases (methane, nitrogen oxides, ammonia, sulphur dioxide, carbon monoxide, etc.) formed by the combination of primary gases or released by some sources. Some of the main air pollutants are oxides of nitrogen (NO_2), sulphur dioxide (SO_2), volatile organic compounds (VOCs), carbon monoxide (CO), particulate matter (PM), etc. which may have immediate and severe impacts on the health of humans beings, animals and plants.

The ambient air quality is being polluted at a considerable rate due to the various anthropogenic activities. Change in the land use for agriculture and settlements, various upcoming mega developmental projects and increased consumption of fossil fuels has tremendously polluted the air. Industries like thermal power plants, cement, steel, refineries and mines have become main contributors to air pollution. Vehicles are the main contributors of air pollutants in the urban centres. Air pollution also results due to natural phenomena such as dust storms in desert areas, smoke from forest fires and volcanoes.

Good air quality is essential for the sustenance and well being of all the living organisms. Retaining the air environment remains a priority issue on most national and international environmental agendas. Studies related to the air quality are of much importance in the Environmental Impact Assessments (EIAs). The EIA helps in studying the impacts of various developmental projects and related activities on the air environment of the region, where the project is proposed. It is generally considered that hydroelectric projects do not alter the ambient air quality, but it may not always be true at least during the construction phase during which various negative impacts on the air environment may be visualised.

Besides the naturally occurring gases in the air environment, there are various suspended particulate matters such as dust, pollen grains, soot, etc., which also keep floating in the air. Any change in the natural composition of gases in air or addition of new gases or particulate matter is called air pollution. Air pollution has adverse impacts directly or indirectly on all the biological and non-biological components of the region. As mentioned earlier it is crucial to maintain the air environment in its ambient condition for the well being of all the biotic and the abiotic components.

12.2 PROJECT AREA

Influence zone and catchment area of the proposed project is sparsely populated and point source of air pollutants is absent. Polluting actions like mining, thermal power plants, heavy vehicular movement and natural phenomenon (storm) are not in action in the region. Forest fires in summer, construction works like roads, river valley projects, burning of fuel woods and marginal vehicular movement contribute to the deterioration of air quality.

12.3 AIR ENVIRONMENT AND TRAFFIC DENSITY

12.3.1 Traffic Density

The traffic density in the project area was recorded during November 2008, March 2009 and August 2009. The highest traffic density per hour was recorded in the summer season near Tapovan (32) which dropped to 21 in upper segment of the road (Table 12.1). During the winter season vehicular density was minimum. Light vehicles (taxies) are main source of public transport in the region while heavy vehicles include trucks and dumpers. The traffic data implies that there is no major vehicular pollution in the region.

Table 12.1 Traffic density on the Joshimath Jelam state highway

	Vehicular traffic density No of vehicles/hr					
	Joshimath to Tapovan			**Tapovan to Suraithoda**		
Season	**HV**	**LV**	**TW**	**HV**	**LV**	**TW**
Monsoon {August, 2009}	10.0	12.0	0	4.0	3.0	0
Summer {March, 2009}	12.0	15.0	5	8.0	9.0	4.0
Winter {November 2008}	7.0	10.0	9.0	4.0	7.0	4.0

HV = heavy vehicle; LV = light vehicle; TW = two wheelers

12.3.2 Air Pollutants

The traffic along the road, agricultural fields, road construction activities and forest fire in the summer are the main sources of air pollution in the region while the source of indoor air pollution is burning of fuel wood. Levels of SPM (RSPM, and NRSPM), NO_x and SO_2 were measured at different locations in the project area by using Respirable Dust Sampler (Envirotech APM 460BL) with gaseous sampling attachment (Envirotech APM 411TE).

12.3.2.1 *Suspended particulate matter (SPM)*

Suspended particulate matter (SPM) is defined as any dispersed matter, solid or liquid ranging in size from 0.0001 microns to 10,000 microns. Based on the aerodynamic ability and diameter of these particles to enter the respiratory track of human beings, the SPM is further divided into respirable suspended particulate matter (RSPM) and non-respirable suspended particulate matter (NRSPM). The RSPM generally has a diameter less than 10 microns and also termed as PM 10. Non-respirable particulate matters has diameter above 10 microns. There are both anthropogenic and natural sources of suspended particulate matter in air. Natural sources include forest fire while the largest anthropogenic sources are combustion of fossil fuels in automobiles and power plants, construction sites and dust blown from the exposed land.

The effect of the particulate matter on health depends on the chemical and biological properties of the individual particles that act in combination with sulphur dioxide. Average concentration of RSPM ranging from 100 to 200 micro grams per cubic meter in presence of sulphur dioxide (around 80 μg per cubic meter) increases incidence of bronchitis and aggravates asthma.

Table 12.2 gives the ambient levels of RSPM and NRSPM measured at different locations in the project area. Highest concentration of SPM was recorded in Malari village that can be attributed to the wind erosion of soils of steep slopes. At Joshimath the SPM levels were comparatively higher in August as compared to that recorded in March. In this region the main sources of SPM are vehicles, open degraded land areas and landslides. In monsoon season the SPM concentrations were lower due to the settling down of dust particles. The SPM recorded in the region further analyzed for RSPM and NRSPM and is given in Table 12.2.

Table 12.2 Air Quality in the proposed Jelam Tamak H.E. project area

S.No.	Location	Month/Year	SO_2 $\mu g/m^3$	NO_x $\mu g/m^3$	SPM $\mu g/m^3$	RSPM $\mu g/m^3$	NRSPM $\mu g/m^3$
1	Joshimath	Mar,09	ND	1.586	72.71	26.1	46.61

2.Malari village	Aug,09	ND	1.484	213.69	45.5	168.18
3.Joshimath	Aug,09	ND	3.517	94.07	24.31	69.76
4.Suraithoda	August	ND	2.421	93.12	19.25	73.87

12.3.2.2 *NO_x*

NO_x is the generic term for a group of highly reactive gases, all of which contain nitrogen and oxygen in varying concentrations. Most of the nitrogen oxides are colourless and odourless gases except nitrogen dioxide (NO_2), which is reddish brown. The sources of NO_x are vehicular and industrial emissions. Nitrogen oxides are formed when fuel is burnt at high temperature. The oxides of nitrogen can cause serious health problems in human beings if present in high concentrations. The problems include clogging of lung tissues and respiratory problems such as emphysema (chronic obstructive lung disease), bronchitis, etc.

The only source of NO_x emissions in the project area is vehicles. Maximum levels of NO_x were observed at Joshimath (3.517 $\mu g/m^3$) in the monsoon season when the region undergo through heavy vehicular movement due to pilgrimage and tourism activities. (Table 12.2). NO_x concentrations recorded at various project sites are significantly lower than the national standard levels approved by Ministry of Environment & Forests for residential areas/rural areas and ecological sensitive areas (Table 12.3).

12.3.2.3 *SO_2*

Sulphur dioxide is a colourless gas with pungent irritating odour. The main source of SO_2 is burning of fuels such as oils and coal. In the entire Chamoli district there is total absence of power plants based on coal and oil. Levels of SO_2 were non-traceable in all the seasons (see Table 12.2), which may be due to low traffic flow in the region.

Table 12.3 National ambient air quality standards approved by Ministry of Environment & Forests

Pollutants Weighted	**Time**	**Concentration in Ambient Air**		**Method of Measurement**
		Ecological Sensitive areas	**Industrial, Residential , Rural & Other Areas**	
Sulphur	Annual Average	20 $\mu g\ m^{-3}$	50 $\mu g\ m^{-3}$	Improved West and

Dioxide	24 hour	80 $\mu g\ m^{-3}$	80 $\mu g\ m^{-3}$	Greek Method
(SO_2)				Ultraviolet fluorescence
Oxides of	Annual	30 $\mu g\ m^{-3}$	40 $\mu g\ m^{-3}$	Modified Jacob Hochheises
Nitrogen	24hour	80 $\mu g\ m^{-3}$	80 $\mu g\ m^{-3}$	(Na-Arsenite)
(NO_x)				Chemiluminescence
Particulate	Annual	60 $\mu g\ m^{-3}$	60 $\mu g\ m^{-3}$	Gravimetric TOEM
Matter	24 hour	100 $\mu g\ m^{-3}$	100 $\mu g\ m^{-3}$	Beta attenuation
(size less than 10 μg)				
Particulate	Annual	40 $\mu g\ m^{-3}$	40 $\mu g\ m^{-3}$	Gravimetric TOEM
Matter	24hour	60 $\mu g\ m^{-3}$	60 $\mu g\ m^{-3}$	Beta attenuation
Matter (Size < 2.5 μg)				
Carbon	8 hour	2 mg m^{-3}	2 mg m^{-3}	Non dispersive infrared
Monoxide	1 hour	4 mg m^{-3}	4 mg m^{-3}`	spectroscopy
(CO)				

12.3.3 Noise Levels

Noise is defined as any unwanted sound or sound that is loud or unpleasant or unexpected. It intrudes unreasonably into the daily activities of human beings and animals creating adverse impacts on them. The adverse impacts of noise also depend on time and season, particularly in case of animals. The average sound level ranged from 47.5±0.66 – 59.3±0.54, 53.6±2.7 – 58.1±3.1 and 53.2±1.6 – 62.3±0.54 during post monsoon, pre-monsoon and monsoon seasons, respectively (Table 12.4). Generally N4 and N5 recorded high sound level. It can be attributed to the construction works of hydro-electric projects.

Table 12.4 Sound levels recorded (in dB) at different locations in the proposed project area of the Jelam-Tamak H.E. Project and the catchment area of Jelam-Tamak

S.N.	Post-Monsoon				Pre-monsoon					Monsoon				
	N1	N2	N3	N4	N1	N2	N3	N4	N5	N1	N2	N3	N4	N5
1	51.3	52.1	59.6	48.1	57.3	57.8	54.2	64.3	59.2	55.8	57.9	61.9	62.7	53.2
2	51.1	53.5	59.9	47.4	57.9	56.9	55.8	62.9	56.8	56.2	58	61.6	63.1	52.4

3	51.9	53	60	47.9	56.7	54.9	57.3	62.2	56.2	58.5	57.6	62.2	61.6	53
4	51.7	53.2	59.4	48.1	58.9	53.6	55.8	57	58.2	56.1	57.8	62.7	63.2	52.7
5	51.2	52.8	58.4	47.3	57.3	54.4	56	58.9	56.6	56.2	57.1	62.6	62.4	51.8
6	53.1	53.1	59.8	48.1	54.5	58.9	51.8	56.7	54.6	56.4	57.3	63.4	62.1	52.2
7	51.2	54.5	59	48.2	55.3	60.4	52.4	55.2	58.6	55.4	58	62	62.5	57.5
8	51.2	52.9	58.6	46.8	54.9	59.6	52.6	54.2	57.3	55.3	58.2	62.7	63.8	52.7
9	51.9	52.9	59	47.1	55.7	56.2	51	54	55.8	56.9	58.1	62.8	63.2	53.9
10	50.1	52.7	59.8	46.6	54.3	56.8	49.6	55.7	56.6	50.1	57.4	61.9	63.8	52.8
Av	**51.4**	**53.0**	**47.5**	**59.3**	**56.0**	**56.9**	**53.6**	**58.1**	**56.9**	**56.4**	**57.7**	**62.3**	**62.8**	**53.2**

N1= downstream of barrage site, N2 = power house site, N3 = downstream powerhouse site, N4 = upstream and downstream of Vishnuprayag and N5 = Jelam Nala

12.4 CONCLUSION

During the construction of the dam, the traffic density would increase significantly. Vehicles like trucks, dumpers, excavators will be continuously plying at the construction sites. Heavy diesel generator sets will also be in operation for electric supply. There will likely be heavy noise, vibrations as well as emission of soot in the region. The noise is likely to disturb the behaviour of animals in that region, particularly when adits and other tunneling activity will be undertaken. The SPM levels in project area are quite low but these are likely to increase further due to the construction activities of the Jelam Tamak HE Project. There will also be increase in the level of NO_x and SO_2. Increased noise levels and continuous noise may disturb the breeding, feeding and various other activities of the animals and birds in the region. However, considering the fact that much of the construction activities will be restricted to day time, the impact on wildlife is anticipated low. The sound level of the running equipment should not be more than 60 dBA beyond 1000 m. During night time strict silence needs to be observed and also there should be minimum use of light.

Chapter 13

SOCIO-CULTURE & ECONOMIC PROFILE

13
SOCIO-CULTURE & ECONOMIC PROFILE

13.1 INTRODUCTION

The state of Uttarakhand (Uttaranchal) lies between $28^0$43' – $31^0$28' N latitude and $77^0$32' – $81^0$00' E longitude. It is surrounded by Himachal Pradesh in the West, Uttar Pradesh in the South, Nepal in the East and Tibet in the North. The new state of Uttaranchal was created in November 2000. The state was carved out from Uttar Pradesh taking out 13 districts covering an area of 53,483 sq km. At 2001 Census, the state of Uttarakhand recorded 13 districts, 49 tehsils. 86 towns and 16,826 villages. The population of Uttarakhand is 84,79,562; predominant with rural population (76.90%). Schedule Caste and Schedule Tribe populations account for 17.8% and 3.02% of the total population, respectively. Total literacy rate is 72%, dominated by males. At Census 2001, Uttarakhand records a sex ratio of 942.

Brief History: Uttarakhand has a very ancient history as it finds mention in the Hindu scriptures as Kedarkhand (Skandhpuran), Manas Khand and Himvant. It is often called the land of the Gods because of its holy places and abundant shrines. The scriptural text (a part of Skandhapuran) mentions a number of tribes like Sakas, Hunas, Nagas, Kiratas, etc. that inhabited the region. Before coming of Brahamins and Rajputs from plains the region was dominated with Khasas. Later, it has been known as Garhwal due to the presence of fifty –two forts (52 'Garhs'), each governed by a separate king (Garhpal). Bhanupratap Pal was one of the Garhpals. The Chandpur Garhi was his kingdom (near Aadi Badri). Bhanupratap Pal was succeeded by his Son-in-law Kanak Pal, came from Rajasthan (Gujardesh). Gradually, Kanak Pal (Panwar) took over one by one almost all kingdoms, therefore, he is known as first king of Garhwal. After a few generations, Panwar dynasty shifted its capital from 'Chandpur' to Devalgarh and Devalgarh to Srinagar during the regimes of Ajay Pal and Sri Shah, respectively. Sri Shah was succeeded by Pradhuman Shah. During the regime of Pradhuman Shah in 1803. Gorkhas from Nepal attacked Garhwal and took over. In this invasion, Pradhuman Shah was killed in the war at Dehradun. His son Sudrasan Shah escaped in the war and took refuge at his relatives' place in Kankhal, Hardwar. Younger Sudarsan Shah took help from British rulers and defeated Gorkhas in 1815. But he failed to pay the cost of war (Rs. 5 lakhs) and left his half kingdom under the British jurisdiction. Thus, the area left bank of river Alaknanda and Mandakini was taken over by British rulers and known as British Garhwal. The remaining part has been known as Tehri Garhwal and was ruled by Panwar dynasty up to 1949. After independence the entire Garhwal was placed under a separate commissioner of Kumaun in Uttar Pradesh. It had two districts Pauri Garhwal and Tehri Garhwal. In early 1960 each district was divided into two and total four districts namely Pauri Garhwal, Chamoli Garhwal, Tehri Garhwal and Uttarkashi came into existence. Later on, in 1968 district Dehradun was carved out from Meerut division and merged in the Garhwal. All these five districts were placed under a separate commissioner of Garhwal division in 1969.

In 1998 district Rudraprayag has been curved out from district Pauri, Tehri and Chamoli and 6th district existed under the Garhwal division. In 2000 a separated state Uttaranchal was curved out from Uttar Pradesh, which was formed by two divisions – Garhwal and Kumaun and a part of Meerut division.

13.2 ETHNOGRAPHY

The catchment area and influence zone are inhabited predominantly by ‘Bhotiyas’ with other Hindu groups. Bhotiyas account for over 80% of the total population. The word “Bhotiya” itself comes from “Bo” which is the native Tibetan word for Tibet. The Bhotiyas of Dhauliganga valley are further subdivided into the Marchas and Tolchas. Marchas are traditionally traders while Tolchas are farmers. The Marcha live mainly in the Mana valley and sparsely in Niti valley on the cold and dry tracts. Though Marchas speak a Garhwali language, their facial features suggest some intermarriage with the Indians. Because they originally migrated from Tibet, the Marcha follow Hinduism, worship in Hindu temples, and rely on the Hindu Brahmins to conduct religious ceremonies. Traditionally, most Marcha were nomadic shepherds and herders. Typically the men work as shepherds rearing sheep and goats, while the women stay in the villages tending the fields. Crops grown in these high mountain areas include rajma (beans), aloo (potatoes), mutter (peas) as well as several different varieties of grains. These animals graze on the rich alpine pastures in the summer, and move to lower altitudes in the winter. The herders sell wool, meat, and milk to earn a living.

The Tolcha-Bhotiya sub community belonging to Indo Mongoloid ethnic group, resembling much more closely to the Indian Jaunsari than the Tibetans. They are also Hindu. All households of Tolcha Bhotiya community do still follow the centuries old transhumant culture entailing two permanent settlements. Their summer homes are located as high as 3600 m. while in chilling winters they come down to lower valleys sprawled at an altitude of 800 to 1500 m.

13.3 PROJECT

Proposed Jelam Tamak H.E Project is located on the Dhauliganga river in Joshimath sub division of Chamoli district in Uttarakhand. Brief socio-economic profiles of Chamoli district and Joshimath sub – division are given in following paragraphs.

The total population of district Chamoli is 3,70,359 with a sex ratio of 1015. About 86.3% of the total population inhabits the rural areas. Total literacy rate of district is 75.4% with maximum in males. The population structure is comprised of Brahmins, Rajputs, Scheduled caste (SC) and Scheduled tribe (ST). SC and ST population account for 18.2% and 2.8% of total population, respectively. The scheduled tribe population is composed mainly of Marchha bhutias and Tolchha bhutias.

Joshimath is one the largest tehsils of Chamoli district in term of area. It is comprised of 93 villages and 27 notified wards. Total population of tehsil is 39,919 with a sex ratio of 774. Literacy rate of Joshimath tehsil is 78.8%. About 62.7% of the total population is rural. The population structure is comprised of Brahmins, Rajputs, Scheduled caste and Scheduled tribe. SC and ST populations account for 13.4%and 14.3% of the total population. Most of the Scheduled tribe population of the district inhabits Joshimath tehsil, it accounts for 54.4% of total ST population.

13.4 VILLAGE LOCATED IN INFLUENCE ZONE

13.4.1 Demography

A total of 14 villages are located in the influence zone of Jelam Tamak H.E. project (Table 13.1). Total population of these villages is 2034 come from 517 households (Census, 2001). The sex ratio in these villages is 1007; is more than district, state and National averages. Age group 0-6 year accounts for 15.50% of the total population. Scheduled caste population forms small part of the population and restricted in 5 villages only. The influence zone is dominated with Scheduled tribe population, accounting for 78.6% of the total population.

Table 13.1 Demographic profile of the villages located in 10 km radius of proposed project

		Population structure						
Villages	**HH**	**T**	**M**	**F**	**P_06**	**SC**	**ST**	**Sex ratio**
Kosa	48	194	99	95	25	29	164	959
Jelam	85	315	164	151	39	0	310	920
Jumma	27	98	54	44	8	2	78	814
Kaga Laga Dronagiri	14	58	30	28	8	0	58	933
Garpak	8	33	19	14	3	0	33	736
Dronagiri	42	89	47	42	8	3	86	893
Bhalgaon	39	205	92	113	43	0	0	1228
Longsagari	20	67	31	36	9	0	67	1161
Pagrasu	27	94	47	47	21	0	92	1000
Tolma	36	145	84	61	30	23	90	726
Sukhi	37	163	79	84	33	35	126	1063
Juwagwar	18	78	37	41	14	0	78	1108
Lata	75	342	150	192	52	59	277	1280
Raini Chak Lata	41	153	82	71	21	0	141	865
Total	**517**	**2034**	**1015**	**1019**	**314**	**151**	**1600**	**1007**

13.4.2 Literacy

All villages of influence area have facilities of primary schools while middle schools are located in Lata, Raini and Jelam. High schools and senior secondary schools are absent in these villages (Table 13.2). Tapovan and Joshimath are the nearest centres of senior secondary education while Joshimath, Karanprayag and Srinagar are the centres of higher education. Average literacy rate in these villages is 66.9% with considerably higher in males (83.35%).

Table 13.2 Education profile of the villages located in 10 km radius of the proposed project

Villages	**No. of Schools**				**Literacy rate (%)**		
	P	**M**	**HS**	**SS**	**Total**	**Male**	**Female**
Kosa	1	0	0	0	72.19	87.64	55.00
Jelam	3	1	0	0	67.03	82.31	49.61
Jumma	1	0	0	0	73.33	85.71	58.54
Kaga Laga Dronagiri	1	0	0	0	64.00	81.48	43.48
Garpak	1	0	0	0	53.33	62.5	42.86
Dronagiri	2	0	0	0	58.02	86.04	27.02
Bhalgaon	1	0	0	0	61.73	85.33	41.38

Longsagari	1	0	0	0	53.45	82.14	26.67
Pagrasu	1	0	0	0	68.49	88.57	50.00
Tolma	1	0	0	0	66.09	77.61	50.00
Sukhi	1	0	0	0	70.00	83.61	57.97
Juwagwar	1	0	0	0	75.00	93.75	56.25
Lata	1	1	0	0	60.34	72.27	52.05
Raini Chak Lata	1	1	0	0	87.88	97.06	78.13
Total	**15**	**3**	**0**	**0**	**66.90**	**83.35**	**50.30**

13.4.3 Land Use Pattern

Total land of these villages is 54807 ha in which major area comes under settlement area, which is not included in the table. The forest land account for 6.7% of total land (Table 13.3). The forest land is used for livelihood like fodder, fuel wood, pasture etc. Agriculture land accounts only for 1.3% of the total land. Total land is unirrigated.

Table 13.3 Land Use pattern in the villages located in the 10 km radius of proposed dam

		Land (in ha)			
Villages	**Total**	**Forest**	**Unirrigated**	**Waste**	**ANAC**
Kosa	2063	63	40	0	507
Jelam	15436	3	143	627	45
Jumma	659	11	13	57	11
Kaga Laga Dronagiri	1582	162	5	127	346
Garpak	1120	13	4	55	21
Dronagiri	26593	11	37	14	28
Bhalgaon	178	79	5	47	47
Longsagari	419	168	90	5	20
Pagrasu	258	148	74	20	16
Tolma	208	13	21	14	50
Sukhi	445	282	58	15	90
Juwagwar	3322	1724	167	1350	81
Lata	2381	951	93	0	0
Raini Chak Lata	143	56	11	34	0
Total	**54807**	**3684**	**761**	**2365**	**1262**

ANAC = Area not available for cultivation

13.4.4 Crop and Occupation Pattern

Maize, millets, beans, potato and spices are main crop in the area. In addition, certain species like Chippi or Gandrayani (*Angelica glauca*) and Kut (*Sausssurea costus*) are cultivated mainly for local consumption. The people are engaged in various other occupations. Nearly 49% people form the workers in these villages in which 71% are main workers (Table 13.4). Agriculture, sheep and goat rearing, government jobs and labour work are main occupation in these villages. Homespun wool and woolen items have long been produced and knit by women to supplement family income. A few families are engaged in extracting the minor forest products like Pharan (spice) and other medicinal plants for small scale commercial purpose.

Table 13.4 Occupation pattern in the villages located in 10 km radius of proposed project.

Villages	Work Force			Main Workers			Marginal W.			Non Worker		
	T	M	F	T	M	F	T	M	F	T	M	F
Kosa	94	43	51	66	28	38	28	15	13	100	56	44
Jelam	170	90	80	160	84	76	10	6	4	145	74	71
Jumma	61	33	28	29	28	1	32	5	27	37	21	16
Kaga Laga Dronagiri	33	17	16	2	1	1	31	16	15	25	13	12
Garpak	22	12	10	1	0	1	21	12	9	11	7	4
Dronagiri	63	31	32	5	5	0	58	26	32	26	16	10
Bhalgaon	88	52	36	87	51	36	1	1	0	117	40	77
Longsagari	4	4	0	2	2	0	2	2	0	63	27	36
Pagrasu	28	16	12	21	11	10	7	5	2	66	31	35
Tolma	69	43	26	36	30	6	33	13	20	76	41	35
Sukhi	79	38	41	73	34	39	6	4	2	84	41	43
Juwagwar	42	20	22	33	20	13	9	0	9	36	17	19
Lata	170	72	98	167	70	97	3	2	1	172	78	94
Raini Chak Lata	80	38	42	31	29	2	49	9	40	73	44	29
Total	1003	509	494	713	393	320	290	116	174	1031	506	525

13.4.5 Health Status and Predominant Diseases

The influence zone is poor in health facilities. Child welfare centres are located in Bhalgoan and Lata villages while health centre is located in Bhalgoan. To avail the facilities of hospital people have to move Joshimath, distanced about 20–40 km. The prevalent diseases in the area are tuberculosis, rheumatism and asthma. In addition to the allopathic system of medicines (not common), the dependence on traditional health care system is reported to be over 80%. The important medicinal plants used in traditional health care system are Khirku, Biskanara, Jatasmasi, Bhainkal, Pharan, Bhojpatra, etc., respectively. These medicines are used to care the disease like fever, headache, dyspepsia, jaundice, pregnancy complications, asthma cold and cough. The entire area is located in low temperature zone, so that possibility of water born diseases is negligible. During the field survey, no water borne disease was observed.

13.4.6 Other Amenities

All villages in influence zone are electrified. The villages are located along sided the State highway from Joshimath to Malari. The distance of these villages from road ranges from a few meters to 4 km. All villages have tap water facilities. Generally villagers use a common post to access the drinking water. The branch post offices are located in Lata, Raini and Jelam villages. They cater to all villages in influence zone.

13.5 AFFECTED VILLAGES

A total of three villages are affected due to the various project activities. Detailed socio-economic profile of these villages, mainly based on Census 2001, is given below.

13.5.1 Jelam Village

Jelam is nearest village of proposed barrage site, located on the right bank of Dhauliganga river. It comprises Jelam, Dungri, Kuthar and Sengla. Village Jelam is spread over 15,436 ha land, of which 143 ha is used for agriculture. Total population of Jelam village is 315 comes from 85 households. The sex ratio of Jelam village is 920. Out of 85 households, 84 belong to Scheduled tribe (98% of total population). Majority of the population belongs to Tolcha Bhotiya community. Age group 0-6 year accounts for 12.3% of total population. Average literacy rate is nearly 67%. About 54% of total population is engaged in various works including government jobs, agriculture, etc. Village has tap water facilities, well connected with state highway. The village is electrified. A primary school and a branch post office are located within village boundary. Main crops grown in the village are millets, potato, beans and rice. Homespun wool and woolen items also contribute to the family income. In chilling winter all inhabitants descend to lower reaches along with their livestock. They generally settle near Nandprayag area. The land of Jelam village has to be acquired for dumping areas and colony area is 4.28 ha as naap land. Total 8 households will be affected. Details of the affected land is given in Table 13.5.

13.5.2 Jumma Village

Jumma village is located on the right bank of Dhauliganga river. It is located on a land cover of 659 ha, in which 13 ha is used for cultivation. Total population of Jumma village is 98 belong to 27 households. The sex ratio is 814, considerably lower than district and sub district averages. SC and ST communities account for 2% and 79.5% of the total population. The average literacy rate is 73.33% with maximum in male population. Education is catered to a primary school only. About 62.2% of the total population is employed in various works. Village has tap water facilities, well connected with state highway. The village is poorly electrified. Main crops grown in the village are millets, potato, beans and rice. Homespun wool and woolen items also contribute to the family income. In winter season people migrate to lower reaches along with their livestock. They settle at Kaleshwer and Karanprayag areas. The land of Jumma village to be acquired for dumping areas, contractor and labour colony area is 3.34 ha. Total 6 households will be affected due to various project activities (Table 13.5).

13.5.3 Longsagari Village (Tamak)

Longsagari village is located on the right bank of Dhauliganga river and is nearest village of proposed power house. Earlier the village was located on the left bank of the river. Due to frequent land slide and flood, village had to displace to the left bank. Total area of the village is 419 ha, in which 90 ha is used for cultivation. Total population of Longsagari is 67 of 20 households. The average sex ratio is 1161. All households belong to Scheduled tribe community, which comprises of Tolcha Bhotiya. It records very low literacy rate (53.45%) with considerably high in male population. Among the other amenities, only a primary school is located in the village. The village is poorly electrified. It is supplied with tap water facility. The state highway passes through the village. About 6% people come under the worker category. Unlike other upstream villages, inhabitants of Longsagari do not descend to lower reaches in winter season. The land of Longsagari village to be acquired for proposed power house complex is 0.36 ha as naap land. A total of 17 households are displaced with the population of 56 comprising 31 families as per NPRR 2007. These families are residing on civil soyam land (1.81 ha) since their shifting from original habitats near Markoda due to devastating, avalanche/ land slide which destroyed the life and property. These villagers will need to be covered under R&R policy of THDC/NPRR 2007 (Table 13.5).

13.5.4 Dronagiri

Dronagiri revenue village is located on the left bank of Dhauliganga river and comprises of four villages namely Dronagiri, Garpak, Kaga, and Ruing. Total area of these villages is 29295 ha with maximum in Dronagiri village. As per Census 2001 total population of these villages is 180, comes from 64 households. More than 98% of the total population comprises scheduled tribe population. Two primary schools cater to the primary education of these villages. The villages are non-electrified. It is supplied with spring water facility. The villages are far away from the state highway. To cope the low temperature in winter season villagers move to lower reaches of Alaknanda valley. No naap land will be acquired from the Dronagiri revenue village, however 9.8 ha van panchayat land of these villages will be affected due to various project activities. Thus, Dronagiri revenue village is not directly affected but needs to be compensated for their rights and privileges on van panchayat land Table 13.5).

Table 13.5 Details of the land to be acquired for Jelam Tamak H.E. project

Village	Forest land (ha)	Van Panchayat Land (ha)	Naap Land (ha)	Total Land (ha)
Jelam	67.81	-	4.28	72.09
Jumma	1.17	-	3.34	4.51
Longsagari (Tamak)	9.51	-	0.36	9.87
Dronagiri	-	9.80	-	9.80
Total	**78.49**	**9.80**	**7.98**	**96.27**

13.6 AFFECTED FAMILIES

A total of 47 households from three villages are directly affected due to various project components of Jelam Tamak H.E. Project. As per the definition of NPRR (2007) total 94 families reside these villages. Out of 47 households total 31 families of 17 households belonging to Longsagari village are displaced. Only one household is common under between category of displaced and project affected. Detailed socio-economic profile of affected families is given in following paragraphs.

13.6.1 Demography

Total population of affected families of proposed project is 217 with average sex ratio of 1028 (Table 13.6). All population comes from Scheduled tribe families. Age group 0-6 year accounts for 6.4% of the total population. Longsagari village records maximum affected persons, in which 17 households are displaced and 16 are affected due to land acquisition. One household is common between these categories.

Table 13.6 Demographic profile of the project affected families due to Jelam Tamak H.E. Project

			Population structure					
Villages	**HH**	**Families**	**Total**	**Male**	**Female**	**0-6 yrs**	**ST**	**Sex R.**
Jelam	8	16	32	15	17	02	32	1133
Jumma	6	18	73	34	39	05	73	1147
Longsagari	33	60	112	58	54	07	112	931
Total	**47**	**94**	**217**	**107**	**110**	**14**	**217**	**1028**

13.6.2 Literacy

Average literacy rate in affected families is 79.2%, which is higher than district average and average of influence area. Literacy rate is considerably higher in male population. Around 18.8% of the affected persons has got higher education (Table 13.7).

Table 13.7 Literacy rate in projected affected families of Jelam Tamak H.E. Project

	No. of individuals under various categories							
Village	**Pri**	**Mid**	**HS**	**SS**	**UG**	**PG**	**Total**	**Literacy (%)**
Jelam	11	6	4	2	6	0	29	96.67
Jumma	12	7	13	16	16	1	65	95.59
Longsagari	17	25	11	7	12	6	78	74.29
Total	**40**	**38**	**28**	**25**	**34**	**7**	**172**	**79.2**

Pri = Primary, Mid = middle, HS = high school, SS = senior secondary, UG Under graduate, PG = post graduate level of education

13.6.3 Occupation Pattern

Nearly 46% of the total population is employed in various works; the majority is engaged in cultivation and agricultural practice (Table 13.8). Only 11.9% of the total population is employed in government or private jobs. Only one person from Jelam village is beneficiary of pension while three families from these villages have taken small scale business.

Table 13.8 Occupation pattern in the affected households of Jelam Tamak H.E. Project

	Occupation Classes						
Village	**Govt/Pvt.**	**Pens.**	**Cultiv.**	**Busi**	**Laborers**	**Total**	**(%)**
Jelam	3	1	7	1	0	12	38
Jumma	14	0	20	1	0	35	48
Longsagari	9	0	43	1	0	53	47
Total	**26**	**1**	**70**	**3**	**0**	**100**	**46**

13.6.4 Livestock Population

Livestock population of affected families comprises of cows, goats, ox, and buffaloes (Table 13.9). Cows are reared almost by all families. Cows are major source of milk in the affected villages. The commercial production of milk is nil among these families. A few families of Jumma village keep buffaloes for milk purpose.

Table 13.9 Livestock population in the affected households of Jelam Tamak H.E. Project

Village	Cow	Ox	Goat	Buffalo	Chiken	Total
Laung Sangdi	55	10	4	0	0	69
Jelam	2	0	0	0	0	2
Jumma	5	2	0	2	0	9
Total	**62**	**12**	**4**	**2**	**0**	**80**

13.6.5 Vulnerable persons

Vulnerable category includes old age fellows (above 50 years), BPL families, widow and physically handicapped. Old age fellows account for maximum vulnerable persons. In addition, 19 households are BPL card holders while 11 persons are widow (Table 13.10).

Table 13.10 Vulnerable persons in the families of Jelam Tamak H.E. Project

Village	BPL	Widow	Handicapped	Senior citizen
Laung Sangdi	16	9	00	25
Jelam	0	2	00	2

Jumma	2	3	00	5
Total	**19**	**11**	**00**	**32**

13.6.6 Concerns of Dronagiri

Dronagiri revenue village is located on the left bank of Dhauliganga river. It comprises of Dronagiri (proper), Garpak and Kaga villages. Though none of the private land of these villages is affected due to Jelam Tamak H.E. project, however, due land acquisition of Panchayat land (community land) on which villagers have their right and privileges. Due to acquisition of 9.8 ha panchayat land these villages have been considered as affected villages. Total population of these villages is 807 belonging to 145 families (Family register) with maximum in Dronagiri (Table 13.11) and Annexure-V.

