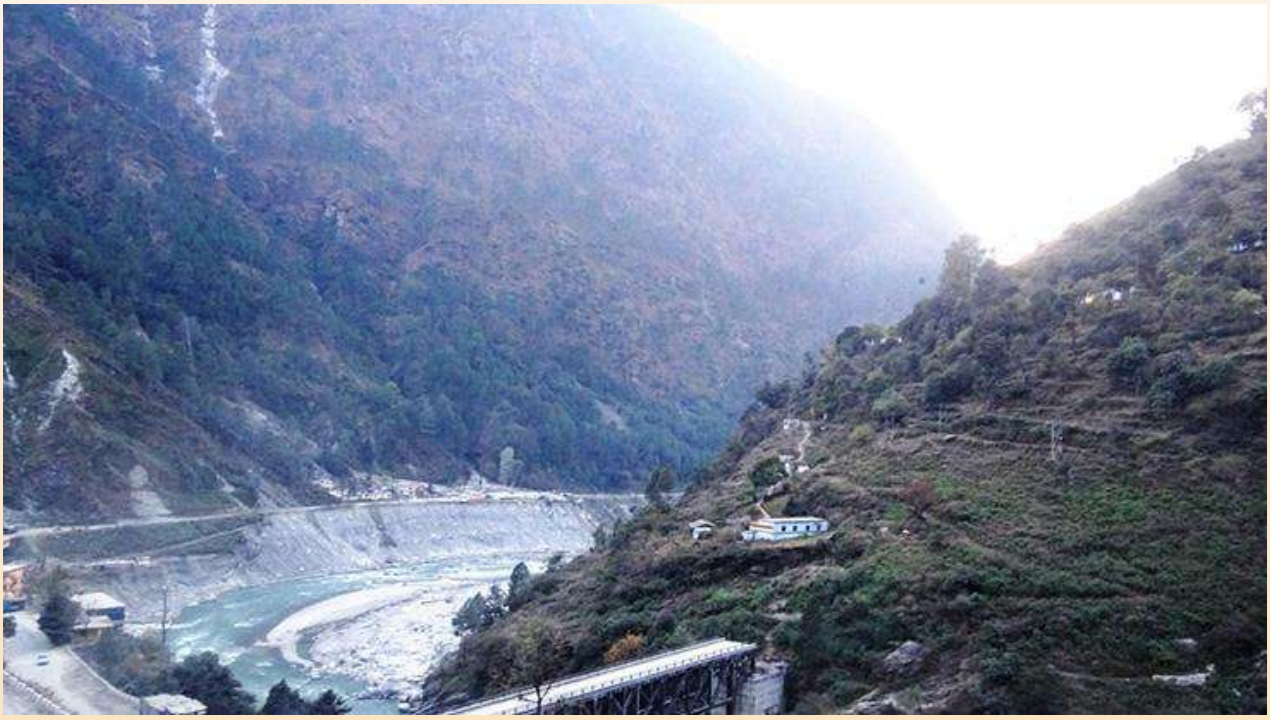
THDC INDIA LTD.



ENVIRONMENTAL IMPACT ASSESSMENT & ENVIRONMENTAL MANAGEMENT PLAN BASED ON ONE SEASON STUDY FOR VISHNUGAD PIPALKOTI HEP (444 MW), UTTARAKHAND

REIA REPORT

वाप्कोस लिमिटेड
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DECLARATION

Name of the Work: Rapid Environmental Impact Assessment Study for Vishnugad Pipalkoti Hydroelectric Project

We, hereby declare that information submitted in the EIA/EMP report submitted by us is factually correct and contents of the EIA report pertaining to a project have not been copied from other EIA reports.

Dr. Aman Sharma
Chief Executive Director
(Environment, Construction Management and Administration)
WAPCOS Ltd.

टीएचडीसी इण्डिया लिमिटेड

THDC INDIA LIMITED

(Schedule-A, Mini Ratna PSU)

Letter No: THDCIL/RKSH/S&E/F-117/89 (E)

Date: 08.07.2021

TO WHOM IT MAY CONCERN

This is to certify that M/s WAPCOS Limited, a Government of India Undertaking under Ministry of Jal Shakti, a NABET Accredited Consultant, having its Headquarter at 76C, Sector-18,Gurgaon-122015,Haryana, has been entrusted the work of "Environmental Impact Assessment Study for Vishnugad Pipalkoti Hydro-electric project".

It is further certified that the content/information provided in this EIA report has not been copied from the EIA reports of any other project.

08.07.2021

Authorized Signatory

महाप्रबंधक (सामा. एवं पर्या.)
General Manager (Soc. & Env.)
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THDC India Ltd. Rishikesh

CHAPTER-1
INTRODUCTION

CHAPTER-1
INTRODUCTION

1.1 GENERAL OVERVIEW

THDC India Limited, a schedule-A mini-Ratna PSU under the administrative control of Power Ministry, has signed a MoU with Govt. of Uttarakhand for the construction of 444MW Vishnugad-Pipalkoti Hydro-Electric project (VPHEP) in District Chamoli, Uttarakhand.

VPHEP (4 x 111 MW) is located on river Alaknanda, a major tributary of river Ganga, in district Chamoli in the state of Uttarakhand. It is a run-of-the river hydro power project & envisages construction of a diversion dam of 65 m height near village Helong (79°29'30" E and 30°30'50" N). An underground power house is being constructed at village Haat (79°24'56" E and 30°25'31"N), 3 km from Pipalkoti. The nearest railway station is at Rishikesh about 225 km from project site. The project and all its major components are located on right bank of the river Alaknanda. Project is accessible through National Highway NH-58 (Ghaziabad-Rishikesh-Pipalkoti-Joshimath) which is located on the left bank of the river.

VPHEP is suited to help in providing peaking power to the national grid. Once commissioned, the project will provide 1657.09 million units (with 95% machine availability) of electricity each year to the Northern Region to meet India's growing energy needs.

The project location map is enclosed as Figure 1.1.

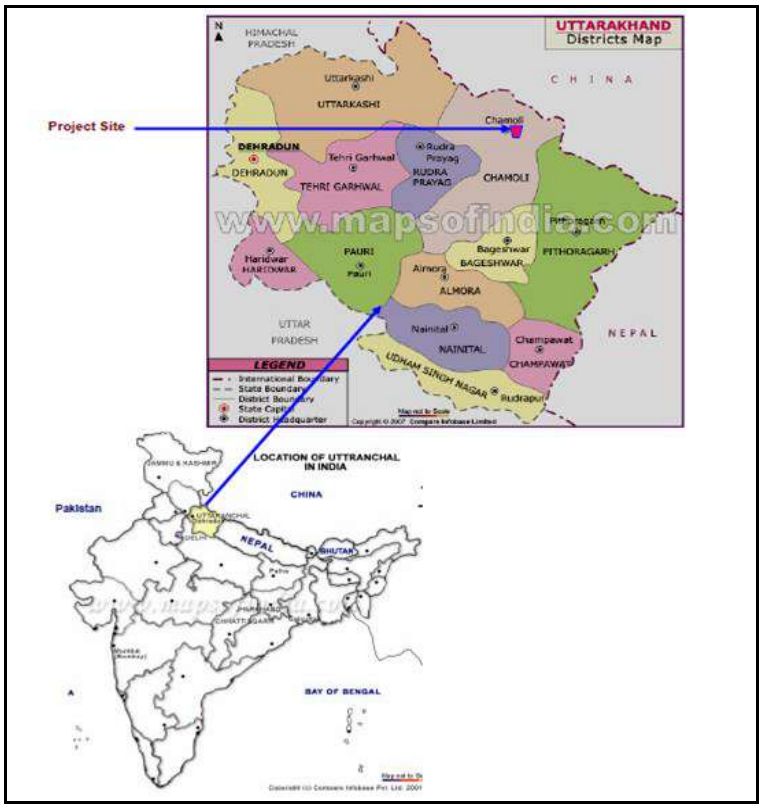


Figure-1.1: Location Map

1.2 POLICY, LEGAL AND ADMINISTRATIVE FRAMEWORK

The principal Environmental Regulatory Agency in India is the Ministry of Environment, Forests and climate Change (MOEF&CC), Government of India (GoI). MOEF&CC formulates environmental policies and accords environmental clearance for the projects. The State Pollution Control Board (SPCB) accords No Objection Certificate (NOC) and Consent for Establishment and Operation for the projects. MoEF&CC, has issued a notification called EIA Notification 2006 on September 14, 2006 which states that prior Environmental Clearance from Ministry of Environment, Forest & Climate Change (MoEF&CC) shall have to be obtained by the projects.

1.3 STATUTORY CLEARANCES

Environmental Clearance was granted to VPHEP by MoEF&CC vide letter no. J-12011/29/2007 IA-I dtd 22-08-2007 for 10 years which was further extended vide letter no**.** J-12011/29/2007 IA-I dtd 25-04-2018 and valid upto August, 2020. The copy of earlier EC is given in **Annexure-I.** Meanwhile, MoEF&CC issued notification dated 18.01.2021 specified that the period from 1st April, 2020 to 31st March, 2021 shall not be considered for the purpose of calculation of the period of validity of Environmental Clearance in view of outbreak of Corona Virus (COVID-19). The validity of above notification is extended upto 31.12.2021 vide MoEF&CC notification dated 16.06.2021. Accordingly, Validity of Environmental Clearance of VPHEP is extended upto 31.12.2021.

The Terms of Reference (ToR) for the Rapid EIA study based on one season has been issued vide MoEF&CC letter no. J-12011/10/2020-IA-I(R) dated 02nd March, 2021. The copy of approved ToR and exemption from public hearing is given in **Annexure-IIA & Annexure-IIB respectively.** The compliance of ToR is given in **Annexure-III.**

The latest Six Monthly Compliance Report of earlier Environmental Clearance of VPHEP is given in **Annexure-IV-A.** The status of all pending cases is attached as **Annexure IV-B**. The current status of statutory clearances and their Compliance Status as on May, 2021 is given in Table-1.1.

Table-1.1: Current status of statutory clearances and their Compliance Status as on May, 2021

S. No	Clearances	Dated	Remarks	Compliances
1	Environmental Clearances as per EIA Notification 2006	J-12011/29/2007 IA-I dated 22-08-2007	For a period of 10 Years	**Annual Environment Statement:** Last Environment statement was sent on dated: 10.09.2020 for FY 2019-20 Report for the FY 2020-2021 is being prepared and will be send on/before 30th September
2	Validity Extension in Environmental Clearances as	J-12011/29/2007 IA-I dated 25-04-2018	For a period of 3 Years up to August 2020	

S. No	Clearances	Dated	Remarks	Compliances
	per EIA Notification 2006			**Six Monthly Compliance Report**: 14th (July 2020-December 2020) has already been sent to concerned official on 15.01.2021.
3	Stage 1 forest Clearance	3rd June 2011	Principle Approval	7th (FY 2020-2021): Yearly compliance report is being regularly sent to concerned official, Last report for the FY 2020-2021 has sent on date 10.05.2021.
4	Stage 2 forest Clearance	28th May 2013	Final Approval	
5	NOC from State Pollution Board	Till completion of the Project	Consent to establishment	Monthly compliance report is being regularly sent to UEPPCB. The said report for the month of April, 2021 has been sent to UEPPCB on dated 19.05.2021 and report of the month of May, 2021 is being prepared.

1.4 OBJECTIVE OF THE STUDY

As per EIA notification 2006, An EIA study is a pre-requisite for obtaining Environmental Clearance (EC). As any developmental activity, while providing planned benefits could lead to a variety of adverse environmental impacts. However, by proper planning at the inception and design stages and by adopting appropriate mitigatory measures in the planning, design, construction and operation phases, the adverse impacts can be minimized to a large extent, whereas the beneficial impacts could be maximized.

Therefore, the main objective of an EIA-EMP study is to assess the positive and negative impacts likely to accrue as a result of the construction and operation of project under study. A suitable Environmental Management Plan (EMP) is then suggested to ameliorate the adverse impacts and enhance the positive impacts. A well- designed environmental monitoring program covering various critical parameters to be covered in the project construction and operation phases is also suggested.

The EC of VPHEP is going to expire on 31.12.2021 and since there is no provision for further extension of validity of EC beyond 10+3 years, Project is applying for the Fresh EC from MOEF&CC.

The current study is for assessing the Impact of projects activities on the Environment based on study of one season as per the ToR granted by MoEF&CC vide letter J-12011/10/2020-IA-A(R) dated: 02.03.2021.

The Project Proponent, THDC India limited has appointed M/s WAPCOS Limited, a government of India Undertaking in the Ministry of Water Resources as its EIA consultant and awarded the work related to Rapid EIA study for VPHEP.

1.5 INTER-STATE / INTER-NATIONAL ASPECTS

Project is envisaged on the Alaknanda River, which is flowing throughout its length within the State of Uttarakhand. Thus there is no interstate aspect involved with the project.

1.6 EARLIER INVESTIGATION AND STUDIES

An Identification Report for development of Vishnugad Pipalkoti H.E. Project for an installed capacity of 340 MW was prepared by U.P. Irrigation Department in July 1984. Various alternatives for the development of the scheme were proposed which also includes Barrage at Helong and underground power house at Birahi on right bank.

A large storage was proposed to be created with the construction of a high dam. Two alternatives of high dams were discussed. In the first alternative, an underground power house at Birahi on right bank was considered and in the second alternative, a surface power near village Hat on left bank of Alaknanda river was proposed. Since then no detailed topographical, geological and geo-technical investigation were taken up at this site.

In order to harness the available potential of river Alaknanda in various reaches, Uttarakhand allocated the responsibility of developing hydro-power schemes at pre- identified sites. Under this proposal, THDCIL was also assigned the task of executing the investigations at Vishnugad Pipalkoti site and accordingly, a MOU was signed in April 08, 2003 between Government of Uttarakhand and THDC for the investigation and preparation of feasibility report and assessment of the techno-economic viability of the Project. For carrying out the investigations, clearance from MOEF was obtained in July 2003. After getting the clearance, THDC started carrying out the preliminary investigations for the preparation of feasibility report. Detailed Project Report (DPR) for Vishnugad Pipalkoti HEP was prepared in year 2006 and Environmental Clearance was obtained in year, 2007.

1.7 SCOPE OF THE EIA STUDY

As per the ToR granted by MoEF&CC, the brief scope of this EIA study includes:

- Assessment of the existing status of physico-chemical, ecological and socio-economic aspects of environment
- Identification of potential impacts on various environmental components due to activities envisaged during construction and operational phases of the ongoing hydro-electric project.
- Prediction of significant impacts on major environmental components using appropriate techniques.

- Delineation of Environmental Management Plan (EMP) outlining measures to minimize adverse impacts during construction and operational phases of the ongoing project.
- Formulation of Resettlement and Rehabilitation (R&R) Plan.
- Formulation of Catchment Area Treatment (CAT) Plan.
- Formulation of Environmental Quality Monitoring Programme for implementation during construction and operation phases.
- Estimation of Cost for implementation of Environmental Management Plan, Resettlement & Rehabilitation Plan, Catchment Area Treatment Plan and Environmental Monitoring Programme.
- Formulation of Disaster Management plan, Dam break analysis and fisheries Management plan.
- Environment Cost benefit analysis.

1.8 STAGES IN EIA STUDY

The purpose of this section is to enumerate the steps involved in an Environmental Impact Assessment (EIA) study, which are described in the following paragraphs.

Scoping: An exhaustive list of all likely impacts drawing information from as many sources as possible was prepared. The next step was to select a manageable number of attributes which were likely to be affected as a result of the underconstruction project VPHEP. The various criteria applied for selection of the important impacts were follows:

- magnitude
- extent
- significance

Description of Environment: Before the start of the project, it is essential to ascertain the baseline levels of appropriate environmental parameters which could be significantly affected by the implementation of the project. The baseline status assessed as a part of EIA study through data from primary as well as secondary sources.

Prediction of Impacts: is essentially a process to forecast the future environmental conditions of the project area that might be expected to occur as a result of the construction and operation of the underconstruction hydroelectric project; VPHEP. An attempt was made to forecast future environmental conditions quantitatively to the extent possible. However, for intangible impacts, qualitative assessment has been made so that planners and decision-makers are aware of their existence as well as their possible implications.

Environmental Management Plan (EMP): the approach for formulation of an Environmental Management Plan (EMP) is to maximize the positive environmental impacts and minimize the negative ones. The steps suggested as a part of EMP include modifications of plans, engineering designs, construction schedules and techniques, as well as operational and management practices. After selection of suitable environmental mitigation measures, cost required for implementation of various management measures has also been estimated as a part of the present study.

Environmental Monitoring Programme: An Environmental Monitoring Programme for implementation during project construction and operation phases is outlined as a part of the EIA Report to oversee the environmental safeguards, to ascertain the correlation between prediction and reality and to suggest remedial measures not foreseen during the planning stage but arising during construction and operation phases. The exercise will also generate data for future use and serve as a reference for assessment of impacts of hydropower projects in similar settings.

1.9 OUTLINE OF THE REPORT

The present document outlines the findings of the EIA study for the Vishnugad Pipalkoti Project. The contents of the document are organized as follows:

Chapter-1 gives an overview of the project. The policy, legal and administrative framework as well as the current status on Environmental Clearance has been summarized. The objectives and need for EIA study too have been covered.

Chapter-2 gives a brief description of the Vishnugad Pipalkoti Hydro-Electric Project (VPHEP)

Chapter-3 covers the environmental baseline conditions covering physical, ecological and socio-economic aspects of environment. The baseline study involved both field work and review of existing documents, which is necessary for appropriate utilization of data which may already have been collected for other purposes.

Chapter-4 describes the anticipated positive and negative impacts as a result of the construction and operation of the VPHEP Vishnugad Pipalkoti Project on physico-chemical and ecological aspects of environment. Impact Assessment is essentially a process to forecast the future environmental conditions of the project area that might be expected to occur as a result of the construction and operation of the ongoing project. An attempt was made to forecast future environmental conditions quantitatively to the extent possible. But for certain parameters, which cannot be quantified, approach has been to discuss such intangible impacts in qualitative terms so that planners and decision-makers are aware of their existence as well as their possible implications. Mitigation measures for amelioration of adverse Impacts too have been deliberated in the chapter.

Chapter-5 describes the alternatives considered for this project.

Chapter-6: covers the Environmental Monitoring Program for implementation during project construction and operation phases.

Chapter-7 describes various additional studies conducted during the study which included Status of compliance of Public hearing details, Dam Break analysis and Disaster Management Plan (DMP), Status of compliance of R&R Plan for PAFs

Chapter-8: covers the Project Benefits due to implementation of the Vishnugad Pipalkoti Hydro Electric Project

Chapter 9: Outlines the Environmental Cost Benefit analysis.

Chapter-10: present the Environmental Management Plan (EMP).

Chapter-11: covers the Summary and Conclusion of the project.

Chapter-12: lists the Experts involved in the EIA study for Vishnugad Pipalkoti Project

CHAPTER-2
PROJECT DESCRIPTION

CHAPTER-2
PROJECT DESCRIPTION

2.1 GENERAL

THDC India Limited (THDCIL) is constructing Vishnugad Pipalkoti Hydro-Electric Project (VPHEP) on river Alaknanda, a major tributary of the river Ganga. It is a run of the river (RoR) type hydropower project with an installed capacity of 444 Mega Watts. A dam is being constructed near village Helong in Joshimath Tehsil and an underground power house, at village Haat in Chamoli Tehsil. The nearest railway station is at Rishikesh about 225 km from project site. The project and all its major components are located on right bank of the river Alaknanda. Project is accessible through National Highway NH-58 (Ghaziabad-Rishikesh-Pipalkoti-Joshimath) which is located on the left bank of the river.

River Alaknanda is originating from the glacial regions of the Himalayas. The river has tremendous scope for development of hydro-power, which needs to be harnessed to meet the ever-growing demand for power. At present, various hydropower schemes are in different stages of development on the river. Vishnugad Pipalkoti hydropower is one such scheme envisaged in this region.

The operation of VPHEP is linked to the upstream projects on Alaknanda–(by M/S Jai Prakash) and Tapovan- Vishnugad on river Dhauliganga (by M/S NTPC). Downstream of this project, further run of the river power projects are planned.

VPHEP is suited to help provide peaking power to the national grid. Once commissioned, the project will provide 1677.4 GWh of electricity each year to the Northern Region to meet India's growing energy needs. The Project shall also help to improve the hydro-thermal mix in the country.

The Project benefits of VPHEP are as follows:

- Capacity addition of 444 MW in the Northern Region, reducing peaking power shortage in the region.
- Annual Design Energy of 1657.09 MU (with 95% machine availability).
- Integrated Development of Chamoli / Garhwal region in the areas of employment, communication, education, health, tourism, development of flora & fauna etc.
- Out of 13% free power to the home state Uttarakhand, 1% shall be utilized for contribution towards local area development.