Table 13.11 Population structure of Dronagiri revenue village

Village	Total No. of Family	Total Population	Male	Female	Above 18 yrs*
Dronagiri	105	565	299	266	163
Garpak	16	100	55	45	33
Kaga	24	142	71	71	40
Total	**145**	**807**	**424**	**382**	**236**

13.7 QUALITY OF LIFE

The residents of villages Kosa, Jalam, Jumma, Kaga Laga Dronagiri and Garpak (located in influence area) descend in lower reaches of Chamoli district to cop peak winter. They are located in various hamlets and villages like Mangroli, Paunkhila, Kaleshwer, Karnprayag and Mathiyana Pursari of Karanprayag, Nandprayag and Chamoli sub divisions of the district. However, their revenue records are under the jurisdiction of Joshimath sub division. All villagers have *pucca* houses, mostly made up of stone masonry. Road network and transportation are poor and all villagers depend on a single State Highway. All villages of influence area have primary education facilities but lack secondary and senior secondary education facilities. Health facilities are also poor in the region; Joshimath (30-60 km) avails this facility to the villagers. Majority of the villages are electrified but power supply in these villages is not satisfactory. Villagers depend on spring water and tap water; none of the family exploits river water for the drinking purpose.

The region is poor in telecommunication facilities as cellular phone network is not available in these villages. Television and radio are the means of entertainment. Only 28% of the families have access to these facilities. Survey of affected families reveals that wood is main fuel in the influence area; all families are found to use wood as fuel. Among the affected households nearly 40% households have access to LPG. The remotely located villagers like residents of Kaga Laga Dronagiri, etc. are not consumers of this facility.

The migrant populations have relatively rich amenities in their households located in lower reaches. At these villages all houses are *pucca* provided with electricity, many families have accesse to telecommunication facility including cellular phone facility, they have access to good education, health, transportation and market facilities.

13.8 PUBLIC PERCEPTION

During the door to door survey of affected families, a large number of people including affected persons and indirectly affected persons of surrounding villages were interviewed on their willingness to the project, merit and demerit of the project. A total of 208 persons were interviewed; all were above 18 years. All people were aware of Jelam Tamak H.E. Project. Nearly 87% of respondents were in the favour of project, 11% opposed it and 2% could not reply.

Among the affected households, a total of 71 persons were interviewed, of which 94% respondents supported the project while remaining opposed it. The proponents of the project put various conditions, in which majority was for jobs in the project. Similarly, opponents showed their distrust on the project authorities. They were worried of deterioration of their cultural values due to influx of outside workers in the area.

13.9 CONCLUSION

The surrounding of the proposed project is an abode of tribes in Uttarakhand. One of the major parts of tribal population of the state inhabits these areas. Though, they follow Hindu beliefs but have different culture and customs. People are closely associated with forest and forest is a mean of livelihood. They have incredible traditional knowledge of land races, folk variety and medicinal plants. Maize, millets, beans, potato and spices are main crops in the area. In addition, certain species like Chippi or Gandrayani (*Angelica glauca*) and Kut (*Sausssurea costus*) etc are also grown. Some of the villagers descend in lower places of Chamoli district in peak winter.

Due to adverse climatic conditions and inadequate infrastructure facilities in the area the quality of life is not satisfactory. However, in their other villages located in lower areas of district, the quality of life is relatively better.

Proposed Jelam Tamak H.E. Project would affect 46 households (List is given for 47 households because one household is common among affected and displaced families) comprise of 94 families. Among the affected households 17 would be displaced and would be rehabilitated by the project authorities. Detailed list of households and their families which are directly affected is given in Table 13.12. In addition, the families whose panchayat land will be acquired have been listed in Table 13.13

Table 13.12 List of affected families of proposed Jelam Tamak H.E. Project

S.No.	Village	Name of the Owner	Father's /Husband Name	Family Member >18 yrs	Remarks
1	Jelam (khoya Nami Tauk)	Sh. Kamlesh	Sh. Kirpa Ram	1 Sh. Kamlesh	Affected
2	Jelam (khoya Nami Tauk)	Sh. Lachmu Ram	Sh. Kamal Das	1 Sh. Lachmu Ram 2 Sh. Mahesh Chandra	Affected
3	Jelam (khoya Nami Tauk)	Sh. Chandershekhar	Sh. Vishan Ram	1 Sh. Chandershekhar	Affected
4	Jelam (khoya Nami Tauk)	Sh. Rojash Pallabh	Sh. Vishan Ram	1 Sh. Rajesh Pallabh	Affected
5	Jelam (khoya Nami Tauk)	Smt. Ramti Devi	W/o Sh. Vishan Ram	1 Smt. Ramti Devi 2 Sh. Denesh Chandra	Affected
6	Jelam (khoya Nami Tauk)	Sh. Mohan Lal	Sh. Viyashi	1 Sh. Mohan Lal 2 Sh. Arvind Lal 3 Sh. Ravinder Lal	Affected
7	Jelam (khoya Nami Tauk)	Sh. Santosh Lal	Sh. Mukandi Lal	1 Sh. Santosh Lal	Affected
8	Jelam (khoya Nami Tauk)	Smt. Basanti Devi	W/o Sh. Kishan Lal	1 Smt. Basanti Devi 2 Sh. Rajender Lal 3 Sh. Partip Lal 4 Smt Runi 5 Sh. Jitender Lal	Affected
9	Jumma	Sh. Sher singh	Lt. Sh. Alam Singh	1 Sh Sher Singh 2 Sh. Kalam Singh 3 Sh. Hitesh Singh 4 Sh. Kunwar Singh	Affected

10	Jumma	Sh. Rajesh singh	Sh. Shiv Singh	1	Sh. Rajesh Singh	Affected
11	Jumma	Sh. Man singh	Sh. Alam Singh	1 2	Sh. Man Singh Sh. Parshant Singh	Affected
12	Jumma	Sh. Pratap singh	Lt. Sh. Gobind Singh	1 2	Sh. Pratap singh Sh. Lakhpat Singh	Affected
13	Jumma	Sh. Jagat singh	Lt. Sh. Gobind Singh	1 2 3 4	Sh. Jagat singh Sh. Harender Singh Sh. Kunwar Singh Sh. Raghubir Singh	Affected
14	Jumma	Sh. Narayan singh	Lt. Sh. Gobind Singh	1 2 3 4 5	Sh. Narayan singh Sh. Gajender Singh Sh. Vijay Singh Sh. Nandan Singh Sh. Himu Singh	Affected
15	Laung Sangdi	Sh. Dhoom Singh	Sh. Thel Singh	1 2 3	Sh. Dhoom Singh Sh. Tej Singh Sh. Pushakar Singh	Displaced Displaced Displaced
16	Laung Sangdi	Smt. Sangarami Devi	W/o Sh.Chander Singh	1	Smt. Sangarami Devi	Displaced
17	Laung Sangdi	Sh. Shiv Singh Sh Bishan Singh	Sh. Thel Singh Sh Shiv Singh	1 2	Sh. Shiv Singh Bishan Singh	Displaced Displaced
18	Laung Sangdi	Sh. Nandan Singh	Sh.Shiv Singh	1	Sh. Nandan Singh	Displaced
19	Laung Sangdi	Sh. Prem Singh	Sh. Chander Singh	1	Sh. Prem Singh	Displaced
20	Laung Sangdi	Sh. Ajab Singh	Sh. Shiv Singh	1 2 3	Sh. Ajab Singh Sh. Mukesh Singh Sh. Rajesh Singh	Displaced Displaced Displaced
21	Laung Sangdi	Smt. Swari Devi	W/o Sh. Gopal Singh	1 2	Smt. Swari Devi Sh. Rai Singh	Displaced Displaced
22	Laung Sangdi	Sh. Ram Singh	Sh. Kanak Singh	1	Sh. Ram Singh	Displaced
23	Laung Sangdi	Sh. Hayat Singh	Lt. Sh. Thel Singh	1 2 3	Sh. Hayat Singh Sh. Darwan Singh Sh. Gaber Singh	Displaced Displaced Displaced
24	Laung Sangdi	Sh. Hukum singh	Sh. Ram Singh	1 2	Sh. Hukum singh Sh. Manoj Singh	Displaced Displaced
25	Laung Sangdi	Sh. Kalyan Singh	Sh. Shiv Singh	1	Sh. Kalyan Singh	Displaced
26	Laung Sangdi	Sh. Nathi Singh	Gopal Singh	1	Sh. Nathi Singh	Displaced
27	Laung Sangdi	Sh. Hukum singh	Sh. Hayaat Singh	1	Sh. Hukum singh	Displaced
28	Laung Sangdi	Sh. Dhan Singh	Sh. Aalam Singh	1 2 3 4	Sh. Dhan Singh Sh. Kedaar Singh Sh. Bharat Singh Sh. Puran Singh	Displaced Displaced Displaced Displaced
29	Laung Sangdi	Sh. Lakshman Singh	Sh. Dhan Singh	1	Sh. Lakshman Singh	Displaced
30	Laung Sangdi	Sh. Ashad Singh	Sh. Kanak Singh	1 2	Sh. Ashad Singh Sh. Devender Singh	Displaced Displaced

31	Laung Sangdi	Sh. Madan Singh	Sh. Chander Singh	1 Sh. Madan Singh 2 Sh. Dinesh Singh	Displaced Displaced
32	Laung Sangdi	Smt. Maita Devi	W/o.Lt. Sh. Paan Singh	1 Smt. Maita Devi	Affected
33	Laung Sangdi	Sh. Jaye Singh	Sh. Gopal Singh	1 Sh. Jaye Singh	Affected
34	Laung Sangdi	Sh. Har Singh	Sh. Shoniya Singh	1 Sh. Har Singh	Affected
35	Laung Sangdi	Sh. Kutal Singh	Sh. Shoniya Singh	1 Sh. Kutal Singh 2 Sh. Jagat Singh 3 Sh. Amar Singh	Affected
36	Laung Sangdi	Sh. Pat Gul Singh	Sh. Shoniya Singh	1 Sh. Pat Gul Singh	Affected
37	Laung Sangdi	Sh. Dhan Singh	Sh. Aalam Singh	1 Sh. Dhan Singh 2 Sh. Kedar Singh 3 Sh. Bharat Singh 4 Sh. Puran Singh	Affected
38	Laung Sangdi	Sh. Bhawan Singh	Sh. Kartig Singh	1 Sh. Bhawan Singh 2 Sh. Ashish Singh	Affected
39	Laung Sangdi	Sh. Bachan Singh	Sh. Kartig Singh	1 Sh. Bachan Singh 2 Sh. Nitin Singh	Affected
40	Laung Sangdi	Sh. Ranjeet Singh	Sh. Kartig Singh	1 Sh. Ranjeet Singh 2 Sh. Rakesh Singh 3 Sh. Mukesh Singh	Affected
41	Laung Sangdi	Sh. Dharam Singh	Sh. Kalam Singh	1 Sh. Dharam Singh 2 Sh. Meharbaan Singh	Affected
42	Laung Sangdi	Sh. Anand Singh	Lt. Sh. Gyan Singh	1 Sh. Anand Singh 2 Sh. Pushakar Singh	Affected
43	Laung Sangdi	Sh. Dev Singh	Lt. Sh. Gyan Singh	1 Sh. Dev Singh	Affected
		Smt Naurati Devi	W/o Lt Sh Gyan Singh	2 Naurati Devi	Affected
44	Laung Sangdi	Buddh Singh	Lt. Sh. Gyan Singh	1 Sh. Buddh Singh	Affected
45	Laung Sangdi	Sh. Hira Singh	Sh. Krit Singh	1 Sh. Hira Singh	Affected
46	Laung Sangdi	Smt. Hira Devi	W/o Lt. Sh. Paan Singh	1 Smt. Hira Devi	Affected
47	Laung Sangdi	Sh. Shankar Singh Smt Sangrami Devi	Sh. Fathe Singh W/o Lt Fathe Singh	1 Sh. Shankar Singh 2 Sngrami Devi	Affected Affected

Chapter 14

ENVIRONMENTAL FLOW ASSESSMENT

14

ENVIRONMENTAL FLOW ASSESSMENT

14.1 INTRODUCTION

Environmental flow is the amount of water to be released in the downstream section of the river to maintain the ecosystem integrity and socio-economic needs. The environmental flow is a complex subject and requires an integrated knowledge of engineering, hydrology, ecology, economy etc (e.g. IUCN 2003). Significantly, it also requires negotiations between stakeholders of downstream area. The concept of application of environmental flow is new in India, which has emerged due to a large number of hydroelectric projects, proposed on Indian rivers especially in Himalaya.

The Barrage site of Jelam Tamak H.E. Project is located around 52 km from Joshimath on river Dhauliganga at 2623.50 m. elevation. The water will be diverted through an HRT of 4.428 km length.

EAC, MOEF in their 52nd meeting held on 16-17th September 2011 had directed THDC to take a conscious decision to release a minimum 5 cumec in Monsoon. THDC agreed for the same. Subsequently EAC, MOEF in its 54th meeting held on 26-27th December 2011 had directed THDC to carryout and submit the cumulative optimization of power potential of the three projects i.e. upstream project of Malari Jelam of 114 MW and downstream 252 MW Tamak Lata projects including the present Jelam Tamak project (128 MW) to arrive at an environmentally viable solution. During the above meeting THDC agreed for an Environmental flow of 5 cumecs in monsoon and 2.97 cumecs in rest of the season. Accordingly the cumulative power potential studies of all the 3 projects was carried out by THDC and UJVNL and submitted to EAC, MOEF in its 57th meeting held in April 2012 with installed capacity of the up stream project i.e. Malari Jelum HEP as 65 MW (reduced from 114 MW), the present intermediate Jelam Tamak Project with installed capacity of 108 MW (reduced from 128 MW) and the down stream project i.e Tamak Lata HEP with installed capacity of 190 MW (reduced from 250 MW).

Based on the above the river stretch of nearly 5 km of JT HEP (108 MW) would receive the environmental flow releases of 5 cumecs during monsoon season and 2.97 cumecs in rest of the season as approved by EAC, MOEF in their 54th meeting held on 26-27 December 2011.

Additionally on immediate down stream of the proposed Jelam Tamak Barrage the Environment flow will be joined by 2 major Gadheras viz Dronagiri Gadhera (at 0.52 KM.) and Jumma Gad (at 3.60 KM) From these Gadheras an average discharge of 10.24 cumecs is added in the river in addition to 2.97 cumecs of environmental flow from the Barrage, totaling 13.21 cumecs between the Barrage and TRT in the small river stretch of around 5 KM. Subsequent to the approval of the configuration and the revised installed capacity of all the 3 projects based on the cumulative optimization of the power potential by EAC, MOEF in its 57th meeting held in April 2012, the power potential studies have been approved by CEA New Delhi for the Jelam Tamak HEP for the installed capacity of 108 MW in August 2012.

The above river stretch is a fishless zone. Though adequate quantity of water is available in the river between Barrage and TRT outlet, it was thought prudent to carry out model studies/flow analysis for assessment of the adequacy of depth of water column, width of channel and water current velocity for biotic communities for the 5 km river stretch in downstream of barrage of Jelam Tamak Hydro Electric Project (108 MW).

14.2 METHODOLOGY

In this study 11 cross-sections within 5 km stretch were used for the downstream flow analysis (**Fig. 14.1**). These cross-sections were surveyed at an interval of 500 m. The plot of cross-sections, river profile with cross-sections and river gradient profile are given in **Appendix-I**. HEC-RAS 4.1.0 was used for modeling the downstream environmental flow. Therefore, the results were accomplished by simulating the recommended downstream flows on the basis of hydrological and hydraulic bases to draw the geomorphological attributes (depth of water column, width of the channel and water current velocity) of the river in downstream sections. HEC-RAS model is an integrated system of software, designed for interactive use in a multi-tasking environment. The system is comprised of a graphical user interface, separate hydraulic analysis components, data storage and management capabilities, graphics and reporting facilities. The present version of HEC-RAS contains three one-dimensional hydraulic components for: i) steady flow surface computations; ii) quasi unsteady flow simulation and iii) unsteady flow simulation. The steady/unsteady flow components are capable of modeling sub-critical, supercritical and mixed flow regime water surface profiles. The system can handle a full network of channels, a dendric system, or a single river reach. The basic computational procedure is based on the solution of one-dimensional energy equation. Energy losses are evaluated by friction (Manning’s equation) and contraction/ expansion (coefficient multiplied by the velocity head).

The momentum equation is utilized in situations where the water surface profile is rapidly varied. The graphics include X-Y plots of the river system schematic, cross-sections, profiles, rating curves, hydrographs and many others variables. The output of the model can be displayed in tabular form.

14.2.1 Data Editing

Before the analysis a quality check was performed on the geometry data (River profile and Cross-sections) to ensure no erroneous and redundancy information in the cross-sections and the river profile. Later the geometric editor was used to perform the quality check. The best tool for editing cross-sections in HEC-RAS is the graphical cross-section editor. Left bank and right bank stations in the cross-sections sections were modified using the cross section editor.

14.2.2 Entering the Flow Data

In the main HEC-RAS window discharge data for 12 profiles (months) were applied in steady flow interface (**Fig. 14.2**). Likewise five profiles were created according to the chainage axis for the steady flow simulation for the each of the downstream discharge contributed.

a. Dam Site (0 m)
b. Dunagiri Gad (0.52 km d/s)
c. Unnamed gad (1.7 km d/s)
d. Jumma Gad (3.6 km d/s)
e. Bhosing Gad (4.04 km d/s)

Entire downstream stretch was divided into five stretch namely critical stretch (between barrage site to the confluence of first tributary), river stretch between 0.52 km d/s to 1.7 km d/s (between confluence of first and second tributaries), river stretch between 1.7 km d/s to 3.6 km d/s (between confluence of second and third tributaries), river stretch between 3.6 km d/s to 4.04 km d/s (between confluence of third and fourth tributaries) and river stretch between 4.04 km downstream to outlet. The average values of flow velocity, the average river width and flow depth were calculated for the interpretation of data.

14.3 IDENTIFICATION OF INTEREST GROUPS

Environmental flow assessment relies basically on the interest groups in the downstream. The interest groups include fish, other biotic communities (macro-invertebrates, algae, etc.), water quality, livelihood of fishermen, extraction of water for drinking purpose and irrigation, cultural and spiritual values of river water, water quality and geomorphological features of the downstream stretch. The water of river stretch between barrage and powerhouse sites is not used for drinking and irrigation and have not specific cultural and spiritual importance, Therefore, biotic communities have been considered as target group for environmental flow.

14.3.1 Biotic Communities

Among the biotic communities of Himalayan river especially in upper reaches fish is important component and this group targeted for environmental flow in general. However, the river stretch under discussion has been identified as fishless zone. None of the fish species was recorded during the primary surveys in this region. Singh et al. (1987) carried out a detailed study on the ichthyofauna of Garhwal but did include fish of Dhauligang, probably due to absence fish in this river. AHEC (2011) also indicated this area as ‘Epirhithronic’ zone (no fish zone). Thus, only algae and macro-invertebrates constitute the biotic component of the river.

River water harboured about 101 species of algae, dominated by diatoms (Bacillariophyceae). In addition,a total of 21 genera of macro-invertebrates (13 families and 4 orders) inhabited the river water. No specific study for algal species with reference to environmental flow is available. They can grow in lentic and lotic waters or even in damp places, however, vary in species composition. AHEC (2011) recommended minimum hydrological requirement for macro-invertebrates in epirhithronic zone. These values are given in Table 14.1.

Table 14.1 Minimum hydrological requirement for macro-invertebrates in Dhauliganga river (Epirhithronic zone)

Order	MD (cm)	Current velocity (m/s)
Ephemeroptera	15-30	0.5 -1.0
Diptera	20-30	0.5 – 1.0
Trichoptera	20-30	0.5 – 1.0
Plecoptera	15 - 20	> 1.0

Source: AHEC (2011): Alternate Hydro Energy Centre, IIT Roorkee

14.4 ENVIRONMENTAL FLOW

Considering the biotic communities targeted for the environmental flow assessment, the study was carried out and is described below.

In line with the decisions taken in 54th (December 2011) and 57th meeting (April 2012) of EAC, MOEF and approved power potential studies of Jelam Tamak H.E. Project (108 MW) by

CEA in August, 2012 5 cumecs of water would be released from the barrage site during mansoon (4 months June to September) while in remaining months 2.97 cumecs i.e. 20% of average water discharge of lean season has been designed. With respect to 90% dependable year, total inflow to be released from the barrage is given in Table 14.2. Dhauliganga river receives 4 nallahs on the either sides, which contribute water to main river. First tributary Dunagiri joins Dhauliganga on the left bank after 0.52 km. It contributes major discharge to Dhauliganga. Average monthly water discharge in this tributary ranges from 1.17 to 10.24 cumec. The water discharge in Dhauliganga gradually increases in the downstream course due to confluence of other tributaries like Jumma Gad aand Bhosing Gad. The monthly variation in the discharge of these tributaries is given in Table 14.3.

The simulation of flows indicated that average current velocity, average surface width and average column depth range from 0.85 to 1.74 m/s, 20.68 to 41.39 m and 0.15 to 1.02 m, respectively (Table 14.4). These channel characteristics seems adequate to river flora and fauna, especially for the nymphs of insect taxa mentioned in Table 14.1 in general.

14.5 ENVIRONMENTAL IMPLICATION & RECOMMENDATION

Due to absence of ichthyofauna in the river stretch under discussion, the environmental flow is designed for macro-invertebrates and algal species. The simulation results of different flows in the 5 km river stretch indicated the channel characteristics would be adequate for macro-invertebrates taxa mentioned in Table 14.1. Average surface width, water current velocity and column depth fulfill the requirement of these taxa. The scenario was considered on the basis of the EAC, MOEF approval in its 57th Meetings held in April 2012 for the revised installed capacity of Jelum Tamak HEP for 108 MW based on the cumulative optimization of the power potential of the 3 projects viz. up stream MJ HEP (65 MW), JT HEP (108 MW) and TL HEP (190MW) providing the Techno-Economic and Environmentally Viable Solution and also on the basis of power potential studies of Jelam Tamak H.E. project approved by CEA in August 2012 for an installed capacity of 108 MW.

From the environmental point of view being a fishless zone, no significant variation was observed in the channel characteristics and seems adequate for biotic communities found in the river stretch.

Table 14.2 Ten daily water discharge stipulated to be released from barrage site of Jelam Tamak H.E. project considering the power potential studies submitted to EAC, MOEF in April 2012 and approved by CEA in August 2012.

Month	10 daily	90% DY discharge (cumecs)	EF (cumec)	Intake discharge	Spillage (cumecs)	Total downstream discharge (cumecs)
Jun	I	64.70	5.00	57.58	2.12	7.12
	II	62.80	5.00	57.58	0.22	5.22
	III	61.00	5.00	56.00	0.00	5.00
Jul	I	60.30	5.00	55.30	0.00	5.00
	II	51.50	5.00	46.50	0.00	5.00
	III	63.40	5.00	57.58	0.82	5.82
Aug	I	63.60	5.00	57.58	1.02	6.02
	II	61.60	5.00	56.60	0.00	5.00
	III	57.40	5.00	52.40	0.00	5.00
Sep	I	52.00	5.00	47.00	0.00	5.00
	II	45.70	5.00	40.70	0.00	5.00
	III	43.40	5.00	38.40	0.00	5.00
Oct	I	42.10	2.97	39.13	0.00	2.97
	II	40.70	2.97	37.73	0.00	2.97
	III	32.30	2.97	29.33	0.00	2.97
Nov	I	32.60	2.97	29.63	0.00	2.97
	II	22.60	2.97	19.63	0.00	2.97
	III	18.60	2.97	15.63	0.00	2.97
Dec	I	16.80	2.97	13.83	0.00	2.97
	II	17.20	2.97	14.23	0.00	2.97
	III	15.30	2.97	12.33	0.00	2.97
Jan	I	15.90	2.97	12.93	0.00	2.97
	II	16.40	2.97	13.43	0.00	2.97
	III	14.30	2.97	11.33	0.00	2.97
Feb	I	13.40	2.97	10.43	0.00	2.97
	II	13.90	2.97	10.93	0.00	2.97
	III	12.90	2.97	9.93	0.00	2.97
Mar	I	12.90	2.97	9.93	0.00	2.97
	II	13.20	2.97	10.23	0.00	2.97
	III	15.70	2.97	12.73	0.00	2.97
Apr	I	16.80	2.97	13.83	0.00	2.97

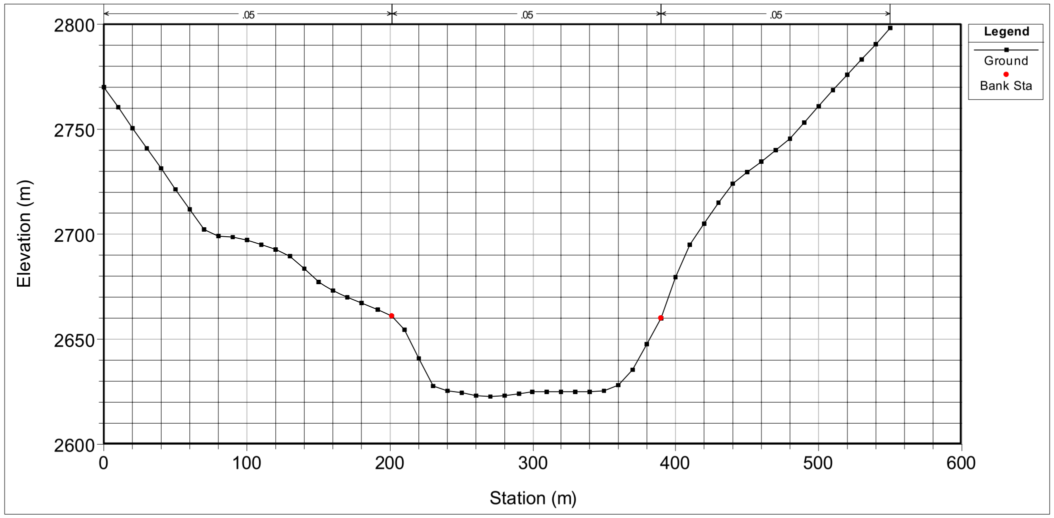
	II	22.70	2.97	19.73	0.00	2.97
	III	23.60	2.97	20.63	0.00	2.97
May	I	27.80	2.97	24.83	0.00	2.97
	II	48.40	2.97	45.43	0.00	2.97
	III	60.50	2.97	57.53	0.00	2.97

Table 14.3 Monthly variation in the water discharge of tributaries joining Dhauliganga river between Barrage and TRT (in around 5 KM river stretch)

Months	Dunagiri Gad	Unnamed Gad	Jumma Gad	Bhosing Gad
Jun	8.17	0.26	1.49	0.29
Jul	10.24	0.33	1.86	0.37
Aug	9.55	0.31	1.74	0.34
Sep	6.92	0.22	1.26	0.25
Oct	4.18	0.14	0.76	0.15
Nov	2.42	0.08	0.44	0.09
Dec	1.67	0.05	0.30	0.06
Jan	1.28	0.04	0.23	0.05
Feb	1.17	0.04	0.21	0.04
Mar	1.34	0.04	0.25	0.05
Apr	2.32	0.08	0.42	0.08
May	5.78	0.18	1.05	0.21

Table 14.4 Channel characteristics in downstream of barrage site of Jelam Tamak H.E. Project (108 MW)

Months	Critical stretch				0.52 km d/s				1.7 km d/s				3.6 km d/s				4.04 km d/s			
	WD	V	SW	D	WD	V	SW	D	WD	V	SW	D	WD	V	SW	D	WD	V	SW	D
Jun	5.78	1.02	24.35	0.25	13.95	1.27	41.39	0.29	14.21	1.71	27.63	0.32	15.70	1.09	28.38	0.52	15.99	1.21	20.68	0.96
Jul	5.27	1.00	23.84	0.24	15.51	1.31	42.22	0.31	15.84	1.76	28.67	0.33	17.70	1.12	29.58	0.54	18.07	1.25	21.15	1.02
Aug	5.34	1.11	22.86	0.23	14.89	1.32	42.38	0.30	15.20	1.74	28.28	0.33	16.94	1.11	29.14	0.53	17.28	1.23	20.98	1.00
Sep	5.00	1.00	23.73	0.23	11.92	1.24	39.84	0.27	12.14	1.65	26.20	0.29	13.41	1.05	26.86	0.48	13.66	1.16	20.11	0.89
Oct	2.97	0.85	20.83	0.18	7.15	1.07	36.46	0.21	7.29	1.48	22.18	0.23	8.05	0.93	22.61	0.40	8.19	1.01	18.13	0.69
Nov	2.97	0.85	20.83	0.18	5.39	0.97	35.18	0.18	5.47	1.37	20.36	0.20	5.92	0.86	20.30	0.35	6.00	0.94	17.03	0.59
Dec	2.97	0.85	20.83	0.18	4.64	0.95	35.09	0.16	4.69	1.33	19.41	0.19	5.00	0.83	19.11	0.33	5.06	0.90	16.41	0.55
Jan	2.97	0.85	20.83	0.18	4.25	0.95	33.80	0.15	4.29	1.30	18.92	0.18	4.52	0.81	18.41	0.31	4.56	0.88	16.07	0.52
Feb	2.97	0.85	20.83	0.18	4.14	0.91	34.13	0.16	4.18	1.29	18.77	0.18	4.40	0.81	18.23	0.31	4.44	0.87	15.98	0.51
Mar	2.97	0.85	20.83	0.18	4.31	0.90	34.34	0.16	4.36	1.30	19.00	0.18	4.60	0.82	18.53	0.32	4.65	0.88	16.12	0.53
Apr	2.97	0.85	20.83	0.18	5.29	0.99	35.89	0.18	5.36	1.37	20.18	0.20	5.79	0.86	20.14	0.35	5.87	0.93	16.94	0.59
May	2.97	0.85	20.83	0.18	8.75	1.13	37.71	0.23	8.94	1.54	23.69	0.26	9.99	0.98	24.33	0.43	10.19	1.07	18.99	0.77



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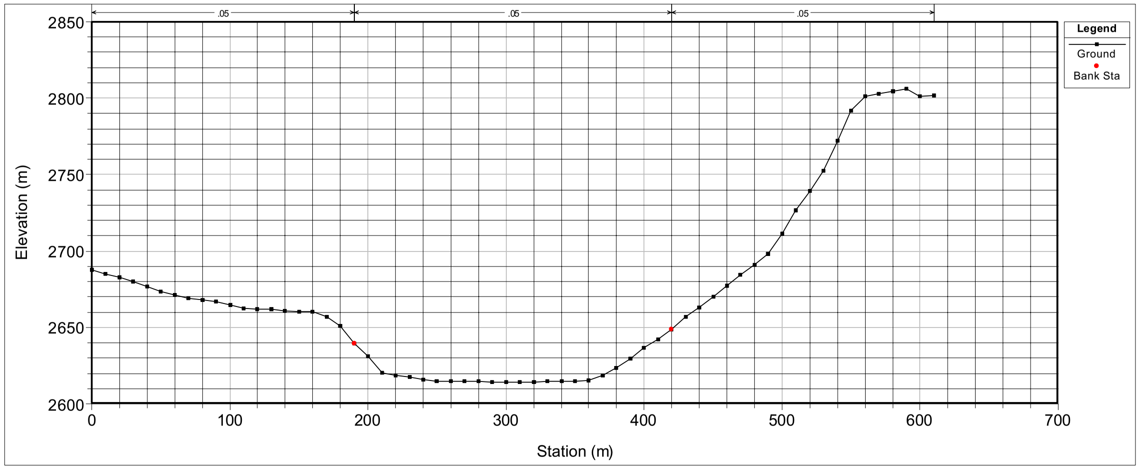

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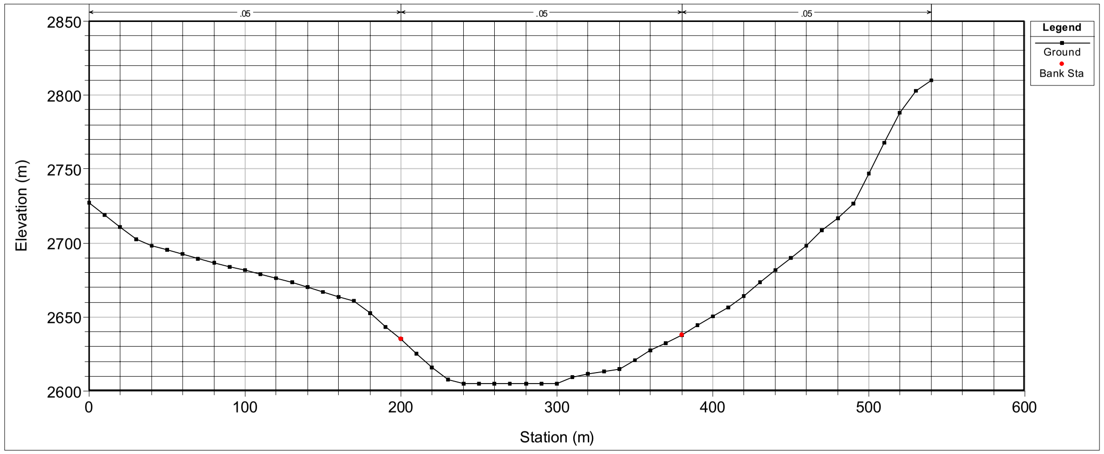

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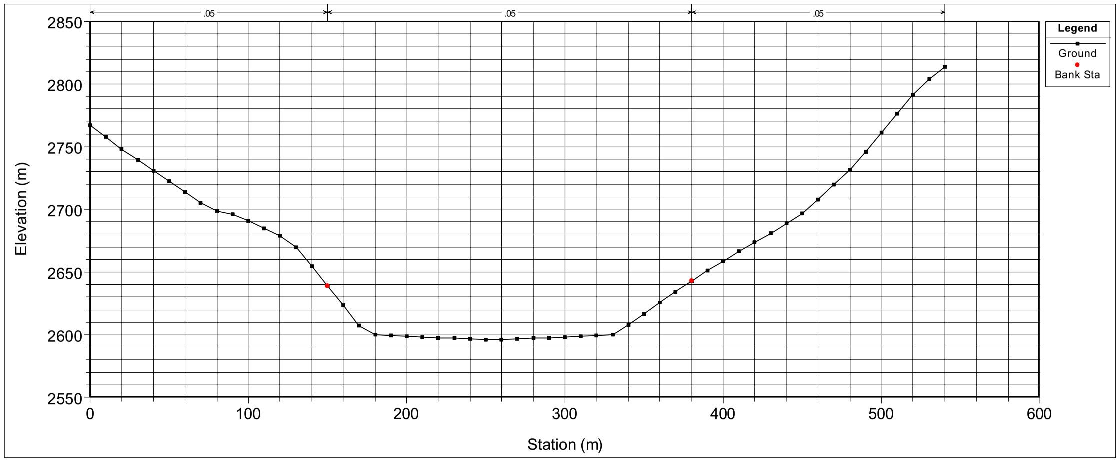