The details of approval obtained for VPHEP is given in Table-2.1.

Table-2.1 Details of approvals obtained for VPHEP

S. No.	Description of Approvals	Date
1	Signing of MoU between THDCIL and GoUK for investigation & preparation of DPR	08.04.2003
2	Approval of Commercial viability of the project by CEA.	03.02.2005
3	Signing of Implementation agreement.	02.06.2006

S. No.	Description of Approvals	Date
4	Approval of Techno-Economic clearance to the project by CEA.	21.09.2006
5	Environment Clearance by MoEF&CC	22.08.2007
6	Investment approval to the project amounting to 2491.58 Cr (March-08 PL) by CCEA.	21.08.2008
7	Revision in "Minimum Environmental Flow" by MoEF from 3 Cumec to 15.65 Cumec.	31.05.2011
8	Stage-1 clearance forest clearance for transfer of 80.507 Ha of forest land	03.06.2011
9	Stage-2 clearance forest clearance for transfer of 80.507 Ha of forest land MoEF.	28.05.2013
10	Wildlife clearance from NBWL/SBWL	20.12.2012 /03.05.2013
11	Issuance of G.O. for transfer of 80.507 Ha of forest land by GoUK.	06.12.2013
12	Signing of Lease agreement for 80.507 Ha Forest land	05.04.2014
13	Declaration of Land (identified for compensatory afforestation) as protected forest in lieu of 80.507 Ha. forest land	26.08.2014
14	Extension of validity of Environment Clearance by MoEF&CC	25.04.2018
15	MoEF&CC issued notification dated 18.01.2021 specified that the period from 1st April, 2020 to 31st March, 2021 shall not be considered for the purpose of calculation of the period of validity of Environmental Clearance in view of outbreak of Corona Virus (COVID-19)	18.01.2021
16	MoEF&CC issued notification dated 16.06.2021 specifying that the validity of above notification i.e MoEF&CC notification dated 18.01.2021 is extended upto 31.12.2021. Accordingly, Validity of Environmental Clearance of VPHEP is extended upto 31.12.2021.	16.06.2021

2.2 PROJECT PROFILE

The layout map of the under construction Vishnugad Pipalkoti Hydro-electric Project is also enclosed as Figure-2.1. The salient features of Vishnugad Pipalkoti Hydro-electric project are given in Table-2.2.

Table-2.2: Salient Features of VPHEP

1. LOCATION	
State	Uttarakhand
Distt.	Chamoli
River	Alaknanda
Dam site	Near Village Helong (E- 79˚29'30'', N-30˚30'50'')
Power House(PH)site (underground)	Near Village Hat (E- 79˚24'56'', N-30˚25'31'')
2. HYDROLOGY	
Catchment Area at Dam Site	4672 km^2
Annual mean flow	5682.6 Mcum
Submergence area	24.5 ha
Design Flood	SPF 6700 m^3/sec (For Design) PMF 10840m^3/sec (For Checking)
Diversion Flood (1: 25 yr Non monsoon flood)	725 m^3/sec

3. RESERVOIR	
Full reservoir level	EL 1267 m
Maximum Water Ievel	EL 1269.5 m (PMF)
Minimum Draw Down level	EL 1252.5 m
Gross storage at FRL	3.63 Mcum
Storage at MDDL	1.16 Mcum
Live storage	2.47 Mcum
Surface Area at FRL	24.5 ha
4. DIVERSION ARRANGEMENT	
A. Diversion Tunnel	
Location	Left bank
Length	559 m (494 m tunnel and 65 m cut & cover)
Diameter	10.5 m, Circular
Design Discharge	725 m^3/sec
Gates	4 m x 10.5 m, Vertical lift fixed wheel
Invert level at Entry	1224 m
B. U/S Coffer Dam	
Type	Colcrete
Length	60 m
Height	24 m
Top Elevation	EL 1242 m
C. D/S Coffer dam	
Type	Rock fill
Length	40 m
Height	7.5 m
Top EL.	EL. 1222.5 m
5. DIVERSION DAM	
Type of dam	Concrete, gravity dam
Height of dam above deepest foundation level	65 m
Top of dam	EL 1270 m
River bed level	EL 1225 m
Foundation level	EL 1205 m
Length	98.85 m (NOF 31.85 m, OF 67 m)
6. SPILLING ARRANGEMENT	
A. Sluices:	
Nos.	5
Design Flood	10840 m^3 /sec
Size of sluice	7.8 m (W) x 16 m (H)
Type of gate	Radial Stop log (1 no. 7.8 m x 22.5 m)
Crest level of sluice	1233 m
B. Diversion cum Spillway Tunnel	Diameter 10.5 m (Φ) ,Circular
Invert level at Entry	1249 m
Length	100 m
Design Discharge	1578 m^3/sec
Gate	2+1 no., 4 m x 10.5 (Vertical lift fixed wheel Gate)
C. Spill Tunnel (12 m Φ)	
Size	12 m Φ, Circular
Invert level at Entry	1245 m
Length	250 m
Design Discharge	1618 m^3/sec
Gate	2+1 no., 4.8 m x 12 m

	(Vertical lift fixed wheel Gate)
6. POWER INTAKE	
Location	Right bank
Nos.	3
Type	Straight intake with bell mouth
Maximum discharge	274.63 m^3/sec
Intake invert level	EL 1242.5 m
Size	3+3 nos. 5.20 m x 6.2 Horse shoe type
Gates	Vertical lift fixed wheel gate (service gate+ emergency gate)
Silt Flushing Tunnel (Below Intake)	
Size of Intake	3 nos. of 3m x 3m
Size of SFT ducts	3 nos. of 2m x 5m
Gate	3+3 nos. of 3m x 3m
Design Discharge capacity	378 cumec
7. DESILTING CHAMBER	
Nos.	3
Size	390 m (L) x 16 m (W) x 21.25 m (H)
Particle size to be removed	0.2 mm & above
Gates	3 nos. 5.24 m x 6 m (H), Vertical lift fixed wheel
Gate chamber	6 m (W) x 9 m (H) x 155 m (L)
Operation level	EL 1270 m
Silt Flushing Tunnel:	
Size	3.6 m x 4.0 m (D shaped)
Flushing discharge	45.8 m^3/sec
Length	680 m
Gates	3 nos. 1.8 m x 2.12 m, (Vertical lift slide Gate)
Gate chamber	4.8 m x 4.8m x 118 m
Operation level	EL 1233.5 m
8. HEAD RACE TUNNEL	
Length	13.4 km (1.4 km by DBM & 12.0 km TBM)
Diameter	8.8 m Circular
Design discharge	228.86 m^3/sec
Velocity	3.76 m/sec
Bed slope (average)	1:121 (upstream of Maina River) 1:321 (Downstream of Maina River)
No. of adits	2
9. UPSTREAM SURGESHAFT	
Type	Restricted Orifice type
Diameter	15/22 m Φ (15 m Φ from EL. 1165 m to EL. 1236 m) (22 m Φ from EL. 1236 m to EL. 1309 m)
Height (from HRT invert)	154 m
Top EL	1309 m
Orifice level	1165 m
Orifice diameter	1.5 m, 3 nos
Tunnel invert	EL 1155 m
Maximum surge level	1307.42 m
Minimum surge level	1209.24 m
Pressure shaft gates	2 nos., 4.2 m x 5.2 m

10. BUTTERFLY VALVE CHAMBER	
Size	50 m (L) x 9.8 m (W) x 19 m (H)
Butterfly Valve	2 nos., 5.2 m
11. PRESSURE SHAFT	
Nos.	2/4
Type	Circular- vertical
Diameter	5.2 m /3.65 m
Length of each PS	466.4 m/51m
Design velocity	5.39 m/sec
12. POWER HOUSE	
Type	Underground
Size of P/H cavern	146 m x 20.3 m x 48 m
Size of Transformer cavern	140.3 m x 15 m x 25.5 m
Nos. of units	4
Rated unit capacity	111 MW
Installed capacity	4 x 111 MW = 444 MW
Gross Head	237.0 m
Rated Head	212.46 m
Centre line of unit	EL 1022.0 m
Service bay level	EL 1036 m
Maximum flow through each unit	57.22 m^3/sec
Generator:	
Synchronous speed of Generator	250 rpm
Power factor, Generator voltage	0.9, 13.8 kV
Excitation system	Quick response static
Transformers- Type, Nos., No. of Phases,	OFWF, 4, 3, single phase, 46MVA, 13.8/ 420 /3kV.
Step-up voltage, Capacity	400kV
14. D/S SURGE TANK	
Type	Underground
Size	150 m (L) x 13 m (W) x 27 m (H)
Maximum Surge level	1040.8 m
Minimum Surge level	1022.37 m
15. TAIL RACE TUNNEL	
a) Size	9.1 m Φ, (circular)
b) Length	3.07 km
c) Max. TWL	1030.0 m (with all M/C running)
d) Min. TWL	1028.2 m (with 10% load)
e) TRT invert level	EL 1020.6 (at Outlet) crest level of weir at outlet is 1027 m.
16. SWITCHYARD	
a) Type of Switchyard	GIS
b) No. of bays in the switchyard	7 bays
c) Voltage level	420 kV
d) Size of potyard	40m x 84 m
17. POWER GENERATION	
a) Firm power	74.69 MW
b) Annual Energy	1677.40 GWh
c) Load factor (lean flow)	16.82%
d) Design Energy	1657.09 GWh
18. PROJECT COST	
Total cost	Rs. 3860.35 Cr
19. TARIFF	

First year tariff	Rs. 4.71 / kWh
Levelised tariff	Rs. 4.52/ kWh

The layout map of the under construction Vishnugad Pipalkoti Hydro-electric Project is also enclosed as Figure-2.1.

2.3 PROJECT PROFILE/ PROJECT DETAILS

The key project components are described in the following paragraphs:

Dam Site:

A 65m high concrete diversion dam with spillway section having 5 No. 7.8m x 16m opening is being constructed near village Helong. The reservoir will have a gross storage capacity of 3.63 million cum, out of which 2.47 million cum shall be live storage. A diversion cum spill tunnel of 10.5 m dia. is constructed to divert the discharge of 725 m^3/sec during the construction period.

Power House Site:

The power house site is located inside a hill in right bank of Alaknanda River downstream of Haat village. It will comprise of two separate underground caverns for installation of turbines and transformers. The dimensions of power house will be 146 m x 20.3 m x 48 m. The size of transformer cavern is 140.3 m x 15 m x 25.5 m. The power house will have 4 units of 111 MW. The project would afford an annual energy generation of 1677.40 GWH on 95% dependability basis.

Head Race Tunnel:

13.4 km long & 8.8 m dia Circular shaped head race tunnel is under construction on right bank of the Alaknanda River. About 12 km of HRT is to be constructed through Tunnel boring Machine and rest of the HRT is being constructed using Drill and Blast method.

Tail Race Tunnel:

3.07 km long & 9.1 m dia Circular shaped tail race tunnel is under construction on right bank of the Alaknanda River.

Desilting Chamber:

03 Nos desilting chambers of size 390 m x 16m x 21.25m are being constructed to remove the silt particles of size above and equal to 0.2 mm. the silt particles removed from the desilting chambers will be removed though silt flushing tunnel of size 3.6m x 4.0m

Intake Structure:

Intake consist of 03 Nos. circular shaped tunnels of 6.2 m diameter**.**

2.4 CONSTRUCTION MATERIAL

The details of construction material and source of Construction material required for the project is given in Table - 2.3 & 2.4.

Table-2.3: Details of Construction Material Required

Material	Quantity
Quantity of material to be excavated	1413800 m3
Concrete	400,000 m3
Steel	50,000 Tonnes

Source: EIA Report prepared by WAPCOS

Table-2.4: Sources of Construction Material

S. No.	Material	Source
1.	Coarse Aggregate	• Rock quarry in Power House area • Rock quarry/ Excavation in Dam area • Riverbed materials along river Birahi • Boulders along river bed along river Birahi • Terrace deposit in Patalganga
2.	Fine Aggregate	• Crushed sand made out of rock
3.	Cement	• From Open market
4.	Steel	• Rishikesh stock yard
5.	Explosives	• Authorized dealers
6.	Miscellaneous materials like drill nodes, diamond bits, welding rods, oil & lubricants, etc.	• From open market

2.5 INFRASTRUCTURE WORKS

The implementation of the project requires development of infrastructure works at site as well as in the surrounding area, so as to facilitate timely completion of the project and proper operation & maintenance of the project. The Infrastructure works include:

Connectivity and Communication:

Pipalkoti and surrounding area of the project is well connected by telephone lines and various mobile networks. For effective execution and monitoring of the work at various work fronts (mostly underground) walkie-talkie is used.

The Area is well connected to the National highway -58 which is on the left bank of Alaknanda in the district Chamoli. However, most of the villages and towns situated on the right bank are comparatively less connected to NH-58 due to lesser number of bridges and approach roads. Since the most of the project components are located on the right bank therefore development of approach roads and bridges was needed**.**

Approach Roads and Bridges: Approach roads and bridges are constructed by the project for smooth transportation of resources to the project sites. These roads and bridges is also being used by the local public for their day to day commute. The details of major approach roads and bridges constructed by Project are given in Table-2.5.

Table-2.5: Details of major approach roads and bridges constructed/proposed by Project

S. No.	Details of major approach roads and bridges	Remarks
1.	Approach Road to Power house & colony site (Koriya to Siyasain)	Constructed
2.	Approach Road to Maina Adit (Pipalkoti to Maina Nadi)	Constructed

S. No.	Details of major approach roads and bridges	Remarks
3.	Approach Road to dam site (Helong to Dam Site)	Constructed
4.	Approach Road to Langsi Adit (Gulabkoti to Dwing)	Proposed
5.	Steel Bridge at Lungsi (70m , 40-R)	Proposed
6.	Steel Bridge at Haat Bridge (55m, 70-R)	Constructed
7	Steel Bridge at Birahi (60 mtr.)	Constructed
8	Steel bridge at Dam axis (33.5 m, 40-R)	Constructed

- **Water Supply & Sewage Disposal**: The water requirement for all residential accommodation for officers & staff, hospitals and other utilities are met by underground water and surface water (natural springs). The water is being supplied to various users by a dedicated water supply network laid in the area.

  A dedicated sewer line is constructed in the residential & non-residential area is connected to the sewage treatment plant d/s of residential complex.
- **Power Supply**: The construction power at various works fronts and power for residential / non buildings and other infrastructure facilities is being taken from Uttaranchal Power Corporation. However, to ensure continuous and uninterrupted power supply for the project during execution and operation and maintenance of the project, stand by arrangements of power from DG set are also made.

2.6 POWER POTENTIAL & INSTALLED CAPACITY

The power potential studies have been carried out for VPHEP. This is a run-of-the-river type development with diurnal storage and would utilize a net rated head of water of 212.46 m. The plant would operate as peak load station. For determination of power potential, the following efficiency applicable for Francis turbine driven generating unit have been considered:

- Efficiency of turbine: 94.5%
- Efficiency of Generator: 98.5%
- Combined efficiency of turbine and generator: 93.08%

The power potential studies carried out indicates that installed capacity of 444 MW comprising 4 generating units of 111 MW each would be required for this power project to derive optimum power benefits.

2.7 POWER EVACUATION

The Long Term Access (LTA) is granted by Central Transmission Utility (PGCIL) subject to fulfillment of CERC connectivity regulations and signing of requisite LTA agreement to evacuate the generated power of VPHEP (444 MWw) by PTCUL under Uttarakhand Integrated Transmission Project (UITP) scheme upto Khandukhal on 400 KV level. After Khandukhal, power transmission to NR is being taken up separately by CTU.

2.8 PROJECT COST & IMPLEMENTATION SCHEDULE

Investment approval to the project amounting to 2491.58 Crore (Mar' 2008 Price level) was accorded by CEA in Aug' 2008 RCE of Rs. 3860.35 Cr (February, 2019 Price level) has been vetted by CEA on 20.03.2020. The first unit likely to be commissioned by December 2023 and the project by June 2024 as a whole. However, commissioning of the project might delay due to prevailing COVID-19 situation.

2.9 PROJECT FUNDING

Construction of the project is being funded with a Debt: Equity ratio of 70:30. The Equity portion; 50% is to be shared by THDCIL and remaining 50% is to be shared by NTPC and GOUP in the ratio of 75: 25 respectively.

For the funding of the debt portion (70%) of the project, loan agreement for US $648 million has been signed with World Bank on 10th Aug-11. The loan includes US $10 million for Capacity Building and Institutional Strengthening (CBIS). The loan has become effective from 7th Nov-11 with tenure of 29 years.

However, on the request of THDCIL, the World Bank has agreed to cancel partial loan proceeds in the order of US $100 million. The loan amount for this project is now US $548 million.

2.10 STATUS OF WORKS

The status of Civil & Hydro Mechanical Works and Electro-mechanical works are as follows:

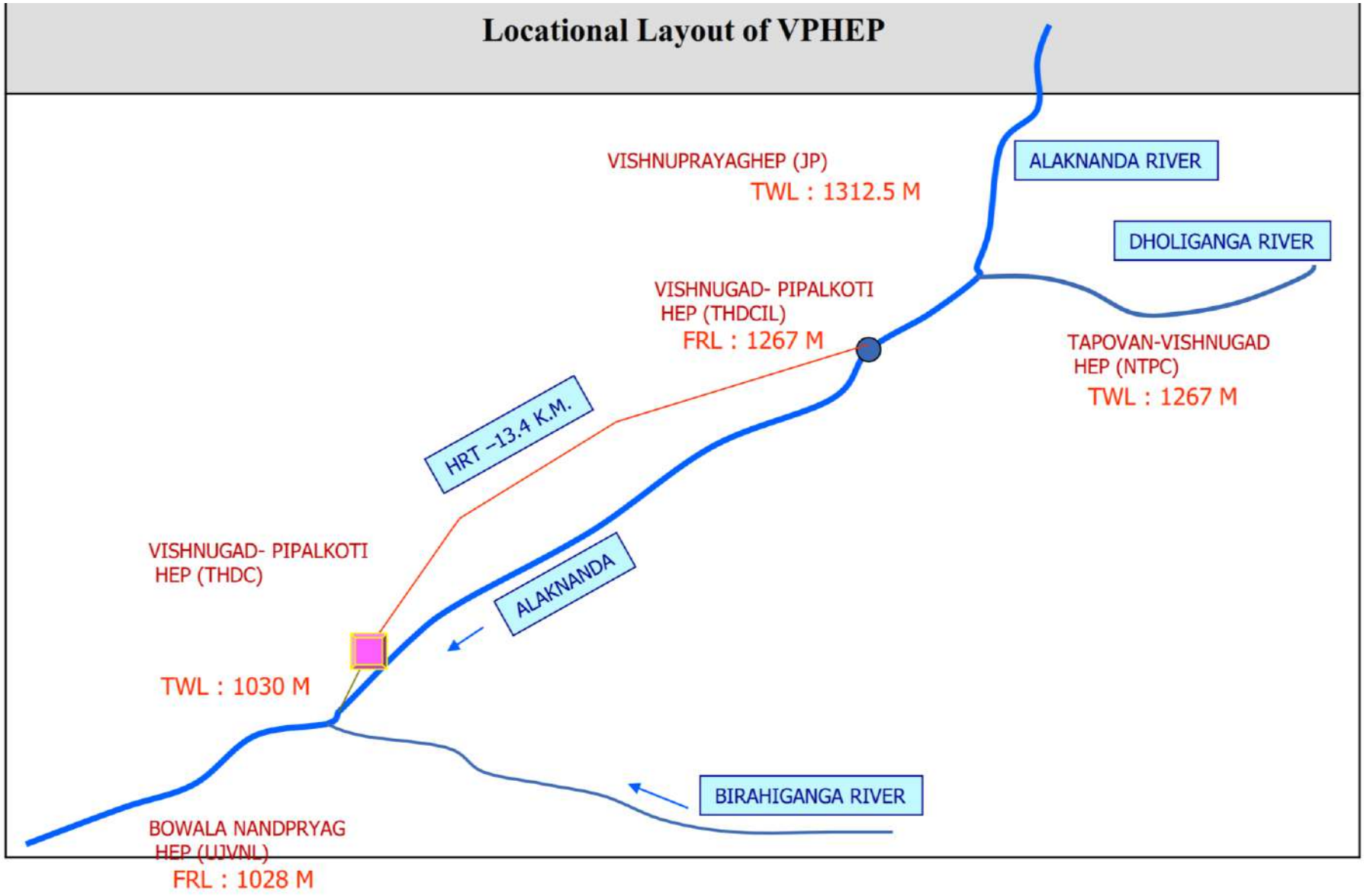
Civil & HM Works:

- River Diversion has been completed.
- Construction of U/S Coffer Dam has been completed.
- Open excavation in Dam area including plunge pool - 40% has been completed.
- Heading of all 3 De-silting Chambers has been completed and benching 40% completed.
- HRT by DBM - 77% Heading excavation completed
- Intake tunnel - 1, 2 and 3 - Excavation 100% completed. First phase of Overt concrete lining has been completed 100 % in Intake Tunnel-1 & 2 and 80.50% in Intake Tunnel-3. Invert concrete lining in Intake Tunnel-1 has been 94% completed.
- TBM has been commissioned. During operation of TBM in the RBM zone, big boulders have been encountered, which has hampered TBM operation. To overcome this problem two Approach Adits are being constructed to reach the cutter head. One Adit has been completed 23m out of 36m.
- In Machine Hall, crown excavation has been completed and strengthening of geologically weak section with steel rib supports is in progress.
- In Transformer Hall, pilot tunnel completed 100% and 70% crown excavation completed. Balance in progress along with stabilization with steel rib supports.

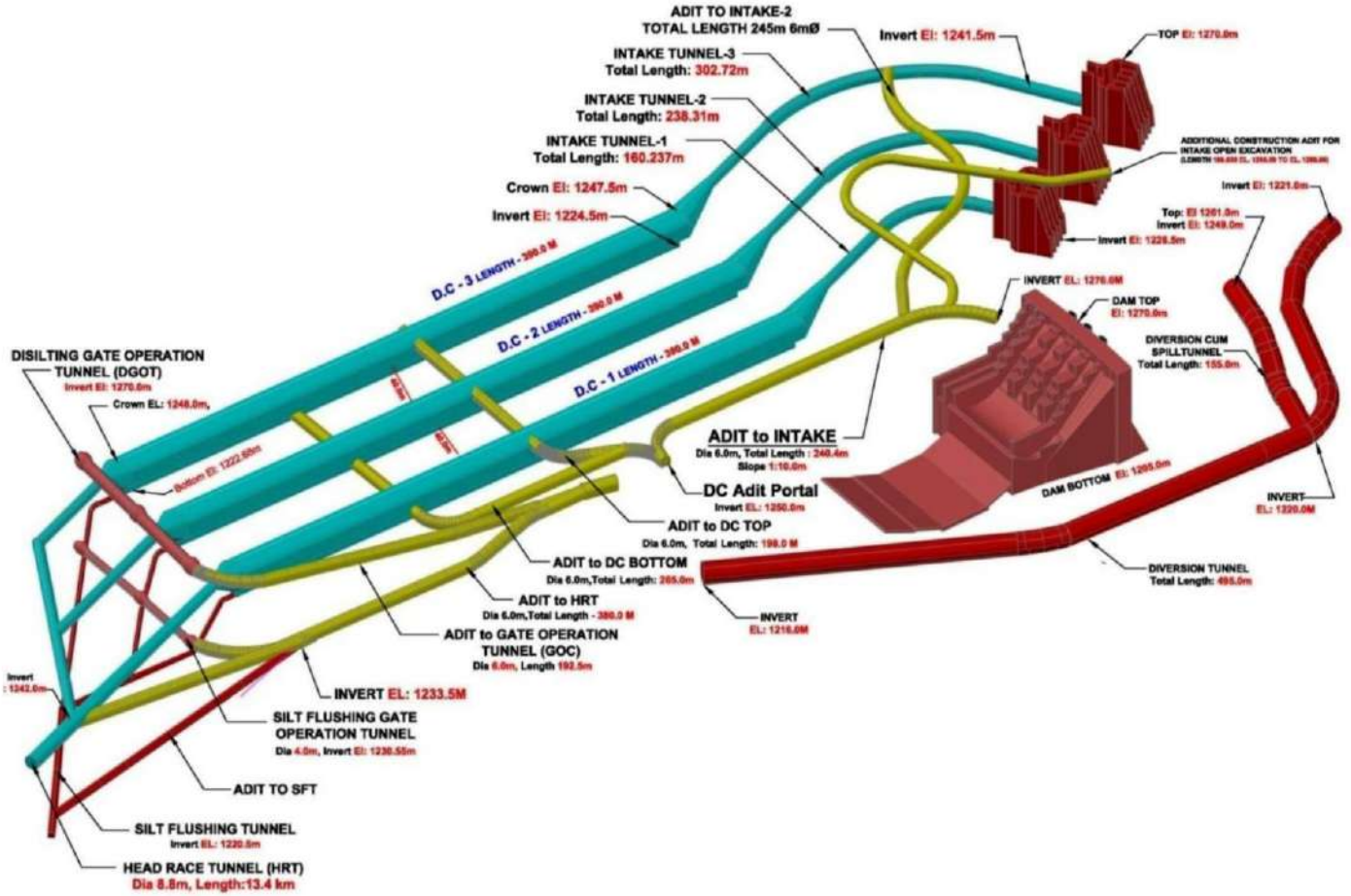
- In TRT, heading excavation 14.40% completed.
- At TRT outlet area, 80% slope stabilization work has been completed.

Electro - Mechanical Works:

Design and Engineering is in progress. Model testing of Turbine has been successfully completed in BHEL. Supply of EM equipment amounting to Rs. 167.60 cr has been completed. The Overall Physical Progress and Overall Financial Progress is 51.50% and 58% respectively.

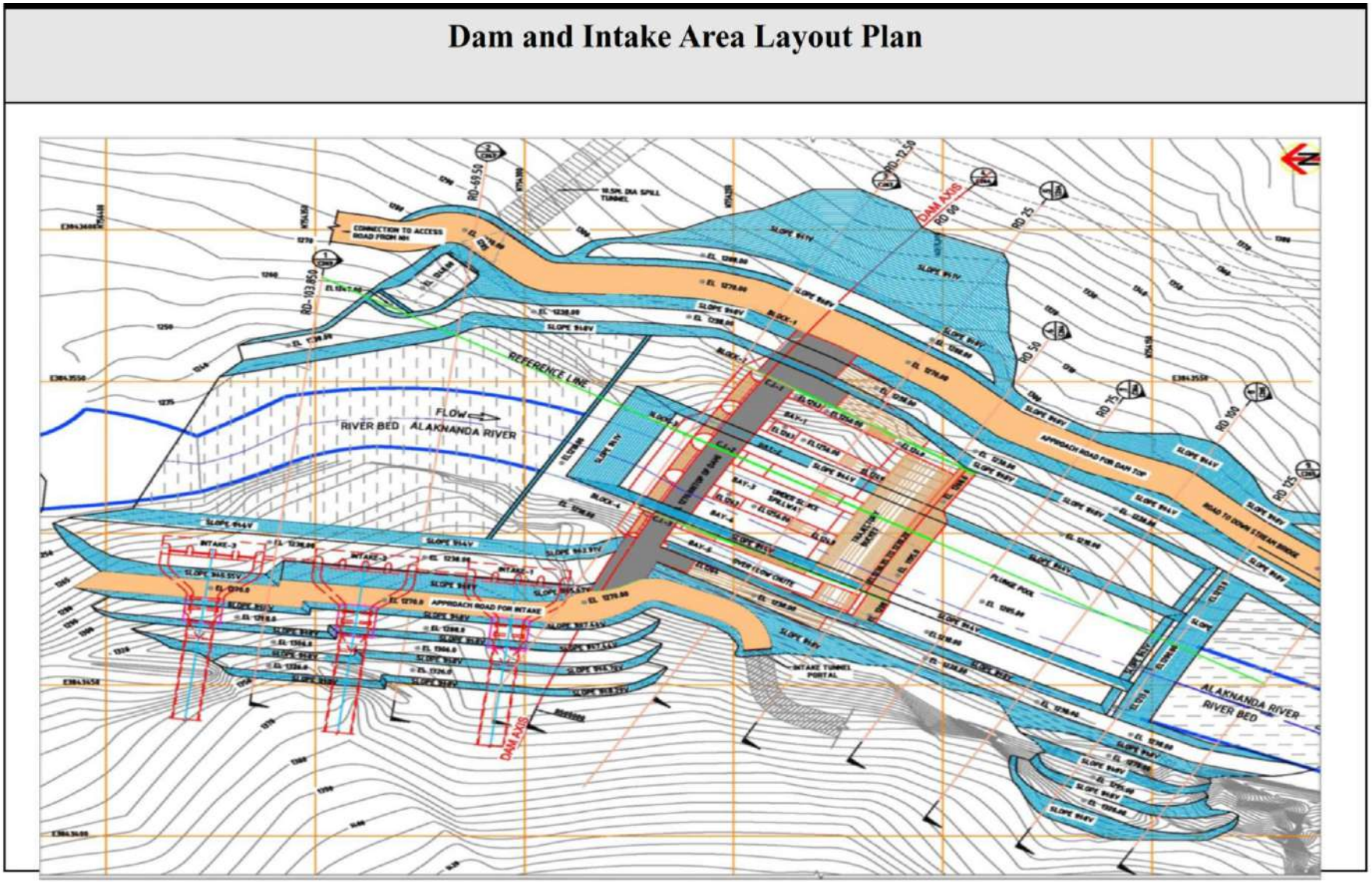

Locational Layout of VPHEP
VISHNUPRAYAGHEP (JP)
TWL : 1312.5 M
ALAKNANDA RIVER
DHOLIGANGA RIVER
VISHNUGAD- PIPALKOTI
HEP (THDCIL)
FRL : 1267 M
TAPOVAN-VISHNUGAD
HEP (NTPC)
TWL : 1267 M
HRT –13.4 K.M.
VISHNUGAD- PIPALKOTI
HEP (THDC)
ALAKNANDA
TWL : 1030 M
BIRAHIGANGA RIVER
BOWALA NANDPRYAG
HEP (UJVNL)
FRL : 1028 M

DAM Complex 3D Layout Plan



Salient Features

Dam and Intake Area Layout Plan



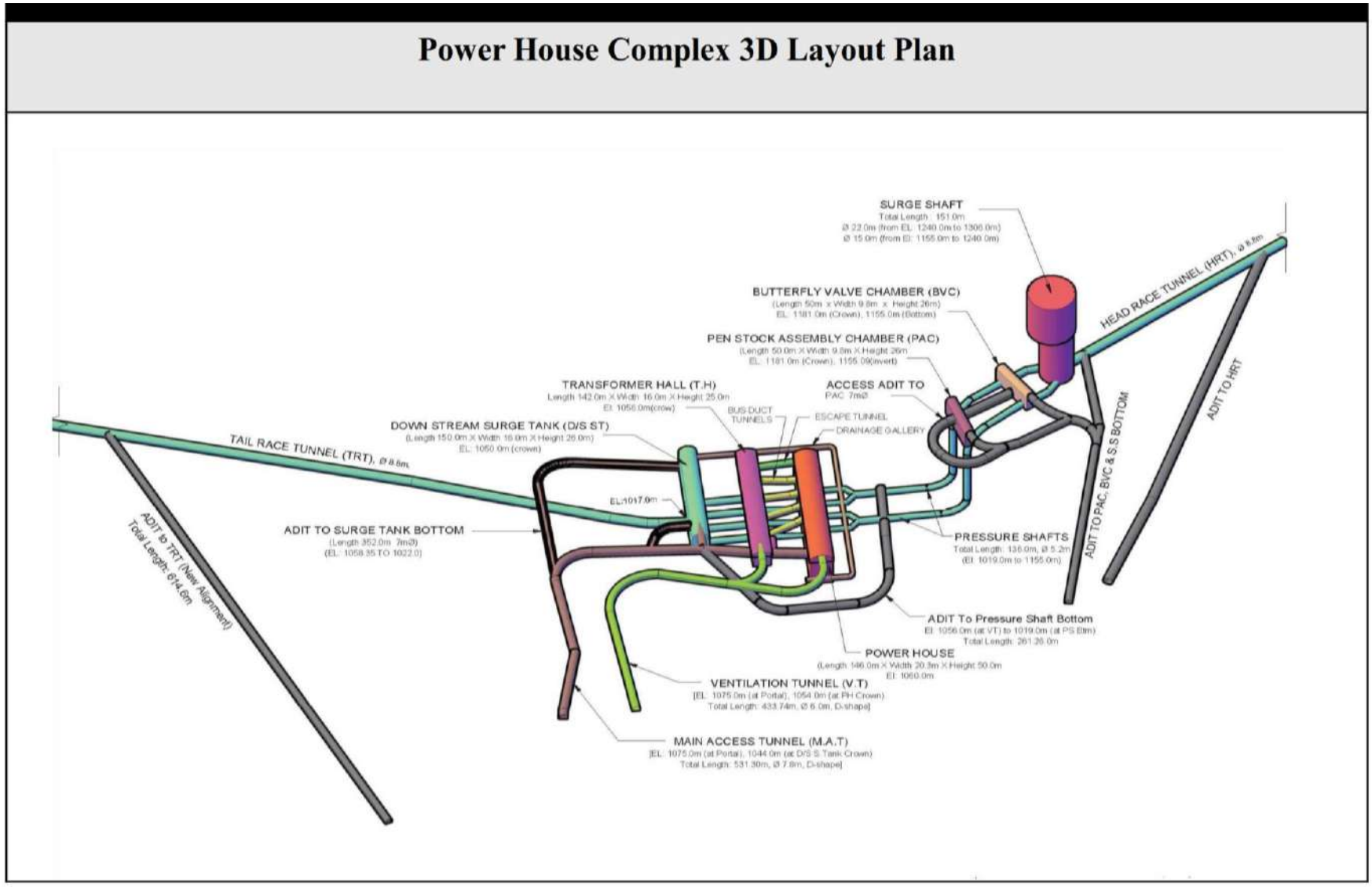


Figure-2.1: layout map of the underconstruction Vishnugad Pipalkoti Hydro-electric Project

CHAPTER-3
DESCRIPTION OF ENVIRONMENT

CHAPTER-3
DESCRIPTION OF THE ENVIRONMENT

3.1 GENERAL

Before starting any Environmental Impact Assessment study, it is necessary to identify the baseline levels of relevant environmental parameters which are likely to be affected as a result of the construction and operation of the Vishnugad Pipalkoti Hydro Electric Project (VPHEP). A similar approach has been adopted for conducting the REIA study for VPHEP. Standard methodologies of Environment Impact Assessment were followed for conducting the REIA study. A Scoping Matrix was formulated to identify various issues likely to be affected as a result of the project. Based on the specific inputs likely to accrue in the project, aspects to be covered in the EIA study were identified and taken for further study. Thus, planning of baseline survey commenced with the shortlisting of impacts and identification of parameters for which the data needs to be collected.

3.2 STUDY AREA

The study area covered as a part of the REIA study is as below (Refer Figure-3.1):

- Land to be acquired for various project appurtenances including reservoir submergence
- 10 km on either side from the periphery of reservoir submergence
- Area within 10 km on either side of various project appurtenances
- Catchment area intercepted at dam site

The baseline status has been divided into following three categories:

- Physico-chemical aspects
- Ecological aspects
- Socio Economic aspects

As a part of the REIA Study, field studies for various aspects were conducted for Post-Monsoon season (November 2020).

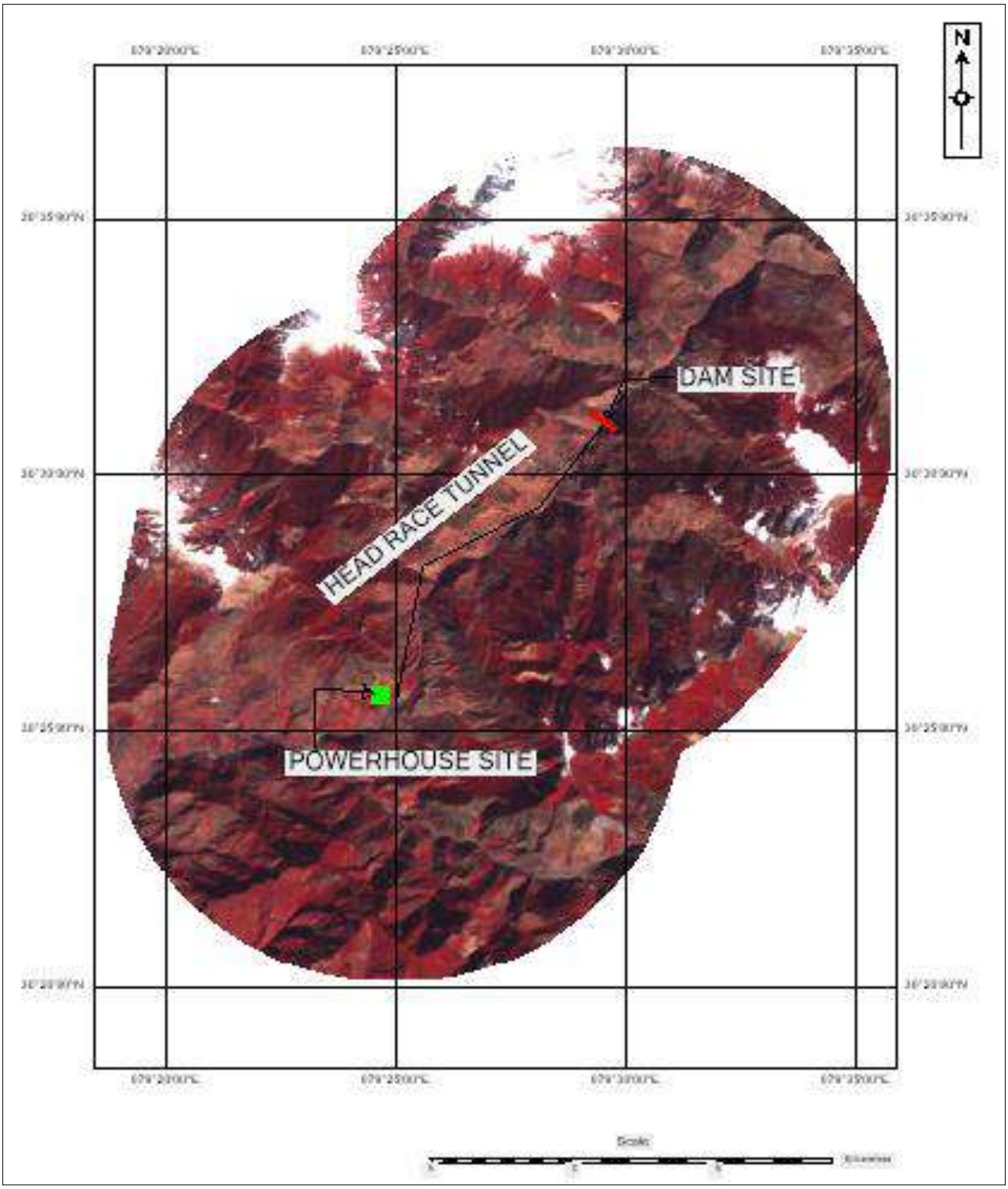


Figure-3.1: Study Area Map

3.3 PHYSICO-CHEMICAL ASPECTS

3.3.1 Meteorology

General Meteorological Scenario

The climate of the area is tropical characterized by a hot summer from March to Mid June, a little humid monsoon or rainy season stretching from Mid June to mid October, a short pleasant post-monsoon from middle of October to November, and a very cool winter spanning between Decembers to February. Therefore, climatologically, four seasons viz. summer (pre-monsoon), monsoon, post-monsoon and winter could be deciphered comprising the following months:

Summer : March, April, May

Monsoon : June, July, August, September, mid October

Post-monsoon : mid October, November

Winter : December, January, February.

The Temperature in the area varies with elevation. It rises rapidly after March and the month of July is the hottest month of the year with mean daily maximum temperature going up to 27-28°C. With the withdrawal of monsoons, by the end of September, there is a sharp decrease in temperatures. The months of December and January are the coolest months of the year, with mean daily minimum tempoerature as low as 4-5˚C.

The average annual rainfall is about 125 cm per annum. The maximum rainfall is received in the months of July and August. About 60% of the rainfall is received under the influence of south west monsoons during the months from July to September. On an average, there are about 88 rainy days (i.e. days with rainfall of 2.5 mm) in a year.

The average humidity is about 61%. Apart from the monsoon months, humidity is around 50-55% throughout the year.

Meteorological Scenario at site

The parameters monitored at a micro-meteorological station set up at THDC Pipalkoti, Chamoli, Uttarakhand were wind speed, wind direction, temperature and relative humidity. The monitoring results obtained from Oct 2020 - Dec 2020 are summarized below in **Table-3.1**.