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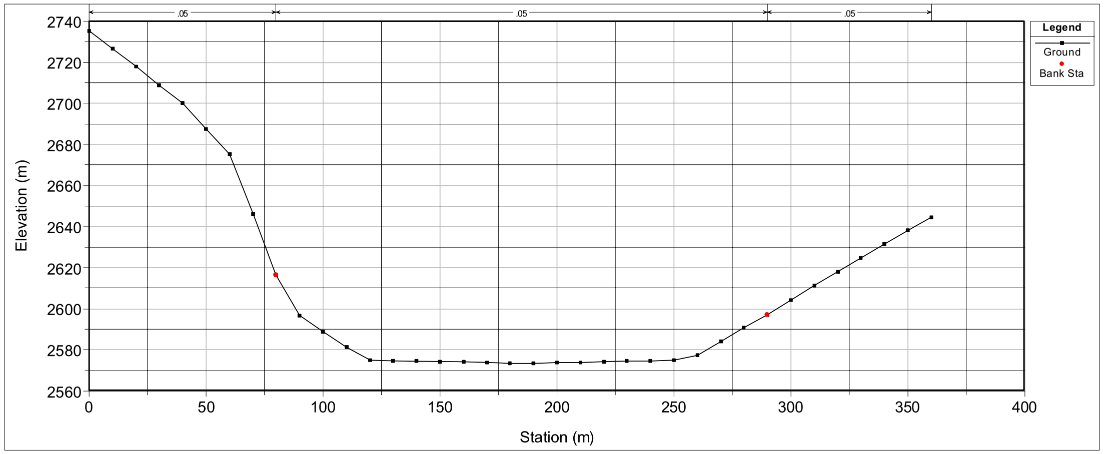

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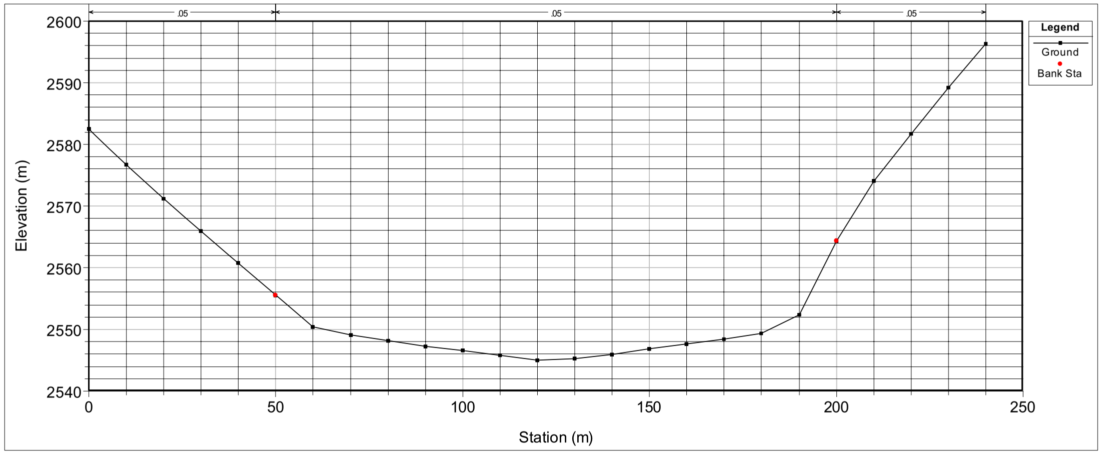

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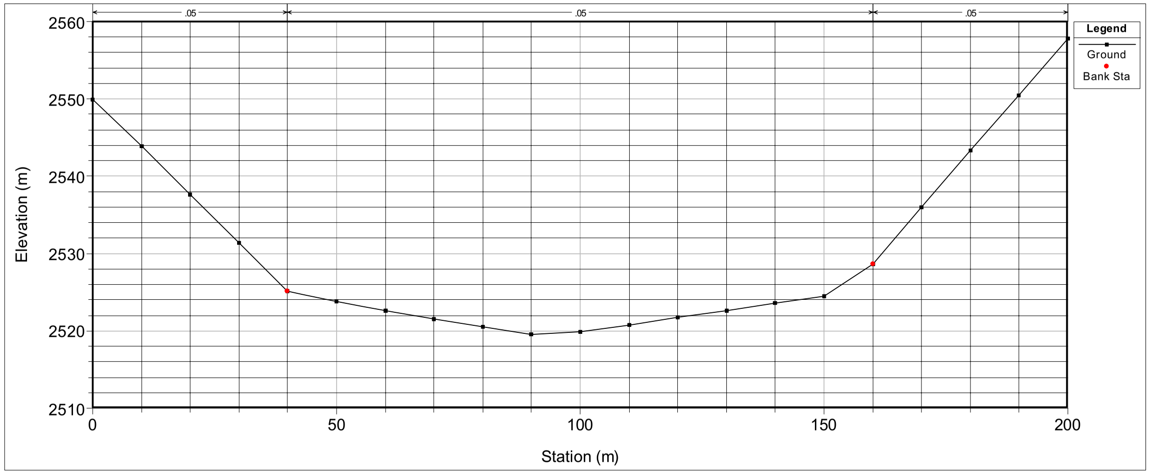

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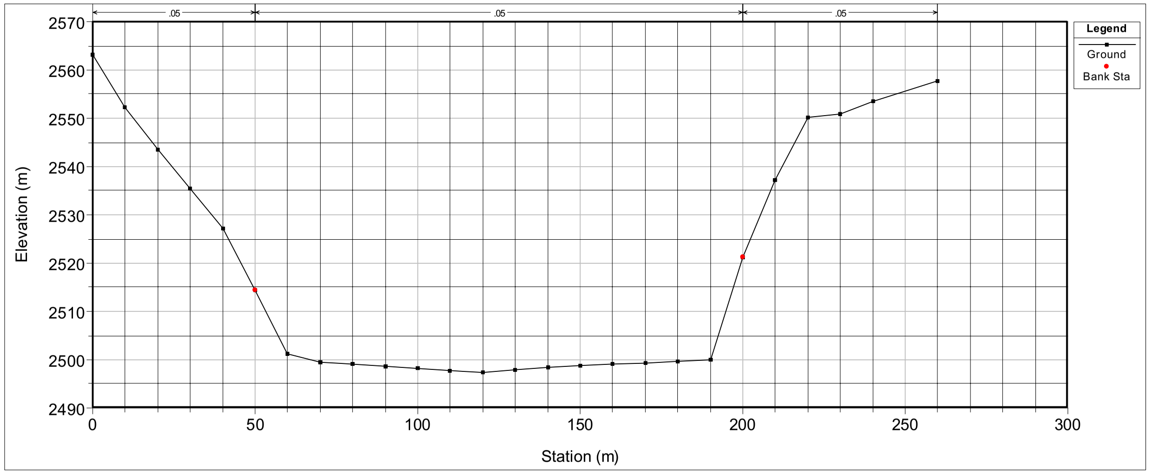

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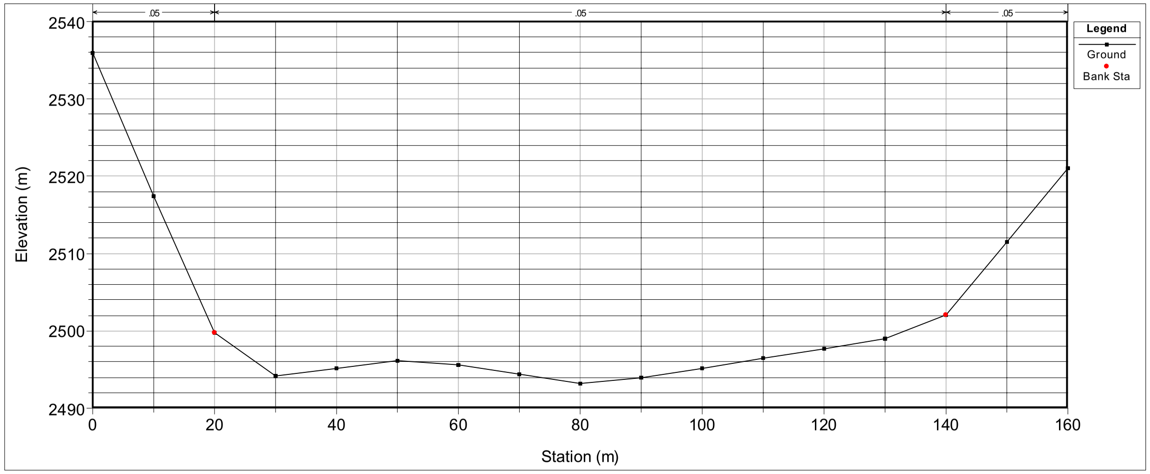

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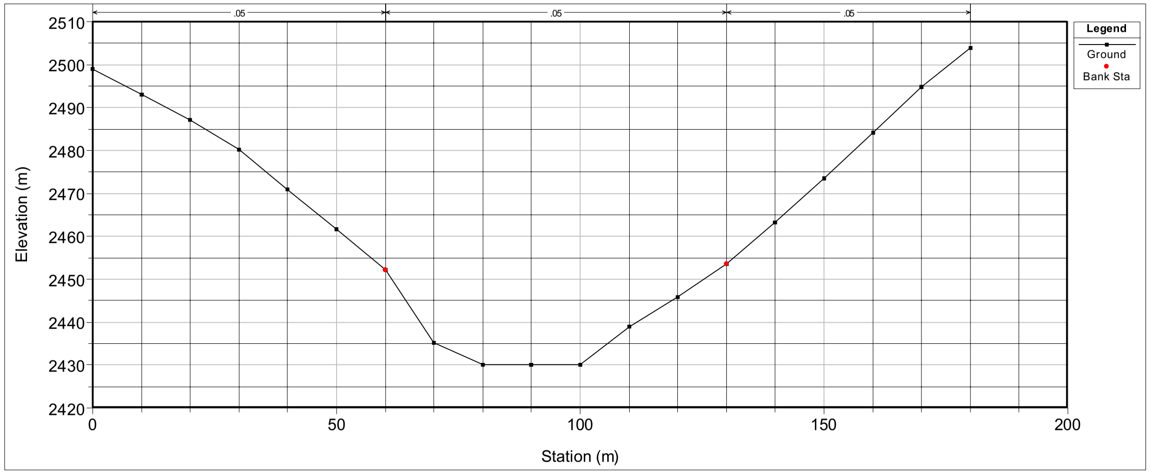

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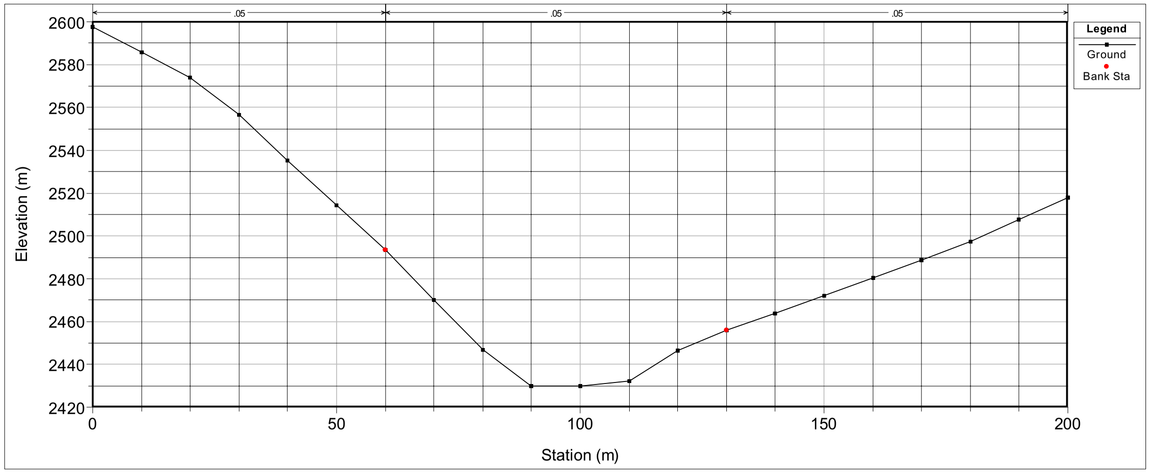


Chainage 5000 m D/S

Fig.14.1 Cross-sections of downstream flow at 500 m interval

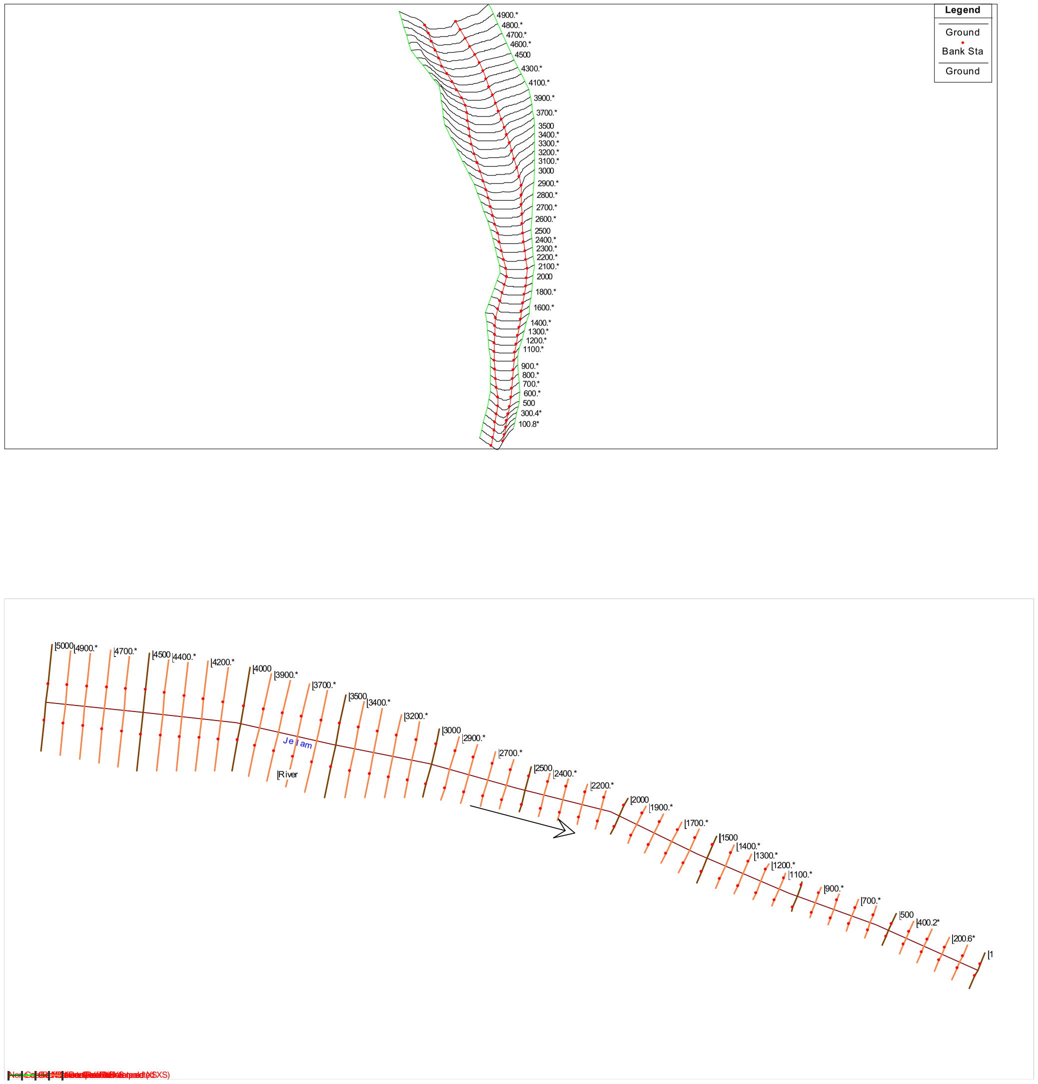


Fig.14.2 (a) 3D view of cross-sections and its interpolated cross-sections at 100 m interval and (b) Cross section in 1 Dimensional view

Chapter 15

IMPACT ASSESSMENT

15

IMPACT ASSESSMENT

15.1 INTRODUCTION

The impact assessment is most important and critical remark of the EIA study as it is ultimate aim of the collection of baseline data (Erickson, 1994). The mitigation measures suggested in the Environmental Management Plan (EMP) largely depend on the accuracy of identification and prediction of the impacts of project activities on the environmental variables thus, play an important role in decision making.

The impact prediction includes assessment of direct primary impacts, indirect secondary impacts and cumulative impacts. The impacts may be positive or negative, reversible and irreversible and of various longevities. An impact prediction requires good understanding of the nature of the project, knowledge of the outcomes of the similar projects undertakes in the past and information about the relevant receptors (Singh, 2008).

In order to strengthen the assessment of likely impacts, they are quantified with the various identification methods ranging from simple checklists and matrices to complex computerized model and network. Considering the project actions and environmental components the present impact statement is quantified with the help of modified Leopold matrix (as there are not 100 project actions and 88 environmental components). Each impact was weighted by taking the nature viz. positive or negative, reversible or irreversible, short lasting or long lasting and importance into the account.

15.2 IDENTIFICATION OF IMPACTS

Impacts of various activities of proposed Jelam Tamak H.E. Project were spotted on the various ecosystems in the surrounding of the project. The likely impacts are assessed in view of the importance, magnitude and duration because some of the impacts are limited to the construction phase while others are long lasting. The identification of the impacts on different ecosystem is described in the following paragraphs.

15.2.1 Land Environment

In order to execute the proposed project, a total of 96.27 ha of land would be acquired for the various components. Out of the total land, 88.29 ha is forest land including civil soyam, reserve forest and van panchayat land would be acquired. Private Naap land is 7.98 from three villages namely Jelam, Jumma and Tamak. The major components, require maximum land are reservoir (38.33 ha), roads (10.2 ha), dumping area (9.58 ha), query and RBM (10.09 ha) and colony area (12.07 ha). Most of the activities are confined to the right bank of the river. The construction work is expected to lead to adverse impacts on the flora and wild life of the region. In addition to land use changes, the impacts were identified on plant species in the surrounding, wildlife etc.

15.2.2 Water Environment

The construction of a 28 m high barrage would change the flow regime in downstream and upstream and lead to changes in river hydraulics and ultimately lead to environmental consequences. The area of reservoir is 37.92 ha with a length of more than 3.3 km along the river in upstream while nearly 5.00 km of river stretch in downstream would suffer the paucity of water and regular fluctuation. The river water of Dhauliganga and some tributaries like Jumma nallah and Dronagiri Nallah would likely be prone to receive sewage and effluents as a result of settlement of additional workforce and installation of various equipments alongside the rivers, which deteriorate the water quality.

15.2.3 Air and Noise Environment

A large number of equipments and vehicles like crushers, cranes, bulldozers, trucks, boring machines, rock bolter, robojet Shot, shotcrete machine, front end loader, dumpers, transit mixer, compressors, DG sets and a large number of light vehicles would be required for the construction work of the project. These equipments exhaust high concentrations of NOx, SOx, SPM and CO in the ambient air. In addition, the process of excavation and blasting for tunneling, road construction and dumping and transportation of muck would add to the significant amount of SPM in the air. These air pollutants would adverse impacts on human health, plants and wildlife. The impacts of increased noise level and their impacts on the human health and wildlife will also be assessed

15.2.4 Geophysical Environment

Tunneling, road construction, quarrying, reservoir etc may give rise to the new active land slide in the region. Also, these activities damage the water tables and hot spring in the region.

15.2.5 Human Environment

The likely impacts due to coming workers, labourers and other project staff would be assessed with reference to anthropogenic pressures on the natural resources of pristine ecosystem like collection of fuel wood from forest area, poaching and hunting of wild animals. The migrant population may be carrier of some diseases hitherto unknown in the area. The threats of likely cultural confliction and demographic changes would also be assessed for the proposed project.

15.2.6 Downstream Environment

The water of Dhauliganga river would be diverted through a head race tunnel (HRT) of 4.4 km which would affect the river stretch of 5.00 km. Diversion of water from the main river channel adversely affect not only the aquatic flora and fauna but also livelihood of the people inhabiting the surroundings and reduce the purifying capacity of the river water. The impacts arise from the diversion would be highlighted in this perspective.

15.2.7 Socio-economic Environment

Project authority takes up many activities with respect to the social upliftment and peripheral development. These activities play a positive role in the infrastructure development like roads, transportation facilities, education, employment opportunity, health facilities, etc. The project would provide a good share of jobs to local people. These impacts are long term and strategic. Tribal population is predominant in the project surroundings, the impacts of such types of activities would be of great importance in the region.

15.3 PREDICTION OF IMPACTS (CONSTRUCTION PHASE)

15.3.1 Land Environment

15.3.1.1 *Land use changes*

Out of 96.27 ha of land to be acquired, out of the total land, 88.29 ha is forest land including civil soyam, reserve forest and van panchayat land would be acquired. Private Naap land is 7.98

from three villages namely Jelam, Jumma and Tamak. The impacts on 89.00 ha of land are negative and irreversible while the activities on 7.24 ha of land would be negative, temporary and reversible. The area used for the labour camps and other temporary activities would be rehabilitated suitably after the construction.

15.3.1.2 *Species loss*

The areas of direct activities like roads, dam structure, dumping area etc. house very sparse forest and are dominated with scrubs. The predominant species of these areas are *Fraxinus xanthoxyloides*, *Sorbaria tomentosa*, *Berberis aristata*, *Ribes orientalis, Fragaria nubicolia*, *Alliums* pp. *Artemisia gmilinii, Anaphalis* spp. etc Sparse mix coniferous forest (*Cedrus deodara*, *Pinus wallichiana*, *Fraxinus zxanthoxyloides*, *Hippophae salicifolia*) are dominant in the areas of indirect activities (uphills and ridges). The species located on the areas of direct activities would be affected adversely. The impacts are negative and reversible, however, the major impacts on the species are not anticipated because these species are well distributed in the area and none of the species is threatened. A few species like *Fragaria nubicolia*, *Alliums* pp. *Artemisia gmilinii, Anaphalis* spp etc. are used as traditional medicines in the area.

15.3.1.3 *Habitat loss/ degradation*

The construction activities and influx of workers are anticipated to lead to the habitat degradation. The diffused disposal of solid waste like plastic, metals, etc, increased level of SPM, NOx, SOx, CO, noise and changes in the land use are major threats to the habitat. These impacts are negative, temporary and reversible. Such types of activities are confined mostly to the construction phase. In addition to the appropriate management plan, the project authorities would release restrict and imperative guidelines on the activities of workers to prevent the pristine ecosystem from degradation.

15.3.1.4 *Habitat Fragmentation*

The proposed dam site and upstream area have been identified as corridors of wildlife viz., *Pseudois nayaur*, *Nemorhaedus goral, Moschus chrysogaster*, *Muntiacus muntjak* etc. The project activities and human turmoil would likely hamper the movement of animals. Thus, the likely impacts on the wildlife are negative, local and irreversible.

15.3.1.5 *Wildlife*

The project activities like blasting, road construction, vehicular movement, establishment of colony etc., which produce obnoxious sound and is supposed to be harmful for wild animals. The sound level may cross the limit of 90 dB. The area is inhabited by the animals like musk deer, Tahr, black bear, *Lerwa lerwa*, *Tetragallus himalayensis*, *Lophophorus impejanus* etc. which are shy in nature and prefer a calm and relaxed environment. The project activities may affect them adversely especially breeding activities. The impacts on the wildlife due to project activities are negative, short term and irreversible.

15.3.1.6 *Phytoretardation*

The activities like excavation, dumping and transportation of mucks produce a huge quantity of suspended particulate matters (SPM) in the air, if not managed properly. The increased concentration of SPM triggers not only the human health problem but settled on the leaves of plants, leading phytoretardation. Though, major impacts are not anticipated due to the low density of plants in and around the projects. The impacts are negative, reversible and short term.

15.3.1.7 *Exploitation of natural resources*

The coming labourers are expected to cause threats to natural resources like hunting and poaching, collection of wood and medicinal plans. Hunting and poaching is not a common phenomenon in the region, therefore, possibilities of hunting and poaching is negligible. The surrounding area houses a variety of medicinal plants, therefore, possibility of migrant labourers to involve in such activities occurs. Such types of impacts are negative, temporary and reversible, last up to the construction phase. The project authorities are suggested to insure these issues in their guidelines to workers. The project activity area must clearly be demarcated. The workers should not be allowed to enter the forest area without any valid reason.

15.3.2 Water environment

15.3.2.1 *Water Quality*

The likely impacts on nearby water bodies during construction phase are anticipated due to the increased labourer, dumping of muck etc. The possibilities of sewage outfall from labourer colony, open defecation alongside the river and leaching of muck persist in the area if not managed properly. The additional population of around 2400 may exert the pressure on the river water due to sewage outfall, bathing and other activities. The annual estimated outfall of sewage due to additional population in Jelam Tamak H.E. Project would approximately be 8,76,00,000 litres, if not managed properly.

The impacts would be indifferent, reversible and local. The river water does not house any endemic and threatened algal and macro-invertebrates. Therefore, significant negative and positive changes are not anticipated. Increasing water fringe due to reservoir may likely favour the vectors of water borne disease. However, climatic conditions in the region are not conducive for high concentration of the vectors.

15.3.2.2 *Fish and Fisheries*

None of the fish species has been recorded in 10 km radius of the project sites during the survey, therefore, negative impacts on fish population are not anticipated. Contrarily, increased water fringe due to the creation of reservoir would provide a fair possibility to culture some fish species. It is advisable that project authority would formulate a fishery management plan for indigenous species.

15.3.2.3 *Species/ Habitat Loss*

The algal and macro-invertebrates species recorded from the river Dhauliganga within 10 river stretch are well distributed in other Himalayan rivers. Any threatened and endemic species could not be located from the area under discussion. Thus, possibility of wiping out of any species from the ecosystem is not expected.

15.3.3 Air Environment

The process of excavation, tunneling, quarrying, dumping and transportation of muck and road construction would increase the level of suspended particulate matter many folds. The present concentration of SPM (about 95 μg/m^3) near project area might increase to 400 – 500 μg/m^3 during the construction phase. The significant increase in the vehicular movement and operation of a large number of equipments and machine would increase the level of NOx, SOx, CO and noise level in the surrounding area. The concentration of each of the pollutants might go beyond 10 μg/m^3. These pollutants would lead to adverse impacts on human health and the presence of wildlife in the surrounding. The impacts are negative and short term, however, they are strategic in nature as would spread in a larger area of the valley. In order to minimize the predicted impacts a comprehensive Air Management Plan has been suggested in the EMP report.

15.3.4 Human Environment

The influx of labourers and workers for construction activities is anticipated to influence the human environment negatively as well as positively. Nearly 2400 persons including labourers and project staff are expected to come in the area for the purpose of project work. Increasing population may put in additional pressure on the natural resources that may range from fuel wood collection to exploitation of medicinal plants. New settlements put in stresses on the existing water bodies and habitat. In addition, there is likelihood of change in landscape features as a result of large number of additional human population living in the area.

The project influence area is inhabited by the Bhotya tribe having different culture and tradition. There is possibility of social evils, cultural confliction and new disease with migrant labourers and workers. The migrant workers would lead to the temporary demographic changes and subsequently lead to the following impacts:

i) There may be threat of cultural invasion and social conflicts among the migrant workers and natives.
ii) Migrant workers might act as carriers of various diseases like AIDS, VDS, gastro-enteritis, etc.
iii) Increase/initiation of social vices or evils like drinking. This is an area of concern that the project authorities will have to seriously prepare for and tackle problem with the help of local administration.

Simultaneously, a few positive impacts are foreseen due to the migrant population. Some of the positive impacts are described below:

i) Increased population would provide fair possibilities of small scale business in the region.
ii) A number of marginal activities and jobs opportunities would be available to the locals.
iii) The locals would be beneficiaries of the entire infrastructure like schools, hospitals, roads, free electricity, buses, etc. provided by the project authorities.
iv) Interaction between local people and project staff may provide the new scope of opportunities.

The impacts outlined above are negative as well as positive, short term (up to construction phase), reversible and strategic in the nature.

To mitigate the negative impacts project authorities have proposed proper quarantine procedure for screening and detecting such cases. In addition the existing medical facilities would also be strengthened and proper health delivery system to be proposed in the project areas. There should be a demarcated boundary of the project activities. Each employee should be provided with an identity card. Project authority should issue guidelines to workers, contractors and project staff highlighting the do and don'ts. The workers should not be permitted to enter the villages and forest area without a valid reason.

15.3.5 Economic Upliftment

In order to mitigate or to avoid adverse impacts predicted, project authorities would implement many mitigation measures related to environment and societies. The local people would get good share of employment in the project activities directly (jobs) and indirectly (contract, supply of transportation vehicles and other goods). The Rehabilitation and Resettlement Plan in EMP report is directly related to the local people and their upliftment. In addition to the relief package, project authorities would implement a peripheral or social development plan. The provisions would also have been made towards local participation in the project activities, infrastructure development like school, health centre, adoption of village, scholarship scheme, play ground, development of small scale business, etc. The social development plan would play an important role in empowering the vulnerable groups of the region. It would put in positive impacts on the tribal community for long time and would be strategic in the nature.

15.3.6 Geophysical Environment

The project activities like road construction, tunneling, blasting, etc have many geophysical consequences. The road construction near proposed power house site might trigger the new land slides and may change the profile of existing drainage system in uphills. Excavation of HRT is prone to damage the water table. Notably, the area is rich in hot springs. However, HRT alignment does not passes through any hot spring and water table, therefore, adverse impacts on the water tables are not foreseen. In order to mitigate or avoid any negative impacts, a separate road management plan is suggested in the EMP report.

Geothermic study indicates that there are a total of 6 thermal springs in the influence area of which two namely Yong and Sumna are located in project component areas. There is possibility of existence of geothermal field in the area. This is more so as the area is located in the vicinity of Tapoban Geothermal field which could influence the geothermal conditions in the project area. Therefore, the possibility of encountering the warm water with moderate temperature cannot be ruled out completely in case of underground structures where ground cover is excessive. It is therefore recommended that measures required for countering the effects of warm water, if encountered may be included in the construction plans.

15.4 PREDICTION OF IMPACTS (OPERATION PHASE)

15.4.1 Land Environment

Most of activities will be ceased in the construction phase so that no major changes in the terrestrial environment are anticipated. However, some of the impacts which will occur in the operation phase are described in following paragraphs.

15.4.1.1 *Land use change: Submergence*

This activity would occur in the transition phase. A total area of nearly 38 ha including river area will be submerged due to the barrage of Jelam Tamak H.E. Project. The area is not rich in vegetation cover. Also, the proposed submerged area does not harbour any threatened and endemic species. Predominant species of the area are *Fraxinus xanthoxyloides*, *Sorbaria tomentosa*, *Berberis aristata*, *Ribes orientalis, Fragaria nubicolia*, *Alliums* pp. *Artemisia gmilinii, Anaphalis* spp. etc. These species are commonly and widely distributed in the same altitudinal zone of Himalaya. The impacts are irreversible and negative.

15.4.1.2 *Wildlife*

The proposed project area is identified as a corridor of animal species like *Pseudois nayaur*, *Nemorhaedus goral, Moschus chrysogaster*, *Muntiacus muntjak* etc, therefore, submergence may act as habitat fragmentation. In addition, project colonies, and offices may keep these species away from the areas, though, activities like blasting, vehicular movement would either be ceased or low during the operation phase. The impacts are negative and irreversible.

15.4.2 Water Environment

15.4.2.1 *Hydrological Regime*

Changes in the flow pattern are anticipated nearly for 5 km downstream and 3.3 km upstream due to diversion of water and inundation, respectively. These changes would lead to minor changes in the hydrological regime in very small area.

15.4.2.2 *Habitat loss/ Water Quality*

Changes in the physical, chemical and biological properties are foreseen in upstream and downstream sections, however, the changes are not expected to lead to major habitat and species loss as the river water does not harbour any endemic and threatened species. Major impacts in the water quality are foreseen in downstream section, described separately.

15.4.2.3 *Fisheries*

The river water does not harbour any fish species in the close vicinity of the project. A reservoir of nearly 38 ha would provide a fair possibility of development of fisheries. It is a positive, long term and permanent impact.

15.4.3 Air & Noise Environment

All construction activities like excavation, blasting and quarrying would be ceased in the operation phase while the running equipment and vehicular density would be considerably low. The concentration of Nox, Sox, SPM and CO and sound level would decrease considerably as compared to that of constriction phase but will be higher than existing level.

15.4.4 Human Environment

About 80% of work force will be homed in the operation phase so that threats of cultural confliction and social vices and evils will decrease. On the other hand the scope of small scale business would also decrease.

15.4.5 Social Environment

In the operation phase the scope of employment would decrease and possibilities of new jobs will be negligible but the work of peripheral developmental plan would be continued. In addition, Corporate Social Responsibility Cell of Project authorities will be committed to spend a certain amount of budget in social upliftment.

15.4.6 Geophysical Environment

Most of the geophysical impacts are anticipated during the construction phase, when tunneling, excavation, blasting etc would be in operation. In operation phase only impact related to geophysical environment is induced seismicity and possibility of new land slides in the periphery of reservoir. Due to the reservoir, however, the area of reservoir is only about 38 ha, therefore, major impacts is not anticipated.

15.4.7 Downstream Environment

Downstream impacts are anticipated in operation phase only. The downstream impacts due to the barrage/dam are imperative to highlight, because it is directly related to the biotic communities of the river, riparian vegetation, channel deformation and socio-cultural and economic aspects. Though, magnitude of downstream impacts would be small in Jelam Tamak H.E. Project because water will be diverted from a very small stretch, fish species are absent in this section, people in the area are not dependant on the river water for drinking, irrigation etc. However, the predicted impacts due to the diversion of water are described in the following paragraphs.

15.4.7.1 *Water Availability in Downstream*

The problem of water availability would be more serious in downstream section, where most of the discharge would be diverted through HRT and this stretch would have lost its purifying capacity. In the downstream 4 tributaries join river Dhauliganga at 0.52 km (Dunagiri Gad on left bank), 1.7 km (unnamed nallah on left bank), 3.6 km (Jumma Gad on right bank) and 4.04 km (Bhosing Gad on left bank). These tributaries have different discharge capacity depending on the area of watershed, thus, in downstream course river discharge increases gradually. Considering 20% average discharge of lean months 2.97 cumec of water would be released from the barrage axis during non monsoon months while 5 cumec of water would be released in monsoon months (June to September). After the confluence of first Dunagiri nallah water discharge would increase to 4.14 cumec (February) to 15.24 cumec (July). Water discharge would gradually increase in downstream and before tailrace discharge it would be 4.44 cumec to 17.49 cumec in respective months (see Fig. **15.1**).