Table-3.1: Results of Micrometeorology around the project site

Parameters	**Oct 2020 – Dec 2020**
Max. Temperature	30.8°C
Min. Temperature	1.4°C
Max. Wind speed (km/hr)	11.2 km/h
Average Wind speed (km/hr)	3.5 km/h
Relative Humidity	19.8% to 91.2 %.
Predominant Wind Direction	East North East

The wind rose diagram of the site for Oct 2020 - Dec 2020 is shown in **Figure-3.2.**

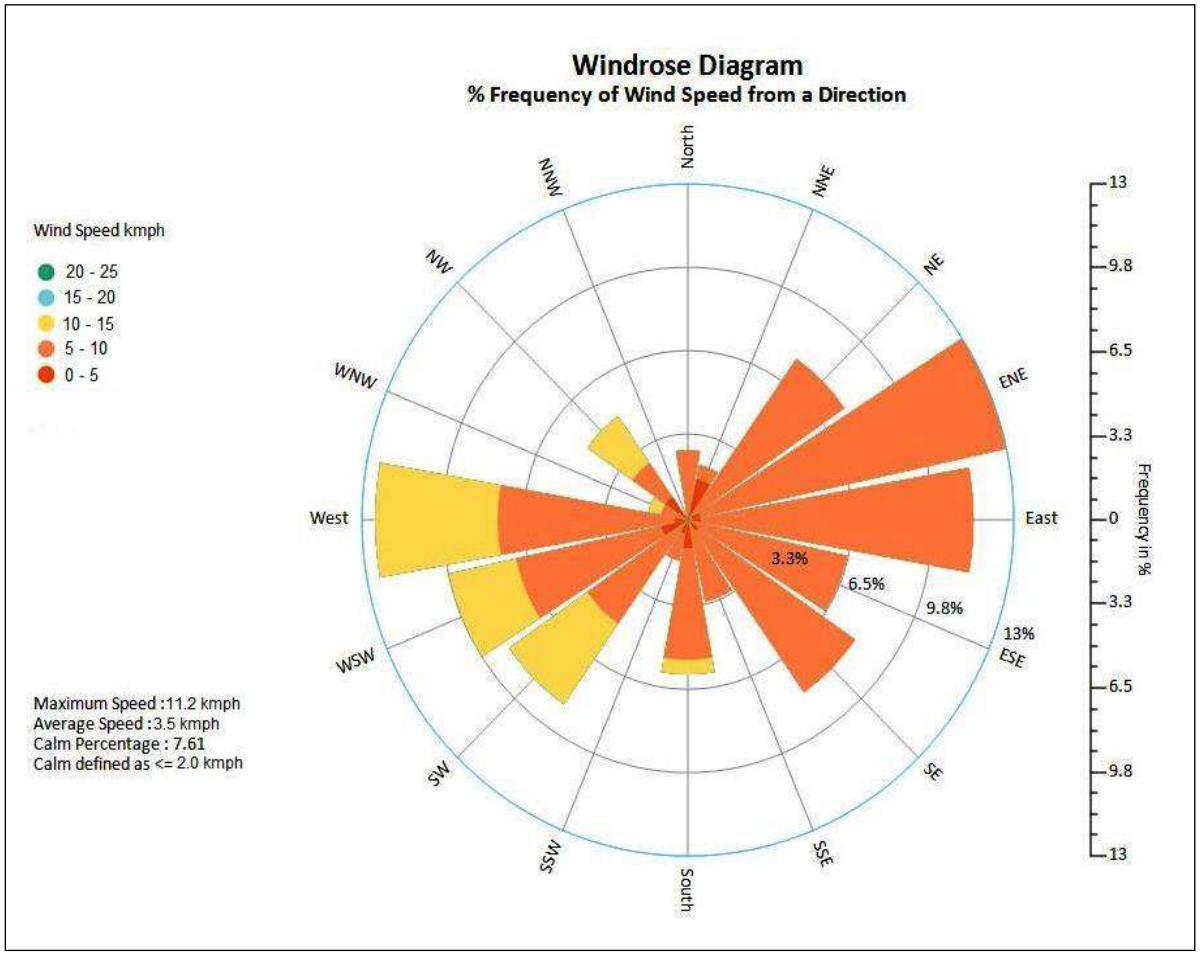


Figure-3.2: Wind rose Diagram of THDC Pipalkoti, (October 2019 to December 2019)

3.3.2 Geology & Geotechnical aspects

The region belongs to Garhwal Group, rocks belonging to Proterozoic age are exposed in the area. These are separated in the north from Central Crystalline group of rocks by the Main Central Thrust.

3.3.2.1 Geomorphology

The area is drained by Alaknanda River, which has originated from the Satopanth-Bhagirath Kharak group of glacier. There are number of countless perennial and ephemeral tributaries of River Alaknanda. The prominent tributaries of River Alaknanda are Dhauli Ganga, Nandakini, Pinder and Mandakini. This is an antecedent river and flows transverse to the structural axes in a deeply incised channel with irregularly terraced patches of Quaternary gravelly and sandy deposits along its path in the Inner Lesser Himalayan belt. The Inner Lesser Himalayan belt south of Helong is of comparatively gentle gradient and milder topography than metamorphic belt of Higher Central Himalaya. The hills around the valley rise to lofty heights highly dissected and reveal various geomorphic landforms. The average height ranges from 1500 m to 4500 m. Generally higher slopes shows gentle slopes, while

the lower reaches shows deep recently rejuvenation, dissected topography and concave hill slope.

Around Pipalkoti three prominent river terraces have been reported while the maximum villages of the project area are situated over the colluvial deposits. The small streams feeding the main river flow to the structural strike and drain the areas either northeastward or southwestward. Generally a trellis type of drainage has developed in this area.

Most of the geomorphic features present in the project area are the result of polycyclic endogenic and exogenic processes of varying intensities through times. From Dam site to TRT outfall Alaknanda River is drained by its three major tributaries namely Maina Nadi, flowing almost in northwest-southwest direction, while the Patal Ganga and Garur Ganga flowing in southeast-northwest direction. This is an antecedent river and flow transverse to the structural axes in gorgeous channels with irregularly terraced patches of subrecent gravelly and sandy deposits along their paths. The study area is covered by closely spaced network of channels, tributaries and streams fed by spring water. It seems that the drainage of the area is still in its mature stage, which is mainly controlled by lithology, structure and tectonics. Higher order streams have both tectonic and lithological control while lower order streams have developed on the neo-tectonic uplifts etc.

The present landscape scenario of the study area represents the complex process of denudation under the influence of fluvial condition, which was later modified by recent reactivation. The area is characterized by gentle and mature topography exhibiting tell-tale evidence of recent rejuvenation. The Alaknada watershed in the project area is part of Inner Lesser Himalaya with minimum and maximum altitudes of 1000 m and 5100 m above sea level. It is deeply dissected resulting in steep valley flanks and narrow crested ridges. The valley flanks have a slope of 70º to 90º and width of valley floor is limited to width of drainage channel. The higher peaks are snow-clad during the winter season. The geomorphic cycle is in youthful stage. The hill slopes are formed of frequent rock outcrops, free faces (rocky cliffs), and mantle of colluvium and in places deposits of quaternary. The geomorphic processes operative are sheet wash (laminar flow), fluvial dissection and deposition, freezing and thawing, and mass wasting.

The Alaknanda River from Helong to Birahi has almost flow along Northeast-Southwest direction. The valley floor is narrow, valley sides are steeper, axial slope of valley is not yet graded and hence the flow is swift. The rocky hill slopes form riverbanks in most of the places and 2 to 8 m high vertical face within fluvial terraces (in patches) form the bank in a few places. Major tributaries such as Dwing Gad, Tirosi Gad, Mena nadi, Ghanpani Nala and Jaisal Nala (all in the right bank of Alaknanda) have near straight valleys indicating structural control but the tributaries of Mena Nadi viz. Gangartoli and Barma Gad flow in a cascade pattern indicating glacial origin. Maina Nadi is the major tributary of Alaknanda in the project

area which is feeding by its nine tributaries namely Gangartoli Gad, Barma Gad, Dogara Gad, Gairal Gad, Bagdari Gad, Rikhni Gad, Pang Gad, Sari Gad and Laudau Gad. Gangartoli Gad has originated from Kalpani Glacier and Barma Gad is originated from Ruptalla bank, while all the other tributaries are spring fed. The tributary valleys are deep, narrow, steep, and channel gradient is higher. The Alaknanda river valley and its tributary valleys are being down-cut and have rocky channel with channel materials formed mostly of pebbles, cobbles and boulders resting over rocky floor. On both the bank of Alaknanda along the hill slopes from channel to crest there are no significant break in slope.

The fluvial terrace is preserved in the powerhouse area near bridge mainly on the left bank of river. The terraces have near flat topography with very gentled axial and cross slopes. The fluvial terrace material consists of predominantly cobbles, boulders, pebbles which are semi-rounded to rounded in a matrix of coarse sand and they are semi-consolidated. The direct effects of surface drainage and associated landslides have given rise to a wide variety of soil types on moderately sloping to moderately steep sloping banks of the river Alaknanda in the form of a narrow valley. These are excessively drained loamy-skeletal soils with slight stoniness and moderate erosion. The soil on cliff and precipitous slopes are excessively drained loamy skeletal soils with strong stoniness and very severe erosion.

On the summit and ridge tops different types of soil is present. Steeply sloping (>30º) surfaces register mostly coarse-grained soils with rock fragments. Moderately steep slope (16º-30º) surfaces exhibit thick soil cover. They are well to somewhat excessively drained, coarse-loamy to fine-loamy soils, with little or no rock fragments. Moderately sloping (<15º) surfaces are composed of welldrained fine-loamy soils with local strewn pebbles on the surface. They are also associated with coarse loamy soils at places

3.3.2.2 Seismicity of the Area

State comes under **Seismic Zones V and IV** of Seismic Zoning Map of India, which corresponds to Zone Factors of 0.36 and 0.24 (effective peak ground acceleration in terms of ‘g’) (IS 1893 part I, 2002). The earthquake record reveals that several seismic events have ravaged different parts of the State in the last 200 years Oldham (1869) mentions of a strong earthquake occurring in the upper valley of Ganga on 1st September 1803 at 1.35 hrs. The tremors, which were reported to be very violent, killed 200-300 people at Barabal and inflicted severe damage at Badarinath. Another major earthquake of an estimated magnitude of 6.5 at Richter’s scale occurred in Mathura 1 hrs 5 min before the Upper Ganga event. The Oldham catalogue mentions of another major earthquake near Gangotri on 25 May 1816 that included numerous landslides. On 28 August 1916 an earthquake of magnitude 7.5 on Richter’s Scale having its epicenter in west Nepal had a considerable influence in Kumaon region and caused heavy damage at Dharchula. In the Kapkot earthquake of 28 December

1958 over a dozen houses collapsed. The 29th July 1980 DharchulaBajang earthquake of M 6.1 and epicentral Intensity VIII on MM scale caused extensive damage and even well constructed building in Dharchula town were not spared. The tremors induced numerous landslides and ground fissures.

The most destructive earthquake documented so far in Uttarakhand was that of Uttarkashi of 20th October 1991 which took a toll of 768 human lives, caused injuries to 5000 people and damaged 45,765 houses, besides inducing numerous rock slides, ground fissures and changes in hot spring chemistry (GSI, 1992). The epicentral tract occupying an area of 20 sq km around Maneri in Bhagirathi valley recorded an intensity of IX on MSK-64 scale. The main shock was followed by a series of over 2000 aftershocks in a period of two months.

On the 29 March 1999 another major earthquake shook the entire State and inflicted moderate to heavy damage in the central part of Uttarakhand. The event, referred to as Chamoli earthquake, registered a magnitude of 6.8 at Richter's scale and an epicenter intensity of VIII. Its effects, most severe in the Alaknanda valley, were noticeable as far as up to Delhi. The strong motions damaged a total of 1,87,619 houses in Chamoli, Rudraprayag, Tehri and Pauri districts causing death of 106 persons and injuries to 453.

Numerous landslides were induced by the tremors apart from development of tension fissures. Uttarakhand, including the western part of Nepal Himalaya has been classified in to four hazard classes as very high (VHH), High (HH), moderate (MH) and (LH) (Pande 1996). The HH zone lying between energy contours 1015 and 1017 ergs km-2 yr-1 occupies 36% area of Uttarakhand and encompasses major parts of Uttarkashi, Chamoli, Bageshwar, Almora, Pithoragarh and Champawat districts. Here, possibility of occurrence of earthquake of $6<M<7$ exists in every 100 years. The MH zone, where there is possibility of $5<M<6$ in every 100 years, spreads in 41% of the area. Places like Purola, Tehri, Rudraprayag and Haridwar fall under this zone.

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

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 dam 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 VPHEP dam

site. A number of other less prominent structural dislocations are also present in the area. All the project components of this project lie downstream of the Main Central Thrust.

3.3.2.3 Thermal Springs

In the Garhwal Himalaya, as many as 62 thermal springs are reported. As per the Geothermal Atlas of India (GSI Pub.) as many as 19 thermal springs have been recognized in Alaknanda valley from Kharbagar in the south (29º59'30":79º55'56") to Madhyamaheshwar (30º59'20": 79º12'30") and the area includes the Tapovan (30º29'30" : 79º33'30") which is upstream of the dam site in the Dhauli Ganga valley. In addition to this site, one hot spring had been reported on the right bank of river Dhauliganga closer to river bank at Charmi Village (30º30'49.6'':79º36'36.9'') during the geological mapping of Tapovan-Vishngad. During the reconnaissance and mapping of the Dam site area, for locating the intakes and sedimentation tank, hot water springs have been recorded at three location, two are closer to the right bank and one to the left bank. In the drill hole El. 1229.07 (Ground Elevation) (E3843517.505, N754281.482) on the right bank (No. DH-8) hot water was encountered in overburden and the temperature was 68ºC recorded by drilling party. The details of the thermal springs are presented in **Table-3.2.**

Table-3.2: Details of Thermal Springs

Location	Lat/Long	Elevation	Geological Setting	Approx Temperature (ºC)
Left Bank of Alaknada	E3843547.416 N754365.372	1230.30 m	On the left bank of river through the vertical joints in quartzites	50ºC (approx)
Right Bank of Alaknada	E3843492.948 N754411.086	1231.84 m	Through foliation joint of the quartzite on the right bank.	55ºC (approx)
Right Bank of Alaknada	E3843500.135 N754407.922	1231.20 m	Through oblique joint of the quartzite on the right bank.	60ºC (approx)

Source: DPR, VPHEP

3.3.2.4 Geology of the Project Area

The project area forming a part of Alaknanda valley exposes rocks belonging to Garhwal Group and Central Himalayan Crystalline and is composed mainly of calcarenaceous rocks with basic intrusive and migmatite bodies, while around Helong low to medium grade metamorphic rocks are exposed.

The rocks occurring at the dam site are quartzites and along most of the length of the tunnel alignment are: quartzite with biotite schist, interbedded and interbanded grey slates and dolomites/limestone, grey thinly bedded slates with minor interbeds of limestone, dolomitic limestone with subordinate grey slates, grey pyritous shale / slates, thinly bedded dolomitic limestones, grey slate / phyllite, white siliceous dolomite with magnesite and talc schist; light grey dolomite with stromatolitic structures, interbedded quartzite phyllite and dolomite belong

to Garhwal Group.Calcareous shale and dolomitic limestone / dolomite are observed at the dam site. Along Tail race Tunnel, dolomitic limestone, metabasics, augen gneisses and schist are observed. The Litho-tectonic set up in the Vishnugad Pipalkoti H.E. Project area is given in **Table-3.3**.

Table-3.3: Litho-tectonic set up in the Vishnugad Pipalkoti H.E. Project

	Litho-Units	**Lithology**
Central Crystalline	Joshimath Fm. (Inner Crystalline)	Kyanite gneiss, banded augen gneiss, migmatite, garnetiferous-biotite-schit and amphibolite
	----------Vaikrita Thrust / MCT-II---------- (Jharkula-Bargaon-Saldhar)	
	Helong Fm. (Outer Crystalline)	Mylonitised augen gneisses and migmatites, mica- schist, amphibolites and crystalline marble Sericite quartzite and quartz mica schist Quartzite and chlorite schist.
	----------Munsiari Thrust / MCT-I / Floor Thrust---------- (1.5 km South-west of Helong to south of Tapovan via Salur)	
Garhwal Group / Lesser Himalaya	Chamoli/ Gulabkoti Formation	Grey fine-grained dolostone. Siliceous on the top and base. Numerous magnesite lenses. Medium grained, grey to greyish green quartzite along the contact. Subordinate schistose quartzites with a thin band of amphibolite.
		----------Gulabkoti Thrust (?)---------
	Pipalkoti Formation	Alternate slate and dolostone units. Slates are mainly graphitic and calcareous. Thinly intercalated limestone and slate unit. In the upper horizon of this unit limestone becomes massive and contains chip of bluish limestone. This is arenaceous phyllite and chloritoid slate. Numerous pockets of magnesite.
		----------Birhi Fault----------
	Chamoli/ Chinka Formatio	Shear Zone: Mylonite quartzites, blasto mylonites, augen mylonites, augen schists. Thin amphibolites along Birhi fault
		----------Chinka Fault----------
		Pure quartzites of greyish green colour. Orthoquartzites and subordinate schistose quartzites

Source: DPR, VPHEP

3.3.2.5 Various Studies

Seismic Refraction Studies

The Seismic refraction studies in the dam area on surface and subsurface was carried out by CWPRS, Pune. Seismic refraction survey both on land and under water was carried out along five traverses upstream of VPHEP dam axis. The seismic traverse on land reveled three subsurface layers consisting of loose boulders, 2nd layer indicate compact / partially saturated boulders. The depth of rock as per the interpreted results is from 15 m to 23 m. No major shear zone or fault has been detected in the foundation of dam complex which may

create problem during execution. This has been confirmed by the various hole drilled in the dam complex where in the compact rock is available at 10 to 25 m depth.

Electrical Resistivity Survey & Investigation

For the efficient and economical design of earthing system of transmission towers so as to minimise the transmission losses, apparent resistivity of the subsurface material is required. As lower the apparent resistivity of the material better will be the electrical contact and hence minimum the transmission losses. With the above in view electrical resistivity profiling and imaging survey at two terraces in the switch yard area to measure apparent and true resistivity of the subsurface strata was carried out. The apparent resistivity values will help in deciding the level and in designing the earthing system for electrical installations efficiently and economically.

The profiling was carried out in the terraces in switchyard area. The centre of the electrodes in both the cases was moved by 2 m i.e. apparent resistivity profile with 10 m electrode separation on the lower level terrace revealed that depending on the variation of resistivity, the area along this profile can be divided into three zones. Zone-1 having average apparent resistivity 235 ohm m is the most conducting of the three zones. For Zone-II & III, the apparent resistivity is 290 ohm-m and 420 ohm-m respectively. It is inferred from the results that apparent resistivity values for these three zones that along this traverse from upstream to dam stream either clay or moisture content or both are decreasing. On lower level terrace zone-1 with lower apparent resistivity values should be preferred for earthing purpose.

On the upper level terrace, the more or less uniform nature of strata is available. However, the resistivity imaging carried out at the upper level terrene revealed that in the middle of profile there exists a narrow zone with high trace resistivity values. This zone either be avoided for earthing purpose or special care are to be taken for earthing to minimize the transmission losses.

Geo-thermal Investigation

Hot springs have been noticed near the dam area. To have on the spot assessment Geo-thermal investigations have been taken up through GSI & IIT Roorkee, and the effect of results will considered during detailed design stage of the project.

Tectonics

The main tectonic unit namely the higher Himalyan central crystalline is thrust South ward along the main central thrust (MCT) over the rocks belonging to the lesser Himalyan. Gneisses of the Joshimath formation are falling into a broad symform with plunge towards north. Major tectonic lineament has been identified along Dhauli Ganga and Alaknanda valley’s having general westerly trend. The other lineaments are along NW & NE-SW directions. Few minor lineaments are noted along N-S ad NNE-SSW direction.

Design Seismic Parameter

The project area falls under seismic zone V of seismic zoning map of India (IS8493:2002) corresponding to zone factors of 0.36 & 0.24 (effective peak ground acceleration in terms of (g) of seismic intensities VIII and > IX (MSK-64 scale). Detailed site specific seismic study to estimate the design parameters are being worked out by IIT, Roorkee.

3.3.2.6 Recommendations

Dam: The geological mapping has indicated that rock types exposed on both the bank are quartzites with minor bands of schist. At least two drift at the Final Dam site one at the left bank and other on the right bank should be excavated at the final dam axes to know the depth of the stripping during pre-construction period. Exploration by ten Drill holes on the left and right bank of the river has been carried out. These drill holes have proved overburden up to 25 m below which bed rock consist of quartzites with minor bands of schist down to the bottom of the hole.

Desilting Chamber: In the desilting area it is likely to encounter hot water springs as has been recorded in the dam site area. Therefore it is suggested to take care of the findings of geothermal investigations.

Accordingly, project authorities have taken up the Geo-thermal investigations separately & the results will be taken into consideration during the execution of the project.