The main concern of discharge is whether it would be adequate to sustain aquatic life or not. Since fish fauna is absent in the river stretch under discussion or barely some bottom dweller species so that the available water discharge seems adequate for such types of species. As far as other aquatic species like algae and macro-invertebrates are concerned, the available data can sustain these species, however, changes in species composition are anticipated.

15.4.7.2 *Water Quality*

The water discharge would decrease significantly after the diversion at intake. The low volume of water is expected to reduce its capacity of self purification and accommodation of pollutants. Water temperature, concentrations of BOD, coliform etc would increase considerably while concentration of dissolved oxygen, hardness and alkalinity would decrease due to the sinking process in the reservoir. The changes in the physical and chemical characteristics would reflect in the biotic communities. Algal diversity is likely to decrease. The downstream water could sustain pollution tolerant taxa of macro-invertebrates like *Chronomus*. The downstream stretch would not be conducive for other insects especially, mayfly, cadisfly, stonefly, etc.

15.4.7.3 *Instability in Biotic Communities*

Biotic communities of downstream stretch of Dhauliganga river would likely face the problem of instability due to the regular fluctuation of in the water level. High current velocity triggers the adverse impacts on the river biota.

15.4.7.4 *Bank Erosion*

The water released at the outlet would be turbid free having more eroding capacity. The water of high current velocity with high eroding capacity would cause bank erosion and channel deformation in downstream.

15.4.7.5 *Habitat Fragmentation*

Fish are most affected taxon of fresh water ecosystem. As earlier stated that fish are absent in the upper stretch of Dhauliganga river, therefore, such types of impacts are not anticipated. However, micro-organisms may suffer from the habitat fragmentation, however, major impacts are not foreseen in the Jelam Tamak H.E. Project.

15.4.7.6 *Riparian vegetation*

After the diversion, flow of water would be confined to a small channel in downstream. It would lead to adverse effect on the riparian plant species, viz. *Hippophae salicifolia, Sorbaria tomentosa* etc.

15.4.7.7 *New Corridor*

Dhualiganga river acts as a barrier come in the way of movement of animals especially small size animals. After diversion of water, downstream stretch would facilitate new corridors for wild animals. Though, it would not be of highly significance because construction activities are expected to lead to disturbances to wildlife.

15.5 QUALITATIVE AND QUANTITATIVE ANALYSIS OF IMPACTS

After a detailed analysis the predicted impacts were divided on the basis of their nature like positive, negative, short term and long term major, minor, reversible and irreversible, permanent and temporary (Table 15.1). Each impact was analysed under the categories mentioned above and quantified using modified Leopold matrix. Each impact was assigned with a score using a scale of 1 - 5, depending on the magnitude, potential and importance. A positive and negative sign was provided for beneficial and harmful impact, respectively. The row total of matrix reflects the total impact value of a action on various environment component while the column total reflect the impacts all actions on one environmental variable.

Table 15.1 indicates that majority of the impacts is negative but minor in the potential. The activities confined up to construction phase, lead to short term impacts, in which most of them are temporary. On the other hand the activities last for long time would lead to long term impact and most of the said characteristics of a particular impact of an activity, it was quantified at a 0-5 scale. Modified Leopold **Matrix 15.1** gives a quantified result of said impacts during the construction phase while the **Matrix 15.2** indicates the impacts in operation phase. During the construction phase project activities stand for a total of (-) 96 impact values, in which a score of 126 indicate negative impacts and a score of 30 indicate positive impacts (Table 15.2 and 15.3). In operation phase negative impact values decrease significantly score for (-) 20 with 52 value for negative and 32 value for positive impacts.

Most of the activities lead to adverse impacts while a few of them like road construction, community development, etc. (Table 15.2) have positive impacts on the society. In the construction phase excavation, tunneling and quarrying are major activities lead to the high adverse impacts while in operation phase submergence and diversion of water would trigger the high adverse impact. The peripheral developmental plan seems to have maximum positive impacts in construction and operation phase.

Considering the environmental variables impacted due to various activities, SPM, NOx, SOx, land use changes and landslides are the main variables which are most vulnerable (Table 15.3). Terrestrial environment and Air environment are anticipated for major adverse impact while upliftment in the economy of region is foreseen for major positive impacts.

15.6 IMPACTS AND MITIGATION MEASURES

The impacts outlined above have been quantified for the worst case scenario, if not mitigated properly. After the implementation of management plans the magnitude and potential of negative impacts could be minimized or avoided significantly. The impacts and their mitigation measures can be divided into three phases, viz. pre-construction phase, construction phase and post-construction phase. Some of the important mitigation measures which are warranted to conserve the environment are listed below :

i). Adequate safeguard measures for wildlife conservation and preservation of biodiversity
ii). The activity like blasting must be scheduled and controlled taking the animal behaviour like movement time, breeding, corridor, etc. into account
iii). Afforestation in degraded land and catchment area
iv). Adequate engineering measures at construction sites, catchment area, dumping areas, land slides to arrest the soils
v). Restoration of quarry sites, colony area, road sites and other construction sites
vi). Maintenance of water quality, air quality and noise level
vii). Regular monitoring of migrant population to ensure the overexploitation of forest resources, poaching, crime, social evils, and cultural confliction.
ix). Development of infrastructure in the surrounding area towards education, health, transportation, etc.
x). Adequate measures for disposal of waste
xi). Suitable mitigation measures for downstream impacts

Table 15.1 Nature and magnitude of impacts on various environmental variables

Impacts	Nature of Impacts								
	Positive	Negative	Short term	Long term	Major	Minor	Reversible	Irreversible	Temporary
Terrestrial Environment									
Landuse changes	X	√	X	√	√	X	X	√	X
Species loss	X	√	X	√	X	√	√	X	√
Habitat loss	X	√	X	√	X	√	X	√	X
Fragmentation	X	√	X	√	X	√	X	√	X
Phytoretardation	X	√	√	X	X	√	√	X	√
Wildlife	X	√	√	X	X	√	√	X	X
Pressure on nature	X	√	√	X	X	√	√	X	X
Aquatic Environment									
Water quality	X	√	X	√	X	√	X	√	X
Fish & Fisheries	√	X	X	X	X	X	X	X	X
Species loss/habitat loss	X	√	X	√	X	√	X	√	X
Habitat fragmentation	X	√	X	√	X	√	X	√	X
Air Environment									
SPM level	X	√	√	X	√	X	√	X	√
NoX, SoX and CO	X	√	√	X	√	X	√	X	√
Noise Level	X	√	√	X	X	√	√	X	√

Downstream Impacts									
Water quality	X	√	X	√	√	X	X	√	X
Biotic communities	X	√	X	√	√	X	X	√	X
Bank Erosion	X	√	X	√	X	√	X	√	X
Riparian vegetation	X	√	X	√	X	√	X	√	X
New corridors	√	X	X	√	X	√	X	√	X
Geophysical Environment									
Water Tables	X	√	√	X	X	√	√	X	√
Seismicity	X	√	X	√	X	√	X	√	X
Landslides	X	√	√	X	X	√	√	X	√
Social Environment									
Demographic changes	X	√	√	X	X	√	√	X	√
Cultural confliction	X	√	√	X	X	√	√	X	√
Threats of disease/evils	X	√	√	X	X	√	√	X	√
Interaction	√	X	X	√	X	√	X	√	√
Economic upliftment									
Business activities	√	X	√	X	X	√	X	√	√
Job opportunities	√	X	X	√	√	X	X	√	X
Infrastructure facilities	√	X	X	√	√	X	X	√	X

Table 15.2 Project activities showing cumulative scores of impacts on environmental variables

Actions	Construction phase			Operation Phase		
	Positive	Negative	Total	Positive	Negative	Total
Barrage	0	11	-11	0	1	-1
Road construction	2	16	-14	4	7	-3
Submergence	0	0	0	4	17	-13
Power house	0	7	-7	0	1	-1
Adits	0	9	-9	0	0	0
Dumping	0	14	-14	0	0	0
Excavation/ Tunnel.	0	17	-17	0	0	0
Quarrying	0	16	-16	0	0	0
Colony	8	11	-3	5	3	2
Diversion	0	0	0	1	11	-10
Migrant population	4	11	-7	1	5	-4
Construction method	0	10	-10	0	3	-3
Vehicular Movement	2	4	-2	0	3	-3
Community Development	14	0	14	16	0	16
Total	**30**	**126**	**-96**	**32**	**52**	**-20**

Table 15.3 Environmental variables showing cumulative scores of impacts due to project activities

Environmental variables	Construction Phase			Operation Phase		
	Positive	Negative	Total	Positive	Negative	Total
Terrestrial Environment						
Species loss	0	8	-8	0	2	-2
Habitat loss/ Degradation	0	9	-9	0	3	-3
Habitat fragmentation	0	0	0	0	2	-2
Wild life	0	8	-8	1	2	-1
Phytoretardation	0	8	-8	0	1	-1
Exploitation of resource	0	6	-6	0	1	-1
Land use change	0	9	-9	0	2	-2
Water Environment						
Water quality	0	5	-5	0	2	-2
Species /Habitat loss	0	1	-1	1	0	1

Fragmentation	0	3	-3	0	2	-2
Fisheries	0	0	0	2	0	2
Human Environment						
Migration	0	0	0	0	0	0
Interaction /Exposure	6	0	6	3	1	2
Culture	0	4	-4	0	2	-2
Demographic change	0	4	-4	0	2	-2
Social evils	2	5	-3	3	3	0
Health hazards	0	2	-2	1	0	1
Air Environment						
SOx & NOx level	0	9	-9	0	3	-3
SP level	0	14	-14	0	1	-1
Noise level	0	11	-11	0	4	-4
Geophysical Environment						
Faults	0	4	-4	0	1	-1
Weathering/Seismicity	0	6	-6	0	2	-2
Ground water	0	2	-2	2	0	2
Land slides	0	8	-8	0	3	-3
Downstream Environment						
Water quality	0	0	0	0	2	-2
Flow regime	0	0	0	0	3	-3
Livelihood	0	0	0	0	0	0
Biotic communities	0	0	0	0	3	-3
Drinking water	0	0	0	0	0	0
Bank Erosion	0	0	0	0	1	-1
Riparian vegetation	0	0	0	0	4	-4
Economic Upliftment						
Employment	6	0	6	4	0	4
Social value	7	0	7	5	0	5
Basic amenities	6	0	6	7	0	7
Land values	0	0	0	0	0	0
Marketing	3	0	3	3	0	3
Total	**30**	**126**	**-96**	**32**	**52**	**-20**

Matrix 15.1 Modified Leopold Matrix to study the environmental impacts during construction phase

Environmental effects / Developmental Activities	Terrestrial Environment							Aquatic Environment					Human Environment					Air Environ-ment & Noise			Geo-physical Environment				Downstream Environment							Economic Upliftment Plan					
	Species loss	Habitat loss/ Degradation	Habitat fragmentation	Wild life	Phytoretardation	Exploitation of resource	Land use	Water quality	Species /Habitat loss	Fragmentation	Fisheries	Migration	Interaction /Exposure	Culture	Demographic change	Health hazards	Social evils	SOx & NOx level level	SP level	Noise level	Faults	Weathering	Ground water	Land slides	Water quality	Flow regime	Livelihood	Biotic communities	Drinking water	Bank Erosion	Riparian vegetation	Employment	Social value	Basic amenities	Land values	Marketing	**Total**
Barrage	0	-2	0	0	0	0	-1	-2	-1	-3	0	0	0	0	0	0	0	0	0	0	-1	0	0	-1	0	0	0	0	0	0	0	0	0	0	0	0	**-11**
Road construction	-1	-2	0	-1	-1	-1	-1	0	0	0	0	0	0	0	0	-2	0	0	-2	-1	-1	-2	0	-3	0	0	0	0	0	0	0	1	1	2	0	0	**-14**
Submergence	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
Power house	-1	-1	0	-1	0	-1	-1	0	0	0	0	0	0	0	0	0	0	0	0	-2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**-7**
Adits	-1	-1	0	0	-1	0	-1	0	0	0	0	0	0	0	0	0	0	0	-2	0	0	-2	0	-1	0	0	0	0	0	0	0	0	0	0	0	0	**-9**
Dumping	-1	-1	0	0	-2	-1	-1	-1	0	0	0	0	0	0	0	-3	0	0	-3	0	0	0	0	-1	0	0	0	0	0	0	0	0	0	0	0	0	**-14**
Excavation/Tunnel.	0	0	0	-2	-2	0	-1	0	0	0	0	0	0	0	0	0	0	-2	-3	-2	-1	-1	-2	-1	0	0	0	0	0	0	0	0	0	0	0	0	**-17**

Quarrying	-2	0	0	-1	-2	0	-1	0	0	0	0	0	0	0	0	0	0	-2	-3	-2	-1	-1	0	-1	0	0	0	0	0	0	0	0	0	0	0	0	-16
Colony/Camp	-1	-1	0	0	0	-1	-2	-1	0	0	0	0	2	-2	-2	2	-1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	0	0	1	-3
Diversion	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0
Migrant population	0	-1	0	-1	0	-2	0	0	0	0	0	0	2	-2	-2	-2	-1	0	0	0	0	0	0	0	0	0	0	0	0	0		1	0	0	0	1	-7
Construction method	-1	0	0	-1	0	0	0	-1	0	0	0	0	0	0	0	0	0	-3	-1	-3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-10
Vehicular Movement	0	0	0	-1	0	0	0	0	0	0	0	0	0	0	0	0	0	-2	0	-1	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	-2
Community Development	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	2	4	0	1	14
Total	**-8**	**-9**	**0**	**-8**	**-8**	**-6**	**-9**	**-5**	**-1**	**-3**	**0**	**0**	**6**	**-4**	**-4**	**-3**	**-2**	**-9**	**-14**	**-11**	**-4**	**-6**	**-2**	**-8**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**6**	**7**	**6**	**0**	**3**	**-96**

Matrix 15.2 Modified Leopold Matrix to study the environmental impacts during operation phase

Environmental effects / Developmental Activities	Terrestrial Environment							Aquatic Environment					Social Environment					Air Environment & Noise			Geo-physical Environment				Downstream Environment							Economic Upliftment Plan					
	Species loss	Habitat loss/ Degradation	Habitat fragmentation	Wild life	Phytoretardation	Exploitation of resource	Land use	Water quality	Species /Habitat loss	Fragmentation	Fisheries	Migration	Interaction /Exposure	Culture	Demographic change	Health hazards	Social evils	SOx & NOx level level	SP level	Noise level	Seismicity	Weathering	Ground water	Land slides	Water quality	Flow regime	Livelihood	Biotic communities	Drinking water	Bank Erosion	Riparian vegetation	Employment	Social value	Basic amenities	Land values	Marketing	**Total**
Barrage	0	0	0	0	0	0	0	0	0	-1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**-1**
Road construction	0	0	0	-1	-1	0	0	0	0	0	0	0	0	0	0	-2	0	0	-1	-1	0	0	0	-1	0	0	0	0	0	0	0	1	1	2	0	0	**-3**
Submergence	-2	-2	-2	-1	0	0	-2	-1	1	-1	2	0	0	0	0	0	0	0	0	0	-1	-2	2	-2	0	0	0	0	0	0	-2	0	0	0	0	0	**-13**
Power house	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**-1**
Adits	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
Dumping	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
Excavation/Tunnel.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**

Quarrying	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
Colony	0	0	0	0	0	0	0	0	0	0	0	0	-1	-1	-1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	**2**
Diversion	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-2	-3	0	-3	0	-1	-2	0	0	0	0	0	**-10**
Migrant population	0	-1	0	0	0	-1	0	0	0	0	0	0	1	-1	-1	-1	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	**-4**
Construction method	0	0	0	0	0	0	0	-1	0	0	0	0	0	0	0	0	0	-1	0	-1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**-3**
Vehicular Movement	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-2	0	-1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**-3**
Community Development	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	3	5	0	2	**16**
Total	**-2**	**-3**	**-2**	**-1**	**-1**	**-1**	**-2**	**-2**	**1**	**-2**	**2**	**0**	**2**	**-2**	**-2**	**0**	**1**	**-3**	**-1**	**-4**	**-1**	**-2**	**2**	**-3**	**-2**	**-3**	**0**	**-3**	**0**	**-1**	**-4**	**4**	**5**	**7**	**0**	**3**	**-20**

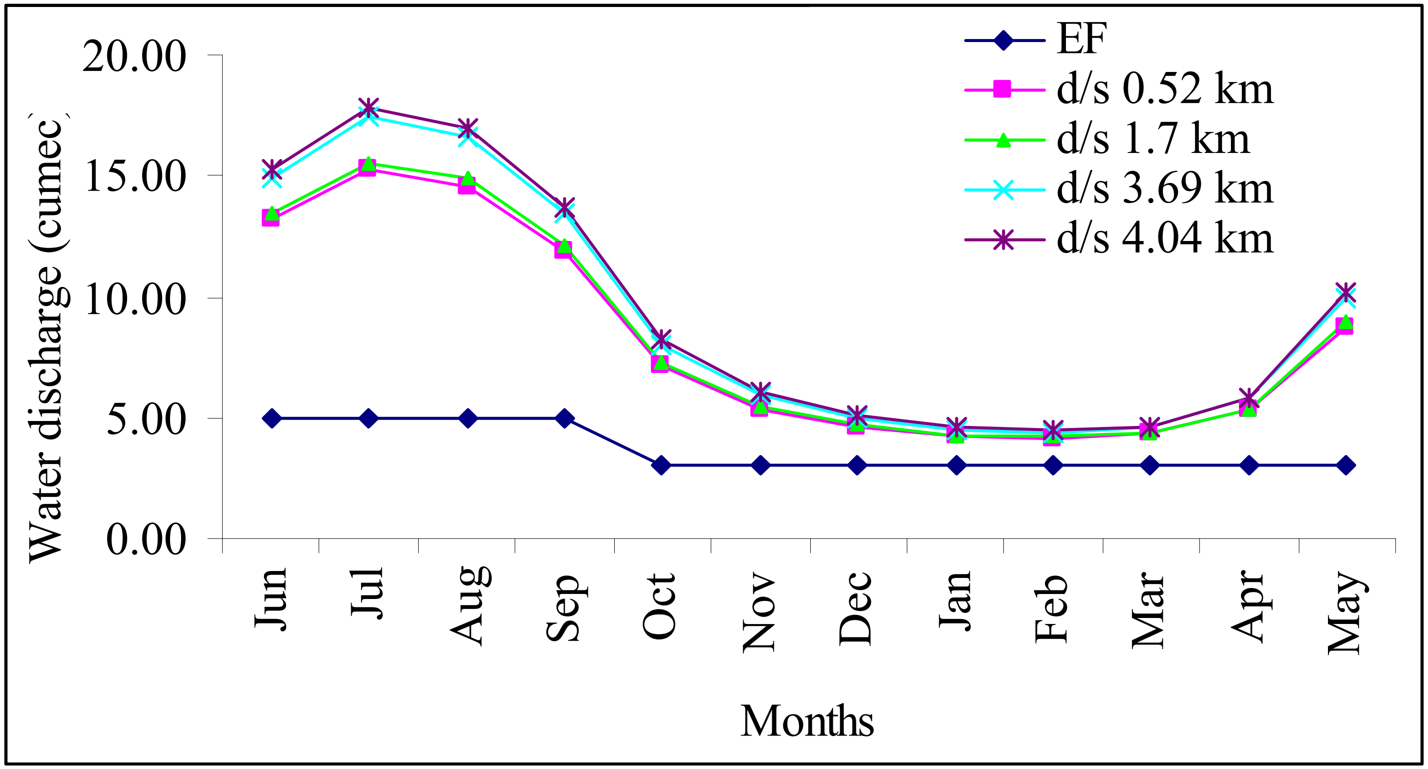


Fig. 15.1 Water discharge pattern in downstream of Jelam Tamak barrage after completion of project

Chapter 16

CUMULATIVE IMPACT ASSESSMENT

16

ASSESSMENT OF IMPACT OF U/S PROJECT MALARI JELAM (65 MW) ON JELMA TAMAK HEP (108 MW): A CUMULATIVE IMPACT ASSESSMENT

16.1 INTRODUCTION

Malari Jelam H.E project and Jelam Tamak H.E. Projects are part of a cascade development scheme proposed on the Dhauliganga river in District Chamoli of Uttarakhand. Malari Jelam is the upstream project, located between 30^0 40' 54.7" N Latitude and 79^0 53' 4.5" E Longitude near Malari village. Jemal Tamak is downstream project located between 30^o 37' 35.4"N Latitude and 79^o 49'39.5"E Longitude. The distance between tail end of reservoir of Jelam Tamak H.E. Project and TWL of Malari Jelam H.E. Project is nearly 1 km. Both projects are located on same river and in a cascade way, therefore, cumulative impacts on the surrounding environments of both projects are foreseen. The cumulative impacts, however, would rely on the variation in the Construction period because in Hydro Electric Projects majority of the impacts occur during the construction phase. Subsequently post commissioning these run-of-the-river schemes result in the upliftment of the Socio Economic status of the village population living in the area and reduced pressure on the Environment with less felling of trees in the forest for meeting daily needs of the populace.

To examine the cumulative impacts it is therefore imperative to look into the Construction schedule of the two Projects and the deployment of Manpower strength therein. As per the Bar Chart attached herewith at **Enclosure-I**, the proposed date of start of Construction activities at Jelam Tamak HEP is April, 2014 where as the proposed date for Malari Jelam HEP is April' 2017. Total construction period for Jelam Tamak HEP is 52 months while as it is 42 months for Malari Jelam HEP (65 MW). In Jelam Tamak HEP 2400 persons including laborers and Project staff are expected during the peak hours of construction. The total persons expected for Malari Jelam is considered as 1600 during peak time of construction.

As can be seen from the Graph prepared indicating the Man power potential during the Construction phase of both the Projects, the overlap period is only 16 months, for which cumulative impacts can be assessed imperatively. Further maximum potential of persons is 2400 only during the Construction phase of the both the Projects. This maximum potential of 2400 persons shall be reached during the Construction of the Jelam-Tamak Project while as during the brief overlap period the potential of Manpower deployment at the both Projects shall be 1800 only.

The Jelam Tamak (108 MW) has a small HRT of 4.4 km while as the Malari-Jelam has around 3 km of HRT with all major components with like Denading Chamber, PH, SS, TRT as underground. The Projects taking off at different time periods and due to the fact that these are run–off-the-river schemes with underground structures the impacts are expected to be minimal, however, these are broadly discussed in the following paras and have been/ shall be adequately addressed in the EMP Reports of the Projects.

16.2 ASSESSMENT OF IMPACTS

Cumulative impacts of both projects like Malari Jelam and Jelam Tamak H.E. Projects have been assessed on the land environment, water environment, geophysical environment, biological environment and socio-economic environment. The impacts are described separately for Construction phase and Operation phase herein after.

16.2.1 Land Use Changes

Total land required for Jelam Tamak H.E. Project is 96.27 ha while Malari Jelam Project would require approximately 80 ha of land. Thus, total land use changes is expected on the 176 ha of land in the immediate vicinity of both projects. It includes Forest Land, Private Naap Land and river bed area. The land would be required for various project components like barrage site, reservoir, powerhouse, dumping area, road construction, colony area, quarry area etc. Land use change is permanent in nature and considered as a negative impact in general, however the land use changes in confined to the immediate vicinity of river. Some of the measures like landscaping plan, green belt scheme, rehabilitation of dumping area, compensatory afforestation in double the land as per Govt. norms would reduce the magnitude of impacts.

16.2.2 Generation of Solid Waste

As can be seen from the Graph in the Bar Chart indicating the Construction schedule of the Malari-Jelam and Jelam-Tamak Hydro Electric Projects, attached herewith the peak Manpower strength for Jelam-Tamak is 2400 and the same is not going to increase even when the construction of Malari-Jelam Project would be taken up. Rather the peak shall start tapering in the 3rd year for Jelam-Tamak when the construction of Malari-Jelam is proposed to be taken up in April 2017. The peak Manpower deployment for Malari-Jelam shall be in the range of 1600. The cumulative peak Manpower for both the Projects at any given point of time shall not be crossing 1800 and is less than the peak Manpower deployment of 2400 assessed for the present scheme of Jelam-Tamak. Thus the Malari-Jelam Project will not have any significant additional Burden/Impact during the Construction Phase of the two Projects. This migrant population is anticipated to generate about 900 kg solid waste per day including biodegradable and non biodegradable wastes during the overlapping period which is less than 1200 Kg expected to be generated for Jelam-Tamak during its peak time construction Phase. The solid wastes exert many secondary impacts on the land environment. The anticipated impacts are temporary (confined to the construction phase), reversible and local in nature. Though, with strict implementation of the proposed solid waste management plan, the magnitude of impacts would be reduced significantly.

16.2.3 Impacts on Wildlife

Both projects are spread on very small area; all project activities are confined within 10 km aerial distance. The surrounding area is inhabited by some mammalian species viz. Himalayan Tahr, Musk deer, etc which are shy in nature. Various project activities like blasting, vehicular movement, migrant labourers etc may lead to adverse impacts on the wildlife especially on the movement and breeding habit during the construction phase. but with control blasting and many other mitigation measures like no blasting during night the Impacts shall be reduced which has been/shall be elaborated in the EMP.

16.2.4 Changes in Flow Pattern

Due to diversion of water and storage of water in both projects flow pattern of the Dhauligang river would change in around 12 km (approx). Such changes would have various impacts on the aquatic ecology of Dhauliganga river. In order to maintain regular flow in the downstream area, a minimum environmental flow would be maintained in both projects. The target groups of environmental flow would be macro-invertebrates because the surrounding area has been identified as ‘No Fish zone’. The impacts would occur in operational phase only.

16.2.5 Generation of Liquid Waste

Calculating per capita use of water and ancillary use of water other than human consumption approximately 2 lakh litre of waste water may be generated from both projects. The waste water would be treated scientifically and as per norms. In the pristine ecosystem, such quantity of waste water can be foreseen as major adverse impact on aquatic diversity and water quality. The 90% generation of waste water would occur in the construction phase. The waste management plan under EMP shall include all mitigation measures to reduce the adverse impacts of waste water.

16.2.6 Air Environment

The surroundings of Jelam-Tamak and Malari-Jelam Projects are considered as pristine ecosystem. In the construction phase of both Projects during the small overlapping period of 16 months only, the traffic density, human population, construction activities etc anticipated in the region shall not cross the peak limits of Jelam-Tamak Project since there is a sufficient time gap between the start of the Construction of Malari-Jelam and Jelam-Tamak Projects and the Manpower deployment shall be around 1800 for the combined/overlapping periods. Various Project activities would increase the concentration of air pollutants (NOx, SOx, SPM, CO etc), sound level and traffic density etc. Such types of pollutants may lead to adverse impacts on human health, make the environment obnoxious. Though 90% of such types of activities would occur in construction phase, in operation phase adverse impacts would be reduced significantly. Adequate mitigation measures have been /will be detailed in the EMP.

16.2.7 Socio-economic Environment

16.2.7.1 Demographic changes

A total of 1800 migrant persons are expected to come in the area during peak construction period of overlapping for both Projects. The said migrant population may have major demographic changes during the construction phase. However, it will be a temporary phase and after the completion of construction nearly 90% of the population will be homed and also adequate measures for the same have been / will taken in the EMP.

16.2.7.2 Cultural Confliction

The entire are is dominated with bhotya tribe, having unique culture and traditions. The migrant population would likely come from different parts of India with different culture and tradition. During the construction phase possibility of cultural confliction between locals and outsiders cannot be denied, however separate colonies and walled dwellings to the minimize the interference with the local villagers.

16.2.7.3 Interaction

The interaction between locals and outsides is foreseen as positive impacts on the society. The interaction may provide new opportunities for locals in the area of employment, economic upliftment, etc.

16.2.7.4 Economic Upliftment

For the construction of the projects, an addition population of nearly 1800 would likely come to the area during the overlapping period of 16 months. The migrant population would require additional goods, and food grains for daily needs and would promote the small scale business in the area, which would contribute surplus income to locals. The locals would be engaged in the employment and other activities of the projects like small contracts, direct and indirect employment etc. In addition, migrant population is considered as customer of local goods and handicrafts.

16.2.8 Local Area Deveolment

The local area development plans proposed by THDC Ltd for both projects (approx 1000 lakhs) would play a vital role in the economic upliftment of the area. The entire area is sparsely populated and dominated by *bhotya* tribe. The local area development plan would focus on the development of infrastructure in the area.

16.2.9 Reverse Migration

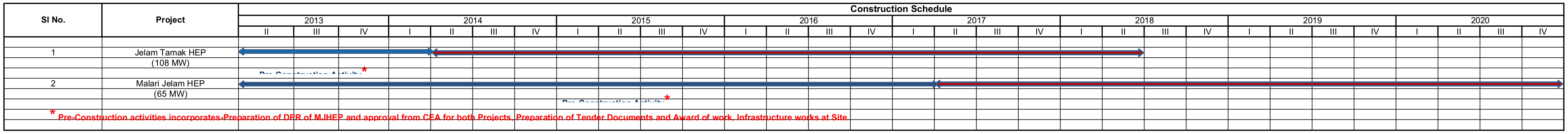
Due to scarcity of the job opportunities and other means of living the local population has been reducing in the area. This can also be seen from the statistics of the dwindling population of the villagers in these remote border areas of Niti Valley in District Chamoli. The villagers usually in search of living/jobs migrate to other areas/Plains.

However with the Construction/Operation of these Projects there will be lot of job opportunities both direct & indirect available for the youth and Vocational Training for farmers and Mahila Mangal Dal, etc. which shall be mostly taken up by the locals. This will not only result in the

Reverse Migration but with the availability of the basic facilities of living the six month migration of the population during winter may also reduce to a great extent thus proving these Projects to be a boon for this remote border area of Chamoli in True sense. This shall also help from the point of view of Border safety and security in the region.

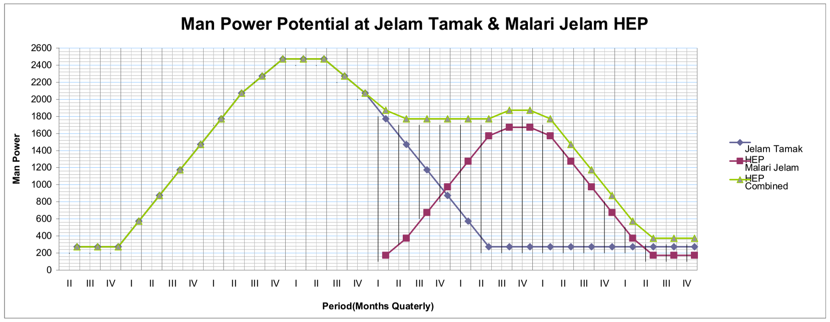
Enclosure-I6.1

Bar Chart indicating the Construction Schedule of Malari Jelam & Jhelam Tamak HEP



* Pre-Construction activities incorporates-Preparation of DPR of MJHEP and approval from CEA for both Projects, Preparation of Tender Documents and Award of work, Infrastructure works at Site.

Year	Quaterly	JTHEP	MJHEP	Combined
2013	II	200		200
	III	200		200
	IV	200		200
2014	I	500		500
	II	800		800
	III	1100		1100
	IV	1400		1400
2015	I	1700		1700
	II	2000		2000
	III	2200		2200
	IV	2400		2400
2016	I	2400		2400
	II	2400		2400
	III	2200		2200
	IV	2000		2000
2017	I	1700	100	1800
	II	1400	300	1700
	III	1100	600	1700
	IV	800	900	1700
2018	I	500	1200	1700
	II	200	1500	1700
	III	200	1600	1800
	IV	200	1600	1800
2019	I	200	1500	1700
	II	200	1200	1400
	III	200	900	1100
	IV	200	600	800
2020	I	200	300	500
	II	200	100	300
	III	200	100	300
	IV	200	100	300



Chapter 17

ISSUES OF PUBLIC HEARING

The Uttarakhand Environment Protection and Pollution Control Board conducted the Public Hearing of Jelam-Tamak Hydro Electric Project (108MW) on 06 Sept 2012 at the Project site. The Public hearing was conducted successfully by SPCB Dehradun. The copies of the minutes of Public Hearing alongwith Video recording have been forwarded to Secretary MoEF, New Delhi vide letter No. UEPPCB/HO/NOC-1734/2012/1349 dtd. 24.09,2012 (Ref **Appendix I**).

Issues of Public Hearing

1 DRONAGIRI VILLAGE AS AFFECTED VILLAGE

The consideration of Dronagiri villages as project affected village was one of the major issues raised by some speakers in public hearing meeting. The project proponents would acquire private naap land from three villages namely Jelam, Jumma and Laung sengdi. However, a total of 9.8 ha of van panchayat land will also be acquired from Dronagiri village. THDC has held Meetings with the Gram Sabha Dronagiri at the village and also in SDM office Joshimath. All the points raised by the villagers have been addressed and a Tripartite Agreement signed on 09.11.2012 with the Gram Sabha for smooth implementation of the Project.

Due to right of all families of Dronagiri village on Van Panchayat Land, all families have been considered as project affected (see page 9 of chapter 13 of EIA report).

The compensation measures have been formulated under the clause "loss of common property resource" for Dronagiri village.

2 BLASTING & DUMPING OF MUCK

Blasting activities and its negative impacts in and around the surrounding area was also one of the concerns of villagers. They also wanted the clarification on the dumping of muck The villagers were informed that Control blasting will be resorted to for the construction of the Project and utmost care will be taken in this regard by THDC. Further as mentioned in the report prior to construction, the videography of the villages located in nearby areas of blasting activities like HRT, powerhouse, barrage site will be conducted by project proponents. If any damage is found during the construction, the affected family will be compensated suitably (see page 3 of chapter 16 in EMP report). Regarding dumping of muck and rehabilitation of dumping area detailed information with supporting drawings on PPT was displayed during the Public Hearing and the same has been addressed in EMP report (chapter 1 of EMP report). Further the lateral distance of the base of muck retaining structures has been kept at least 30 m away from the river bed at HFL with proper approach road. Also for excavation and transportation of muck all guidelines shall be followed which are mentioned in EMP report (see page 2-3 of chapter 7 of EMP report) Elaborate muck disposal plan has been incorporated in the EMP under chapter II.

3 PUBLIC REPRESENTATIVE CONCERNS

The Project was welcomed in the border region by the Gram Pradhan/Ex Gram Pradhans, Chairman Nagar Palika, Joshimath, Block Pramukh etc. who expected it to be the harbinger of prosperity and development in the remote district of Chamoli, Uttarakhand in the Indo-Tibet Border region

Some of the speakers raised the issues of general public concerns, and advised the Project proponent not to involve in anti public activities and to respect the local sentiments. Chairman Nagar Palika, Joshimath appreciated the step of THDC for proposing implementation of 100 units of free electricity to PAFs upon the commissioning of the Project.