• **Diversion Tunnel:** For locating the inlet portal of the diversion tunnel the rock is not available as proved by the drill hole (DTH-2), drilled at the site i.e., the initial reach will be in open cut / channel with suitable protective measures of the bank / slope before opening the portal in the quartzite.

Head Race / Tail Race Tunnel: A drill hole is drilled along the HRT alignment at the Ghanpani nala, to ascertain the depth of overburden and physical condition of the rock at the tunnel grade.

In addition to the general tunneling problems high temperature during tunneling may also be encountered. Geo-thermal investigations already conducted. Accordingly, preventive measures should be adopted in the effective reaches.

Due to the presence of sets of number of joints the tunnel is beset with the problems of rock fall and roof collapse in the reaches where chlorite schist, shale/slates shall be encountered. This problem is likely to be more pronounced in the weak zones where water seepage is also encountered. Maina Nadi is another important drainage which has to be negotiated by the HRT. Three number drill holes have been drilled during the feasibility stage in this area. The area has been topographically resurveyed which indicate that more than 3 D rock cover (30.50 m) shall be available while driving the tunnel at the proposed location of the crossing. A fault has been interpreted along Maina Nadi which shall have to be negotiated while

driving the HRT. It is suggested that advance probe hole may be planned along the HRT alignment in this reach to know the tunneling condition in advance and for planning the support system.

The flat dips occurring in certain reaches of HRT may also pose problems of roof collapses and over breaks. The zones where the rocks are more closely jointed and charged with water shall require heavy supports therefore it is suggested that advance probe hole ahead of face are very necessary to know such eventuality in advance. In addition, fore polling, control blasting, rock bolting, shotcreating and steel rib support etc. shall also be planned in advance while driving the tunnel.

In the course of tunneling water seepage is apprehended below the major perennial streams and dolomite reaches. These reach of the tunnel calls for suitable tunneling technique, supporting systems and monitoring connectivity with excavations.

Surge Shaft / Pressure Shaft: The surge shaft will be located in the hard and compact, moderately jointed dolomite and no major problem is anticipated during the excavation of surge shaft / pressure shaft but encountering of inflow of water can not be rulled out in the pressure shaft excavation.

Power House & Transformer Caverns: The underground power house/ Transformer caverns are being planned to be located in moderately jointed and compact dolomite. Suitable drainage galaries all around and these caverns shall have to be planed in advance for excavating the power house cavity as ingress of water while excavation can not be rulled out and the same have to be retained during Operation & Maintenance of the project.

Proper steel support system alongwith rock bolts, shotcrete etc. are to be planned in advance while excavating the power house cavity. As the dolomite which shall be encountered during excavation are expected to be moderately to highly jointed, and water charged. Control blasting with protective measures shall have to be adopted for safe excavation of these cavities.

3.3.2.7 Important Mineral Reserve

Important minerals that are found to occur in the State are high-grade limestone in Almora, Bageshwar, Dehradun, Nainital, Pauri-Garhwal, Pithoragarh & Tehri-Garhwal districts; magnesite and steatite in Almora, Bageshwar, Chamoli & Pithoragarh districts; and tungsten in Almora district. No mineral reserve that are found in project area and its vicinity.

3.3.3 Hydrology

3.3.3.1 Catchment Area

The total catchment area of Alaknanda river above the VPHEP Dam site is 4672 Sq. Km and the catchment area and above Joshimath is 4508 Sq. Km out of which 2896 sq. km is snow bound area. The catchment area between Joshimath and VPHEP dam site is drained by

smaller tributaries and do not contribute significant flow in the river Alaknanda and are not snow fed.

3.3.3.2 Hydro-Meteorological Data

There are several gauge & discharge sites in Alaknanda river basin being maintained by Central Water Commission. The G&D site at Joshimath where the long term data from May 1971 onwards is found to be most appropriate for carrying out the water availability studies for Vishnugad Hydro Electric Project. There are several rain gauge stations established by IMD and State Government Departments in the catchment of Alaknanda. Most of the R.G. Stations lie in the lower reaches of the Vishnugad Project catchment which are not representative and hence not considered. The mean daily evaporation in a year is 3.5mm recorded at Joshimath.

3.3.3.3 Water Availabilty Studies

For constructing a 10 daily inflow series for Vishnugad Project, the discharge data available from 1971 to 2004 at Joshimath G&D site on Alaknanda river (CA. 4508 Sq. Km) has been considered. The consistency has been checked by Double-Mass Curve technique by making use of discharge data at Rudraprayag & Devprayag G&D sites on Alaknanda river. The double mass curves constructed reveals that the discharge data observed at Joshimath is consistent. The consistency has also been checked by comparing the specific discharges computed at Joshimath, Rudraprayag & Devprayag, the consistency has also been checked by using Degree Day Method. A degree day factor of snow melt of 0.575 cm/ C^{o} /day has been considered. For estimating the snow melt contribution, the normal monthly temperature at Joshimath with a lapse rate of 0.65°/ 100 metre change in elevation has been considered. The snow melt contribution works out to 59% of the total flow and remaining is rainfed contribution. The mean annual flow depth at Joshirnath works out to 1216 mm and the normal annual rainfall is 1160 mm. This shows the discharges measured at Joshimath are consistent.

After making the consistency checks at Joshimath (CA. 4508 Sq. Km), the 10 daily observed inflow series for 33 years from 1971 to 2004 has been constructed. This 10 daily inflow series has been transferred at Vishnugad H.E. Project site (CA. 4672 Sq. Km.) on catchment area proportion basis. In the free catchment between Joshimath & Vishnugad Project site, there is no major tributary joins Alaknanda except for four small tributaries which have no signification flow and will have no significant affect in the 10 daily inflow series thus computed at Vishnugad H.E. Project site. From the 10 daily series, the annual dependable yield at 90%, 50% and the average yield estimated are 3737 Mcum, 5751 Mcum and 5682 Mcum, respectively.

3.3.3.4 Design Flood

The dams are classified according to their size by using the hydraulic head (from normal or annual average flood level on the downstream to maximum water level) and the gross storage capacity of the reservoir. The hydraulic head in case of Vishnugad Project is more than 30 metre but the gross storage capacity is only 3.63 Mcum. The structure is to be designed for the Probable Maximum flood according to the criteria laid down in IS: 11223. The design flood for Vishnugad Hydro Electric Project has been estimated by Hydro-meteorological and stochastic approach.

The standard Project flood (SPF) of 6700 m^3/ sec and Probable Maximum Flood of 10840 m^3/sec, based on the method of unit hydrograph principle as per Flood Estimation Report of Western Himalayas (Zone-7), CWC publication are recommended for the design of structure. It is seen that the flood values computed by other methods do not differ much.

Based on the one-day storm value of 15 cm as SPS & 23.6 cm as PMS, and clock hour correction of 15%, the standard project flood and the Probable Maximum Flood have been estimated. In the estimation of flood, base flow of 450m3/sec has been considered which will account for the snow melt.

The design flood for river Diversion structures required during the construction works has been estimated as 725 m^3/sec for a return period of 1 in 25 year based on Frequency Analysis according to BIS criteria 14815.

3.3.3.5 Sedimentation Study

The detailed sedimentation study in case of diversion project is neither warranted nor necessary as in the case of storage project. However, particle size analysis of silt load and studies control of entry of particles larger than the certain size is important from the point of view of turbine maintenance. It is proposed to exclude silt particles size of 0.2 mm and above from water before it enters the power house.

3.3.3.5.1 Sedimentation Management of the Reservoir near Power Intakes

The sediment management of the reservoir near the power intakes is very important for efficient and satisfactory operation of the power house. Three numbers of silt flushing tunnels of size 3m x 3m are provided just below the power intakes with silt level at EL 1228.0 m with a length of nearly 300 m and bed slope of 1 in 75 approximately. This will avoid any bed material entering in the power intakes. A system of flushing the sediments by opening spillway sluices and silt flushing tunnel during monsoon and non monsoon seasons when inflow in the reservoir is above and below 300 m^3/sec is proposed to keep the level of sediment deposit well below the silt level of dam sluices and inlet tunnels. Hydraulic model studies will have to be done to check the adequacy and schedule of

operation of the tunnels provided and the schedule of flushing of the sediment to clear that deposited in the vicinity of the intakes.

The total sediment concentration up to which power house can be operated safely has also been studied and the same is recornmendrd as 5000 PPM.

3.3.3.6 Status of Ground Water Resources

Large-scale ground water development is not possible in the Chamoli district since it is a hard rock area with steep slopes and low ground water potential. The district Chamoli is mainly occupied by Himalayan Mountain ranges. Around 50% of the area is perennially covered under snow. Hence, there is no scope of ground water development in the area. However, at lower reaches, there is scope of ground water development through hand pumps. These discontinuous aquifers along with favourable physiographical set-up can help to develop ground water by hand pumps. Besides, there are number of natural springs which can be utilized to cater the need for drinking and irrigation. There are numerous springs with sufficient discharge, the water of these springs can be channelized for irrigation. During non-monsoon period, the discharge of springs gets reduced. To augment the discharge and sustainability of these springs, small surface water reservoir can be developed at suitable locations on higher level.

The depth of the handpumps ranges from 36.57 to 99.80 mbgl. The Pre-monsoon Depth to Water (DTW) ranges from 1.02 to 55.90 mbgl whereas the Post-monsoon DTW ranges from 9.06 to 60.75 mbgl. The seasonal Water level fluctuations, range from –10.44 to 11.02. Ground water abstraction is mainly done through handpumps with very negligible discharges. The other source of ground water in the district is in the form of springs.

3.3.4 Landuse

Landuse describes how a patch of land is used (e.g. for agriculture, settlement, forest), whereas land cover describes the materials (such as vegetation, rocks or buildings) that are present on the surface. Accurate land use and land cover identification is the key to most of the planning processes. The land use pattern of the study area has been studied through digital satellite imagery data. The land use pattern has been studied through satellite imagery data. Remote sensing satellite data of two Resourcesat- 2 Satellite (LISS-IV, Sensor) Data path 117 row 069 dated 21.10.2020 was procured from National Remote Sensing Agency (NRSA), Hyderabad. The data was processed through ERDAS software package available with WAPCOS. Ground truth studies were conducted in the area to validate various signals in the satellite images and correlate them with different land use domains. The classified images of the Study area is given in Figures-3.3(a) and 3.3(b)

respectively. Land use pattern of Study area is outlined in Table-3.4 and presented in Figure-3.4.

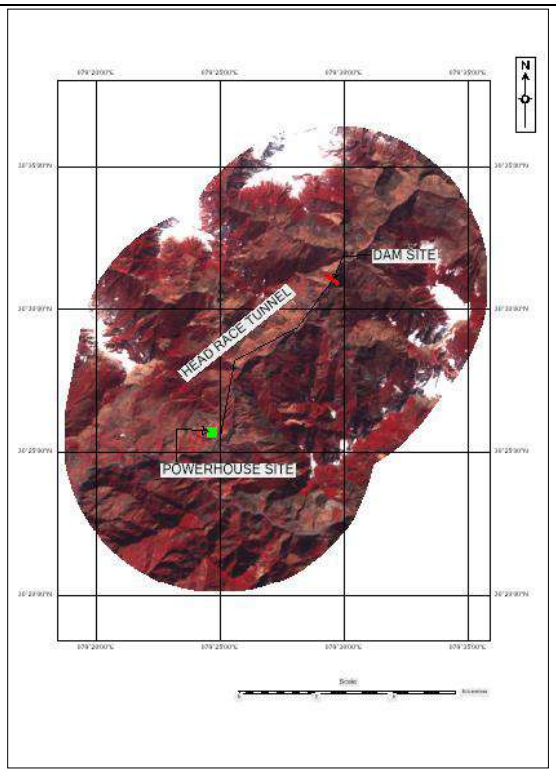


Figure-3.3(a): FCC of the Study area

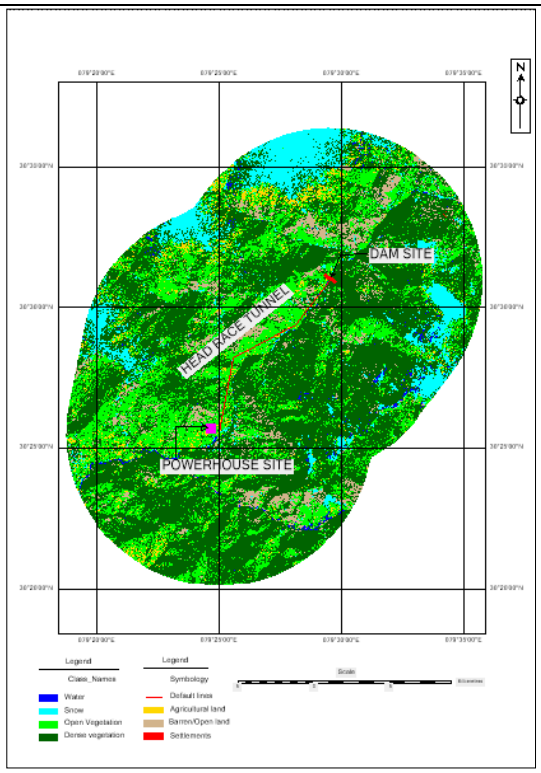


Figure-3.3(b): Classified Imagery of Study Area

Land use pattern of study area

The major landuse category in the study area of Vishnugad Pipalkoti Hydropower Project is open vegetation, as it accounts for about 42.79% of the study area followed by Dense vegetation (26.67%). The area under Barren land and snow is 17.81% and 7.3% of the study area respectively.The settlement is sparse in the area. Settlements and River account for about 0.43% and 0.60% of the study area respectively. Agriculture land accounts for about 4.4% of the Study area.

Table-3.4: Landuse pattern of the Study Area based on satellite data

Category	Area(ha)	Area (%)
Water/River	415	0.60
Snow	5075	7.30
Dense vegetation	18536	26.67
Open Vegetation	29736	42.79
Agriculture Land	3060	4.40
Barren Land	12375	17.81
settlement	300	0.43
Total	**69497**	**100.00**

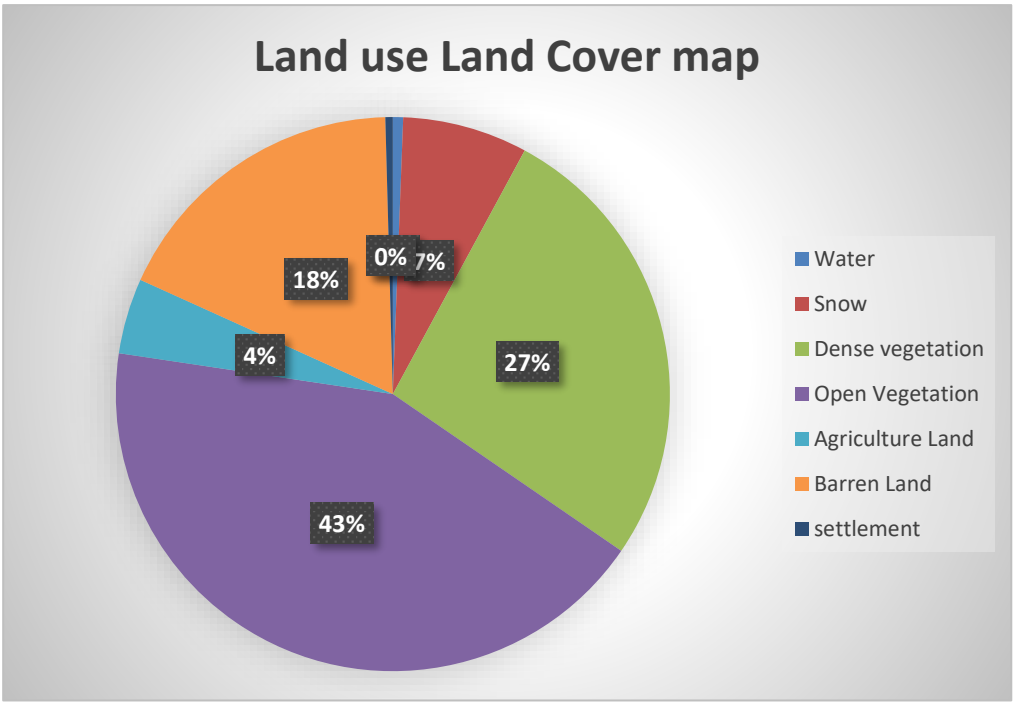


Figure-3.4: Landuse pattern of the Study Area based on satellite data

3.3.5 Soils

Soil is the product of geological, chemical and biological interactions. The soil in a region varies according to altitude and climate. The soil in the project and the study areas, like any other region of Himalayas are young. Soil on the slope above 30°, due to erosion and mass wasting processes, are generally shallow and usually have very thin surface horizons. Such soils have medium to coarse texture. Residual soils are well developed on level summits of lesser Himalayas, sub-soils are deep and heavily textured.

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

As a part of field studies, soil samples were collected from 6 locations in the study area. The depth of locations ranged from 20 to 50 cm below the ground. Sampling locations are listed in Table-3.5. The results of the analysis of soil sampling conducted for post-monsoon season are given in Tables-3.6. The sampling location map is enclosed as Figure-3.5.

Table-3.5: Details of Locations of Soil Sampling

S. No.	Sample Name	Location	Co-ordinates
1.	S1	Bhim Tapovan	30°29'41.20"N 79°28'35.40"E
2.	S2	Gundala Village	30°27'11.74"N 79°25'35.26"E
3.	S3	Angthala Village	30°25'49.07"N 79°25'30.27"E
4.	S4	Batula Village	30°25'15.58"N

S. No.	Sample Name	Location	Co-ordinates
			79°24'54.50"E
5.	S5	Jaisaal	30°24'54.97"N 79°24'20.09"E
6.	S6	Bhimtala Village	30°24'41.80"N 79°22'26.80"E

Table-3.6: Results of soil sampling analysis of study area for post-monsoon season

S. No	Parameters	S1	S2	S3	S4	S5	S6
1.	pH	7.25	7.41	6.98	7.84	7.16	7.33
2.	Electrical Conductivity, µS/cm	286	326	225	351	272	315
3.	Calcium (as Ca), mg/kg	1423	1288	1621	1720	1421	1650
4.	Magnesium (as Mg) , mg/kg	235	186	278	260	227	248
5.	Sodium (as Na), mg/kg	136	121	152	178	132	152
6.	Available potassium (as K), mg/kg	212	208	245	254	215	236
7.	Salinity, µS/cm	286	234	290	302	282	282
8.	Organic matter, % by mass	2.50	2.32	2.88	2.80	2.48	2.38
9.	Sodium Absorption Ratio	0.68	0.56	0.72	0.75	0.65	0.49
10.	Nitrogen, % by mass	1420	1432	1521	1482	1418	1285
11.	Available Phosphorus (as P_2O_5), mg/kg	28.80	26.50	30.12	26.78	28.60	22.60
12.	Bulk Density, gm/cc	1.05	1.02	1.10	1.12	1.05	1.02
13.	Organic Carbon, % by mass	1.62	1.78	1.54	1.75	1.60	1.54
14.	Particle Size Distribution Sand,% Clay, % Silt,%	 68.0 19.0 13.0	 64.0 16.0 20.0	 65.0 18.0 17.0	 61.0 18.0 21.0	 64.0 16.0 20.0	 62.0 19.0 19.0
15.	Exchangeable Sodium percentage, % by mass	4.21	4.55	3.80	4.08	4.20	4.05

The pH in various soil samples ranged from 6.98 to 7.84 in post-monsoon season, which indicates that neutral range having slight alkalinity. The low EC values ranging between 225 - 351 µS/cm indicate lower salt content in soils. It is an important indicator of soil health as it affects crop yields, crop suitability, plant nutrient availability, and activity of soil microorganisms. Excess salts in soil hinder plant growth by disturbing the soil-water Balance. The texture of soil in the area is sandy loam.