Block Pramukh wanted THDC to do work as per the aspirations of PAPs

These issues have also been addressed in EIA/EMP report

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ANNEXURES & APPENDIX

ANNEXURE – I

QUESTIONNAIRE FOR SOCIO-ECONOMIC SURVEY OF AFFECTED VILLAGES DUE TO PROJECT RELATED ACTIVITIES OF PROPOSED JELAM TAMAK H.E. PROJECT

1. Village Name ____________________

    a) District ____________ b) Development Block ________

    b) Tehsil ____________ d) Panchayat ____________

2. Area (ha) ____________________

3. Number of households ____________________

4. Population Profile:

    Total population:

    a) Male ____________________

    b) Female ____________________

    c) Scheduled Castes ____________________

    d) Scheduled Tribes ____________________

5. Workers:

    a) Main workers ____________________

    b) Farmers ____________________

    c) Marginal workers ____________________

    d) Others ____________________

6. Total Cultivable area (ha) ____________________

7. Net Sown area (ha) ____________________

8. Net Irrigated area (ha) ____________________

9. Cropping Pattern:

    Area (ha) under principal crops and yield (per ha) ____________

Cereals

a) Wheat ______________________________

b) Maize ______________________________

c) Rice ______________________________

d) Others ______________________________

Pulses

Rajmah ______________________________

Others ______________________________

10. Horticulture:

Area (ha) under principal crops and annual production

a) ______________________________

b) ______________________________

c) ______________________________

d) ______________________________

11. Medical Facilities:

a) Allopathic institutions	No.	No. of Beds	No. of Doctors	Other Staff
1) Hospitals				
2) Community Health Centres				
3) Primary Health Centres				
4) Dispensary				
5) Health Sub-centre				

b) Ayurvedic Institutions: Nos. No. of Beds

1) Hospitals ______________________________

2) Dispensary ______________________________

c) Health & Hygiene:

Prevalent Diseases ______________________________

Endemic Diseases ______________________________

Epidemic Diseases ______________________________

12. Educational Institutions:	Number	Student Strength	No. of Teachers
a) Primary schools			
b) Middle schools			
c) High / Higher Secondary schools			
d) Colleges			

If there is no school, then nearest school and distance from the village.

13. Veterinary Facilities:

a) Hospitals ______________________________

b) Dispensary ______________________________

c) Artificial Insemination Centres ______________________________

14. Sewage & Sanitation Facilities, if any ______________________________

____

15. Whether Electrified Yes / No

– Any electrical sub-station ______________________________

– If not electrified, then the nearest electrified village ______________________________

16. Roads Length (km)

a) Unmetalled ______________________________

b) Metalled ______________________________

c) Jeepable ______________________________

d) If not connected by any road, then the nearest road head (distance)

____

17. Post Office Yes / No

If the answer is 'No', then the location and distance of nearest post office

____

18. Telegraph Office ______________________________

19. Banks ______________________________

20. Police Post ______________________________

21. State Government Employees ______________________________

22. Central Govt. Employees ______________________________

23. Drinking water availability:

Source ______________________________
(River, Well, Hand-pump, Tap, Public Standpost, springs and others)

Quality : Satisfactory : Yes/ No
(Nature of problem, if No)

Quantity : Adequate/ Inadequate For drinking water (litres)
For other use (litres)
Any other specific drinking water problem

If the water is not fit for drinking, how do you purify it.

(filtering through cloth, boiling, alum treatment, disinfectant, decantation) etc.

Water borne diseases, if any

(Dysentary, Diarrhoea, Jaundice, Gastroenteritis, others, etc.)

24. Livestock:

- Sheep ______________________ Buffaloes ______________________

- Goat ______________________ Horses & Mules ____________________

- Cows ____

25. Co-operative Societies & NGOs ____

26. Village Panchayat ____

27. Fair Price Shop ____

28. Tourist/Recreational Spot ____
(Religious place, historical monument, sanctuary, others, etc.)

29. Fertilisers used and consumption _____________________________________

30. a) Forest Range/Division ____

Forest Check Post/s ____

b) Forests & Forest Produce:

Forests:

Reserve Forest ____

Protected Areas ____

Revenue Forest ____

Forest produce:

Medicinal herbs ____

Misc. ____

31. Natural Water Sources:

a) Springs ____

b) Brooks ____

c) Water Quality____

32. Literacy ______________________________

33. Income Pattern:

a) Farming ______________________________

b) Salaried:

- Government ______________________________

- Private ______________________________

c) Businessman/Shops/Trading ______________________________

34. Government Schemes (Both Central & State Govt.) like IRDP, etc.

____

____

35. Vocational Training Centres, if any ______________________________

____

36. Meteorological Data:

a) Rainfall
i) Average Annual ____________ ii) Daily (mm) ____________

b) Temperature Mean: ________ Max. ________ °C Min. ________ °C

Daily record, if available ______________________________

c) Snowfall ______________________________

d) Hailstorms a) Intensity ____________ b) Frequency ________

e) Flashfloods a) Historical ____________ b) Frequency ________

37. Fishery Resources:

Type of Fish ______________________________

Licenced Fisherman, if any ______________________________

Fish catch ___

38. Small Scale Industries:

a) Medicinal herbs collection ___

b) Handicrafts ___

c) Shawl making ___

d) Carpet weaving ___

e) Paper Machie ___

f) Wooden carving ___

g) Apiary ___

h) Others ___

39. Mode of transport : ___

40. Vehicles:

a) Bicycles ___

b) Tractors ___

c) Scooters/Bikes ___

41. Marketing Facilities:
Local Trading Centre ___

42. Non-conventional Energy Sources:

Solar lighting etc. ___

43. Recreational facilities ___
(Library, Club, TV, Cinema, etc.)

44. Wastewater
How do you dispose-off wastewater ___
(Drainage, Sewer, Soak pit, No organised system, etc.)

Any specific problem related to wastewater ___

Suggestions for improvement ___

45. Sanitation and Health

No. of families : Latrine proper sanitation facilities

Soakpit : _______________ Septic tank : ____________Any other : ___________

(If No, where do you go for defecation)

Open space: Field: Road side: Public latrine:

46. Solid waste disposal:

(Unused land, road side, community dustbin, composting, any other)

ANNEXURE – II

QUESTIONNAIRE FOR SOCIO-ECONOMIC SURVEY OF AFFECTED FAMILIES DUE TO PROJECT RELATED ACTIVITIES OF PROPOSED JELAM TAMAK H.E. PROJECT

1. Name of the head of the family ____________________

2. Religion of the family ____________________

3. Caste of the family ____________________

4. Number of Family Members ____________________

5. Age group of the family members: Adults ____________________
   Children (0-6) ____________________
   Children (6-17) ____________________

6. Number of earning members

7. Number of non-earning members   Male ☐   Female ☐

8. Number of dependants & relationship with head of the family
   Male ____________________
   Female ____________________
   Children: (Male : 0-6) ____________________
   (Female : 0-6) ____________________

9. Marital status of dependants : Married : Male ☐ Female ☐
   Unmarried : Male ☐ Female ☐

10. Occupation of family members:
    Father ____________________
    Mother ____________________
    Children : Daughter ____________________
    Son ____________________
    Others ____________________

11. Occupation details:

Service Government/ Non-government

Agriculture ____________________

Business ____________________

Any other ____________________

12. Educational qualifications of family members:

Primary ____________________

Higher Secondary ____________________

Graduate ____________________

Post-graduate ____________________

and above ____________________

13. Homestead Land:

	No. of house/houses	Area (Acres)
a) Owner	____________	____________
b) Tenant	____________	____________

14. No. of houses affected due to construction of project ____________

15. No. of houses left ____________________

16. Land holding:

Total ____________ Acres/ hectare/ any other ( )

Land under cultivation ____________ Acres

Location of land Same village ________ (Area in acres/ha/any other)

Other village ________ (Area in acres/ha/any other)

17. Land self tilled or by labourers ____________________

18. Whether living in village or not, permanently/temporarily ____________

19. No. of shops/mills to be acquired/affected

20. No. of shops left

21. No. of animals : Sheep ____________________

Goat ____________________

Cow ____________________

Bull ____________________

Horse ____________________

Pig ____________________

Others ____________________

22. Income:

a) Source/s ____________________

b) Total annual income including agriculture,
self employment, salaries, casual wages, etc. ____________________

____

22. Cropping Pattern ____________________

23. Income /expenditure Pattern ____________________

24. Details of government grants, if availed
under Indian Rural Developmental Programme
(IRDP) or other such schemes ____________________

____

25. Health Status:

- Name major diseases by which family ____________________
  members fell sick in last 3 years
- Type of treatment, family generally avails ____________________
  (allopathy, homoeopathy, ayurvedic, unani, etc.)
- Does family knows preventive measures ____________________
  of the above diseases
  (Immunisation, water treatment, personal hygiene, do not know, etc.)
- Where does family go for treatment ____________________
  (Household treatment, Pvt. medical practitioner, Govt. hospital, PHC, etc.)

- Have any member got vaccinated in the last one year ______________________
  (Cholera, Jaundice, any other)

26. Land aquisition

    a) Total land of the owner____

    b) Land to be acquired (ha) ____

    c) Land left (ha)____

    d) Type of land acquired (ha)- Landuse __________________________________

    e) Type of land left (ha) - Landuse _____________________________________

    f) Estimated loss due to loss of agricultural land, if any____________________

27. Immovable Properties:

    a) Houses____

    b) Wells ____

    c) Ponds ____

    d) Water- mills ____

    e) Others ____

28. Willingness to Accept:

    a) Willing to accept the loss of land (homestead/agricultural) Yes/No

    b) Is ready to accept the proper compensation offered for the loss as per the State policy Yes/No

    c) If answers to above questions are No, then give reasons _______________

    ____

29. Would you welcome the project. Yes/ No
    (If No, give reasons)

____

Surveyor Name:_________________________ Signature of the respondent

Date : ______________________

Annexure III

PUBLIC PERCEPTION ABOUT THE JELAM TAMAK H.E. PROJECT

Name of respondent : ______________________________

Date of survey : ____________________ Place of survey : ____________

A. Are you aware of the project in this area : Yes / No

If yes, source of information : ☐

[Visually/ Other peron/ Newspaper/ Radio/ T.V./ Any other specify]

B. What is your opinion about project : ☐

[Good/ Bad/ Mix-reaction/ Neutral/ Don't know]

C. In your opinion, what are the effects of this project in your area ?

1. More generation of electricity : Yes / No
2. More job opportunities : Yes / No
3. More sale of local products : Yes / No
4. Development of additional market potentials : Yes / No
5. Improvements in transport facilities : Yes / No
6. Improvement in medical facilities : Yes / No
7. Improvement in educational facilities : Yes / No
8. Availability of other products from outside : Yes / No
9. Improvement in irrigation facilities for agriculture : Yes / No
10. Increase in valuation of property (Land, House, etc.) : Yes / No
11. Generation of income sources : Yes / No

    (Rental value of house, land, etc.)

12. Development/ setting up auxiliary and ancillary units : Yes / No

13. Development of new tourist spot : Yes / No

14. Increase/ development of infrastructure facilities : Yes / No

    (Telecommunication/ Post office/ Bank, etc.)

15. Increase/ development in welfare facilities : Yes / No

16. Adoption of village by project authority : Yes / No

17. Adoption of village by NGO : Yes / No

18. Improvement in aesthetic environment : Yes / No

19. Increase/ development of entertainment/ recreation facilities : Yes / No

20. Change in social attitude because of mixed culture from the people of other state : Yes / No

21. It could help in personality development : Yes / No

22. Any other specific positive comments on the project :

    ____

    ____

23. Suggestion for further improvement of positive impacts of the project :

    ____

    ____

D. In your opinion what are the adverse impacts due to this project :

1. Increase in population : Yes / No

2. Housing problem : Yes / No

3. Displacement and relocation effects home, families, occupation : Yes / No

4. Loss of agriculture land : Yes / No

5. Inadequate compensation : Yes / No

6. Adverse effect on agriculture crops and products : Yes / No

7. Project disrupt existing land use : Yes / No

8. Essential commodities become costlier : Yes / No

9. Affect infrastructural amenities due to strain and demands : Yes / No

10. Deterioration in air quality (specify) : Yes / No

11. Deterioration in drinking water quality (specify) : Yes / No

12. Deterioration in land quality (specify) : Yes / No

13. Deterioration in general health (specify) : Yes / No

14. Increase in landslides, etc. Yes / No

15. Increase in erosion : Yes / No

16. Irrigation would be affected : Yes / No

17. Loss of natural water resources : Yes / No

18. Loss of fishing and other aquatic animals : Yes / No

19. Deterioration of water sources : Yes / No

20. Loss of forest : Yes / No

21. Loss of some unique species of flora : Yes / No

    If yes, please specify :

22. Effect on wild life : Yes / No

23. Loss of some unique wildlife : Yes / No

    If yes, please specify :

24. Loss of economic base of the area : Yes / No

25. Problem due to increase in transport and traffic : ☐

    [Dust, increase in air pollutants, Noise, Vibrations, Accidents)

26. Increase in social problems : Yes / No

If yes, please specify :

27. Loss of aesthetic environment : Yes / No

28. Living become costlier : Yes / No

29. Any adverse effect on :

i) Religious place (specify) ____________________

ii) Historical place (specify) ____________________

iii) Sanctuary (specify) ____________________

iv) Any other (specify) ____________________

30. Any other specific environmental problem (specify) ____________________

____

31. Suggestion for improvements (specify)

____

32. Do you foresee any other specific problem/ loss due to project (specify)

____

____

33. Any other specific negative comments on project (specify)

____

____

34. Suggestion for improvements (specify)

____

____

Surveyor Name : ____________________

____
Signature

Date : ____________________

Annexure-IV

Tamak

टी0 एच0 डी0 सी0 इण्ड़िया लि0 जोशीमठ के जेलम–तमक जल विद्युत परियोजना के सम्बन्ध में ग्राम लॉग सेगड़ी (तमक) की निम्न लिखित मांगों के सम्बन्ध में आज दिनांक 03.02.2010 को तहसील सभागार जोशीमठ में संयुक्त मजिस्ट्रेट/ उपजिलाधिकारी जोशीमठ की अध्यक्षता में टी0 एच0 डी0 सी0 इण्ड़िया लि0 जोशीमठ तथा ग्राम लॉग सेगड़ी (तमक – ग्राम पंचायत तोलमा) के ग्रामवासियों की संयुक्त बैठक का कार्यवृत्तः–

मांग संख्या	बैठक का कार्यवृत्त
01	ग्राम लॉग सेगड़ी (तमक) के समस्त ग्रामवासियों को उनके हक व कब्जे की भूमि के प्रभावित होने पर ग्रामवासियों को राज्य सरकार की पुर्नस्थापना तथा पुर्नवास नीति के अनुसार कार्यवाही करने पर सहमति।
02	राज्य सरकार की पुर्नवास नीति के अनुसार भूमि, मकान, फलदार वृक्ष व अन्य प्रजाति के पेड़ो की क्षति का ऑकलन कर पुर्नवास नीति के अनुसार उचित मुआवजे की कार्यवाही पर सहमति।
03	ग्राम लॉग सेगड़ी (तमक) के प्रभावित शिक्षित तथा अशिक्षित व्यक्तियों को उत्तराखण्ड़ सरकार के नियमों के अनुसार प्राथमिकता के आधार पर रोजगार देने पर सहमति।
04	कम्पनी के मुख्य ठेकेदारों के आने पर मुख्य ठेकेदार योग्य ग्राम वासियों को उनकी योग्यता और क्षमता के अनुसार तथा अपनी जरूरत के अनुसार कार्य को ठेके पर करवाये जाने पर सहमति।
05	परियोजना से पूर्ण प्रभावित होने की दशा में परियोजना प्रभावित परिवार के एक ब्यक्ति को योग्यतानुसार स्थायी नियुक्ति दिये जाने हेतु कारपोरेशन/सरकारी प्रावधानों के अनुसार प्राथमिकता प्रदान किये जाने पर सहमति ।
06	ग्राम लॉग सेगड़ी (तमक) के परियोजना प्रभावित अप्रशिक्षित बेरोजगारों को प्रशिक्षण देने के लिये सहमति।
07	पर्यावरण संरक्षण हेतु वृक्षारोपण की कार्ययोजना को स्थानीय समिति के सहयोग से उत्तराखण्ड़ सरकार की नीति के अनुसार कराये जाने पर सहमति ।
08	ग्राम लॉग सेगड़ी (तमक) के समस्त घरों की वीडियो ग्राफी टी0 एच0 डी0 सी0 इण्ड़िया लि0 द्वारा की जायेगी। इसके अतिरिक्त ग्राम तमक के समस्त घरों और ग्रामवासियों का बीमा टी0 एच0 डी0 सी0 इण्ड़िया लि0 द्वारा करवाने पर सहमति ।
09	ग्राम लॉग सेगड़ी (तमक) के महिला एवं युवामंगल दल के सदस्यों के लिये बुनाई कताई, जनरेटर तथा बर्तन आदि के लिये प्रशिक्षण तथा व्यवस्था करने पर सहमति।
10	ग्राम लॉग सेगड़ी (तमक) के 4 मन्दिरों (माँ भगवती मन्दिर, भूमियाल मन्दिर, दाणी देवता मन्दिर एवं एक अन्य मन्दिर) के सौन्दर्यीकरण पर सहमति।
11	ग्राम लॉग सेगड़ी (तमक) में बारात घर/सामुदायिक भवन के निर्माण पर टी एच डी सी लि0 द्वारा सहमति इस आधार पर की गयी कि सम्बन्धित भवन हेतु भूमि निशुल्क ग्राम पंचायत द्वारा उपलब्ध करायी जायेगी ।
12	ग्राम लॉग सेगड़ी (तमक) के लिये आपातकालीन परिस्थितियों में एम्बुलेन्स जैसे वाहनों की सेवा प्रदान किये जाने पर सहमति ।
13	ग्राम लॉग सेगड़ी (तमक) के प्राथमिक विद्यालय में कीड़ा स्थल के निर्माण किये जाने पर सहमति ।
14	सार्वजनिक सम्पत्तियों को क्षति होने पर उचित क्षतिपूर्ति दिये जाने पर सहमति ।
15	ग्राम लॉग सेगड़ी (तमक) के अन्तर्गत पुला नामक तोक में पेयजल आपूर्ति की ब्यवस्था स्थल निरीक्षणोंपरान्त किये जाने पर सहमति। रखरखाव की ब्यवस्था ग्राम पंचायत स्वयं करेगी ।
16	ग्राम लॉग सेगड़ी (तमक) के नीचे संयुक्त निरीक्षणोंपरान्त सुरक्षा दीवार के निर्माण पर सहमति।
17	परियोजना में परियोजना प्रभावित गॉवों के व्यक्तियों के वाहन (जो कि दो वर्ष से अधिक पुराने न हों) आवश्यकतानुसार परियोजना में किराये पर लगाये जाने पर सहमति।

	गॉव के रास्तों में यात्री प्रतिक्षालय बनाने पर सहमति परन्तु भूमि ग्राम पंचायत द्वारा निशुल्क उपलब्ध करवायी जायेगी।
	मलारी से जोशीमठ तक मलारी–जेलम और जेलम–तमक परियोजना से सम्बन्धित लोगो के लिये आने जाने हेतु बस सेवा की व्यवस्था करने पर सहमति।
	ग्राम प्रधान के माध्यम से ग्राम लॉग सेगड़ी (तमक) में होने वाले सामाजिक कार्यो में जो निर्माण कार्य है उसे करने के लिये ग्रामवासियों द्वारा एक श्रमिक समिति सोसायटी एक्ट में रजिस्टर्ड करने पर सहमति हुई। इस सोसायटी को दो लाख रूपये तक के कार्य सीधे ही दिये जाने पर सहमति।
21	ग्राम लॉग सेगड़ी (तमक) की स्ट्रीट लाइट से सम्बन्धित निर्माण कार्य कराये पर टी एच डी सी द्वारा सहमति किन्तु विद्युत आपूर्ति राज्य सरकार द्वारा प्रदान की जायेगी।
22	ग्राम लॉग सेगड़ी (तमक) की मॉग के अनुसार तीन बेरोजगारों को तुरन्त उत्तराखण्ड़ पूर्व सैनिक कल्याण निगम लि0 के माध्यम से नौकरी पर लगाया जायेगा इस सम्बन्ध में टी एच डी सी द्वारा यह सहमति व्यक्त की गयी कि एक व्यक्ति को ग्राम लॉग सेगड़ी (तमक) से सम्बन्धित सामाजिक कार्यो को सम्पादित करने हेतु अगले 15 दिनों में लगाया जायेगा एवं अन्य दो व्यक्तियों को 1 अप्रैल 2010 से तमक ग्राम में साइट कार्यालय में लगाये जाने की कार्यवाही की जायेगी।
23	ग्राम लॉग सेगड़ी (तमक) में सी0 सी0 फुटपाथ का निर्माण टी0 एच0 डी0 सी0 इण्ड़िया लि0 और ग्राम के प्रतिनिधियों द्वारा संयुक्त निरीक्षण के उपरान्त अगले पॉच साल के अन्दर ग्राम समिति द्वारा कराने पर सहमति।
24	कम्पनी द्वारा निर्माण कार्य में कन्ट्रोल ब्लास्टिंग से कार्य करने पर सहमति।
25	ग्राम लॉग सेगड़ी (तमक) के ग्रामवासियों द्वारा यह भी सहमति व्यक्त की गयी कि ग्राम लॉग सेगड़ी मे तमक नामे तोक में मोटर मार्ग एवं धोलीगंगा नदी के मध्य जो नाप भूमि स्थित है उस भूमि को टी0 एच0 डी0 सी0 इण्ड़िया लि0 को परियोजना निर्माण हेतु देने पर सहमति।
26	ग्रामवासियों की ओर से बैठक के अन्त में यह सहमति बनी कि भविष्य में यदि किसी भी प्रकार का वाद विवाद हो तो उसको संयुक्त मजिस्ट्रेट/उपजिलाधिकारी जोशीमठ की उपस्थिति में सुलझाने पर सहमति।
27	भविष्य में तमक की मांगे आपसी सहमति तथा प्रशासन के सुझाव के अनुसार पूरा किया जाने पर सहमति।
नोट	संयुक्त मजिस्ट्रेट/उपजिलाधिकारी महोदय ने गॉव वालों के साथ वार्ता के बाद यह निर्देश दिया कि उपरोक्त कार्य परियोजना निर्माण के दौरान अगले पॉच वर्षो में टी0 एच0 डी0 सी0 इण्ड़िया लि0 के कारपोरेट सोशल रेस्पोन्सिबिलिटी फंड के अन्तर्गत किया जायेगा तथा ग्राम लॉग सेगड़ी (तमक) जेलम–तमक परियोजना को पूर्ण करने के लिये अपना पूरा सहयोग देगें ताकि पूरे समस्त क्षेत्र का तथा राज्य का सर्वांगीण विकास हो।

उक्त बैठक में उपस्थित सभी टी0 एच0 डी0 सी0 इण्ड़िया लि0 के अधिकारियों एवं ग्राम तमक के ग्रामवासियों की आपसी सहमति बनने पर उन्हें धन्यवाद देकर बैठक समाप्त हुई।

उपस्थित प्रशासनिक अधिकारियों, ग्रामवासियों तथा टी0 एच0 डी0 सी0 इण्ड़िया लि0 के अधिकारियों की सूची सलंग्न है।

दिनॉक : 03.02.2010

संजय रवेर
3/2/10

प्रधान
ग्राम पंचायत तोलमा

प्रधान ग्राम पंचायत तोलमा
वि0 ख0 जोशीमठ (चमोली)

अपर महाप्रबन्धक
टी0 एच0 डी0 सी0
इण्ड़िया लि0 जोशीमठ

अपर महाप्रबन्धक
मलारी जेलम एवं जेलम तमक
जल विद्युत परियोजनायें
टी.एच.डी.सी. इण्डिया लि. जोशीमठ

संयुक्त मजिस्ट्रेट/उपजिलाधिकारी
जोशीमठ

T.H.D.C. India Ltd. Joshimath
Distt. Chamoli (U.K.)

Tolmati Villagers
Attendance at SDM office
Joshimath

Dtd 3/2/10

गंगा
Date
Page

1/2

दिनांक 03-02-2010 को उपजिलाधिकारी [illegible]

क्र.सं.	नाम	पद नाम	हस्ता.
(1)	श्री उप जिलाधिकारी जोशीमठ		
(2)	" तहसीलदार जोशीमठ		
(3)	पी०एल० तिवारी सहायक [illegible]		
(4)	[illegible]		
(5)	के०पी० [illegible]		
(6)	प्रेम सिंह पंवार	प्रधान	
(7)	सुरेन्द्र सिंह पंवार	प्रधान [illegible]	
(8)	नत्थी सिंह पंवार		
(9)	अब्बल सिंह पंवार		
(10)	[illegible] सिंह रावत		
(11)	[illegible] सिंह		
(12)	पूरन सिंह		
(13)	पान सिंह		पान सिं
(14)	धन सिंह		
(15)	[illegible]		
(16)			
(17)	[illegible] सिंह पंवार [illegible]		
(18)	[illegible] सिंह		
(19)	[illegible]		
(20)	[illegible] सिंह		
(21)	त्रिलोक सिंह		
(22)	दिवान सिंह रावत		
(23)	बलवन्त सिंह पवार		
(24)	[illegible] सिंह		
(25)	दरवान सिंह		
(26)	केदार सिंह		केदारसि
(27)	भरत सिंह		भरतसि
(28)	देवेन्द्र सिंह		

[illegible] at SDM office Joshimath

दिनांक 3/2/10

2/2

Manoj Raj (रा.उ.अ.)
A.V.O.
3-1-10

गंगा
Date
Page

[illegible]

श्री [illegible] THDC [illegible]

(29)	लेखनपाल		[illegible]
(30)	राय सिंह		[illegible]
(31)	बिशन सिंह		[illegible]
(32)	प्रदीप सिंह		प्रदीप सिंह
(33)	शंकर पवांर		Shankar
(34)	महेश सिंह राणा		महेश
(35)	कुंवर सिंह		कुंवर सिंह
(36)	शोभन सिंह पवार		[illegible]
(37)	रणजीत सिंह पवांर		[illegible]
(38)	गब्बर सिंह पंवार		[illegible]
(39)	कुंवर सिंह पवांर		[illegible]
(40)	पूरण सिंह रावत		Rawat
(41)	मुकेश सिंह		[illegible]
(42)	रघुवीर पवांर		Raghubir
(43)	कु. सरस्वती		Saraswati
(44)	श्रीमती कलावती देवी		कलावती देवी
(45)	श्रीमती लक्ष्मी देवी		[illegible]
(46)	श्रीमती मंगली देवी		मंगली
(47)	श्रीमती भादी देवी		भादी देवी
(48)	श्रीमती नौबी देवी		नौबी देवी
(49)	श्रीमती माघी देवी		माघी देवी
(50)	श्रीमती मालमती देवी		मालमती देवी
(51)	श्रीमती देवकी देवी		[illegible] चंद जी [illegible]
(52)	श्रीमती बसुन्ती देवी		
(53)	श्रीमती [illegible] देवी		
(54)	श्रीमती पार्वती देवी		
(55)	श्रीमती सीता देवी		[illegible]
(56)	श्रीमती देवकी देवी		
(57)			
(58)			

Jumma

झेलम–तमक जल विद्युत परियोजना के ग्राम जुम्मा

के निवासियों के साथ आज दिनॉक 23.02.2010 को टी एच डी सी इण्ड़िया लि0 जोशीमठ में हुई **बैठक का विवरण** :–

आज दिनॉक 23.02.2010 को टी एच डी सी इण्ड़िया लि0 के अधिकारियों और ग्राम जुम्मा के निवासियों के मध्य परियोजना कार्यालय जोशीमठ में एक बैठक हुई । इस बैठक में ग्राम जुम्मा की ओर से सर्व श्री शेर सिंह राणा, अध्यक्ष नन्दा देवी राजजात यात्रा, बलवीर सिंह क्षेत्र पंचायत सदस्य, सुरेन्द्र सिंह एडवोकेट, चन्दन सिंह रावत, अवतार सिंह राणा तथा अन्य गणमान्य नागरिक उपस्थित थे । साथ ही टी एच डी सी इण्ड़िया लि0 की तरफ से अपर महाप्रबन्धक श्री संजय खेर, वरिष्ठ प्रबन्धक श्री आल्हा सिंह, वरिष्ठ अभियन्ता श्री एच0पी0 भट्ट, सहायक विधि अधिकारी श्री मनोज राय तथा कनिष्ठ अभियन्ता श्री आर0 के0 नागर उपस्थित थे।

बैठक में ग्रामवासियों तथा टी एच डी सी इण्ड़िया लि0 के मध्य निम्नलिखित बिन्दुओं पर सर्वसहमति बनी:–

1. ग्राम जुम्मा को परियोजना से किसी भी प्रकार की क्षति होने की दशा में टी0 एच0 डी0 सी0 इण्ड़िया लि0 /सरकार की पुर्नस्थापना एवं पुर्नवास नीति के अनुसार विस्थापित किये जाने पर सहमति हुई।
2. झेलम–तमक परियोजना से सम्बन्धित समस्त विकास कार्य झेलम ग्राम पंचायत के साथ हुए समझोते के अनुरूप पंजीकृत समिति के माध्यम से कराये जायेंगे।
3. ग्राम जुम्मा में कराये जाने वाले कार्यो के लिये ग्राम जुम्मा की एक सलाहकार समिति बनायी जायेगी जो समय–समय पर ग्राम पंचयात झेलम की पंजीकृत समिति से सहमति बनाकर ग्राम जुम्मा के विभिन्न विकास कार्यो का विवरण प्रस्तुत करेगी और उनको पूर्ण करने में सहयोग करेगी ।
4. ग्राम जुम्मा के समस्त विकास कार्य टी एच डी सी इण्ड़िया लि0 जोशीमठ के अनुमोदन के उपरान्त सम्पादित होंगे।

उक्त बैठक में उपस्थित सभी टी0 एच0 डी0 सी0 इण्ड़िया लि0 के अधिकारियों एवं ग्राम जुम्मा के ग्रमवासियों की आपसी सहमति बनने पर उन्हें धन्यवाद देकर बैठक समाप्त हुई।

8/c

ग्राम जुम्मा के प्रतिनिधिः–

श्री शेर सिंह राणा, अध्यक्ष नन्दा देवी राजजात यात्रा
बलवीर सिंह क्षेत्र पंचायत सदस्य
सुरेन्द्र सिंह एडवोकेट
चन्दन सिंह रावत
अवतार सिंह रावत

टी0 एच0 डी0 सी0 इण्ड़िया लि0 के प्रतिनिधि
श्री संजय खेर, अपर महाप्रबन्धक। संजय खेर 23/2/10
श्री आल्हा सिंह, वरिष्ठ प्रबन्धक। 23/2/10
श्री मनोज राय सहायक विधि अधिकारी। 23-2-10

दिनाँक 03.02.2010 को तहसील जोशीमठ में प्रशासन, टी0 एच0 डी0 सी0 इण्डिया लि0 जोशीमठ व ग्राम पंचायत तोलमा के प्रभावित ग्राम तमक के ग्रामवासियों व उनके प्रतिनिधियों के साथ बैठक का कार्यवृत्तः–

टी0 एच0 डी0 सी0 इण्डिया लि0 जोशीमठ के प्रतिनिधिः–

1. अपर महाप्रबन्धक – श्री संजय खेर।
2. वरिष्ठ प्रबन्धक – श्री आल्हा सिंह ।
3. वरिष्ठ अभियन्ता – श्री एच0 पी0 भट्ट।
4. सहा0 विधि अधिकारी – श्री मनोज राय।

प्रशासन प्रतिनिधिः–

1. संयुक्त मजिस्ट्रेट जोशीमठ (एस0डी0एम0)।
2. तहसीलदार ।
3. नायब तहसीलदार।

तमक ग्राम (ग्राम पंचायत तोलमा)

पदमसिंह मागीदेवी

सीता

कलावती देवी

माधोसिंह रावत

धानसिंह

SrMgr(MJ-JT)
CC. SrEngr(HPB)
— SrEnm(DLS)

JELAM
① Original Enl — keep in safe custody by SrMgr
② Pl. take action for full implementation of the agreement.
Sany
9/1
AGM

टी0 एच0 डी0 सी0 इण्ड़िया लि0 जोशीमठ के जेलम–तमक जल विद्युत परियोजना के सम्बन्ध में ग्राम पंचायत जेलम की निम्न लिखित मांगों के सम्बन्ध में आज दिनांक 06.01.2010 को तहसील सभागार जोशीमठ में संयुक्त मजिस्ट्रेट/उपजिलाधिकारी जोशीमठ की अध्यक्षता में टी0 एच0 डी0 सी0 इण्ड़िया लि0 जोशीमठ तथा ग्राम सभा जेलम के ग्रामवासियों की संयुक्त बैठक का कार्यवृत्त :–

जेलम

मांग संख्या	बैठक का कार्यवृत्त
01	ग्राम जेलम में धटूडी तोक के नीचे वाली सुरंग को बन्द करने पर सहमति तथा गॅाव को किसी भी प्रकार की यदि क्षति हुई है उसका सुयक्त निरीक्षण टी0 एच0 डी0 सी0 इण्ड़िया लि0, प्रशासनिक अधिकारी एवं गॅाव के प्रतिनिधि के उपरान्त आवश्यक कार्य करने पर सहमति। इसके अतिरिक्त ग्राम की वीडियों ग्राफी टी0 एच0 डी0 सी0 इण्ड़िया लि0 द्वारा की जायेगी।
Impmt Est DLS VPK 02	ग्राम पंचायत जेलम में सीसी फुटपाथ का निर्माण टी0 एच0 डी0 सी0 इण्ड़िया लि0 और ग्राम के प्रतिनिधियों द्वारा संयुक्त निरीक्षण के उपरान्त अगले पॅाच साल के अन्दर ग्राम समिति द्वारा कराने पर सहमति।
03	गॅाव के शिक्षित/अशिक्षित बेरोजगारों को ग्राम समिति द्वारा सस्तुति करने पर रोजगार में वरीयता देने पर सहमति।
Impr + Est DLS VPK 04	ग्राम जेलम में सिंचाई व्यवस्था करवाने हेतु सरकारी विभागों द्वारा अनापत्ति प्रमाण पत्र, जो कि ग्राम सभा टी0 एच0 डी0 सी0 इण्ड़िया लि0 को उपलब्ध करायेगी, के उपरान्त कार्य करवाने पर सहमति।
Est Std (Expect) PKG 05	ग्राम पंचायत जेलम में प्रत्येक गॅाव के लिये सार्वजनिक शौचालय की व्यवस्था करवाने पर सहमति।
06	ग्राम पंचायत जेलम में छः मन्दिरों के सौन्दर्यीकरण पर सहमति।
07	परियोजना से सम्बन्धित ग्राम पंचायतों को कुल विद्युत उत्पादन का 01 प्रतिशत प्रतिवर्ष क्षेत्र के विकास में खर्च करने दिया जायेगा, तथा टी0 एच0 डी0 सी0 इण्ड़िया लि0 के कारपोरेट सामाजिक दायित्व के अन्तर्गत प्रभावित क्षेत्रों के विकास में और राशि उपलब्ध कराई जायेगी व ग्राम पंचायत जेलम को उत्तराखण्ड व केन्द्रीय सरकार के नियमानुसार बिजली व पानी की व्यवस्था तथा विकास कार्य पर खर्च करने पर सहमति।
08	कम्पनी द्वारा निर्माण कार्य में कन्ट्रोल ब्लास्टिंग से कार्य करने पर सहमति।
09	ग्राम पंचायत जेलम के शिक्षित तथा अशिक्षित व्यक्तियों को उत्तराखण्ड सरकार के नियमों के अनुसार प्राथमिकता के आधार पर रोजगार देने पर सहमति।
10	मुख्य परियोजना निर्माण के दौरान ग्राम जेलम के लिंक रोड़ का चौड़ीकरण तथा विस्तारीकरण पर सहमति।
Inspn + Est 11	ग्राम पंचायत जेलम के सभी छः ग्रामों में सार्वजनिक भवनों का मरम्मत तथा पुर्ननिर्माण, संयुक्त निरीक्षण के पश्चात परियोजना निर्माण के दौरान करने पर सहमति।
12	गॅाव के लोगों को ठेकेदारी तथा गाड़ी आदि के कार्य में उनके अनुभव और गॅाव वासियों की सहमति के अनुसार परियोजना कार्य शुरू होने पर लगाने पर सहमति।
st/Note for Hiring Action (HPB) 13	मलारी से जोशीमठ तक मलारी–जेलम और जेलम–तमक परियोजना से सम्बन्धित लोगों के लिये आने जाने हेतु बस सेवा की व्यवस्था करने पर सहमति।
Proposal Est. 14	महिला एवं युवामंगल दल के सदस्यों के लिये बुनाई कताई, जनरेटर तथा बर्तन आदि के लिये प्रशिक्षण तथा व्यवस्था करने पर सहमति।

To process notes for implementation of agreement. Afe
[illegible] 9. Sr.
20/1/10

Joint Inspn. with Jelam	15	जेलम में नाप जमीन पर टी0 एच0 डी0 सी0 इण्ड़िया लि0 कालोनी निर्माण हेतु गॉव वालों की सहयोग से कार्य करने पर सहमति। इसके लिये गॉव के प्रतिनिधियों और टी0 एच0 डी0 सी0 इण्डिया लि0 के अधिकारियों का संयुक्त निरीक्षण के उपरान्त तकनीकी जरूरत के अनुसार कार्यवाही होगी।
	16	श्यामा तोक में परियोजना कार्य हेतु खनन कार्य को कम से कम करने पर सहमति।
Forma spn with Jelam	17	श्यामा तोक में शमशान घाट को सुरक्षित रखने पर सहमति।
Videography + Instrument as per prog.	18	ग्राम पंचायत को क्षति होने पर आपसी सहमति द्वारा क्षति की पूर्ति कम्पनी द्वारा करने पर सहमति।
	19	राज्य सरकार के नियमानुसार पुर्नस्थापना तथा पुर्नवास नीति के अनुसार ग्राम पंचायत जेलम के नाप व बेनाप भूमि का मुआवजा उपलब्ध करवाना सुनिश्चित किया जायेगा।
	20	अनुभवी विशेषज्ञों व भूगर्भ वैज्ञानिकों की राय पर तथा सरकारी नीति के अनुसार ग्राम पंचायत जेलम को क्षति होने पर पुर्नस्थापना तथा पुर्नवास नीति के अनुसार विस्थापित करने पर सहमति।
	21	भविष्य में ग्राम पंचायत जेलम की मांगे आपसी सहमति के अनुसार किया जाने पर सहमति।
	22	ग्रामवासियों की तरफ से बैठक के अन्त में यह सहमति बनी कि भविष्य में यदि किसी भी प्रकार का वाद विवाद हो तो उसको संयुक्त मजिस्ट्रेट /उपजिलाधिकारी जोशीमठ की उपस्थिति में सुलझाने पर सहमति।
Help to form society	23	ग्राम प्रधान के माध्यम से ग्राम पंचायत जेलम में होने वाले सामाजिक कार्यो में जो निर्माण कार्य है उसे करने के लिये ग्रामवासियों द्वारा एक श्रमिक समिति सोसायटी एक्ट में रजिर्स्टड करने पर सहमति हुई। इस सोसायटी को दो लाख तक के कार्य सीधे ही दिये जाने पर सहमति।
	24	कम्पनी के मुख्य ठेकेदारों के आने पर मुख्य ठेकेदार योग्य ग्राम वासियों को उनकी योग्यता और क्षमता के अनुसार तथा अपनी जरूरत के अनुसार कार्य को ठेके पर करवायेगा।
	नोट	संयुक्त मजिस्ट्रेट/उपजिलाधिकारी महोदय ने गॉव वालों के साथ वार्ता के बाद यह निर्देश दिया कि उपरोक्त कार्य परियोजना निर्माण के दौरान अगले पॉच वर्षो में टी0 एच0 डी0 सी0 इण्डिया लि0 के कारपोरेट सोषल रेस्पोन्सिबिलिटी फंड के अन्तर्गत किया जायेगा तथा ग्राम पंचायत जेलम परियोजना को पूर्ण करने के लिये अपना पूरा सहयोग देगें ताकि पूरे समस्त क्षेत्र का तथा राज्य का सर्वागीण विकास हो।

उक्त बैठक में उपस्थित सभी टी0 एच0 डी0 सी0 इण्ड़िया लि0 के अधिकारियों एवं ग्राम जेलम के ग्रमवासियों की आपसी सहमति बनने पर उन्हें धन्यवाद देकर बैठक समाप्त हुई।

उपस्थित प्रषासनिक अधिकारियों, ग्रामवासियों तथा टी0 एच0 डी0 सी0 इण्ड़िया लि0 के अधिकारियों की सूची सलंग्न है।

दिनॉक : 06.01.2010

6/1/10

ग्राम पंचायत
जेलम

6-1-10

अपरमहाप्रबन्धक
टी0 एच0 डी0 सी0
इण्ड़िया लि0 जोशीमठ

C.S.
6/1/10

संयुक्त मजिस्ट्रेट/उपजिलाधिकारी
जोशीमठ

उप जिलाधिकारी
जोशीमठ

दिनांक 06.01.2010 को तहसील जोशीमठ में प्रशासन, टी0 एच0 डी0 सी0 इण्ड़िया लि0 व जेलम ग्रामसभा व ग्रामवासियों व उनके प्रतिनिधियों के साथ हुई बैठक का कार्यवृत्तः–

उक्त बैठक मे उपस्थित प्रशासनिक अधिकारी, टी0 एच0 डी0 सी0 इण्ड़िया लि0 के अधिकारी और ग्राम पंचायत जेलम के सदस्यों की सूची निम्नलिखित है :–

टी0 एच0 डी0 सी0 इण्ड़िया लि0 प्रतिनिधिः–

1. अपर महाप्रबन्धक ।
2. वरिष्ठ प्रबन्धक ।
3. वरिष्ठ अभियन्ता ।
4. सहा0 विधि अधिकारी

प्रशासन प्रतिनिधि :–

1. संयुक्त मजिस्ट्रेट जोशीमठ (एस0डी0एम0)।
2. तहसीलदार ।
3. नायब तहसीलदार ।

ग्राम पंचायत जेलम।

ह0
दि0 06-1-10

पार्वती भण्डारी
महिला मंगलदल
ग्राम सभा जेलम
जोशीमठ(चमोली)

रामेश्वरी
पंचम

महेन्द्र लाल

नरेन्द्र

हीरादेवी

KOSA

टी0 एच0 डी0 सी0 इण्ड़िया लि0 जोशीमठ के मलारी–जेंलम जल विद्युत परियोजना के सम्बन्ध में ग्राम पंचायत कोसा की निम्न लिखित मांगों के सम्बन्ध में आज दिनांक 18.05.2010 को तहसील सभागार जोशीमठ में संयुक्त मजिस्ट्रेट/उपजिलाधिकारी जोशीमठ की अध्यक्षता में टी0 एच0 डी0 सी0 इण्ड़िया लि0 जोशीमठ तथा ग्राम पंचायत कोसा के प्रतिनिधियों की संयुक्त बैठक का कार्यवृत्त :–

मांग संख्या	बैठक का कार्यवृत्त
01	ग्राम पंचायत कोसा की वन पंचायत भूमि में स्थित क्षतिग्रस्त पेय जल योजना की आवश्यक मरम्मत ग्रामवासियों द्वारा कराये जाने पर सहमति।
02	ग्राम पंचायत कोसा की वन पंचायत भूमि में जो रास्ता टी एच डी सी इण्ड़िया लि0 द्वारा निर्मित किया जा रहा है उसे ग्रामीणों द्वारा बनवाये जाने पर सहमति ।
03	टी एच डी सी इण्ड़िया लि0 द्वारा यह अवगत कराया गया कि परियोजना की जो टनल बनेगी वो ग्राम कोसा से कॉफी दूरी पर है और नदी के दूसरी ओर पहाडी पर भूमिगत प्रस्तावित है जिससे ग्रामवासियों की नाप भूमि को कोई क्षति की आशंका नहीं है यदि उसके विपरीत कोई क्षति होती है तो उसकी भरपाई टी एच डी. सी इण्ड़िया लि0 द्वारा की जायेगी । इसके अतिरिक्त संयुक्त निरीक्षण के पश्चात कोसा गाड़ में जरूरत पड़ने पर चैक डैम/सुरक्षा दीवार निर्माण किये जाने पर सहमति।
04	ग्राम पंचायत कोसा के आवासीय भवनो को यदि परियोजना के निर्माण कार्य के दौरान ब्लास्टिंग से कोई भी क्षति पहुँचती है तो उसकी क्षतिपूर्ति टी एच डी सी इण्ड़िया लि0 द्वारा किये जाने पर सहमति तथा इसके अतिरिक्त कोसा ग्राम के आवासीय भवनो की विडियोग्राफी तथा बीमा टी एच डी सी इण्ड़िया लि0 द्वारा की जायेगी।
05	यदि परियोजना निर्माण के दौरान ग्राम पंचायत कोसा के पेय जल योजना को कोई क्षति पहुँचती है तो पेयजल आपूर्ति टी एच डी सी इण्ड़िया लि0 द्वारा किये जाने पर सहमति । इसके अतिरिक्त ग्रामवासियों द्वारा अवगत कराया गया कि उनके जल के स्रोत सूख रहे हैं जिस पर यह सहमति बनी कि परियोजना निर्माण के दौरान तथा डी0 पी0 आर0 के पश्चात ग्राम कोसा हेतु लगभग 3 कि0मी0 दूरी से ग्रेविटी द्वारा पेय जल की ब्यवस्था की जायेगी।
06	परियोजना से सम्बन्धित ग्राम पंचायतों को कुल विद्युत उत्पादन का 01 प्रतिशत प्रतिवर्ष क्षेत्र के विकास में भारत और राज्य सरकार के नियमों के अनुसार खर्च किया जायेगा ।
07	टी0 एच0 डी0 सी0 इण्ड़िया लि0 के क़ारपोरेट सामाजिक दायित्व के अन्तर्गत प्रभावित क्षेत्रों के विकास में राशि उपलब्ध कराई जायेगी व ग्राम पंचायत कोसा को उत्तराखण्ड़ व केन्द्रीय सरकार के नियमानुसार बिजली व पानी की ब्यवस्था तथा विकास कार्य पर खर्च करने पर सहमति।
08	कम्पनी द्वारा निर्माण कार्य में कोसा क्षेत्र के अन्तर्गत कन्ट्रोल ब्लास्टिंग से कार्य करने पर सहमति।
09	ग्राम पंचायत कोसा के लिये आपातकालीन परिस्थितियों में एम्बुलेन्स जैसे वाहनों की सेवा प्रदान किये जाने पर सहमति ।
10	ग्राम पंचायत कोसा के सभी ग्रामों में सार्वजनिक भवनों की मरम्मत तथा पुर्ननिर्माण, संयुक्त निरीक्षण के पश्चात परियोजना निर्माण के दौरान करने पर सहमति।
11	गॉव के लोगों को ठेकेदारी तथा गाड़ी आदि के कार्य में उनके अनुभव और गॉव वासियों की सहमति के अनुसार परियोजना कार्य शुरू होने पर अनुबन्ध पर लगाने पर सहमति।
12	मलारी से जोशीमठ तक मलारी–जेलम और जेलम–तमक परियोजना से सम्बन्धित लोगों के लिये आने जाने हेतु बस सेवा की ब्यवस्था करने पर सहमति।
13	ग्राम पंचायत कोसा के शिक्षित तथा अशिक्षित व्यक्तियों को योग्यता एवं टी एच डी सी इण्ड़िया लि0 की आवश्यकता अनुसार उत्तराखण्ड़ सरकार के नियमों के अनुसार प्राथमिकता के आधार पर रोजगार देने पर सहमति।

18/5/2010

Lalita.

4	महिला एवं युवामंगल दल के सदस्यों के लिये बुनाई कताई, जनरेटर तथा बर्तन आदि तथा प्रशिक्षण की व्यवस्था करने पर सहमति ।
15	ग्राम कोसा के निवासी अपनी वण कोसा तोक मे स्थित नाप भूमि को परियोजना के कार्य हेतु देने के यदि इच्छुक हैं । इसके लिये टी एच डी सी इण्डिया लि के अधिकारियों एवं ग्राम कोसा के प्रतिनिधियों द्वारा संयुक्त निरीक्षण के उपरान्त तकनीकी उपयोगिता के आधार पर कार्यवाही करने पर सहमति।
16	ग्राम कोसा की स्ट्रीट लाइट से सम्बन्धित निर्माण कार्य कराने पर टी एच डी सी इण्डिया लि द्वारा सहमति किन्तु विद्युत आपूर्ति राज्य सरकार द्वारा प्रदान की जायेगी।
17	ग्राम प्रधान के माध्यम से ग्राम कोसा में होने वाले सामाजिक कार्यो में जो निर्माण कार्य प्रस्तावित होंगे उन्हें करने के लिये ग्रामवासियों द्वारा एक श्रमिक समिति सोसायटी एक्ट में रजिर्स्टड करने पर सहमति हुई। इस सोसायटी को दो लाख रूपये तक के कार्य सीधे ही दिये जाने पर सहमति।
18	केन्द्र सरकार/राज्य सरकार के नियमानुसार पुनर्स्थापना तथा पुनर्वास नीति के अनुसार ग्राम पंचायत कोसा के नाप व बेनाप भूमि का मुआवजा उपलब्ध करवाना सुनिश्चित किया जायेगा।
19	ग्राम पंचायत कोसा में सी0 सी0 फुटपाथ का निर्माण आदि टी0 एच0 डी0 सी0 इण्डिया लि0 और ग्राम के प्रतिनिधियों द्वारा संयुक्त निरीक्षण के उपरान्त अगले पॉच साल के अन्दर ग्राम समिति द्वारा कराने पर सहमति।
20	ग्रामवासियों की तरफ से बैठक के अन्त में यह सहमति बनी कि भविष्य में यदि किसी भी प्रकार का वाद विवाद हो तो उसको संयुक्त मजिस्ट्रेट/उपजिलाधिकारी जोशीमठ की उपस्थिति में सुलझाने पर सहमति।
21	कम्पनी के मुख्य ठेकेदारों के आने पर मुख्य ठेकेदार के अधीन योग्य ग्राम वासियों को उनकी योग्यता और क्षमता के अनुसार तथा अपनी जरूरत के अनुसार कार्य को ठेके पर करवायेगा।
22	ग्राम पंचायत को क्षति होने पर आपसी सहमति द्वारा क्षति की पूर्ति कम्पनी द्वारा करने पर सहमति।
23	भविष्य में ग्राम पंचायत कोसा की मांगे आपसी सहमति के अनुसार किया जाने पर सहमति।
नोट	**संयुक्त मजिस्ट्रेट/उपजिलाधिकारी महोदय ने ग्रामवासियों के प्रतिनिधियों के साथ वार्ता के बाद यह निर्देश दिया कि उपरोक्त कार्य परियोजना निर्माण के दौरान अगले पॉच वर्षो में टी0 एच0 डी0 सी0 इण्डिया लि0 के कारपोरेट सोशल रेस्पोन्सिबिलिटी फंड के अन्तर्गत किया जायेगा तथा ग्राम पंचायत कोसा परियोजना को पूर्ण करने के लिये अपना पूरा सहयोग देगें ताकि पूरे समस्त क्षेत्र का तथा राज्य का सर्वागीण विकास हो।**

उक्त बैठक में उपस्थित सभी टी0 एच0 डी0 सी0 इण्ड़िया लि0 के अधिकारियों एवं ग्राम कोसा के ग्रामवासियों के प्रतिनिधियें की आपसी सहमति बनने पर उन्हें धन्यवाद देकर बैठक समाप्त हुई।

उपस्थित प्रशासनिक अधिकारियों, ग्रामवासियों के प्रतिनिधियें तथा टी0 एच0 डी0 सी0 इण्ड़िया लि0 के अधिकारियों की सूची सलंग्न है।

दिनॉक : 18.05.2010

18-5-2010
प्रधान
ग्राम पंचायत कोसा

18/5/10
अपर महाप्रबन्धक
टी0 एच0 डी0 सी0 इण्ड़िया लि0
जोशीमठ
(ALO).

18/5/10
संयुक्त मजिस्ट्रेट/उपजिलाधिकारी
जोशीमठ

17/5/10. ①/②

Meeting held with ~~Kosa~~ Kosher Villagers at Kosa on 17/5/10

Name

1. Kaliyan Singh
2. जौंतुली देवी
3. कचनी देवी
4. मुन्ना देवी
5. जशोदा देवी
6. सुकरी देवी
7. हरको देवी
8. भुनी देवी
9. कुन्द भीना
10. श्रीमती स्वारी देवी
11. " डेतुली देवी
12. Surendra Singh Rawat

Signature

Kshe...

जौंतुली देवी

कचनी देवी

इन्द्री देवी

कीलम देवी

गुलाबी देवी

यौता देवी

पुष्पा

कुंजमिता

स्वारी देवी

1 गौरी देवी

2 फतेसिंह रावत
९८१४०९१६
अध्यक्ष

3 वन पंचायत कोषा
जोशीमठ (चमोली)
दि. 18.1.5.12

4. सुरेन्द्र सिंह रावत

(5) Bharat Singh Rawat —

(6) बख्तावरसिंह रावत .

(7) केदारसिंह रावत

(8) कुन्दसिंह कोषा — कुंद

(9) बहादुरसिंह कोषा

(7) चन्द्रसिंह कोषा - Chand

(8) मदन सिंह रावत — Rawat

(9) रघुवीर सिंह

(10) इन्द्रा देवी — इन्द्रा देवी

(11) भागरथी देवी — भागरथी देवी

Meeting held with Kosa Villagers at Kosa

नाम | हस्ताक्षर | on 17/5/10 | ५/2

①	१- फतेसिंह रावत	अध्यक्ष	
②	चेतन सिंह रावत	सचिव	
③	हरेन्द्र सिंह		
④	कल्याणसिंह		
⑤	[illegible]		
⑥	भागीरथसिंह		
⑦	रघुवीर सिंह		
⑧	बद्रीसिंह		
⑨	भरतसिंह		
⑩	उदयसिंह		
⑪	जगतसिंह		उदयसिंह
⑫	गुलाबसी		जगतसिंह
⑬	टीकालाल		गुलाबसी
⑭	पुन्नालालपवार		टीकालाल
⑮	धर्मसिंह		M.lal
⑯	हीरासिंह		रामसिंह
⑰	रामसिंह		रायसिंह
⑱	रायसिंह		
⑲	[illegible]		
⑳	[illegible]		
㉑	माधोसिंह		[illegible]
㉒	मंगलसिंह		
㉓	उरजुनसिंह		

From kosa attended by (18/5/10 Meeting) in SDM Joshimath Office

①	श्री फते सिंह रावत	अध्यक्ष जय पर्वत देवता कोषा
②	श्रीमती ललिता देवी	ग्राम प्रधान कोषा
③	श्री रघुवीर सिंह	
④	" अजब सिंह	उपाध्यक्ष पर्वत देवता कोषा
⑤	श्रीमती गौरा देवी	अध्यक्ष वन पंचायत कोषा
⑥	श्री बच्चन सिंह	अध्यक्ष महिला मंगल कोषा
⑦	भरत सिंह	सचिव पर्वत देवता कोषा
⑧	सुरेन्द्र सिंह रावत	युवक मंगल दल अध्यक्ष कोषा
⑨	कल्याण सिंह "	नगर पंचायत अध्यक्ष नन्द प्रयाग (कोषा)
(10)	बख्तावर सिंह रावत	ग्राम कोषा सदस्य
(11)	कन्ठा सिंह रावत	—॥—
(12)	केदार सिंह रावत	—॥—
(12)	गुलामी कोहल	—॥—
(12)	श्रीमती इन्द्रा देवी	—॥—
(13)	—॥— गुलाबी देवी	—॥—
(14)	—॥— भागीरथी देवी	—॥—
(15)	कु० हिमा	—॥—
(16)	प्रेम सिंह रावत	—॥—
(17)	श्रीमती ललिता देवी	—॥—
(18)	कुहि सिंह भू० ग्रा० प्रधान	—॥—
(19)	बहादुर सिंह रावत	—॥—
(20)	धाम सिंह रावत	—॥—

From THDC India Ltd attended by

① संजय रवैर - अपर महा प्रबन्धक
② टी एस रौतेला - उप महा प्रबन्धक
③ H. P. Bhatt - वरिष्ठ अभियन्ता
④ Manoj Rai - विधि अधिकारी

टी0 एच0 डी0 सी0 इण्ड़िया लि0 जोशीमठ के जेलम–तमक जल विद्युत परियोजना के सम्बन्ध में ग्राम पंचायत द्रोणागिरी की निम्न लिखित मांगों के सम्बन्ध में आज दिनांक 09.11.2012 को ग्राम सभा द्रोणागिरी में टी0 एच0 डी0 सी0 इण्ड़िया लि0 जोशीमठ तथा ग्राम पंचायत द्रोणागिरी के प्रतिनिधियों की संयुक्त बैठक का कार्यवृत्त :–

मांग संख्या	बैठक का कार्यवृत्त
01	ग्राम पंचायत द्रोणागिरी की पेयजल योजना की आवश्यक मरम्मत ग्रामवासियों द्वारा कराये जाने पर सहमति। इस हेतु टीएचडीसी इण्ड़िया लि. खर्च वहन करेगा।
02	टी एच डी सी इण्ड़िया लि0 द्वारा यह अवगत कराया गया कि परियोजना की जो टनल बनेगी वो ग्राम द्रोणागिरी से कॉफी दूरी नदी के दूसरी ओर पहाडी पर भूमिगत प्रस्तावित है जिससे ग्रामवासियों की नाप भूमि को कोई क्षति की आशंका नहीं है । फिर भी कार्य से कोई क्षति होती है तो उसकी भरपाई टी एच डी सी इण्ड़िया लि0 द्वारा की जायेगी ।
03	ग्राम पंचायत द्रोणागिरी के आवासीय भवनों को परियोजना के निर्माण कार्य के दौरान ब्लास्टिंग से कोई भी क्षति पहुँचती है तो उसकी क्षतिपूर्ति टी एच डी सी इण्ड़िया लि0 द्वारा किये जाने पर सहमति।
04	यदि परियोजना निर्माण के दौरान ग्राम पंचायत द्रोणागिरी के पेय जल योजना को कोई क्षति पहुँचती है तो पेयजल आपूर्ति टी एच डी सी इण्ड़िया लि0 द्वारा किये जाने पर सहमति ।
05	परियोजना से सम्बन्धित ग्राम पंचायतों को कुल विद्युत उत्पादन का 01 प्रतिशत प्रतिवर्ष क्षेत्र के विकास में भारत और राज्य सरकार के नियमों के अनुसार खर्च किया जायेगा ।
06	टी0 एच0 डी0 सी0 इण्ड़िया लि0 के कारपोरेट सामाजिक उत्तरदायित्व के अन्तर्गत प्रभावित क्षेत्रों के विकास में राशि उपलब्ध करायें व ग्राम पंचायत द्रोणागिरी को उत्तराखण्ड व केन्द्रीय सरकार के नियमानुसार बिजली व पानी की व्यवस्था तथा विकास कार्य पर खर्च करने पर सहमति।
07	कम्पनी द्वारा निर्माण कार्य में द्रोणागिरी क्षेत्र के अन्तर्गत कन्ट्रोल ब्लास्टिंग से कार्य करने पर सहमति।
08	ग्राम पंचायत द्रोणागिरी के लिये आपातकालीन परिस्थितियों में एम्बुलेन्स जैसे वाहनों की सेवा प्रदान किये जाने पर सहमति ।
09	गॅाव के लोगों को ठेकेदारी तथा गाड़ी आदि के कार्य में उनके अनुभव और टीएचडीसी इण्डिया लि0 की आवश्यकता के अनुसार परियोजना कार्य शुरू होने पर अनुबन्ध पर लगाने पर सहमति।
10	कोसा से जोशीमठ तक मलारी–जेलम और जेलम–तमक परियोजना से सम्बन्धित लोगों के लिये आने जाने हेतु बस सेवा में द्रोणागिरी के निवासियों हेतु सीट की उपलब्धता पर सहमति।
11	ग्राम पंचायत द्रोणागिरी के शिक्षित तथा अशिक्षित व्यक्तियों को योग्यता एवं टी एच डी सी इण्डिया लि0 की नीति एवं उत्तराखण्ड सरकार के नियमों के आधार पर रोजगार देने पर सहमति।
12	महिला एवं युवामंगल दल के सदस्यों के लिये बुनाई कताई, जनरेटर तथा बर्तन आदि तथा प्रशिक्षण की व्यवस्था करने पर सहमति ।
13	ग्राम प्रधान के माध्यम से ग्राम द्रोणागिरी में होने वाले सामाजिक कार्यो में जो निर्माण कार्य प्रस्तावित होंगे उन्हें करने के लिये ग्रामवासियों द्वारा एक समिति, सोसायटी एक्ट में रजिर्स्टड करने पर सहमति हुई। इस सोसायटी को दो लाख रूपये तक के कार्य दिये जाने पर सहमति।
14	केन्द्र सरकार / राज्य सरकार के नियमानुसार पुनर्स्थापना तथा पुनर्वास नीति के अनुसार ग्राम पंचायत द्रोणागिरी के नाप व बेनाप भूमि का मुआवजा उपलब्ध करवाना तथा परियोजना प्रभावित परिवारों को अन्य सुविधायें नियमानुसार दिलवाना सुनिश्चित किया जायेगा।

9/11/12

प्रधान

15	ग्राम पंचायत द्रोणागिरी में सी0 सी0 फुटपाथ का निर्माण आदि टी0 एच0 डी0 सी0 इण्ड़िया लि0 और ग्राम के प्रतिनिधियों द्वारा संयुक्त निरीक्षण के उपरान्त अगले पॉच साल के अन्दर पंजीकृत ग्राम समिति द्वारा कराने पर सहमति।
16	कम्पनी के मुख्य ठेकेदारों के आने पर मुख्य ठेकेदार के अधीन योग्य ग्राम वासियों को उनकी योग्यता और क्षमता के अनुसार तथा अपनी जरूरत के अनुसार कार्य को ठेके पर करवाये जाने पर सहमति।
17	यह अनुबन्ध केवल जेलम–तमक जल बिद्युत परियोजना से सम्बन्धित है।
18	ग्राम समिति के साथ सलाह मशवरे के बाद टीएचडीसी इण्ड़िया लि0 द्वारा ग्राम विकास के कार्य प्रारम्भ करवाने पर सहमति।
19	जुम्मा से द्रोणागिरी, रूईंग से गरपक एवं कागा तक मोटर मार्ग को टीएचडीसी इण्ड़िया लि0 द्वारा लोक निर्माण विभाग से शीघ्रता से बनाये जाने पर सहमति।
20	टीएचडीसी इण्ड़िया लि0 पंचायत घर के निर्माण हेतु ग्राम सभा द्रोणागिरी व वन विभाग से सहयोग करेगी तथा इस कार्य हेतु जमीन व आवश्यक प्रमाण पत्र ग्राम सभा द्रोणागिरी द्वारा उपलब्ध करवाये जाने पर सहमति।
21	जुम्मा से कागा, गरपक से द्रोणागिरी के बीच में प्रतीक्षालय/पर्यटक शोभा स्थल के निर्माण हेतु टीएचडीसी इण्ड़िया लि0 ग्राम समिति के द्वारा कार्य करवाये जाने पर सहमति।
22	रूईंग में स्थित प्राथमिक स्वास्थ्य केन्द्र में एक फार्मेशिस्ट संविदा (यू.पी.एन.एल.) पर रखे जाने पर सहमति।
23	उच्च शिक्षा एवं व्यावसायिक शिक्षा के प्रोत्साहन हेतु पात्र विद्यार्थियों को छात्रवृत्ति एवं प्रशिक्षण टीएचडीसी इण्ड़िया लि. के नियमानुसार दिलवाये जाने पर सहमति।
24	जड़ी बूटी शोध संस्थान/विपणन केन्द्र के निर्माण हेतु द्रोणागिरी ग्राम सभा की मदद करने हेतु सहमति। ग्राम सभा निःशल्क भूमि प्रदान करवायेगी।
25	सम्बन्धित गॉवों को विद्युत उपलब्ध करवाने हेतु जनरेटर ग्राम समिति को उपलब्ध करवाये जाने पर सहमति।
26	चारागाह भत्ता एवं धूल भत्ता प्रभावित गॉवों को पुनर्वास एवं पुनर्स्थापन नीति के अनुसार दिये जाने पर सहमति।
27	ग्राम सभा के अन्तर्गत प्रत्येक प्रभावित परिवार को पुनर्वास एवं पुनर्स्थापन नीति के अनुसार निःशुल्क विद्युत आपूर्ति करवाये जाने पर सहमति।
28	खेलकूद के प्रोत्साहन हेतु योग्य खिलाड़ियों को नियमानुसार मदद करने पर सहमति।
29	परियोजना कार्यो से अगर द्रोणागिरी, रूईंग, कागा व गरपक में कोई भूस्खलन होता तो टीएचडीसी इण्ड़िया लि. द्वारा रोकथाम के उचित उपाय किये जाने पर सहमति।
30	बगवानी को प्रोत्साहित करने एवं पर्यावरण संरक्षण हेतु वृक्षारोपण कार्यो में ग्रामवासियों को प्रशिक्षण दिलवाये जानें पर सहमति।
31	ग्राम समिति द्वारा ग्राम पंचायत में शौचालय एवं स्नानागार के निर्माण पर सहमति।
32	पर्यावरण एवं पुनर्वास नीति के अनुसार भूमि, फलदार वृक्ष आदि का मुआवजा टीएचडीसी इण्ड़िया लि. द्वारा दिलवाये जाने पर सहमति।
33	प्रभावित अन्य ग्रामसभाओं को दी गयी सुविधाओं की तरह द्रोणागिरी ग्राम सभा को भी उक्त सुविधायें दिलवाये जाने पर सहमति।
34	पेयजल व्यवस्था हेतु निमार्ण कार्य ग्राम समिति द्वारा करवाये जाने पर सहमति।
35	भविष्य में ग्राम पंचायत द्रोणागिरी की मांगे आपसी सहमति के अनुसार हल किये जाने पर सहमति।

9/11/12

उप जिलाधिकारी
जोशीमठ

36	ग्रामवासियों व टीएचडीसी इण्ड़िया लि0 में बैठक के अन्त में यह सहमति बनी कि भविष्य में यदि किसी भी प्रकार का वाद विवाद हो तो उसको उपजिलाधिकारी जोशीमठ की उपस्थिति में सुलझाया जायेगा।
नोट 1.	**क्र0 सं0 1, 12, 22 व 25 पर कार्यवाही 06 महीने में, क्र0 सं0 10, 21 पर कार्यवाही 01 साल में तथा क्र0 सं0 24 एवं 31 पर 02 साल में कार्यवाही परियोजना निर्माण के साथ–साथ करने पर सहमति।**
नोट 2.	**ग्रामवासियों के प्रतिनिधियों के साथ वार्ता के बाद यह निर्णय लिया गया कि उपरोक्त कार्य परियोजना निर्माण के दौरान अगले पॅाच वर्षो में टी0 एच0 डी0 सी0 इण्ड़िया लि0 के कारपोरेट सोशल रेस्पोन्सिबिलिटी फंड़ के अन्तर्गत किया जायेगा तथा ग्राम पंचायत द्रोणागिरी परियोजना को पूर्ण करने के लिये अपना पूरा सहयोग देगें ताकि पूरे समस्त क्षेत्र का तथा राज्य का सर्वागीण विकास हो।**

उक्त बैठक में उपस्थित सभी टी0 एच0 डी0 सी0 इण्ड़िया लि0 के अधिकारियों एवं ग्राम सभा द्रोणागिरी के ग्रामवासियों के प्रतिनिधियों की आपसी सहमति बनने पर उन्हें धन्यवाद देकर बैठक समाप्त हुई।

उपस्थित प्रशासनिक अधिकारियों, ग्रामवासियों के प्रतिनिधियों तथा टी0 एच0 डी0 सी0 इण्ड़िया लि0 के अधिकारियों की सूची सलंग्न है।

दिनॉक : 09.11.2012

प्रधान
ग्राम पंचायत द्रोणागिरी

अपर महाप्रबन्धक
टी0 एच0 डी0 सी0 इण्ड़िया लि0
जोशीमठ

उपजिलाधिकारी
जोशीमठ

9/11/12

कमला

बलवीर सिंह
क्षेत्र पंचायत सदस्य

इन्द्र सिंह

बचनसिंह

जगतसिंह

गोविन्दलाल

बालसिंह

कमलसिंह

आनन्दसिंह

सीता देवी

गोविन्द

इन्दरी देवी

महेन्द्र सिंह

रामी देवी

भाईलाल

धौली देवी

हरीश राणा

मति देवी

गोविन्द सिंह

Rawat

Rudra

मूसी देवी

गौरी देवी

कु० बिमला

बिच्छा देवी

S Ram

स्वांरी देवी

टी०एच०डी०सी० एवं ग्राम डोभागिरी _ कामा-रवीग की सार्वजनिक बै

दिनांक 9/11/2012

क्रमांक	अधिकारी/कर्मचारी/जनप्रतिनिधि का नाम/पदनाम	मोबाइल नम्बर	हस्ताक्षर
1	श्री संजय खेडेकर अपर महाप्रबन्धक	9810484487	
2	" आल्हा सिंह वरिष्ठ प्रबन्धक	9412018097	
3	" दिनेश अग्रवाल उप प्रबन्धक	9411735860	
4	" आर०के० मजूमदार अभियन्ता	7351005084	
5	" [illegible]	9675066601	
6	" सैनसिंह		
7	" कमलसिंह		कमलसिंह
8	" जयसिंह		जयसिंह
9	" बलबीर सिंह क्षेत्र पंचायत डोभागिरी		
10	" मंगलसिंह		
11	" दिवान		दिवान
12	" गोविन्द सिंह		
13	" इन्द्र सिंह		इन्द्रसिंह
14	" चैतसिंह		
15	श्रीमती चांपी देवी		
16	" रामी देवी		
17	" गौरी देवी		गौरी देवी
18	श्री नरेन्द्र सिंह		
19	Mr Lachhman Singh		
20	" भूपालसिंह		भूपालसिंह
21	" बालासिंह		बालासिंह
22	" उगमसिंह		
23	सावित्री देवी		सावित्री देवी
24	श्रीमती कुमकुम राणा		
25	" मुसी देवी	कामा	
26	" विमला देवी	कामा	
27	" चन्द्रा देवी	डोभागिरी	
28	" स्वाँरी देवी	"	

Date______________

29.	श्रीमती बैंनी देवी	द्रोणागिरी	
30.	श्री गोविन्द सिंह	"	
31.	" जगतसिंह	"	जगतसिंह
32.	" पूर्णलाल	"	
33.	" भवानीसिंह कुँवर	"	
34.	" शिवलाल	"	शिवलाल
35.	" श्यामलाल	"	श्यामलाल
36.	" कुन्दीलाल	"	
37.	श्रीमती मक्की देवी	कागा	
38.	" कमला देवी	"	कमलादेवी
39.	" चन्द्रा देवी	"	चन्द्रा देवी
40.	" कल्पेश्वरी देवी	"	
41.	" गणेशी देवी	"	गणेशी दे
42.	" ममता देवी	"	ममता देवी
43.	श्री गोविन्द सिंह	द्रोणागिरी	गोविन्द सिंह
44.	" बचनसिंह	"	बचनसिंह
45.	" आनन्द सिंह	गरपक	आनन्दसिंह
46.	श्रीमती इन्द्री देवी	"	इन्द्री देवी
47.	" सरस्वती देवी	कागा	सरस्वती
48.	श्री जगतसिंह भण्डारी	गरफक	
49.	" दीवान सिंह	द्रोणागिरी	
50.	" गोविन्द सिंह	"	गोविन्द
51.	" राघवेन्द्र सिंह राणा	कागा	R Rana
52.	श्रीमती सीता देवी	द्रोणागिरी	सीता देवी
53.	" भागीरथी देवी	"	
54.	श्री गुड्डू लाल	"	Rahul
55.	" राहुल	"	
56.	" महेन्द्र	"	Mahendra Singh
57.	गबर सिंह	"	Rawat

Date________

58.	श्री मोहनराणा	कागा	
59.	,, अनूप सिंह राणा	,,	
60.	,, बलबीर सिंह	डोबागिरी	
61.	,, हीरासिंह	कागा	Singh
62.	,, सोबनसिंह	,,	
63.	,, नरेन्द्रसिंह	,,	
64.	,, अवतारसिंह	,, डोबागिरी	
65.	,, रणजीतसिंह	गरफक	
66.	,, वीरेन्द्र सिंह	डोबागिरी	
67.	,, हरीश	कागा	
68.	,, रवीन्द्र	डोजागिरी	रविन्द्र सिंह
69.	,, वीरेन्द्र सिंह	,,	Singh
70.	,, खीमसिंह	,,	
71.	,, देवेन्द्र सिंह	,,	
72.	,, अरविन्द राणा	जैलम	
73.	,, अवतार सिंह	डोजागिरी	Singh
74.	,, शीतल लाल	जैलम	शीतललाल
75.	,, रमेश भण्डारी	गरफक	
76.	,, सतेन्द्र लाल	डोजागिरी	सतेन्द्रलाल
77.	श्रीमती बिन्द्रा देवी	जैलम	बि देवी
78.	प्रीतम सिंह mosic	डोणागिरी	(गरपक)
79.	,, अमनसिंह	,,	
80.	जसपत सिंह		
81.	हरीश राणा	कागा	–
82.	,, मदनलाल	डोजागिरी	मदनलाल
83.	,, राजेन्द्र	,,	राजेन्द्र
84.	,, कैलाश	,,	कैलाश –
85 –	देवेन्द्र सिंह	,,	
86 –	,, केशर सिंह		कागा केशर
87 –	,, गोविन्द लाल	डोजागिरी	Th.
88 –	,, कमला	,,	Th.