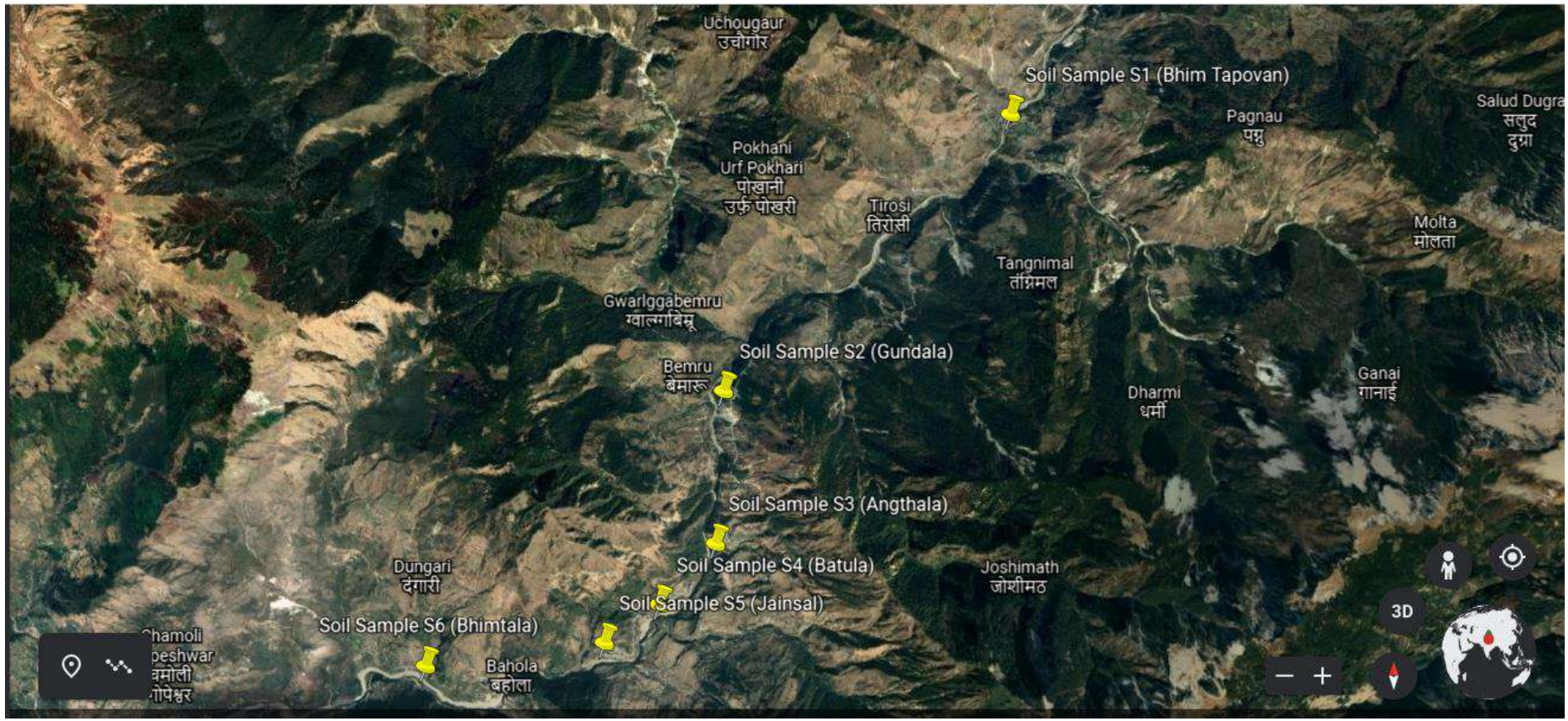


Figure-3.5: Soil Sampling Location Map

3.3.6 Surface Water Quality

The VPHEP is located in an area with low population density with no major sources of pollution. The major source of water in the project area are rivers or nallahs which flow adjacent to the habitations. The water is conveyed to the point of consumption. The sewage so generated, too outfalls into various streams or nallahs flowing adjacent to the settlements. The effluent generated from domestic sources ultimately reaches river Alaknanda or other tributaries through various streams/channels outfalling into the river. Even for minimum flow condition, there is sufficient water available in river Alaknanda, for dilution of untreated sewage generated from domestic sources. There are no industries in the area. The area under agriculture is quite less, which coupled with negligible use of agro-chemicals, means that apart from domestic sources, pollution loading is virtually negligible. Thus, water quality is expected to be excellent in the project area.

As a part of the field studies, water samples were collected at 6 locations in the study area. Sampling locations are listed in Table-3.7. The results of the analysis of water sampling conducted for post-monsoon season is given in Table-3.8. The drinking water quality standards are enclosed as **Annexure-V**. The sampling location map is enclosed as Figure-3.6.

Table-3.7: Surface water sampling locations

S. No.	Sample Name	Location	Co-ordinates	Sample Type	Source
1.	W1	Helong	30°31'35.80"N 79°30'10.30"E	Surface water	Alaknanda River
2.	W2	Bhim Tapovan	30°29'40.70"N 79°28'33.20"E	Surface water	Alaknanda River
3.	W3	Batula Village	30°25'18.19"N 79°25'2.92"E	Surface water	Alaknanda River
4.	W4	Birahi Village	30°24'27.39"N 79°23'16.19"E	Surface water	Alaknanda River
5.	W5	Bhimtala Village	30°24'29.05"N 79°21'29.29"E	Surface water	Alaknanda River
6.	W6	Bazbagar	30°23'36.39"N 79°19'23.24"E	Surface water	Alaknanda River

Table-3.8: Surface Water quality in the study area for post monsoon season

S. No	Parameters	Stations					
		SW1	SW2	SW3	SW4	SW5	SW6
1.	pH	7.10	7.20	7.66	7.55	7.30	7.20
2.	Color	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
3.	Electrical Conductivity, µS/cm	173	164	202	338	303	154
4.	Turbidity, NTU	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
5.	Total Hardness (as $CaCO_3$), mg/l	85	52	80	104	115	71
6.	Fluoride (as F), mg/l	<0.1	<0.1	<0.1	<0.1	0.26	<0.1

S. No	Parameters	Stations					
		SW1	SW2	SW3	SW4	SW5	SW6
7.	Dissolved Oxygen, mg/l	7.60	7.20	7.10	7.20	7.30	7.40
8.	Chlorides (as Cl), mg/l	10.92	12.65	11.78	17.39	19.15	11.74
9.	Calcium (as Ca), mg/l	45.16	32.60	27.63	22.44	38.30	15,24
10.	BOD (3 days at 27°C), mg/l	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
11.	Nitrate (as NO_3), mg/l	3.18	<1.0	1.12	1.56	4.08	<1.0
12.	Total Dissolved Solids, mg/l	113	107	134	210	194	95
13.	Sulphates (as SO_4), mg/l	10.8	16.5	8.23	10.18	15.36	6.50
14.	Magnesium (as Mg), mg/l	13.92	6.80	8.69	11.59	16.17	5.68
15.	Phosphates (as PO_4), mg/l	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
16.	Sodium (as Na),mg/l	118	56	48	72	89	42
17.	Potassium (as K),mg/l	3.02	1.18	0.95	1.10	1.25	0.84
18.	COD(as O_2), mg/l	BDL	BDL	BDL	BDL	BDL	BDL
19.	Residual Sodium Carbonate, mg/l	Nil	Nil	Nil	Nil	Nil	Nil
20.	Total Chromium (as Cr), mg/l	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
21.	Iron (as Fe), mg/l	0.218	<0.05	0.112	0.106	0.164	<0.05
22.	Manganese (as Mn), mg/l	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
23.	Copper (as Cu), mg/l	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
24.	Zinc (as Zn), mg/l	0.28	<0.1	<0.2	<0.2	0.24	<0.1
25.	Arsenic (as As), mg/l	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
26.	Cadmium (as Cd), mg/l	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
27.	Cyanide (as CN), mg/l	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
28.	Lead (as Pb), mg/l	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
29.	Selenium (as Se), mg/l	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
30.	Mercury (as Hg), mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
31.	Total Coliform	Absent	Absent	Absent	Absent	Absent	Absent
32.	Faecal Coliform, (MPN/100ml)	Absent	Absent	Absent	Absent	Absent	Absent

The Electrical Conductivity (EC) in water samples ranged from 154 to 338 μS/cm in the post-monsoon season. Overall, surface water has low electrical conductivity which is reflected from the low concentration of most of the ionic species which are well within the permissible limit used for drinking water. (Refer **Annexure-V**). Hardness ranged from 52 to 115 mg/l in the post-monsoon season.

The BOD and COD levels are quite low, which indicate the absence of organic pollution loading. This is mainly due to the low population density and absence of industries in the area. The heavy metal concentration in the study area is below the permissible limit used for drinking purposes. It can be concluded that water quality was observed to be quite good, as parameters are well below the permissible limits specified for meeting drinking requirements.

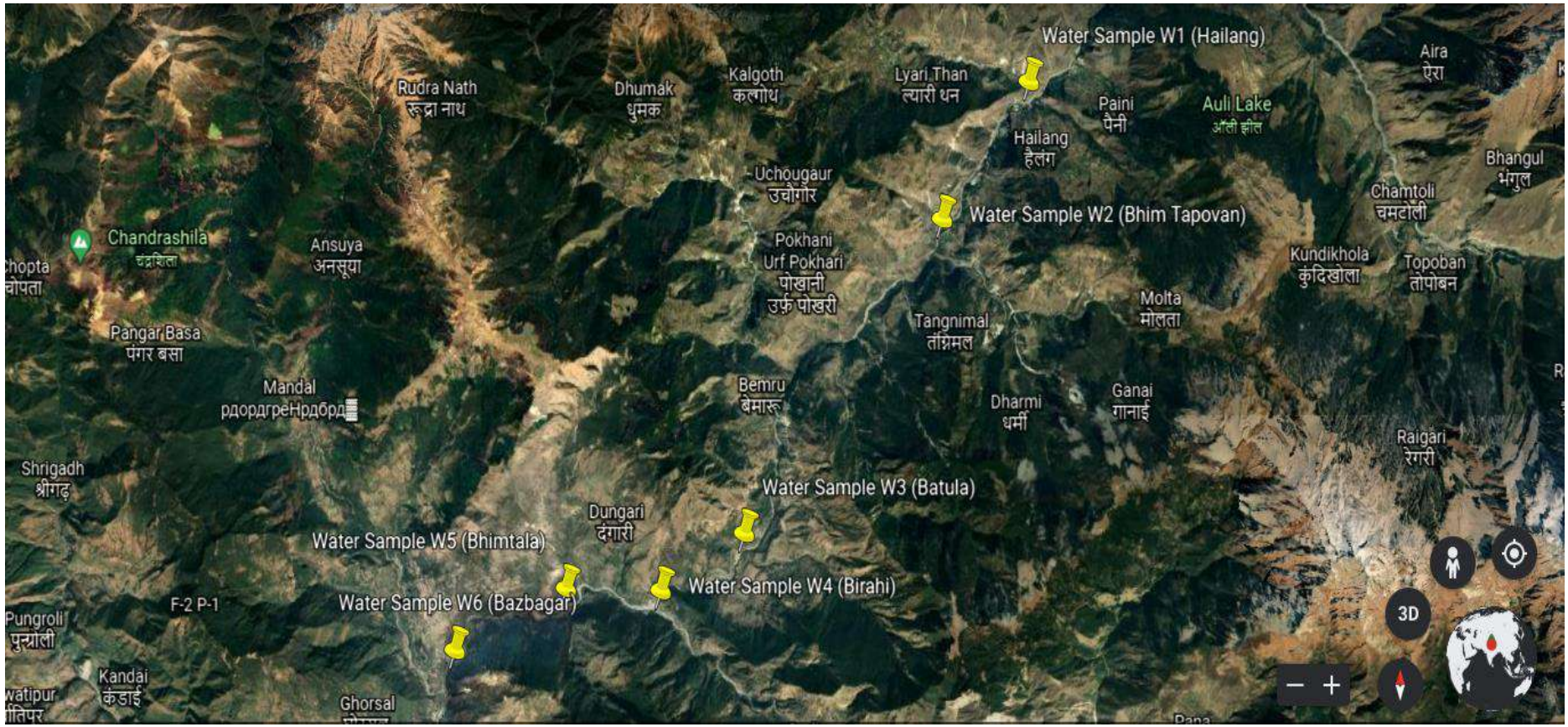


Figure-3.6: Water Sampling Location Map

3.3.7 Ambient Noise Levels

Baseline noise data has been measured using a weighted sound pressure level meter. The survey was carried out in calm surrounding. Sound Pressure Level (SPL) measurement in the outside environment was made using sound pressure level meter. Hourly noise meter readings were taken at various sites. The noise levels were monitored continuously from 6 AM to 9 PM at each location and hourly equivalent noise level was measured. Location of Noise Monitoring stations is given in Table-3.9. The hourly ambient noise levels monitored and day time equivalent noise levels estimated for post-monsoon season are given in Table-3.10 and Table-3.11 respectively. The ambient noise standards for various categories are given in **Annexure-VI**.

Table-3.9: Location of Noise Monitoring stations

S.No.	Station Code	Name of Location
1.	N1	Siyasain Club House
2.	N2	Hat Village, Near TBM Site
3.	N3	Durgapur Village, Near TRT Point
4.	N4	Batching Plant, Near Store
5.	N5	Fabrication Yard, Near Dam Site
6.	N6	Gulabkoti Village, Near Dump Yard

Table-3.10: Hourly equivalent noise levels- Post-Monsoon (Unit:dB(A))

Location	N1	N2	N3	N4	N5	N6
6-7 AM	47.8	48.2	48.5	49.0	49.1	48.9
7-8 AM	49.0	48.7	49.2	50.1	50.1	49.6
8-9 AM	50.2	49.2	50.5	52.7	51.6	51.8
9-10 AM	51.6	50.9	52.2	53.6	54.1	54.7
10-11 AM	51.8	51.4	53.5	54.4	54.8	54.5
11-12 Noon	51.2	52.7	54.8	55.3	54.2	54.1
12 noon - 1 PM	50.8	53.0	56.0	55.8	54.6	53.8
1-2 PM	52.1	53.1	56.2	56.5	54.9	53.7
2-3 PM	53.5	54.0	56.5	57.6	55.5	55.9
3-4 PM	52.9	55.2	56.1	57.9	55.9	56.5
4-5 PM	52.0	53.9	55.7	57.4	56.1	55.7
5-6 PM	51.8	53.2	54.5	55.2	55.4	54.3
6-7 PM	51.2	51.8	52.8	53.4	54.6	52.9
7-8 PM	50.7	49.4	51.6	50.7	52.1	51.4
8-9 PM	50.0	49.1	50.1	50.3	51.3	49.2

Table-3.11: Day time Equivalent noise levels in Post-Monsoon Season

S. No.	Location	Value (dB(A))
1.	Siyasain Club House	51.32
2.	Hat Village, Near TBM Site	52.09
3.	Durgapur Village, Near TRT Point	53.94
4.	Batching Plant, Near Store	54.82
5.	Fabrication Yard, Near Dam Site	54.07
6.	Gulabkoti Village, Near Dump Yard	53.70

Table-3.10: Hourly equivalent noise levels- Post-Monsoon (Unit:dB(A))

Location	N1	N2	N3	N4	N5	N6
09-10 PM	37.71	38.02	38.26	38.66	38.74	38.58
10-11 PM	38.66	38.42	38.81	39.52	39.52	39.13
11-12 PM	39.60	38.81	39.84	41.58	40.71	40.87
12-01 AM	40.71	40.16	41.18	42.29	42.68	43.15
01-02 AM	40.87	40.55	42.21	42.92	43.23	43.00
02-03 AM	40.39	41.58	43.23	43.63	42.76	42.68
03-04 AM	40.08	41.81	44.18	44.02	43.07	42.44
04-05 AM	41.10	41.89	44.34	44.57	43.31	42.36
05-06 AM	42.21	42.60	44.57	45.44	43.78	44.10

Table-3.11: Night time Equivalent noise levels in Post-Monsoon Season

S. No.	Location	Value (dB(A))
1.	Siyasain Club House	40.25
2.	Hat Village, Near TBM Site	41.09
3.	Durgapur Village, Near TRT Point	42.55
4.	Batching Plant, Near Store	43.50
5.	Fabrication Yard, Near Dam Site	42.66
6.	Gulabkoti Village, Near Dump Yard	42.36

The day time equivalent noise level at various sampling stations ranged from 51.32 to 54.82 dB(A) and night time equivalent noise level at various sampling stations ranged from 43.50 to 40.25 in post-monsoon season. The noise levels were observed to be well within permissible limit (55 dB(A)) specified for residential area (Refer **Annexure-VI**).

3.3.8 Ambient Air Quality

Air pollutants are added in the atmosphere from variety of sources that change the composition of atmosphere and affect the biotic environment. Air pollution in India is mainly caused from three sources namely vehicles, industrial and domestic sources. The concentration of air pollutants depends not only on the quantities that are emitted from air pollution sources but also on the ability of the atmosphere to either absorb or disperse these emissions.

Ambient air quality monitoring is conducted to assess the existing quality of ambient air from the active construction site. It helps us to understand the impact of emissions, from on-going/up-coming projects, on surrounding environment of the area. On the basis of these findings, management plan is prepared to minimize the impact and to keep the environment healthy.

As a part of field studies, ambient air quality was monitored at six locations in the study area for post-monsoon season. The parameters monitored were SPM, Particulate matter less than 10 micron (PM_{10}), Particulate matter less than 2.5 micron ($PM_{2.5}$), Sulphur Dioxide and Nitrogen Dioxide. Monitoring locations were selected based on predominant wind direction, habitation, notified sanctuaries and terrain features of the study area. The ambient air quality monitoring was conducted twice a week on 24 hourly basis for four consecutive weeks The sampling locations are shown in Figure-3.7. The ambient air quality monitoring stations are given in Table-3.12. The national ambient air quality monitoring standards are enclosed as **Annexure-VII**.

Table-3.12: Location of ambient air quality monitoring stations

S.No.	Station Code	Name of Location	Location
1.	AAQ1	Siyasain Club House	30°24'47" N 79°24'16" E
2.	AAQ 2	Hat Village, Near TBM Site	30°25'9" N 79°25'26" E
3.	AAQ 3	Durgapur Village, Near TRT Point	30°24'33" N 79°23'24" E
4.	AAQ 4	Batching Plant, Near Store	30°30'35" N 79°29'27" E
5.	AAQ 5	Fabrication Yard, Near Dam Site	30°31'26" N 79°29'27" E
6.	AAQ 6	Gulabkoti Village, Near Dump Yard	30°30'35" N 79°29'28" E

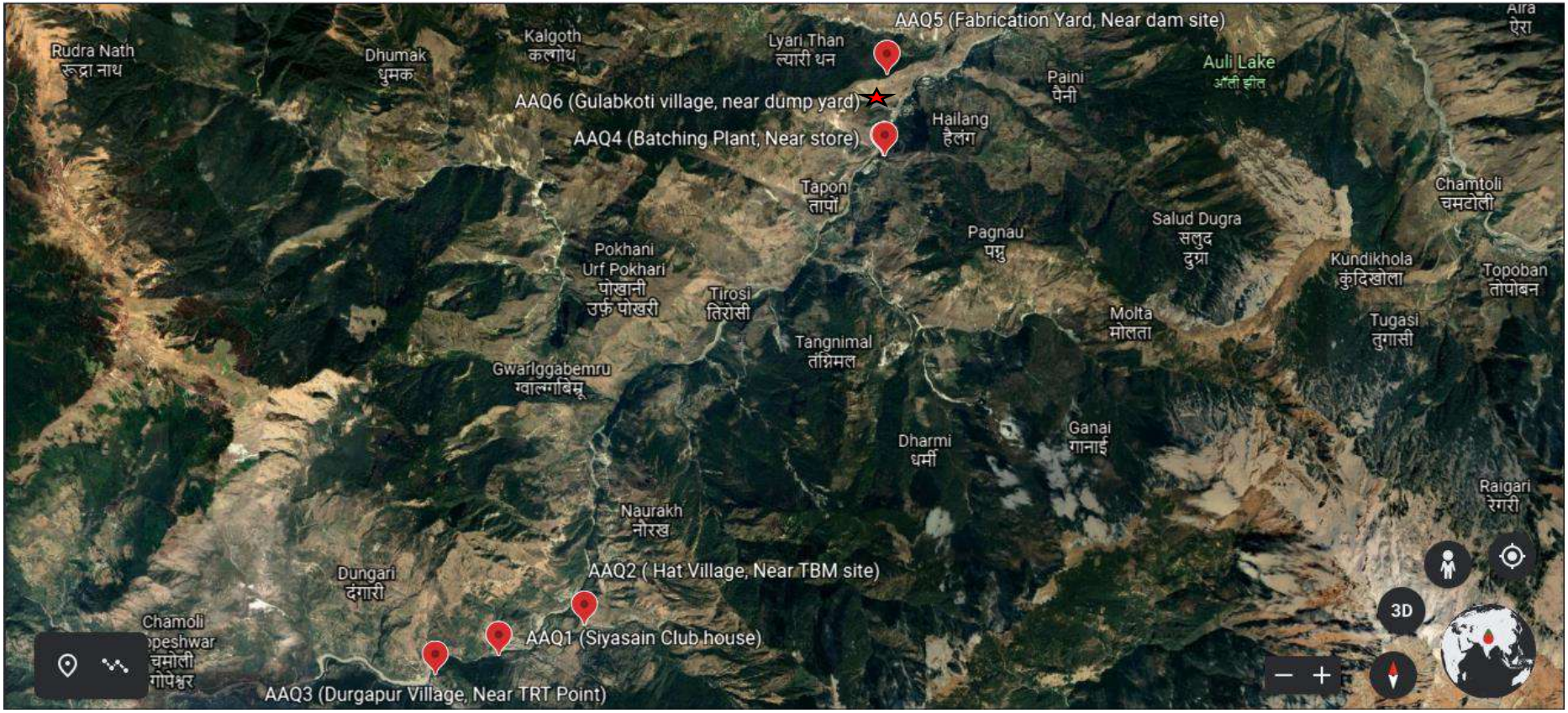


Figure-3.7: Air Quality Sampling Location Map

Table-3.13: Ambient air quality status for Post-monsoon Season

S. No.	Date of sampling	Parameter			
		PM_{10} ($\mu g/m^3$)	$PM_{2.5}$ ($\mu g/m^3$)	SO_2 ($\mu g/m^3$)	NO_2 ($\mu g/m^3$)
Siyasain Club House					
1	31.10.2020	52.3	31.6	9.9	36.9
2	01.11.2020	50.7	36.6	9.5	32.2
3	11.11.2020	47.5	31.7	9.5	34.7
4	12.11.2020	56.9	38.1	7.4	30.5
5	14.11.2020	50.5	31.6	9.0	30.5
6	15.11.2020	54.8	31.6	9.5	34.7
7	25.11.2020	52.7	32.0	8.2	33.7
8	26.11.2020	55.2	35.0	11.7	39.6
Hat Village, Near TBM Site					
1	02.11.2020	59.6	42.1	12.3	41.7
2	03.11.2020	57.9	43.0	8.9	37.0
3	09.11.2020	51.4	36.8	10.7	43.3
4	10.11.2020	56.6	35.0	10.2	23.6
5	16.11.2020	56.1	37.0	9.4	38.9
6	17.11.2020	60.8	39.0	10.2	41.2
7	23.11.2020	53.8	35.3	11.9	27.8
8	24.11.2020	53.8	42.0	9.9	25.7
Durgapur Village, Near TRT Point					
1	04.11.2020	58.9	39.6	9.9	25.7
2	05.11.2020	52.5	32.1	9.0	30.5
3	07.11.2020	55.0	34.6	7.8	34.3
4	08.11.2020	49.2	32.6	10.7	40.7
5	18.11.2020	57.0	41.0	7.8	26.3
6	19.11.2020	55.7	47.4	8.2	36.1
7	21.11.2020	58.6	33.0	10.4	40.7
8	22.11.2020	51.0	36.8	9.0	34.5
Batching Plant, Near Store					
1	31.10.2020	59.0	37.0	8.6	32.8
2	01.11.2020	54.2	36.8	9.9	30.5
3	11.11.2020	58.8	42.1	10.7	33.7
4	12.11.2020	53.7	35.0	7.8	36.6
5	14.11.2020	55.7	42.1	9.4	29.0
6	15.11.2020	57.1	40.0	10.2	32.0
7	25.11.2020	58.4	35.0	7.8	36.6
8	26.11.2020	50.7	42.8	12.2	38.1
Fabrication Yard, Near Dam Site					
1	02.11.2020	55.9	30.0	10.9	34.3
2	03.11.2020	61.5	34.6	6.7	27.6
3	09.11.2020	56.4	40.0	10.2	35.1
4	10.11.2020	55.0	32.6	7.4	37.7
5	16.11.2020	53.0	31.6	7.4	30.5
6	17.11.2020	59.3	45.0	10.2	35.1
7	23.11.2020	61.7	41.0	7.8	39.6
8	24.11.2020	54.0	36.8	6.6	26.5
Gulabkoti Village, Near Dump Yard					
1	04.11.2020	51.6	31.6	6.6	26.5
2	05.11.2020	59.8	38.6	7.8	29.0
3	07.11.2020	57.1	38.1	6.7	27.6

S. No.	Date of sampling	Parameter			
		PM_{10} ($\mu g/m^3$)	$PM_{2.5}$ ($\mu g/m^3$)	SO_2 ($\mu g/m^3$)	NO_2 ($\mu g/m^3$)
4	08.11.2020	54.4	35.0	9.4	33.5
5	18.11.2020	52.6	30.0	8.2	30.5
6	19.11.2020	57.0	35.4	7.0	29.0
7	21.11.2020	53.9	38.2	9.4	33.5
8	22.11.2020	58.6	33.3	8.2	27.6

Table- 3.14: Summary of ambient air quality monitoring for Post-monsoon Season (Unit: $\mu g/m^3$)

Station	Maximum	Minimum	Average	98 percentile
Particulate Matter less than 10 micron (PM_{10})				
Siyasain Club House	56.9	47.5	52.6	56.7
Hat Village, Near TBM Site	60.8	51.4	56.3	60.6
Durgapur Village, Near TRT Point	58.9	49.2	54.7	58.9
Batching Plant, Near Store	59	50.7	56	59
Fabrication Yard, Near Dam Site	61.7	53	57.1	61.7
Gulabkoti Village, Near Dump Yard	59.8	51.6	55.6	59.6
Particulate Matter less than 2.5 micron ($PM_{2.5}$)				
Siyasain Club House	38.1	31.6	33.5	37.9
Hat Village, Near TBM Site	43	35	38.8	42.9
Durgapur Village, Near TRT Point	47.4	32.1	37.1	46.5
Batching Plant, Near Store	42.8	35	38.9	42.7
Fabrication Yard, Near Dam Site	45	30	36.5	44.4
Gulabkoti Village, Near Dump Yard	38.6	30	35	38.5
Sulphur dioxide (SO_2)				
Siyasain Club House	11.7	7.4	9.3	11.4
Hat Village, Near TBM Site	12.3	8.9	10.4	12.2
Durgapur Village, Near TRT Point	10.7	7.8	9.1	10.7
Batching Plant, Near Store	12.2	7.8	9.6	12
Fabrication Yard, Near Dam Site	10.9	6.6	8.4	10.8
Gulabkoti Village, Near Dump Yard	9.4	6.6	7.9	9.4
Nitrogen dioxide (NO_2)				
Siyasain Club House	39.6	30.5	34.1	39.2
Hat Village, Near TBM Site	43.3	23.6	34.9	43.1
Durgapur Village, Near TRT Point	40.7	25.7	33.6	40.7
Batching Plant, Near Store	38.1	29	33.7	37.9
Fabrication Yard, Near Dam Site	39.6	26.5	33.3	39.3
Gulabkoti Village, Near Dump Yard	33.5	26.5	29.7	33.5

Observations on ambient PM_{10} levels

It is observed from Table-3.14 that average concentration of PM_{10} at various monitoring stations ranged from 52.6 to 57.1 $\mu g/m^3$ in post-monsoon season. The highest PM_{10} value was recorded as 61.7 $\mu g/m^3$ at Fabrication Yard, Near Dam Site and lowest value of 47.5 $\mu g/m^3$ was recorded at Siyasain Club House. The PM_{10} values monitored during the field survey were well below the permissible limit of 100 $\mu g/m^3$ for industrial, residential, rural and other areas.

Observations on ambient $PM_{2.5}$ levels

The average concentration of $PM_{2.5}$ at various monitoring stations monitored ranged from 33.5 to 38.9 µg/m^3 in post-monsoon season. The highest $PM_{2.5}$ value was recorded as 47.4µg/m^3 at Durgapur Village, Near TRT Point and lowest value of 30µg/m^3 was recorded at Gulabkoti Village, Near Dump Yard and Fabrication Yard, Near Dam Site. The $PM_{2.5}$ values monitored during the field survey were well below permissible limit of 60 µg/m^3 for industrial, residential, rural and other areas.

Observations on ambient SO_2 levels

The average concentration of SO_2 at various stations monitored ranged from 7.9 to 10.4 µg/m^3 in post-monsoon season. The highest SO_2 value was recorded as 12.4µg/m^3 at Hat Village, Near TBM Site The average concentration of SO_2 at various stations in the study area was well below the prescribed limits of 80 µg/m^3 specified for industrial, residential, rural and other areas.

Observations on ambient NO_2 levels

The average NO_2 concentration at various sampling stations ranged from 29.7 to 34.9 µg/m^3 in post-monsoon season. The highest NO_2 value was recorded as 43.3µg/m^3 at Hat Village, Near TBM Site. The average concentration of NO_2 at various stations in the study area was observed to be well below the prescribed limit of 80 µg/m^3 specified for industrial, residential, rural and other areas.

3.4 ECOLOGICAL ASPECTS

3.4.1 Terrestrial Flora

3.4.1.1 Terrestrial

Uttarakhand is known for natural beauty having total geographical area of 53,483 km^2. The region is a part of northern India crossed by the Himalayas and is known for its Hindu pilgrimage sites due to numerous Hindu temples and pilgrimage centers found throughout the state. The State lies between 28°43' N to 31°28' N latitude and 77°34' E to 81°03' E longitude and It borders China to the north; Nepal to the east; the Indian states of Uttar Pradesh to the south and Himachal Pradesh to the west and north-west. As the State lies in the Himalayan range, the climate and vegetation vary greatly with altitude, from glaciers at the highest elevations to subtropical forests at the lower elevations. Ice and bare rocks cover the higher elevations. The average annual rainfall is 1,500 mm and the annual temperature varies from 0 C to 43 C. Many major rivers including Ganga, Yamuna, and Ramganga & Sharda drain the State along with their tributaries.

The Vishnugad-Pipalkoti Hydro Electric Project is situated in Alaknanda valley of Chamoli district of Uttarakhand state of India. The study area is lies between 30°30'50" to 30°25'31"

N and 79°29'30" to 79°24'56" E and elevation of 1252.2 meters above sea level. The Chamoli district is located in the Central Himalaya and is surrounded by Uttarkashi district in the north-west, Pithoragarh district in the east, Bageshwar district in the south-east, Almora district in the south, Rudraprayag district in the west and Pauri district in the south-west. The geographical area of the district is around 8,030 km^2out of which 2,695 km^2 area is under forest cover (Anonymous 2011). Besides, enriched with great ranges of biodiversity, it bears unique cultural heritage and significant land and water resources. The Vishnugad-Pipalkoti Hydro Electric Project area represents the eastern part of the Garhwal Himalaya. The area has highly diversified ecological region and covers a wide range of climatic conditions under altitudinal variation. They have a unique culture and tribal customs. The annual temperature varies from 0 ^{0}C to 42 ^{0}C. As per Census report 2011, Chamoli district has a population of 3, 91,114. Hindi and Garhwali languages are commonly spoken in the study area.

3.4.1.1 Forest Types and Vegetation Composition

Forest type has been defined as a unit of vegetation which possesses a broad characteristic in physiognomy and structure, sufficiently pronounced to permit its categorization from other such units. Fosberg (1961) proposed seven possible bases for the classification of vegetation and forest types of any geographic regions. These includes parameters related to study on physiognomy, structure (or stratification), function, floistic, dynamics, environment and history. Based on these parameters, the vegetation analysis works of Vishnugad Pipalkoti Hydro Electric Project (VPHEP) were carried out. It has been found that the regions are bestowed with rich vegetation and floristic composition due to varied topography, climate and edaphic factors. Based on altitudinal differences, the data collected from field works, taking into account of Champion and Seth (1968) System of Forests Classification and FSI (2013), the forests in VPHE Project mountain regions are broadly grouped into following types:

- **Sub-tropical Forests (10/C1)**
- **Temperate Forests (12/C2, 13/C2)**
- **Alpine and sub-alpine forest (14/C1, 15/C1)**

Sub-tropical Forests

The sub-tropical is confined maximum up to an elevation of 1400 m and occasionally associated with tree species are- *Albizzia lebbeck*, *Quercus Phoenix humilis, Shorea robusta*, *Syzygium cumini*, *Mallotus philippinensis*, *Terminalia* spp. *Ficus* spp, *Callicarpa arborea*, *Diopoknema butyracea*, *Bauhinia variegate, Cassia fistula* and many others. The dominant shrubs found in this forest are- *Justicia adhatoda*, *Woodfordia fruticosa*, *Lawsonia inermis*, *Murraya koenigii, Solanum* species, *Lantana camara* and other shrub found in this type of forest. The common herbs found in this type of forest are- *Oxalis corniculata*, *Taraxacum officinalis*, *Argimone mexicana*, *Achyranthes aspera Verbascum Thapsus*,

Eulaliopsis binate, and common climbers are Abrus precatorius, Tinospora sinensis, Ipomoea purpurea and other climber found in this type of forest.

Temperate Forests

The vegetation components of temperate forests are *Sapindus mukorossi, Cinnamomum tamala, Myrica esculenta*, *Lyonia ovalifolia*, *Pyrus pashia, Lannea coromandelica*, and so many other important trees found in this type of forest. The dominant shrubs like *Rosa moschata*, *Urtica dioca*, Embelia ribes, *Lonicera angustifolia*, *Opuntia monacantha*, *Urena lobata*, *Dendrocalamus strictus* and other important shrubs found in this type of forest. The common herbs are *Elephantopus scaber*, *Evolvulus alsinoides*, *Nepeta ciliaris*, *Potentilla fulgens*, *Ranunculus hirtellus*, *Gallium aparine*, *Viola odorata* and other herbs found in this type of forest. Fern like *Pteris* species and other ferns are predominantly found in these forests. *Cryptolepis dubia*, *Vallaris solanacea* and other climbers is the common in this type of forest.

Alpine and sub-alpine forest

The vegetation components of Alpine and sub-alpine forest are- *Pinus roxburghii*, *Rhododendron arboretum*, *Abies pindrow*, *Betula utilis*, *Cedrus deodara*, *Salix denticulate*, *Cupressus torulosa*, *Grevillea robusta*, *Juniperus communis* and many other important trees found in this type of forest. *Rubus ellipticus*, *Plumbago zeylanica*, *Ephedra gerardiana*, *Debregeasia saeneb*, *Rubus niveus* and many other dominant shrubs are components of this forest. The herbaceous vegetation found in this forest are- *Primula denticulata* , *Pouzolzia hirta*, *Rheum* species, *Silene indica*, *Cardamine impatiens*, *Bergenia ciliate* and so many other important herbs found in this type of forest. *Rubia cordifolia*, *Rubus paniculatus*, *Operculina turpethum* are common climber found in this type of forest and *Vanda tessellate* are common epiphytic plant in this forest.

3.4.1.2 Field Studies

As a part of the Ecological Impact Assessment (EIA) study, detailed ecological survey was conducted at different sites for post-Monsoon Season in the Month of November, 2020 of Vishnugad Pipalkoti Hydro Electric Project (VPHEP), Uttarakhand. The objectives of the ecological survey were to: -

(1) Prepare a checklist of flora in the study area.

(2) Listing the rare/endangered species economically important species.

(3) Determine frequency, density, abundance and IVI of different vegetation components.

(4) Calculate species diversity indices of different plant communities in the study area.

Six sampling sites were selected in the project area keeping in view the area to be adversely affected by the activities of the land to be acquired for VPHEP, construction. The sampling sites selected for terrestrial ecological survey in the project sites were: -

- Dam site
- Submergence area (Haat Village and surrounding areas)
- Catchment area (Helong village and surrounding areas)
- Downstream of dam site (Jaisal Village and surrounding areas)
- Power house site and surrounding areas
- TRT Outlet site(Durgapur, Birahi Village and surrounding areas)

3.4.1.3 Methodology adopted for field survey

3.4.1.3.1 Floristic survey and quantitative analysis of vegetation

For assessing the floral diversity in the study area both floristic survey and quantitative analysis of vegetation were undertaken. The quantitative analysis of vegetation was done by using quadrats as sampling units. The quadrats were laid randomly in identified sites (as per project impact) at the Dam site, Submergence area (Haat Village and surrounding areas), Catchment area (Helong village and surrounding areas), Downstream of dam site (Jaisal Village and surrounding areas), Power house site and surrounding areas and TRT Outlet site (Durgapur, Birahi Village and surrounding areas). The vegetation analysis was undertaken by collecting numerical community data for trees, shrubs, herbs, climbers, ferns, grasses, bamboos and epiphytes from the randomly laid quadrats. Quadrat size of 10 m x 10 m was used to enumerate trees, 5m x 5m was used to enumerate shrubs and herbs were enumerated through 1m x 1m quadrats. The numbers of quadrats laid for different vegetation components at different sampling sites are listed in Table-3.15.

Table-3.15: Number and size of quadrats laid at different sites at the VPHE Project, Uttarakhand during Post-Monsoon Season.

study sites	Vegetation components	Number of quadrat laid	Size of quadrat
Dam site	Tree Shrub Herb	25 25 25	10m x 10m 5m x 5m 1m x 1m
Submergence area (Haat Village and surrounding areas)	Tree Shrub Herb	25 25 25	10m x 10m 5m x 5m 1m x 1m
Catchment area (Helong village and surrounding areas)	Tree Shrub Herb	25 25 25	10m x 10m 5m x 5m 1m x 1m
Downstream of Dam site (Jai sal Village and surrounding areas)	Tree Shrub Herb	25 25 25	10m x 10m 5m x 5m 1m x 1m
Power house site and surrounding areas	Tree	25	10m x 10m

study sites	Vegetation components	Number of quadrat laid	Size of quadrat
	Shrub Herb	25 25	5m x 5m 1m x 1m
TRT Outlet (Durgapur, Birahi Village and surrounding areas)	Tree Shrub Herb	25 25 25	10m x 10m 5m x 5m 1m x 1m

During the survey, each individual within the quadrat was identified up to the species level, and the number of individuals of each species in each quadrat was counted. The GBH of all trees having girth of more than 16 cm (equivalent to 5 cm DBH) was measured. Based on the quadrat data, frequency, density and cover (basal area) for each species were calculated using the following formulae:

Frequency: Frequency is the number of times a plant species occurs in a given number of quadrats. Frequency is usually expressed as a percentage and is sometimes called a Frequency Index.

$$\text{Frequency}(\%) = \frac{\text{Number of quadrats in which the species occured}}{\text{Total number of quadrats studied}} * 100$$

Density: Density in plant ecology is defined as the number of individuals of a given species that occurs within a given sample unit or study area. Density is often used in a vegetation survey to describe a species' status in a plant community.

For tree,

$$\text{Density} = \frac{\text{Total number of individual of a the species in all the quadrats}}{\text{Total number of quadrats studied}} * 50$$

For shrub,

$$\text{Density} = \frac{\text{Total number of individual of a the species in all the quadrats}}{\text{Total number of quadrats studied}} * 100$$

For herb,

$$\text{Density} = \frac{\text{Total number of individual of a the species in all the quadrats}}{\text{Total number of quadrats studied}} * 10{,}000$$

Abundance: It is the study of the number of individuals of different species in the community per unit area. By quadrats method, samplings are made at random at several places and the number of individuals of each species was summed up for all the quadrats divided by the total number of quadrats in which the species occurred. It is represented by the equation:

$$\text{Abundance} = \frac{\text{Total number of individul of a the species in all the quadrats}}{\text{Total number of quadrats in which the species occured}}$$

Basal area:

Basal area (m^2 ha^{-1}) = Mean total basal area of all the individuals of the species per Quadrat and conversion to per hectare basis.

Importance Value Index

This index is used to determine the overall importance of each species in the community structure. In calculating this index, the percentage values of the relative frequency, relative density and relative dominance are summed up together and this value is designated as the Importance Value Index or IVI of the species (Curtis, 1959).

Relative density: Relative density is the study of numerical strength of a species in relation to the total number of individuals of all the species and can be calculated as:

$$\text{Relative density} = \frac{\text{Number of individual of the species}}{\text{Total number of individual in all the species}} * 100$$

Relative frequency: The degree of dispersion of individual species in an area in relation to the number of all the species occurred.

$$\text{Relative frequency} = \frac{\text{Frequency of occurance}}{\text{Total frequency of all occurence of all species}} * 100$$

Relative dominance: Dominance of a species is determined by the value of the basal cover. Relative dominance is the coverage value of a species with respect to the sum of coverage of the rest of the species in the area.

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

The total basal area was calculated from the sum of the total diameter of immerging stems. In trees, poles and saplings, the basal area was measured at breast height (1.5 meters) and by using the formula πr^2. The importance value index (IVI) for different trees species were determined by summing up the Relative Density, Relative Frequency and Relative dominance. The Relative Density and Relative Frequency values were used to calculate the IVI of shrubs and herbs. The importance value index is a measure of the relative contribution of a species to the community.

3.4.1.4.2 Diversity index

To assess diversity of floral elements and structure of the plant community in different study sites, various diversity indices were computed. A diversity index is a mathematical measure of species diversity in a community. They provide more information about community composition than simply species richness (i.e., the number of species present); they also take the relative abundances of different species into account. Three species diversity indices viz., Shannon index of general diversity (H), Dominance index (D) and Evenness index (e) were computed using PAST software.