Annexure-V

List of families affected due to acquisition of van panchayat land

S. No.	Head of the Family	Male	Female	Total	Male above 18 year
Dronagiri					
1	Smt. Bharti Devi	3	3	6	0
2	Smt. Raji Devi	3	1	4	0
3	Sh. Kartik Singh	4	2	6	2
4	Smt. Soni Devi	2	2	4	2
5	Sh. Abbal Singh	3	2	5	2
6	Smt. Janki Devi	2	2	4	1
7	Sh. Mahipal Singh	4	1	5	3
8	Smt. Kuri Devi	-	1	1	-
9	Smt. Chandri Devi	2	1	3	2
10	Smt. Dhuri Devi	3	5	8	1
11	Sh. Visher Singh	3	6	9	2
12	Smt. Bhaga Devi	3	2	5	2
13	Smt. Parvati Devi	6	5	11	5
14	Smt. Jethuli Devi	6	6	12	5
15	Ku. Anushka	1	2	3	-
16	Sh. Anand Singh	6	3	9	3
17	Sh. Shankar Singh	2	5	7	0
18	Sh. Shangram Singh	3	3	6	1
19	Smt. Budhi Devi	2	3	5	1
20	Smt. Jhaudi Devi	1	3	4	1
21	Smt. Rukhma Devi	3	2	5	3
22	Sh. Govind Singh	4	2	6	3
23	Sh. Puran Singh	3	1	4	2
24	Sh. Bachan Singh	2	1	3	1
25	Sh. Khim Singh	4	1	5	3
26	Sh. Anand Singh	4	2	6	2
27	Sh. Lakshman Singh	3	2	5	2
28	Sh. Soniya Singh	7	4	11	2

29	Sh. Sohan Singh	2	3	5	1
30	Smt. Pushuli Devi	-	1	1	1
31	Sh. Baal Singh	5	1	6	4
32	Smt. Parvati Devi	5	5	10	3
33	Sh. Aalam Singh	5	3	8	3
34	Sh. Harak Singh	5	6	11	4
35	Smt. Vishoda Devi	3	4	7	3
36	Sh. Bhopal Singh	3	1	4	2
37	Smt. Jethuli Devi	2	2	4	1
38	Smt. Devki Devi	-	1	1	-
39	Smt. Moonga Devi	6	4	10	4
40	Sh. Jagat Singh	3	1	4	2
41	Sh. Kirat Singh	2	2	4	1
42	Smt. Laati Devi	2	4	6	1
43	Sh. Chandra Singh	5	2	7	4
44	Smt. Puyama Devi	2	3	5	2
45	Sh. Gopal Singh	2	2	4	0
46	Sh. Deewan Singh	2	2	4	1
47	Sh. Rai Singh	6	3	9	3
48	Smt. Kaali Devi	1	3	4	1
49	Sh. Thaan Singh	4	2	6	3
50	Sh. Jai Singh	1	2	3	1
51	Sh. Deewan Singh	3	3	6	3
52	Sh. Dhan Singh	3	2	5	2
53	Sh. Govind Singh	5	5	10	4
54	Smt. Jhuppa Devi	4	7	11	3
55	Smt. Savali Devi	7	4	11	6
56	Smt. Bauni Devi	3	4	7	2
57	Smt. Kedari Devi	2	3	5	2
58	Smt. Bhaagi Devi	3	3	6	2
59	Smt. Jaumti Devi	-	1	1	0
60	Sh. Jagat Singh	4	1	5	3
61	Sh. Ajab Singh	5	5	10	4
62	Smt. Baali Devi	3	4	7	0
63	Smt. Nauma Devi	4	3	7	3

64	Smt. Kaila Devi	3	4	7	2
65	Smt. Belmati Devi	1	3	4	0
66	Sh. Nandan Singh	2	3	5	1
67	Smt. Ganeshi Devi	1	3	4	1
68	Sh. Harendra Singh	3	-	3	2
69	Sh. Maan Singh	2	2	4	1
70	Smt. Mandodhari Devi	2	2	4	2
71	Sh. Puran Das	2	2	4	1
72	Smt. Bindra Devi	3	1	4	3
73	Sh. Madan Lal	3	2	5	1
74	Sh. Kamla Lal	3	3	6	2
75	Sh. Jaitu Das	1	1	2	0
76	Sh. Pushker Lal	3	1	4	2
77	Sh. Shiva Lal	3	3	6	0
78	Sh. Satendra Lal	3	2	5	0
79	Sh. Harak Singh	2	2	4	0
80	Sh. Puran Singh	1	3	4	0
81	Sh. Nandan Singh	2	3	5	0
82	Smt. Jomati Devi	3	3	6	1
83	Sh. Nand Lal	3	1	4	1
84	Sh. Shyam Lal	2	2	4	1
85	Sh. Bagh Singh	2	2	4	0
86	Sh. Bhawaan Singh	3	2	5	0
87	Smt. Dhuma Devi	2	2	4	1
88	Smt. Seeta Devi	2	2	4	-
89	Sh. Guddu Lal	1	2	3	0
90	Sh. Bahadur Singh	2	1	3	0
91	Sh. Kripal Singh	1	-	1	0
92	Smt. Parvati Devi	1	2	3	1
93	Sh. Baal Singh	9	2	11	8
94	Smt. Hemlata Devi	5	7	12	0
95	Sh. Bharat Singh	3	2	5	0
96	Sh. Jaman Singh	1	3	4	0
97	Sh. Jai Singh	2	2	4	1
98	Sh. Ranjeet Singh	1	4	5	0

99	Sh. Virender Singh	2	2	4	0
100	Sh. Harender Singh	3	1	4	0
101	Sh. Kripal Singh	2	1	3	0
102	Sh. Kamal Singh	2	2	4	1
103	Sh. Madho Singh	2	2	4	0
104	Sh. Mohan Singh	2	3	5	0
105	Sh. Anil Singh	2	1	3	0
	Sub total	**299**	**266**	**565**	**163**
Garpak					
1	Sh. Dalip Singh	3	1	4	2
2	Sh. Jagat Singh	4	2	6	2
3	Sh. Govind Singh	3	1	4	2
4	Smt. Jashoda Devi	4	4	8	3
5	Smt. Chhanchi Devi	0	2	2	0
6	Sh. Inder Singh	4	2	6	2
7	Sh. Anand Singh	4	2	6	3
8	Smt. Beena Devi	0	4	4	0
9	Sh. Kishan Singh	7	4	11	6
10	Sh. Anand Singh	6	3	9	5
11	Sh. Deewan Singh	8	5	13	4
12	Sh. Lakhan Singh	1	5	6	0
13	Sh. Kundan Singh	4	2	6	2
14	Sh. Chet Singh	3	3	6	2
15	Sh. Veshakh Singh	2	3	5	0
16	Sh. Mangal Singh	2	2	4	0
	Sub total	**55**	**45**	**100**	**33**
Kaga					
1	Sh. Shiv Singh	3	1	4	2
2	Smt. Mati Devi	6	5	11	3
3	Smt. Rami Devi	2	3	5	0
4	Sh. Baal Singh	3	1	4	2
5	Sh. Rajender Singh	3	1	4	0
6	Sh. Keshar Singh	2	5	7	1
7	Smt. Anandi Devi	0	1	1	0
8	Sh. Dev Singh	6	5	11	5

9	Sh. Tej Singh	3	2	5	2
10	Sh. Kirat Singh	3	1	4	2
11	Sh. Baal Singh	2	3	5	0
12	Sh. Narender Singh	2	2	4	0
13	Smt. Devki Devi	0	4	4	0
14	Smt. Jauma Devi	5	8	13	4
15	Sh. Bhawan Singh	3	4	7	2
16	Sh. Deewan Singh	4	1	5	3
17	Smt. Puni Devi	4	4	8	2
18	Sh. Puran Singh	3	3	6	2
19	Smt. Jhaapi Devi	1	1	2	0
20	Smt. Chandra Devi	2	3	5	0
21	Smt. Khati Devi	7	4	11	7
22	Sh. Kanchan Singh	3	2	5	2
23	Sh. Khadak Singh	2	3	5	1
24	Sh. Jaman Singh	2	4	6	0
	Sub Total	**71**	**71**	**142**	**40**
145	**Grand Total**	**807**	**424**	**382**	**236**

Cross Section/Months	Discharge (Cumec)	Min. Channel Elev	Velocity (m/s)	Top Width (m)	Water Depth (m)
June					
5000	5.78	2622.67	1.02	18.45	0.31
4900.*	5.78	2621	1.26	19.18	0.24
4800.*	5.78	2619.32	0.89	24.06	0.27
4700.*	5.78	2617.64	1.18	24.85	0.2
4600.*	5.78	2615.97	0.75	35.22	0.22
4500	13.95	2614.29	0.96	74.36	0.2
4400.*	13.95	2612.43	1.19	34.64	0.34
4300.*	13.95	2610.57	1.45	32.41	0.3
4200.*	13.95	2608.72	1.09	40.8	0.31
4100.*	13.95	2606.86	1.24	50.08	0.22
4000	13.95	2605	0.91	61.46	0.25
3900.*	13.95	2603.21	1.2	49.95	0.23
3800.*	13.95	2601.42	1.05	40.06	0.33
3700.*	13.95	2599.63	1.51	29.75	0.31
3600.*	13.95	2597.83	1.16	27.75	0.43
3500	13.95	2596.04	1.73	26.85	0.3
3400.*	13.95	2591.54	1.7	28.53	0.29
3300.*	14.21	2587.03	1.67	30.78	0.28
3200.*	14.21	2582.52	1.62	33.61	0.26
3100.*	14.21	2578.02	1.57	37.18	0.24
3000	14.21	2573.51	1.49	42.37	0.23
2900.*	14.21	2567.8	1.58	36.33	0.25
2800.*	14.21	2562.09	1.64	31.75	0.27
2700.*	14.21	2556.38	1.73	27.9	0.29
2600.*	14.21	2550.67	1.79	24.83	0.32
2500	14.21	2544.95	1.86	22.2	0.34
2400.*	14.21	2539.88	1.87	21.84	0.35
2300.*	14.21	2534.8	1.87	21.52	0.35
2200.*	14.21	2529.73	1.89	21.06	0.36
2100.*	14.21	2524.65	1.9	20.66	0.36
2000	14.21	2519.58	1.92	20.17	0.37
1900.*	14.21	2515.14	1.86	21.66	0.35
1800.*	14.21	2510.71	1.84	23.03	0.34
1700.*	14.21	2506.28	1.79	24.63	0.32

1600.*	14.21	2501.84	1.76	26.15	0.31
1500	14.21	2497.41	0.93	37.21	0.41
1400.*	15.7	2496.55	1.07	32.6	0.45
1300.*	15.7	2495.7	1.05	29.79	0.5
1200.*	15.7	2494.84	1.26	25.13	0.5
1100.*	15.7	2493.99	0.98	25.98	0.62
1000	15.99	2493.13	2.1	17.36	0.44
900.*	15.99	2480.5	2.07	18.29	0.42
800.*	15.99	2467.88	2	20.01	0.4
700.*	15.99	2455.25	1.93	21.83	0.38
600.*	15.99	2442.62	1.9	23.55	0.36
500	15.99	2429.99	0.38	25.52	1.63
400.2*	15.99	2429.97	0.46	22.81	1.53
300.4*	15.99	2429.95	0.52	21.26	1.45
200.6*	15.99	2429.93	0.58	20.17	1.37
100.8*	15.99	2429.91	0.64	19.17	1.3
1	15.99	2429.89	0.72	17.46	1.28
July					
5000	5.27	2622.67	0.96	18.23	0.3
4900.*	5.27	2621	1.28	18.58	0.22
4800.*	5.27	2619.32	0.84	23.77	0.26
4700.*	5.27	2617.64	1.21	23.85	0.18
4600.*	5.27	2615.97	0.7	34.77	0.22
4500	15.51	2614.29	0.97	78.55	0.2
4400.*	15.51	2612.43	1.23	35.7	0.35
4300.*	15.51	2610.57	1.5	32.95	0.31
4200.*	15.51	2608.72	1.14	41.09	0.33
4100.*	15.51	2606.86	1.29	50.23	0.24
4000	15.51	2605	0.95	61.56	0.27
3900.*	15.51	2603.21	1.25	50.09	0.25
3800.*	15.51	2601.42	1.1	40.3	0.35
3700.*	15.51	2599.63	1.55	30.17	0.33
3600.*	15.51	2597.83	1.2	28.57	0.45
3500	15.51	2596.04	1.76	27.92	0.31
3400.*	15.51	2591.54	1.75	29.55	0.3
3300.*	15.84	2587.03	1.71	32.04	0.29
3200.*	15.84	2582.52	1.66	34.92	0.27
3100.*	15.84	2578.02	1.6	38.68	0.26
3000	15.84	2573.51	1.53	43.97	0.24
2900.*	15.84	2567.8	1.61	37.78	0.26
2800.*	15.84	2562.09	1.69	32.89	0.29

2700.*	15.84	2556.38	1.76	29.04	0.31
2600.*	15.84	2550.67	1.83	25.78	0.34
2500	15.84	2544.95	1.9	23.03	0.36
2400.*	15.84	2539.88	1.91	22.61	0.37
2300.*	15.84	2534.8	1.92	22.27	0.37
2200.*	15.84	2529.73	1.93	21.83	0.38
2100.*	15.84	2524.65	1.95	21.33	0.38
2000	15.84	2519.58	1.96	20.89	0.39
1900.*	15.84	2515.14	1.93	22.3	0.37
1800.*	15.84	2510.71	1.88	23.9	0.35
1700.*	15.84	2506.28	1.84	25.52	0.34
1600.*	15.84	2501.84	1.81	27.09	0.32
1500	15.84	2497.41	0.95	38.81	0.43
1400.*	17.7	2496.55	1.1	34.06	0.47
1300.*	17.7	2495.7	1.09	31	0.52
1200.*	17.7	2494.84	1.29	26.28	0.52
1100.*	17.7	2493.99	1.01	26.98	0.65
1000	18.07	2493.13	2.14	18.11	0.47
900.*	18.07	2480.5	2.11	19.09	0.45
800.*	18.07	2467.88	2.04	20.97	0.42
700.*	18.07	2455.25	2.02	22.32	0.4
600.*	18.07	2442.62	1.98	23.67	0.39
500	18.07	2429.99	0.4	25.87	1.73
400.2*	18.07	2429.97	0.48	23.1	1.63
300.4*	18.07	2429.95	0.54	21.57	1.54
200.6*	18.07	2429.93	0.6	20.48	1.47
100.8*	18.07	2429.91	0.67	19.52	1.39
1	18.07	2429.89	0.74	17.98	1.35
August					
5000	5.34	2622.67	1.35	16.51	0.24
4900.*	5.34	2621	0.89	20.91	0.29
4800.*	5.34	2619.32	1.3	20.71	0.2
4700.*	5.34	2617.64	0.76	28.3	0.25
4600.*	5.34	2615.97	1.24	27.88	0.15
4500	14.89	2614.29	0.77	85.84	0.22
4400.*	14.89	2612.43	1.62	31.43	0.29
4300.*	14.89	2610.57	1.13	34.93	0.38
4200.*	14.89	2608.72	1.55	39.66	0.24
4100.*	14.89	2606.86	1.28	50.16	0.23
4000	14.89	2605	0.93	61.52	0.26
3900.*	14.89	2603.21	1.23	50.03	0.24

3800.*	14.89	2601.42	1.08	40.21	0.34
3700.*	14.89	2599.63	1.54	29.98	0.32
3600.*	14.89	2597.83	1.18	28.31	0.45
3500	14.89	2596.04	1.77	27.38	0.31
3400.*	14.89	2591.54	1.73	29.15	0.3
3300.*	15.2	2587.03	1.69	31.56	0.28
3200.*	15.2	2582.52	1.64	34.48	0.27
3100.*	15.2	2578.02	1.58	38.15	0.25
3000	15.2	2573.51	1.51	43.36	0.23
2900.*	15.2	2567.8	1.6	37.19	0.26
2800.*	15.2	2562.09	1.68	32.38	0.28
2700.*	15.2	2556.38	1.74	28.65	0.31
2600.*	15.2	2550.67	1.81	25.46	0.33
2500	15.2	2544.95	1.89	22.67	0.36
2400.*	15.2	2539.88	1.9	22.29	0.36
2300.*	15.2	2534.8	1.91	21.94	0.36
2200.*	15.2	2529.73	1.91	21.58	0.37
2100.*	15.2	2524.65	1.92	21.12	0.37
2000	15.2	2519.58	1.95	20.6	0.38
1900.*	15.2	2515.14	1.9	22.07	0.36
1800.*	15.2	2510.71	1.85	23.61	0.35
1700.*	15.2	2506.28	1.82	25.18	0.33
1600.*	15.2	2501.84	1.78	26.83	0.32
1500	15.2	2497.41	0.94	38.2	0.42
1400.*	16.94	2496.55	1.09	33.53	0.46
1300.*	16.94	2495.7	1.08	30.54	0.51
1200.*	16.94	2494.84	1.28	25.85	0.51
1100.*	16.94	2493.99	1	26.62	0.64
1000	17.28	2493.13	2.13	17.8	0.45
900.*	17.28	2480.5	2.08	18.86	0.44
800.*	17.28	2467.88	2.02	20.64	0.41
700.*	17.28	2455.25	1.99	22.12	0.39
600.*	17.28	2442.62	1.94	23.63	0.38
500	17.28	2429.99	0.4	25.74	1.69
400.2*	17.28	2429.97	0.47	22.99	1.59
300.4*	17.28	2429.95	0.53	21.46	1.51
200.6*	17.28	2429.93	0.59	20.37	1.43
100.8*	17.28	2429.91	0.66	19.39	1.36
1	17.28	2429.89	0.73	17.79	1.33
September					
5000	5	2622.67	0.91	18.25	0.3

4900.*	5	2621	1.35	18	0.21
4800.*	5	2619.32	0.79	23.86	0.26
4700.*	5	2617.64	1.32	22.84	0.17
4600.*	5	2615.97	0.63	35.68	0.22
4500	11.92	2614.29	1.04	63.92	0.18
4400.*	11.92	2612.43	1.05	34.2	0.33
4300.*	11.92	2610.57	1.55	30.91	0.25
4200.*	11.92	2608.72	0.95	40.71	0.31
4100.*	11.92	2606.86	1.33	49.67	0.18
4000	11.92	2605	0.78	61.46	0.25
3900.*	11.92	2603.21	1.34	49.51	0.18
3800.*	11.92	2601.42	0.98	39.72	0.31
3700.*	11.92	2599.63	1.45	29.17	0.28
3600.*	11.92	2597.83	1.1	26.62	0.41
3500	11.92	2596.04	1.68	25.31	0.28
3400.*	11.92	2591.54	1.65	26.93	0.27
3300.*	12.14	2587.03	1.61	29.16	0.26
3200.*	12.14	2582.52	1.57	31.64	0.24
3100.*	12.14	2578.02	1.52	34.98	0.23
3000	12.14	2573.51	1.45	39.8	0.21
2900.*	12.14	2567.8	1.51	34.5	0.23
2800.*	12.14	2562.09	1.58	30.13	0.25
2700.*	12.14	2556.38	1.67	26.49	0.27
2600.*	12.14	2550.67	1.73	23.6	0.3
2500	12.14	2544.95	1.79	21.12	0.32
2400.*	12.14	2539.88	1.79	20.85	0.32
2300.*	12.14	2534.8	1.81	20.47	0.33
2200.*	12.14	2529.73	1.82	20.09	0.33
2100.*	12.14	2524.65	1.83	19.73	0.34
2000	12.14	2519.58	1.84	19.29	0.34
1900.*	12.14	2515.14	1.81	20.57	0.33
1800.*	12.14	2510.71	1.77	21.96	0.31
1700.*	12.14	2506.28	1.73	23.39	0.3
1600.*	12.14	2501.84	1.69	24.86	0.29
1500	12.14	2497.41	0.89	35.16	0.39
1400.*	13.41	2496.55	1.03	30.76	0.42
1300.*	13.41	2495.7	1.01	28.28	0.47
1200.*	13.41	2494.84	1.22	23.74	0.46
1100.*	13.41	2493.99	0.94	24.66	0.58
1000	13.66	2493.13	2.01	16.52	0.41
900.*	13.66	2480.5	1.98	17.42	0.4

800.*	13.66	2467.88	1.93	18.96	0.37
700.*	13.66	2455.25	1.87	21.09	0.35
600.*	13.66	2442.62	1.8	23.4	0.32
500	13.66	2429.99	0.36	25.1	1.52
400.2*	13.66	2429.97	0.43	22.47	1.42
300.4*	13.66	2429.95	0.49	20.89	1.34
200.6*	13.66	2429.93	0.55	19.81	1.26
100.8*	13.66	2429.91	0.61	18.74	1.19
1	13.66	2429.89	0.68	16.85	1.19
October					
5000	2.97	2622.67	0.76	16.43	0.24
4900.*	2.97	2621	1.19	15.14	0.16
4800.*	2.97	2619.32	0.67	21.2	0.21
4700.*	2.97	2617.64	1.13	20.13	0.13
4600.*	2.97	2615.97	0.51	31.27	0.18
4500	7.15	2614.29	1.01	46.1	0.15
4400.*	7.15	2612.43	0.89	29.93	0.27
4300.*	7.15	2610.57	1.34	28.99	0.18
4200.*	7.15	2608.72	0.77	39.54	0.23
4100.*	7.15	2606.86	1.12	49.19	0.13
4000	7.15	2605	0.63	61.09	0.19
3900.*	7.15	2603.21	1.12	49.08	0.13
3800.*	7.15	2601.42	0.79	38.81	0.23
3700.*	7.15	2599.63	1.26	27.66	0.2
3600.*	7.15	2597.83	0.93	23.32	0.33
3500	7.15	2596.04	1.51	21.23	0.22
3400.*	7.15	2591.54	1.46	22.61	0.22
3300.*	7.29	2587.03	1.46	24.26	0.21
3200.*	7.29	2582.52	1.41	26.44	0.2
3100.*	7.29	2578.02	1.35	29.24	0.18
3000	7.29	2573.51	1.31	32.79	0.17
2900.*	7.29	2567.8	1.37	28.8	0.18
2800.*	7.29	2562.09	1.44	25.38	0.2
2700.*	7.29	2556.38	1.49	22.58	0.22
2600.*	7.29	2550.67	1.53	20.28	0.24
2500	7.29	2544.95	1.58	18.19	0.25
2400.*	7.29	2539.88	1.6	17.94	0.25
2300.*	7.29	2534.8	1.61	17.68	0.26
2200.*	7.29	2529.73	1.62	17.38	0.26
2100.*	7.29	2524.65	1.64	17.03	0.26
2000	7.29	2519.58	1.65	16.69	0.26

1900.*	7.29	2515.14	1.62	17.7	0.25
1800.*	7.29	2510.71	1.57	18.84	0.25
1700.*	7.29	2506.28	1.55	19.93	0.24
1600.*	7.29	2501.84	1.52	20.84	0.23
1500	7.29	2497.41	0.78	29.37	0.32
1400.*	8.05	2496.55	0.93	25.53	0.34
1300.*	8.05	2495.7	0.86	24.13	0.39
1200.*	8.05	2494.84	1.12	19.73	0.37
1100.*	8.05	2493.99	0.8	21.06	0.48
1000	8.19	2493.13	1.83	13.39	0.33
900.*	8.19	2480.5	1.78	14.59	0.32
800.*	8.19	2467.88	1.73	15.89	0.3
700.*	8.19	2455.25	1.64	18.31	0.27
600.*	8.19	2442.62	1.57	21.26	0.25
500	8.19	2429.99	0.28	23.95	1.2
400.2*	8.19	2429.97	0.35	21.53	1.09
300.4*	8.19	2429.95	0.4	19.87	1.02
200.6*	8.19	2429.93	0.46	18.81	0.95
100.8*	8.19	2429.91	0.52	16.71	0.94
1	8.19	2429.89	0.58	15.16	0.93
November					
5000	2.97	2622.67	0.76	16.43	0.24
4900.*	2.97	2621	1.19	15.14	0.16
4800.*	2.97	2619.32	0.67	21.2	0.21
4700.*	2.97	2617.64	1.13	20.13	0.13
4600.*	2.97	2615.97	0.54	30.6	0.18
4500	5.39	2614.29	0.97	41.04	0.14
4400.*	5.39	2612.43	0.8	27.99	0.24
4300.*	5.39	2610.57	1.24	28.13	0.15
4200.*	5.39	2608.72	0.69	39.02	0.2
4100.*	5.39	2606.86	1.02	48.99	0.11
4000	5.39	2605	0.58	60.88	0.15
3900.*	5.39	2603.21	0.89	49.02	0.12
3800.*	5.39	2601.42	0.7	38.39	0.2
3700.*	5.39	2599.63	1.16	27.05	0.17
3600.*	5.39	2597.83	0.85	21.75	0.29
3500	5.39	2596.04	1.4	19.45	0.2
3400.*	5.39	2591.54	1.38	20.49	0.19
3300.*	5.47	2587.03	1.34	22.26	0.18
3200.*	5.47	2582.52	1.31	24.04	0.17
3100.*	5.47	2578.02	1.27	26.42	0.16

3000	5.47	2573.51	1.21	29.77	0.15
2900.*	5.47	2567.8	1.27	26.42	0.16
2800.*	5.47	2562.09	1.33	23.41	0.18
2700.*	5.47	2556.38	1.38	20.88	0.19
2600.*	5.47	2550.67	1.44	18.63	0.2
2500	5.47	2544.95	1.47	16.83	0.22
2400.*	5.47	2539.88	1.48	16.63	0.22
2300.*	5.47	2534.8	1.48	16.46	0.22
2200.*	5.47	2529.73	1.51	16.16	0.22
2100.*	5.47	2524.65	1.5	15.95	0.23
2000	5.47	2519.58	1.51	15.65	0.23
1900.*	5.47	2515.14	1.49	16.5	0.22
1800.*	5.47	2510.71	1.48	17.32	0.21
1700.*	5.47	2506.28	1.44	18.18	0.21
1600.*	5.47	2501.84	1.42	18.8	0.2
1500	5.47	2497.41	0.72	26.54	0.29
1400.*	5.92	2496.55	0.87	22.76	0.3
1300.*	5.92	2495.7	0.78	21.89	0.35
1200.*	5.92	2494.84	1.06	17.39	0.32
1100.*	5.92	2493.99	0.73	19.16	0.42
1000	6	2493.13	1.71	11.88	0.3
900.*	6	2480.5	1.68	12.86	0.28
800.*	6	2467.88	1.6	14.43	0.26
700.*	6	2455.25	1.53	16.44	0.24
600.*	6	2442.62	1.44	19.96	0.21
500	6	2429.99	0.25	23.38	1.04
400.2*	6	2429.97	0.31	21.05	0.93
300.4*	6	2429.95	0.36	19.37	0.86
200.6*	6	2429.93	0.42	17.98	0.8
100.8*	6	2429.91	0.47	15.62	0.81
1	6	2429.89	0.53	14.33	0.79
December					
5000	2.97	2622.67	0.76	16.43	0.24
4900.*	2.97	2621	1.19	15.14	0.16
4800.*	2.97	2619.32	0.67	21.2	0.21
4700.*	2.97	2617.64	1.13	20.13	0.13
4600.*	2.97	2615.97	1.02	24.23	0.12
4500	4.64	2614.29	0.6	48.87	0.16
4400.*	4.64	2612.43	1.26	22.97	0.16
4300.*	4.64	2610.57	1.17	27.77	0.14
4200.*	4.64	2608.72	0.64	38.79	0.19

4100.*	4.64	2606.86	0.98	48.89	0.1
4000	4.64	2605	0.56	60.8	0.14
3900.*	4.64	2603.21	0.86	48.92	0.11
3800.*	4.64	2601.42	0.66	38.21	0.18
3700.*	4.64	2599.63	1.12	26.74	0.16
3600.*	4.64	2597.83	0.8	21.07	0.27
3500	4.64	2596.04	1.37	18.45	0.18
3400.*	4.64	2591.54	1.32	19.58	0.18
3300.*	4.69	2587.03	1.33	20.86	0.17
3200.*	4.69	2582.52	1.27	22.82	0.16
3100.*	4.69	2578.02	1.19	25.44	0.16
3000	4.69	2573.51	1.2	27.92	0.14
2900.*	4.69	2567.8	1.22	25.2	0.15
2800.*	4.69	2562.09	1.27	22.49	0.16
2700.*	4.69	2556.38	1.34	19.96	0.18
2600.*	4.69	2550.67	1.38	17.86	0.19
2500	4.69	2544.95	1.43	16.15	0.2
2400.*	4.69	2539.88	1.44	15.97	0.2
2300.*	4.69	2534.8	1.46	15.72	0.2
2200.*	4.69	2529.73	1.44	15.62	0.21
2100.*	4.69	2524.65	1.45	15.35	0.21
2000	4.69	2519.58	1.46	15.06	0.21
1900.*	4.69	2515.14	1.44	15.86	0.21
1800.*	4.69	2510.71	1.41	16.67	0.2
1700.*	4.69	2506.28	1.4	17.1	0.2
1600.*	4.69	2501.84	1.4	17.51	0.19
1500	4.69	2497.41	0.69	25.17	0.27
1400.*	5	2496.55	0.84	21.34	0.28
1300.*	5	2495.7	0.74	20.67	0.33
1200.*	5	2494.84	1.03	16.2	0.3
1100.*	5	2493.99	0.7	18.22	0.39
1000	5.06	2493.13	1.66	11.06	0.28
900.*	5.06	2480.5	1.62	11.99	0.26
800.*	5.06	2467.88	1.55	13.51	0.24
700.*	5.06	2455.25	1.49	15.46	0.22
600.*	5.06	2442.62	1.38	19.3	0.19
500	5.06	2429.99	0.23	23.11	0.96
400.2*	5.06	2429.97	0.29	20.72	0.86
300.4*	5.06	2429.95	0.34	19.13	0.79
200.6*	5.06	2429.93	0.39	17.23	0.74
100.8*	5.06	2429.91	0.45	15.09	0.75

1	5.06	2429.89	0.5	13.94	0.73
January					
5000	2.97	2622.67	0.76	16.43	0.24
4900.*	2.97	2621	1.19	15.14	0.16
4800.*	2.97	2619.32	0.67	21.2	0.21
4700.*	2.97	2617.64	1.13	20.13	0.13
4600.*	2.97	2615.97	0.53	30.84	0.18
4500	4.25	2614.29	1.06	35.2	0.11
4400.*	4.25	2612.43	1.25	22.34	0.15
4300.*	4.25	2610.57	0.69	29.66	0.21
4200.*	4.25	2608.72	1.04	37.61	0.11
4100.*	4.25	2606.86	0.86	48.93	0.1
4000	4.25	2605	0.53	60.76	0.13
3900.*	4.25	2603.21	0.84	48.86	0.1
3800.*	4.25	2601.42	0.63	38.11	0.18
3700.*	4.25	2599.63	1.1	26.56	0.15
3600.*	4.25	2597.83	0.78	20.69	0.26
3500	4.25	2596.04	1.36	17.88	0.18
3400.*	4.25	2591.54	1.31	18.95	0.17
3300.*	4.29	2587.03	1.28	20.38	0.16
3200.*	4.29	2582.52	1.25	22.11	0.15
3100.*	4.29	2578.02	1.16	24.76	0.15
3000	4.29	2573.51	1.17	27.09	0.14
2900.*	4.29	2567.8	1.2	24.55	0.15
2800.*	4.29	2562.09	1.25	21.88	0.16
2700.*	4.29	2556.38	1.3	19.5	0.17
2600.*	4.29	2550.67	1.36	17.42	0.18
2500	4.29	2544.95	1.38	15.84	0.2
2400.*	4.29	2539.88	1.4	15.63	0.2
2300.*	4.29	2534.8	1.4	15.49	0.2
2200.*	4.29	2529.73	1.42	15.25	0.2
2100.*	4.29	2524.65	1.41	15.06	0.2
2000	4.29	2519.58	1.43	14.76	0.2
1900.*	4.29	2515.14	1.43	15.45	0.19
1800.*	4.29	2510.71	1.38	16.3	0.19
1700.*	4.29	2506.28	1.36	16.58	0.19
1600.*	4.29	2501.84	1.36	17.01	0.19
1500	4.29	2497.41	0.68	24.41	0.26
1400.*	4.52	2496.55	0.82	20.55	0.27
1300.*	4.52	2495.7	0.72	19.98	0.31
1200.*	4.52	2494.84	1.01	15.53	0.29

1100.*	4.52	2493.99	0.68	17.56	0.38
1000	4.56	2493.13	1.63	10.62	0.26
900.*	4.56	2480.5	1.59	11.52	0.25
800.*	4.56	2467.88	1.52	12.96	0.23
700.*	4.56	2455.25	1.46	14.91	0.21
600.*	4.56	2442.62	1.34	18.96	0.18
500	4.56	2429.99	0.22	22.95	0.92
400.2*	4.56	2429.97	0.27	20.54	0.81
300.4*	4.56	2429.95	0.32	18.99	0.74
200.6*	4.56	2429.93	0.38	16.81	0.71
100.8*	4.56	2429.91	0.43	14.8	0.72
1	4.56	2429.89	0.48	13.71	0.69
February					
5000	2.97	2622.67	0.77	16.4	0.24
4900.*	2.97	2621	1.16	15.31	0.17
4800.*	2.97	2619.32	0.68	21.12	0.21
4700.*	2.97	2617.64	1.09	20.43	0.13
4600.*	2.97	2615.97	0.58	29.85	0.17
4500	4.14	2614.29	0.92	37.22	0.12
4400.*	4.14	2612.43	0.74	26.27	0.21
4300.*	4.14	2610.57	1.12	27.55	0.13
4200.*	4.14	2608.72	0.62	38.58	0.17
4100.*	4.14	2606.86	0.92	48.85	0.09
4000	4.14	2605	0.51	60.78	0.13
3900.*	4.14	2603.21	0.95	48.74	0.09
3800.*	4.14	2601.42	0.61	38.14	0.18
3700.*	4.14	2599.63	1.16	26.36	0.14
3600.*	4.14	2597.83	0.78	20.5	0.26
3500	4.14	2596.04	1.31	17.93	0.18
3400.*	4.14	2591.54	1.32	18.68	0.17
3300.*	4.18	2587.03	1.25	20.37	0.16
3200.*	4.18	2582.52	1.24	21.95	0.15
3100.*	4.18	2578.02	1.14	24.59	0.15
3000	4.18	2573.51	1.17	26.82	0.13
2900.*	4.18	2567.8	1.2	24.28	0.14
2800.*	4.18	2562.09	1.24	21.71	0.16
2700.*	4.18	2556.38	1.29	19.37	0.17
2600.*	4.18	2550.67	1.35	17.3	0.18
2500	4.18	2544.95	1.39	15.66	0.19
2400.*	4.18	2539.88	1.38	15.6	0.19
2300.*	4.18	2534.8	1.39	15.39	0.19

2200.*	4.18	2529.73	1.41	15.17	0.2
2100.*	4.18	2524.65	1.41	14.94	0.2
2000	4.18	2519.58	1.42	14.69	0.2
1900.*	4.18	2515.14	1.4	15.43	0.19
1800.*	4.18	2510.71	1.39	16.08	0.19
1700.*	4.18	2506.28	1.37	16.3	0.19
1600.*	4.18	2501.84	1.37	16.75	0.18
1500	4.18	2497.41	0.67	24.2	0.26
1400.*	4.4	2496.55	0.82	20.35	0.26
1300.*	4.4	2495.7	0.72	19.79	0.31
1200.*	4.4	2494.84	1.01	15.36	0.28
1100.*	4.4	2493.99	0.67	17.4	0.38
1000	4.44	2493.13	1.62	10.5	0.26
900.*	4.44	2480.5	1.57	11.42	0.25
800.*	4.44	2467.88	1.52	12.81	0.23
700.*	4.44	2455.25	1.44	14.83	0.21
600.*	4.44	2442.62	1.35	18.8	0.18
500	4.44	2429.99	0.21	22.91	0.91
400.2*	4.44	2429.97	0.27	20.49	0.8
300.4*	4.44	2429.95	0.32	18.95	0.73
200.6*	4.44	2429.93	0.38	16.7	0.7
100.8*	4.44	2429.91	0.43	14.72	0.71
1	4.44	2429.89	0.48	13.65	0.68
March					
5000	2.97	2622.67	0.78	16.33	0.23
4900.*	2.97	2621	1.13	15.5	0.17
4800.*	2.97	2619.32	0.69	21.04	0.21
4700.*	2.97	2617.64	1.06	20.7	0.14
4600.*	2.97	2615.97	0.58	29.71	0.17
4500	4.31	2614.29	0.9	38.29	0.13
4400.*	4.31	2612.43	0.76	26.36	0.21
4300.*	4.31	2610.57	1.1	27.74	0.14
4200.*	4.31	2608.72	0.64	38.61	0.17
4100.*	4.31	2606.86	0.9	48.9	0.1
4000	4.31	2605	0.52	60.79	0.14
3900.*	4.31	2603.21	0.83	48.88	0.11
3800.*	4.31	2601.42	0.64	38.12	0.18
3700.*	4.31	2599.63	1.09	26.6	0.15
3600.*	4.31	2597.83	0.78	20.73	0.27
3500	4.31	2596.04	1.35	18.04	0.18
3400.*	4.31	2591.54	1.32	18.98	0.17

3300.*	4.36	2587.03	1.27	20.64	0.17
3200.*	4.36	2582.52	1.26	22.23	0.16
3100.*	4.36	2578.02	1.18	24.74	0.15
3000	4.36	2573.51	1.16	27.41	0.14
2900.*	4.36	2567.8	1.2	24.65	0.15
2800.*	4.36	2562.09	1.27	21.83	0.16
2700.*	4.36	2556.38	1.32	19.5	0.17
2600.*	4.36	2550.67	1.35	17.56	0.18
2500	4.36	2544.95	1.4	15.86	0.2
2400.*	4.36	2539.88	1.41	15.71	0.2
2300.*	4.36	2534.8	1.41	15.55	0.2
2200.*	4.36	2529.73	1.44	15.26	0.2
2100.*	4.36	2524.65	1.42	15.11	0.2
2000	4.36	2519.58	1.44	14.79	0.2
1900.*	4.36	2515.14	1.41	15.57	0.2
1800.*	4.36	2510.71	1.38	16.38	0.19
1700.*	4.36	2506.28	1.4	16.52	0.19
1600.*	4.36	2501.84	1.36	17.16	0.19
1500	4.36	2497.41	0.68	24.55	0.26
1400.*	4.6	2496.55	0.83	20.68	0.27
1300.*	4.6	2495.7	0.73	20.11	0.32
1200.*	4.6	2494.84	1.02	15.63	0.29
1100.*	4.6	2493.99	0.68	17.69	0.38
1000	4.65	2493.13	1.64	10.67	0.27
900.*	4.65	2480.5	1.59	11.61	0.25
800.*	4.65	2467.88	1.54	13.03	0.23
700.*	4.65	2455.25	1.46	15.03	0.21
600.*	4.65	2442.62	1.36	18.97	0.18
500	4.65	2429.99	0.22	22.98	0.93
400.2*	4.65	2429.97	0.28	20.57	0.82
300.4*	4.65	2429.95	0.33	19.01	0.75
200.6*	4.65	2429.93	0.38	16.89	0.72
100.8*	4.65	2429.91	0.43	14.85	0.72
1	4.65	2429.89	0.48	13.75	0.7
April					
5000	2.97	2622.67	1.21	13.34	0.18
4900.*	2.97	2621	0.72	18.58	0.22
4800.*	2.97	2619.32	1.16	17.39	0.15
4700.*	2.97	2617.64	0.62	24.6	0.19
4600.*	2.97	2615.97	1.09	23.7	0.11
4500	5.29	2614.29	0.61	53.28	0.16

4400.*	5.29	2612.43	1.29	23.81	0.17
4300.*	5.29	2610.57	0.75	30.38	0.23
4200.*	5.29	2608.72	1.14	37.81	0.12
4100.*	5.29	2606.86	1.02	48.97	0.11
4000	5.29	2605	0.55	60.91	0.16
3900.*	5.29	2603.21	1.02	48.88	0.11
3800.*	5.29	2601.42	0.7	38.37	0.2
3700.*	5.29	2599.63	1.15	27.01	0.17
3600.*	5.29	2597.83	0.84	21.66	0.29
3500	5.29	2596.04	1.39	19.33	0.2
3400.*	5.29	2591.54	1.39	20.27	0.19
3300.*	5.36	2587.03	1.34	22.06	0.18
3200.*	5.36	2582.52	1.32	23.8	0.17
3100.*	5.36	2578.02	1.27	26.23	0.16
3000	5.36	2573.51	1.24	29.15	0.15
2900.*	5.36	2567.8	1.26	26.28	0.16
2800.*	5.36	2562.09	1.33	23.2	0.17
2700.*	5.36	2556.38	1.37	20.8	0.19
2600.*	5.36	2550.67	1.43	18.54	0.2
2500	5.36	2544.95	1.49	16.65	0.22
2400.*	5.36	2539.88	1.48	16.53	0.22
2300.*	5.36	2534.8	1.48	16.36	0.22
2200.*	5.36	2529.73	1.51	16.05	0.22
2100.*	5.36	2524.65	1.52	15.78	0.22
2000	5.36	2519.58	1.53	15.49	0.23
1900.*	5.36	2515.14	1.5	16.34	0.22
1800.*	5.36	2510.71	1.46	17.26	0.21
1700.*	5.36	2506.28	1.43	18.05	0.21
1600.*	5.36	2501.84	1.43	18.55	0.2
1500	5.36	2497.41	0.72	26.35	0.28
1400.*	5.79	2496.55	0.86	22.57	0.3
1300.*	5.79	2495.7	0.78	21.72	0.34
1200.*	5.79	2494.84	1.05	17.22	0.32
1100.*	5.79	2493.99	0.73	19.05	0.42
1000	5.87	2493.13	1.71	11.73	0.29
900.*	5.87	2480.5	1.67	12.75	0.28
800.*	5.87	2467.88	1.61	14.28	0.26
700.*	5.87	2455.25	1.53	16.31	0.24
600.*	5.87	2442.62	1.44	19.83	0.21
500	5.87	2429.99	0.24	23.35	1.03
400.2*	5.87	2429.97	0.3	21.01	0.92

300.4*	5.87	2429.95	0.36	19.34	0.85
200.6*	5.87	2429.93	0.41	17.88	0.79
100.8*	5.87	2429.91	0.47	15.55	0.81
1	5.87	2429.89	0.52	14.28	0.79
May					
5000	2.97	2622.67	0.76	16.43	0.24
4900.*	2.97	2621	1.19	15.14	0.16
4800.*	2.97	2619.32	0.67	21.2	0.21
4700.*	2.97	2617.64	1.13	20.13	0.13
4600.*	2.97	2615.97	0.49	31.79	0.19
4500	8.75	2614.29	1.02	52.73	0.16
4400.*	8.75	2612.43	0.95	31.47	0.29
4300.*	8.75	2610.57	1.41	29.71	0.21
4200.*	8.75	2608.72	0.84	39.95	0.26
4100.*	8.75	2606.86	1.19	49.37	0.15
4000	8.75	2605	0.68	61.22	0.21
3900.*	8.75	2603.21	1.21	49.23	0.15
3800.*	8.75	2601.42	0.86	39.13	0.26
3700.*	8.75	2599.63	1.33	28.21	0.23
3600.*	8.75	2597.83	0.99	24.53	0.36
3500	8.75	2596.04	1.57	22.78	0.25
3400.*	8.75	2591.54	1.53	24.23	0.24
3300.*	8.94	2587.03	1.5	26.2	0.23
3200.*	8.94	2582.52	1.46	28.48	0.22
3100.*	8.94	2578.02	1.44	31.14	0.2
3000	8.94	2573.51	1.36	35.44	0.19
2900.*	8.94	2567.8	1.42	31	0.2
2800.*	8.94	2562.09	1.48	27.22	0.22
2700.*	8.94	2556.38	1.55	24.08	0.24
2600.*	8.94	2550.67	1.61	21.47	0.26
2500	8.94	2544.95	1.67	19.24	0.28
2400.*	8.94	2539.88	1.66	19.05	0.28
2300.*	8.94	2534.8	1.68	18.76	0.28
2200.*	8.94	2529.73	1.7	18.39	0.29
2100.*	8.94	2524.65	1.71	18.05	0.29
2000	8.94	2519.58	1.74	17.61	0.29
1900.*	8.94	2515.14	1.69	18.77	0.28
1800.*	8.94	2510.71	1.64	20.03	0.27
1700.*	8.94	2506.28	1.62	21.26	0.26
1600.*	8.94	2501.84	1.59	22.4	0.25
1500	8.94	2497.41	0.82	31.57	0.35

1400.*	9.99	2496.55	0.97	27.63	0.37
1300.*	9.99	2495.7	0.92	25.8	0.42
1200.*	9.99	2494.84	1.16	21.36	0.4
1100.*	9.99	2493.99	0.85	22.52	0.52
1000	10.19	2493.13	1.91	14.63	0.36
900.*	10.19	2480.5	1.87	15.78	0.35
800.*	10.19	2467.88	1.81	17.14	0.33
700.*	10.19	2455.25	1.73	19.75	0.3
600.*	10.19	2442.62	1.66	22.36	0.28
500	10.19	2429.99	0.31	24.4	1.33
400.2*	10.19	2429.97	0.38	21.9	1.22
300.4*	10.19	2429.95	0.44	20.27	1.15
200.6*	10.19	2429.93	0.49	19.2	1.07
100.8*	10.19	2429.91	0.56	17.59	1.03
1	10.19	2429.89	0.62	15.82	1.03

(*) Interpolated cross-sections at an interval of 100 m within the surveyed cross-sections of 500 m interval

UTTARAKHAND ENVIRONMENT PROTECTION & POLLUTION CONTROL BOARD
E-115, Nehru Colony, Haridwar Road, Dehradun (Uttarakhand)
उत्तराखण्ड पर्यावरण संरक्षण एवं प्रदूषण नियंत्रण बोर्ड
ई-११५, नेहरू कॉलोनी, हरिद्वार रोड, देहरादून (उत्तराखण्ड)
Phone: 0135-2668084, Fax: 0135-2668092 Web: ueppcb.uk.gov.in

UEPPCB/HO/NOC-1734/2012/ 1349 दिनांक 24.9.2012

REGD. POST

To,

The Secretary,
Ministry of Environment & Forests,
Paryavaran Bhawan,
CGO Complex, Lodhi Road,
New Delhi – 110 003

Sub. : **Minutes of Public Hearing of M/S THDC India Ltd. Jelam- Tamak Hydro Electric Project (108 MW) - reg.**

Sir,

This is to inform that the **Uttarakhand Environment Protection and Pollution Control Board** has conducted the public hearing of **THDC India Ltd. Jelam- Tamak Hydro electric Project (108 MW)** on **September 06, 2012** at **Village Jelam, Distt Chamoli.**

The copies of the minutes of public hearing along with video recording, photographs and attendance sheet are enclosed herewith for kind perusal and necessary action.
Encl. : as above.

Yours faithfully,

(Jai Raj)
Member Secretary

Copy to:

1. The **District Magistrate, Distt. Chamoli** for kind information and with the request to display the minutes of respective public hearing at his office for general information please.
2. **Shri. Sanjay Kher, Additional Managing Director, THDC Ltd. Jyoti Hotel, TCP Nazar Joshimath Distt. Chamoli** Uttarakhand for kind information and with request to display the minutes of public hearing in the offices of Panchayats/Urban Local Bodies etc. in whose jurisdiction the project is located for general information please.
3. **Regional Officer, Uttarakhand Environment Protection and Pollution Control Board, Dehradun** with the direction to display the minutes of public hearing at his office for general information please.

Scientific Officer 24.9.12

र्स टीएचडीसी इण्डिया लि0 जनपद चमोली (उत्तराखण्ड) द्वारा प्रस्तावित जेलम-तमक जल विद्युत रियोजना (108 मेगावाट क्षमता) की पर्यावरणीय स्वीकृति हेतु दिनाँक 06.09.2012 को आयोजित लोक सुनवाई का कार्यवृत्त।

उत्तराखण्ड पर्यावरण संरक्षण एवं प्रदूषण नियंत्रण बोर्ड देहरादून को मैसर्स टीएचडीसी इण्डिया लि0 की लम-तमक जल विद्युत परियोजना (108 मेगावाट क्षमता), जनपद चमोली (उत्तराखण्ड) की पर्यावरणीय वीकृति हेतु प्रस्ताव प्राप्त हुआ है। राज्य बोर्ड द्वारा ई.आई.ए. नोटिफिकेशन 2006 के प्रविधानों के अनुसार लोक सुनवाई के आयोजन के सम्बन्ध में जन सूचना दिनांक 05 अगस्त 2012 को दैनिक जागरण एवं टाइम्स ऑफ इण्डिया समाचार पत्रों में सूचना प्रकाशित की गयी। राज्य बोर्ड द्वारा पर्यावरणीय प्रभाव मूल्यांकन रिपोर्ट एवं सारांश की प्रतियाँ नियमानुसार सम्बन्धित कार्यालयों में उपलब्ध करा दी गयी थी। दिनांक 06.09.2012 आयोजित लोक सुनवाई की अध्यक्षता श्री सूर्य मोहन नौटियाल, मुख्य विकास अधिकारी, जनपद चमोली गयी। राज्य बोर्ड के प्रतिनिधि के रूप में श्री रामपाल सिंह, सहा0 पर्यावरण अधिकारी एवं श्री नरेश अवर अभियन्ता उपस्थित थे। क्षेत्र के सम्बन्धित उपजिलाधिकारी, जोशीमठ, जिला चमोली श्री अनूप ार नौटियाल एवं टीएचडीसी के महाप्रबन्धक श्री पी.पी.एस. मान, अपरमहाप्रबन्धक श्री जे.एल. नारंग, श्री सिंह, वरिष्ठ प्रबन्धक सहित अन्य अधिकारी एवं कर्मचारी भी लोक सुनवाई के दौरान उपस्थित थे।

प्रथम उत्तराखण्ड पर्यावरण संरक्षण एवं प्रदूषण नियंत्रण बोर्ड के सहा0 पर्या0 अधिकारी द्वारा मुख्य विकास धिकारी, चमोली की अनुमति से लोक सुनवाई की कार्यवाही प्रारम्भ करने की घोषणा की गई।

सी अनुक्रम में श्री संजय खेर अपर महाप्रबंधक, टीएचडीसी इण्डिया लि0 जेलम-तमक जल विद्युत रियोजना (108 मेगावाट क्षमता), जनपद चमोली (उत्तराखण्ड) द्वारा परियोजना के तकनीकी, पर्यावरणीय, माजिक एवं अन्य विभिन्न पहलुओं पर प्रस्तुतीकरण किया गया।

उपरोक्त प्रस्तुतीकरण के पश्चात जनसमूह से प्रस्तावित परियोजना के सम्बन्ध में सुझाव/अपत्तिया मन्त्रित की गई, जिनका विवरण निम्नवत् है :-

श्री राजेन्द्र राणा, ग्राम द्रोणागिरी– श्री राजेन्द्र द्वारा कहा गया कि ग्राम सभा द्रोणागिरी को प्रभावित ी में नहीं रखा गया है जबकि परियोजना का बैराज स्थल का बायां भाग ग्राम सभा द्रोणागिरी के अन्तर्गत ता है। इस पर परियोजना के अपरमहाप्रबन्धक श्री संजय खेर द्वारा अवगत कराया गया कि यद्यपि ग्राम ा द्रोणागिरी प्रभावित क्षेत्र में नहीं है तदापि यदि यह प्रभावित क्षेत्र में आता है तो इसे प्रभावित क्षेत्र माना ेगा एवं प्रभावितों को उचित मुआवजा दिया जायेगा।

ी बलवीर सिंह रावत, क्षेत्र पंचायत सदस्य जेलम – श्री बलवीर के द्वारा अवगत करवाया कि ग्राम सभा ागिरी की भूमि भी परियोजना निर्माण से प्रभावित होगी। इनके द्वारा परियोजना से जुम्मा ग्राम के छ रिवारो को प्रभावित मानने का मानक पूछा गया है। जिस पर परियोजना के अपरमहाप्रबन्धक श्री संजय खेर रा अवगत कराया गया कि राजस्व अभिलेखों एवं परियोजना की प्रस्तावित पुनर्वास एवं पुनर्स्थापना नीति ो कि एन.पी.आर.आर. 2007 पर आधारित है, के आधार पर प्रभावितों की संख्या का आंकलन किया गया है।

- श्री मंगल सिंह रावत, ग्राम प्रधान द्रोणागिरी– श्री मंगल सिंह द्वारा बताया गयी कि परियोजना निर्माण के रान होने वाली विस्फोट से द्रोणागिरी भी प्रभावित होगा। विस्फोट से प्रभावित होने का मानक भी पूछा । इनके द्वारा मलबे के डपिंग के विषय में भी जानकारी चाही गयी। जिस पर अपरमहाप्रबन्धक श्री संजय द्वारा वांछित जानकारी उपलब्ध करायी गयी।

म सिंह पवार, ग्राम प्रधान तोलमा (तमक) – श्री प्रेम सिंह द्वारा [illegible] किया। इनके द्वारा कहा गया कि परियोजना निर्माण से [illegible] साथ ही यह भी अवगत कराया गया कि परियोजना निर्माण के दौरान यदि [illegible] द्वारा [illegible] ग्रामवासियों के [illegible] तो परियोजना का विरोध किया जायेगा। इनके द्वारा [illegible] परियोजना में तैनात [illegible] के अधिकारी / कर्मचारियों का स्थानान्तरण परियोजना पूर्ण [illegible] नहीं किया जाय। जिससे कि समन्वय की स्थिति परियोजना निर्माण पूर्ण [illegible] तक बनी रहे।

रा ग्रामवासियों द्वारा हस्ताक्षरित प्रत्यावेदन भी प्रस्तुत किया गया।

हरवान सिंह पूर्व प्रधान ग्राम जेलम – श्री [illegible] सिंह द्वारा [illegible] का स्वागत किया गया।

ऋषि प्रसाद सती, अध्यक्ष नगरपालिका, जोशीमठ– श्री [illegible] तक 100 यूनिट प्रतिमाह निःशुल्क विद्युत उपलब्ध कराये जाने [illegible] कदम बताया। इनके द्वारा [illegible] से किये गये वादों को पूर्ण करने की अपेक्षा की गयी। [illegible] परियोजना से [illegible] के अवसर बढ़ाने की अपील की गई। [illegible] परियोजना निर्माण के दौरान [illegible] द्वारा क्षेत्र की जन भावनाओं के विरुद्ध कार्य किया [illegible]।

ती सुचिता चौहान, ब्लाक प्रमुख, जोशीमठ – इनके द्वारा [illegible] से [illegible] भावनाओं के अनुरूप रने की अपेक्षा की गयी। साथ ही अवगत कराया गया कि [illegible] द्वारा बनाई ही है। जनता की अनदेखी होने पर आन्दोलन [illegible]।

प्रतिनिधि श्री सोमपाल सिंह द्वारा उपस्थित गणमान्य [illegible] एवं जनता का आभार व्यक्त किया पैनल के अध्यक्ष की अनुमति से लोक सुनवाई के [illegible] की घोषणा की गई। इस दौरान लोक की कार्यवाही की फोटोग्राफी एवं वीडियोग्राफी भी गयी है ([illegible] फोटो व डी०वी०डी०)।

लग्नक– यथोपरि (फोटो व डी०वी०डी० सहित)

11/12

गोस्वामी
अभियन्ता,
खण्ड
रण सरक्षण
दूषण
ण बोर्ड

(सोमपाल सिंह)
सहा० पर्या० अधिकारी
उत्तराखण्ड पर्यावरण सरक्षण
एवं प्रदूषण नियन्त्रण बोर्ड

([illegible])
उपजिलाधिकारी जोशीमठ
[illegible]

([illegible])
मुख्य विकास अधि०
चमोली

मैसर्स टीएचडीसी इण्डिया लि0, जनपद चमोली (उत्तराखण्ड) द्वारा प्रस्तावित जेलम–तमक जल विद्युत परियोजना (108 मेगावाट क्षमता) की पर्यावरणीय स्वीकृति हेतु दिनाँक 06.09.2012 को आयोजित लोक सुनवाई का कार्यवृत्त।

उत्तराखण्ड पर्यावरण संरक्षण एवं प्रदूषण नियंत्रण बोर्ड, देहरादून को **मैसर्स टीएचडीसी इण्डिया लि0 की जेलम–तमक जल विद्युत परियोजना (108 मेगावाट क्षमता), जनपद चमोली (उत्तराखण्ड)** की पर्यावरणीय स्वीकृति हेतु प्रस्ताव प्राप्त हुआ है। राज्य बोर्ड द्वारा ई.आई.ए. नोटिफिकेशन 2006 के प्रविधानो के अनुसार लोक सुनवाई के आयोजन के सम्बन्ध मे जन सूचना दिनांक 05 अगस्त 2012 को दैनिक जागरण एवं टाइम्स ऑफ इण्डिया समाचार पत्रों में सूचना प्रकाशित की गयी। राज्य बोर्ड द्वारा पर्यावरणीय प्रभाव मूल्यांकन रिपोर्ट एवं सारांश की प्रतियाँ नियमानुसार सम्बन्धित कार्यालयों मे उपलब्ध करा दी गयी थी। दिनांक 06.09.2012 को आयोजित लोक सुनवाई की अध्यक्षता श्री सूर्य मोहन नौटियाल, मुख्य विकास अधिकारी, जनपद चमोली द्वारा की गयी। राज्य बोर्ड के प्रतिनिधि के रूप मे श्री सोमपाल सिंह, सहा0 पर्यावरण अधिकारी एवं श्री नरेश गोस्वामी, अवर अभियंता उपस्थित थे। क्षेत्र के सम्बन्धित उपजिलाधिकारी, जोशीमठ, जिला चमोली श्री अनूप कुमार नौटियाल एवं टीएचडीसी के महाप्रबन्धक श्री पी.पी.एस. मान, अपरमहाप्रबन्धक श्री जे.एल. नारंग, श्री आल्हा सिंह, वरिष्ठ प्रबन्धक सहित अन्य अधिकारी एवं कर्मचारी भी लोक सुनवाई के दौरान उपस्थित थे।

सर्वप्रथम उत्तराखण्ड पर्यावरण संरक्षण एवं प्रदूषण नियंत्रण बोर्ड के सहा0 पर्या0 अधिकारी द्वारा मुख्य विकास अधिकारी, चमोली की अनुमति से लोक सुनवाई की कार्यवाही प्रारम्भ करने की घोषणा की गई।

इसी अनुक्रम मे श्री संजय खेर, अपर महाप्रबन्धक **टीएचडीसी इण्डिया लि0 जेलम–तमक जल विद्युत परियोजना (108 मेगावाट क्षमता), जनपद चमोली (उत्तराखण्ड)** द्वारा परियोजना के तकनीकी, पर्यावरणीय, सामाजिक एवं अन्य विभिन्न पहलुओं पर प्रस्तुतीकरण किया गया।

उपरोक्त प्रस्तुतीकरण के पश्चात जनसमूह से प्रस्तावित परियोजना के सम्बन्ध मे सुझाव/आपत्तियां आमन्त्रित की गई, जिनका विवरण निम्नवत है :–

1– श्री राजेन्द्र राणा, ग्राम द्रोणागिरी– श्री राजेन्द्र द्वारा कहा गया कि ग्राम सभा द्रोणागिरी को प्रभावित श्रेणी मे नहीं रखा गया है जबकि परियोजना का बैराज स्थल का बाया भाग ग्राम सभा द्रोणागिरी के अन्तर्गत आता है। इस पर परियोजना के अपरमहाप्रबन्धक श्री संजय खेर द्वारा अवगत कराया गया कि यदपि ग्राम सभा द्रोणागिरी प्रभावित क्षेत्र मे नही है तदापि यदि यह प्रभावित क्षेत्र मे आता है तो इसे प्रभावित क्षेत्र माना जायेगा एवं प्रभावितो को उचित मुआवजा दिया जायेगा।

2– श्री बलवीर सिंह रावत, क्षेत्र पंचायत सदस्य जेलम – श्री बलवीर के द्वारा अवगत करवाया कि ग्राम सभा द्रोणागिरी की भूमि भी परियोजना निर्माण से प्रभावित होगी। इनके द्वारा परियोजना से जुम्मा ग्राम के छ: परिवारो को प्रभावित मानने का मानक पूछा गया है। जिस पर परियोजना के अपरमहाप्रबन्धक श्री संजय खेर द्वारा अवगत कराया गया कि राजस्व अभिलेखों एवं परियोजना की प्रस्तावित पुनर्वास एवं पुनर्स्थापना नीति जो कि एन.पी.आर.आर. 2007 पर आधारित है, के आधार पर प्रभावितो की संख्या का आंकलन किया गया है।

3– श्री मंगल सिंह रावत, ग्राम प्रधान द्रोणागिरी– श्री मंगल सिंह द्वारा बताया गयी कि परियोजना निर्माण के दौरान होने वाली विस्फोट से द्रोणागिरी भी प्रभावित होगा। विस्फोट से प्रभावित होने का मानक भी

पूछा गया। इनके द्वारा मलवे के डंपिंग के विषय में भी जानकारी चाही गयी। जिस पर अपरमहाप्रबन्धक श्री संजय खेर द्वारा वांछित जानकारी उपलब्ध करायी गयी।

4– श्री प्रेम सिंह पवांर, ग्राम प्रधान तोलमा (तमक) – श्री प्रेम सिंह द्वारा परियोजना निर्माण का स्वागत किया गया एवं इनके द्वारा कहा गया कि परियोजना निर्माण से क्षेत्र का विकास होगा साथ ही यह भी अवगत कराया गया कि परियोजना निर्माण के दौरान यदि टीएचडीसी द्वारा क्षेत्र की जन भावनाओं के विरूद्ध कार्य किया गया तो परियोजना का विरोध किया जायेगा। इनके द्वारा यह मांग की गई कि परियोजना मे तैनात टीएचडीसी के अधिकारी/कर्मचारियों के स्थानान्तरण परियोजना पूर्ण होने तक नही किया जाये। जिससे कि वर्तमान समन्वय की स्थिति परियोजना निर्माण पूर्ण होने तक बनी रहे।

इनके द्वारा ग्रामवासियों द्वारा हस्ताक्षरित प्रत्यावेदन भी प्रस्तुत किया गया।

5– श्री मेहरबान सिंह पूर्व प्रधान ग्राम जेलम– श्री मेहरबान सिंह द्वारा परियोजना का स्वागत किया गया।

6– श्री ऋषि प्रसाद सती, अध्यक्ष नगरपालिका, जोशीमठ– श्री सती द्वारा परियोजना का प्रभावित परिवारों को 10 वर्षो तक 100 यूनिट प्रतिमाह निशुल्क विद्युत उपलब्ध करवाने को सराहनीय कदम बताया। इनके द्वारा टीएचडीसी से किये गये वादो को पूर्ण करने की अपेक्षा की गयी। इनके द्वारा कहा गया कि परियोजना से रोजगार के अवसर बढाने की अपील की गई। और कहा गया कि यदि परियोजना निर्माण के दौरान टीएचडीसी द्वारा क्षेत्र की जन भावनाओ के विरूद्ध कार्य किया गया तो परियोजना का विरोध किया जायेगा।

7– श्रीमती सुचिता चौहान, ब्लाक प्रमुख, जोशीमठ – इनके द्वारा टीएचडीसी से जन भावनाओं के अनुरूप कार्य करने की अपेक्षा की गयी। साथ ही अवगत कराया गया कि परियोजना का जन सामान्य द्वारा कोई विरोध नहीं है। जनता की अनदेखी होने पर आन्दोलन की भी चेतावनी दी गयी।

बोर्ड के प्रतिनिधि श्री सोमपाल सिंह द्वारा उपस्थित गणमान्य नागरिको एवं जनता का आभार व्यक्त किया गया एवं पैनल के अध्यक्ष की अनुमति से लोक सुनवाई के समापन की घोषणा की गई। इस दौरान लोक सुनवाई की कार्यवाही की फोटोग्राफी एवं वीडियोग्राफी की गयी है (संलग्नक–फोटो व डी0वी0डी0)।

कुल संलग्नक– यथोपरि (फोटो व डी0वी0डी0 सहित)

Sd/-	Sd/-	Sd/-	Sd/-
(नरेश गोस्वामी **अवर अभियन्ता, उत्तराखण्ड पर्यावरण संरक्षण एवं प्रदूषण नियन्त्रण बोर्ड**	(सोमपाल सिंह) **सहा0 पर्या0 अधिकारी, उत्तराखण्ड पर्यावरण संरक्षण एवं प्रदूषण नियन्त्रण बोर्ड**	(अनूप कुमार नौटियाल) **उपजिलाधिकारी, जोशीमठ चमोली**	(सूर्य मोहन नौटियाल) **मुख्य विकास अधि0 चमोली**