Shannon index

It is an index used to measure diversity in categorical data. In a basic sense, it is the information entropy of the distribution in a given area treating species as symbols and their relative population sizes as the probability. The diversity index takes into account the number of individuals as well as number of taxa. It varies from 0 for communities with only a single taxon to high values for communities with many taxa, each with few individuals. The advantage of this index is that it takes into account the number of species and the evenness of the species. The index is increased either by having additional unique species, or by having greater species evenness. Higher values of Shannon index indicate that a particular community has more information.

$$\mathrm{H} = \frac{ni}{N} \ln\left(\frac{ni}{N}\right)$$

Dominance index

It is calculated as:- $$\mathrm{D} = \sum\left(\left(\frac{ni}{n}\right)^2\right)$$

Where ni is number of individuals of taxon i. The value of D Ranges from 0 (all taxa are equally present) to 1 (one taxon dominates the community completely).

Buzas and Gibson's evenness index

It was calculated using the formula: $\frac{e^{H}}{S}$ where H is the Shannon's index and S represents the number of species. It indicates the relative abundance or proportion of individuals among the species.

3.4.1.4 Results of the Floral Diversity

Floristic composition

During the floristic survey in the Post-Monsoon Season, a total of 247 plant species were recorded from the VPHE Project, Uttarakhand. Of these, Herbs (104), Tree (66), Shrubs (58), Climbers (12), Ferns (2), Grass (2), Bamboo (2) and Epiphyte (1) species recorded from the study area. While investigating VPHE Project, Uttarakhand, several Floristic compositions documented which is presented in **Table-3.16**.

Table-3.16: Different life forms of the plant species recorded post-monsoon season from the VPHE Project, Uttarakhand

Life form	Number of species
Trees	66
Shrubs	58
Herbs	104
Climbers	12
Ferns	2
Grasss	2
Bamboos	2
Epiphytes	1
Total	**247**

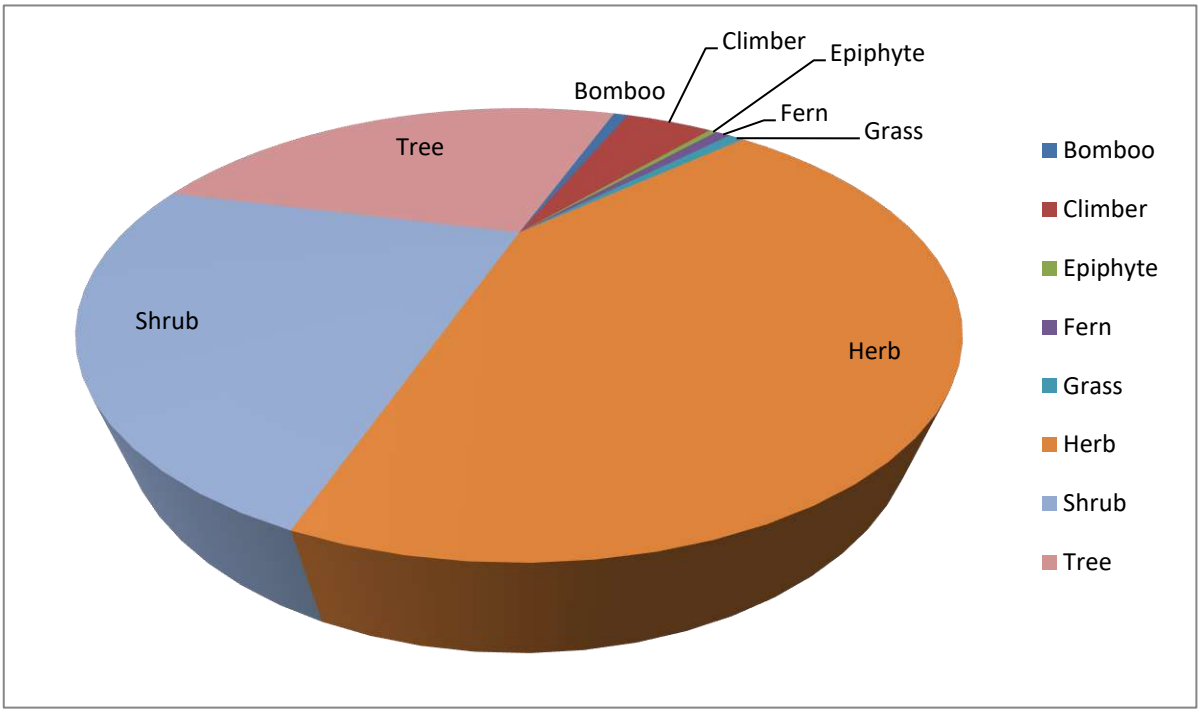


Figure-3.8: Habit variation in floristic composition at VPHE Project, Uttarakhand recorded during post monsoon season

Table-3.17: Complete list of plant species recorded in post-monsoon season from the VPHE Project, Uttarakhand

Botanical name	Local name	Family	Habit	IUCN Red list	Uses
Abies pindrow (Royle ex D.Don) Royle	Raga	Pinaceae	Tree	LC	Timber
Abrus precatorius L	Rati	Fabaceae	Climber	-	Medicinal
Acacia nilotica (L.) Delile	Babool	Mimosaceae	Tree	LC	Construction
Acanthocereus tetragonus (L.) Hummelinck		Cactaceae	Tree	LC	Ornamental
Achillea millefolium L.	Puthkanda	Asteraceae	Herb	LC	Medicinal
Achyranthes aspera L.	Apamarga	Amaranthaceae	Herb	-	Medicinal
Acomastylis elata var.elata	Belocha	Rosaceae	Herb	-	Animal feed
Adiantum caudatum L.		Pteridaceae	Herb	-	Oranmental
Aegle marmelos (L.) Correa	Bael	Rutaceae	Tree	-	Religious
Aerva sanguinolenta (L.) Blume	Safedfulia	Amaranthaceae	Herb	-	Oranmental
Aesculus indica (Wall. ex Cambess.) Hook	Pangar	Sapindaceae	Tree	-	Timber
Ageratina adenophora (Spreng.) R.M.King & H.Rob.	Kala ghas	Asteraceae	Herb	-	Fuel

Botanical name	Local name	Family	Habit	IUCN Red list	Uses
Ageratum conyzoides (L.) L.	Ganye	Asteraceae	Herb	-	Medicinal
Agrimonia pilosa Ledeb.	Kafliya	Rosaceae	Herb	-	Medicinal
Ajuga parviflora Benth.	Ratpatya	Lamiaceae	Herb	-	Medicinal
Albizia lebbeck (L.) Benth.	Siris	Leguminosae	Tree	-	Timber
Allium wallichii Kunth	Jangali Lasun	Amaryllidaceae	Herb	-	Animal feed
Alnus nepalensis D.Don	Utis	Betulaceae	Tree	LC	Firewood
Althaea officinalis L.	Jangalihauli	Malvaceae	Herb	-	Medicinal
Anaphalis busua (Buch.-Ham) DC.	Buki phool	Asteraceae	Herb	-	Medicinal
Aquilegia pubiflora Wall. ex Royle		Ranunculaceae	Herb	-	Medicinal
Argemone mexicana L.	Prickly poppy	Papaveraceae	Herb	-	Medicinal
Arisaema flavum (Forssk.) Schott	Meen	Araceae	Herb	-	Animal feed
Artemisia nilagirica (C.B.Clarke) Pamp.	Kurja	Asteraceae	Herb	-	Medicinal
Astragalus condolleanus Royle	Rudravanti	Asteraceae	Herb	-	Animal feed
Azadirachta indica A. Juss	Neem	Meliaceae	Tree	LC	Medicinal
Bacopa monnieri (L) Wettst	Jalbirahmi	Scrophulariaceae	Herb	LC	Medicinal
Barleria cristata L.	jhinti	Acanthaceae	Herb	-	Medicinal
Bauhinia variegata L.	Koiral	Caesalpiniaceae	Tree	LC	Ornamental
Berberis aristata DC.	Kilmoda	Berberidaceae	Shrub	LC	Medicinal
Bergenia ciliata (Haw.) Sternb.	Silphoda	Saxifragaceae	Herb	LC	Medicinal
Betula utilis D.Don.	Bhojpatra	Betulaceae	Tree	LC	Timber
Bidens pilosa L.	Katere	Asteraceae	Shrub	-	Animal feed
Bistrota amplexicaulis Greene	Kutrya	Polygonaceae	Herb	-	Medicinal
Boehmeria rugulosa Wedd.	Gethi	Urticaceae	Tree	-	Construction
Boehmeria macrophylla Hornem.	Chikmagalur	Urticaceae	Shrub	-	Firewood
Boerhavia diffusa Kuntze	Punarnava	Nyctaginaceae	Herb	-	Medicinal
Brucea javanica (L.) Merr.	Bhakimlo	Anacardiaceae	Shrub	LC	Firewood
Calendula officinalis L.	Ganda	Asteraceae	Herb	-	Medicinal
Callicarpa arborea	Bhatmelu	Verbenaceae	Tree	LC	Timber

Botanical name	Local name	Family	Habit	IUCN Red list	Uses
Roxb.					
Callicarpa macrophylla Vahl.	Daiya	Verbenaceae	Shrub	-	Firewood
Callistemon species		Myrtaceae	Tree	-	Ornamental
Campanula pallida Wall.	Gaanobuti	Campanulaceae	Herb	-	Medicinal
Canna indica L.	Kewara	Cannaceae	Herb	-	Oranmental
Capsella bursa-pastoris (L.) Medik.	Torighash	Brassicaceae	Herb	-	Medicinal
Carissa spinarum L.	Karonada	Apocynaceae	Shrub	-	Edible/fuel
Cassia absus Sesse & Moc.	Cheaksu	Caesalpiniaceae	Herb	LC	Medicinal
Cassia fistula L.	Amaltas	Caesalpiniaceae	Tree	LC	Construction
Cedrus deodara (Roxb. ex D.Don) G.Don	Devdara	Pinaceae	Tree	LC	Timber
Celastrus paniculatus Willd	Kaunya	Celastraceae	Shrub	-	Firewood
Celosia argentea L.	Chare Maguri	Amaranthaceae	Herb	LC	Medicinal
Celtis australis L.	Kharak	Ulmaceae	Tree	LC	Timber
Chromolaena odorata (L.) R.M.King & H.Rob.	Triva gandha	Asteraceae	Herb	-	Medicinal
Cinnamomum tamala (Buch.-Ham.) T.Nees & Eberm.	Tejpata	Lauraceae	Tree	LC	Spices
Cirsium arvense (L.) Scop.	Sumar	Asteraceae	Herb	-	Medicinal
Cissampelos pareira L.	Mus bel	Menispermaceae	Climber	-	Medicinal
Citrus medica L.	Chukh	Rutaceae	Tree	-	Fruit edible
Clematis buchananiana DC.		Ranunculacea e	Shrub	-	Medicinal
Clerodendrum infortunatum L.	Aranyo	Lamiaceae	Shrub		Firewood
Commelina benghalensis L	Kankawa	Commelinaceae	Herb	LC	Medicinal
Coriaria nepalensis Wall.	Makhoi	Coriariaceae	Shrub	-	Medicinal
Cotoneaster microphyllus Wall. ex Lindl.	Khareto	Rosaceae	Shrub	-	Ornamental
Cryptolepis dubia (Burm.f.) M.R.Almeida	Dudhi	Asclepiadaceae	Climber	-	Medicinal
Cupressus torulosa C.Don	Surai	Cupressaceae	Tree	LC	Ornamental
Cynodon dactylon (L.) Persoon	Dub	Poaceae	Herb	-	Religious
Dalbergia sissoo DC.	Sheesham	Papilionaceae	Tree	-	Construction

Botanical name	Local name	Family	Habit	IUCN Red list	Uses
Datura metal L.	Dhatura	Solanaceae	Shrub	-	Medicinal
Debregeasia saeneb (Forssk.) Hepper & J.R.I.Wood	Tushyar	Urticaceae	Shrub		Firewood
Delonix regia (Hook.) Raf.	Gulmohar	Caesalpiniaceae	Tree	LC	Timber
Delphinium denudatum Wall. ex Hook. f. & Thomson	Nirvisi	Ranunculaceae	Herb	-	Medicinal
Dendrocalamus strictus (Roxb.) Nees	Rigal	Gramineae	Bomboo	-	Construction
Desmodium heterocarpon (L.) DC.	Jambhali Dashmi	Fabaceae	Herb	-	Medicinal
Dioscorea bulbifera L.	Githi	Dioscoreaceae	Climber	-	Medicinal
Diploknema butyracea (Roxb.) H.J.Lam	Chewra	Sapotaceae	Tree	-	Timber
Dryopteris species	Fern	Pteridaceae	Fern	-	Oranmental
Dryopteris species	Fern	Pteridaceae	Fern	-	Ornamental
Duchesnea indica (Jack) Focke	Kiphaliya	Pteridaceae	Herb	-	Edible
Echinops echinatus Roxb.	Utkanto	Asteraceae	Herb	-	Medicinal
Elephantopus scaber L.	Ban-tambakhu	Asteraceae	Herb	-	Animal feed
Embelia ribes Burm.f.	Vidanga	Myrsinaceae	Shrub	-	Medicinal
Ephedra gerardiana Wall. ex Stapf	Tutgautha	Ephedraceae	Shrub	-	Firewood
Eragrostis viscosa (Retz.) Trin	Bharbhusi	Poaceae	Herb	-	Animal feed
Erigeron bellidioides (Buch.-Ham. ex D.Don) Benth. ex C.B.Clarke		Asteraceae	Herb	-	Oranmental
Eriophorum comosum (Wall.) Nees	Phurke Jhaar	Cyperaceae	Herb	-	Animal feed
Erythrina suberosa Roxb.	Dhaul	Leguminosae	Shrub	-	Medicinal
Eulaliopsis binata (Retz.) C.E.Hubb.	Bhabar ghas	Poaceae	Herb	-	Animal feed
Eulaliopsis binata (Retz.) C.E.Hubb.	Babul	Gramineae	Grass	-	Medicinal
Euphorbia candelabrum Trémaux ex Kotschy		Euphorbiaceae	Tree	LC	Ornamental
Euphorbia hirta L.	Dudhi	Euphorbiaceae	Herb	-	Medicinal
Evolvulus alsinoides (L.) L.	Sankhpuspi	Convolulaceae	Herb	-	Medicinal
Falconeria insignis Royle	Kheera	Euphorbiaceae	Tree	-	Construction
Ficus palmata Forssk.	Bedu	Moraceae	Tree	-	Construction
Ficus racemosa L.	Umar	Moraceae	Tree	LC	Religious

Botanical name	Local name	Family	Habit	IUCN Red list	Uses
Ficus benghalensis L.	Barh	Moraceae	Tree	-	Construction
Fragaria nubicola (Lindl. ex Hook.f.) Lacaita	Bhuikafal	Rosaceae	Herb	-	Edible
Fumaria indica (Haussk.)Pugsley	Pit papra	Fumariaceae	Herb	-	Medicinal
Galinsoga parviflora Cav.	Marchya	Asteraceae	Herb	-	Animal feed
Galium aparine L.	Kuri	Rubiaceae	Herb	-	Medicinal
Gaultheria fragrantissima Wall	Jalan-thrait	Ericaceae	Shrub	-	Medicinal
Geranium rotundifolium L		Geraniaceae	Herb	-	Medicinal
Geum elatum Wall.	Belocha	Rosaceae	Herb	-	Oranmental
Gmelina arborea Roxb.	Gambhari	Verbenaceae)	Tree	LC	Timber
Grevillea robusta A.Cunn. ex R.Br.	Silver oak	Proteaceae	Tree	LC	Timber
Grewia oppositifolia Roxb. ex DC.	Biul	Tiliaceae	Tree	-	Timber
Hemidesmus indicus (L.) R. Br. ex Schult.	Anantamul	Asclepiadaceae	Shrub	-	Medicinal
Heychium spicatum Sm.	Banhaldi	Zingiberaceae	Herb	-	Oranmental
Hyoscyamus niger L.	Bran juwan	Solanaceae	Herb	-	Medicinal
Hypericum oblongifolium Choisy	Phiunli	Hypericaceae	Shrub	-	Medicinal
Hyssopus officinalis L.	Jufa	Laminaceae	Shrub	-	Medicinal
Indigofera heterantha Brandis	sakina	Fabaceae	Shrub	-	Medicinal
Inula cappa (Buch.-Ham. ex D.Don) DC.	kankhulia	Asteraceae	Shrub	-	Medicinal
Ipomoea purpurea (L.) Roth	Besharam	Convolvulaceaea	Climber	-	Medicinal
Isodon coetsa (Buch.-Ham. ex D.Don) Kudô	Chichiri	Lamiaceae	Shrub	-	Medicinal
Jasminum humile L.	Shunjai	Oleaceae	Shrub	-	Ornamental
Jatropha curcas L.	Desi-kheera	Euphorbiacea e	Shrub	LC	Medicinal
Juglans regia L.	Akhrot	Juglandaceae	Tree	LC	fruit edible
Juniperus communis L.	Jhora	Cupressaceae	Tree	LC	Construction
Justicia adhatoda L.	Vasaka	Acanthaceae	Shrub	-	Medicinal
Lannea coromandelica (Houtt.) Merr.	Jinghini	Anacardiacea e	Tree	-	Ornamental
Lantana camara L.	Raimuniya	Verbenaceae	Shrub	-	Medicinal
Lawsonia inermis L.	Mehandi	Lythraceae	Shrub	-	Ornamental
Leptadenia reticulata (Retz.) Wight & Arn.	Duri	Asclepiadaceae	Shrub	-	Firewood

Botanical name	Local name	Family	Habit	IUCN Red list	Uses
Leptodermis lanceolata Wall.	Padera	Rubiaceae	Shrub	-	Medicinal
Lespedeza sericea (Thunb.) Miq.	Khunju	Leguminosae	Herb	LC	Animal feed
Leucas lanata Benth.	Biskapra	Laminaceae	Herb	-	Medicinal
Lindenbergia indica Vatke	Patthar-chatti	Plantaginacea	Herb	-	Medicinal
Lobelia nicotianifolia Roth ex Schult.	Ban tambacoo	Campanulaceae	Herb	LC	Medicinal
Lonicera angustifolia Wall. ex DC.		Caprifoliaceae	Shrub	-	Medicinal
Lyonia ovalifolia (Wall.) Drude	Angeri	Ericaceae	Tree	LC	Construction
Maesa indica (Roxb.) A.DC.	bakrol	Myrsinaceae	Tree	LC	Timber
Mallotus philippensis (Lam.) Müll.Arg.	Ruina	Euphorbiaceae	Tree	LC	Foddar
Malva verticillata L.		Malvaceae	Herb	-	Medicinal
Mangifera indica L.	Aam	Anacardiaceae	Tree	DD	fruit edible
Melia azedarach L.	Daikan	Meliaceae	Tree	LC	Construction
Mentha longifolia (L.) L.	Poudina	Lamiaceae	Herb	LC	Medicinal
Micromeria biflora (Buch.Ham. ex D. Don) Benth.	Ban Ajwain	Lamiaceae	Herb	-	Animal feed
Morina longifolia Wall. ex DC.	Biskandru	Morinaceae	Herb	-	Medicinal
Moringa pterygosperma Gaertn	Shigru	Morignaceae	Tree	-	Firewood
Murraya koenigii (L.) Spreng.	Kath Neem	Rutaceae	Shrub	-	Ornamental
Myrica esculenta Buch.-Ham. ex D. Don	kaphal	Myricaceae	Tree	-	Edible
Neolitsea pallens (D. Don) Momiy. & H. Hara	Nairkhi	Lauraceae	Tree	-	Ornamental
Nepta podostachys (Benth.)	Amchis	Lamiaceae	Herb	-	
Oenothera rosea L. Her. ex Aiton		Onagraceae	Herb	-	Oranmental
Operculina turpethum (L.) Silva Manso	Triputa	Convolvulaceae	Climber	-	Medicinal
Opuntia monacantha Haw.	Nagphani	Cactaceae	Shrub	LC	Medicinal
Oroxylum indicum (L.) Kurz	Tantia	Bignoniaceae	Tree	-	Construction
Oxalis corniculata L.	Chilmoda	Oxalidaceae	Herb	-	Medicinal
Panicum miliaceum L.	Bhagar	Gramineae	Herb	-	Medicinal
Parthenium	Congress	Asteraceae	Herb	-	Animal feed

Botanical name	Local name	Family	Habit	IUCN Red list	Uses
hysterophoru L.	grass				
Phoenix humilis (L.) Cav.	Khajoor	Palmae	Tree	LC	Construction
Phragmites australis (Cav.) Trin. ex Steud.	Naal	Gramineae	Bomboo	LC	Medicinal
Phragmites communis Trin		Poaceae	Herb	LC	Fuel
Phyllanthus emblica L.	Aonla	Euphorbiaceae	Tree	-	Edible
Pimpinella diversifolia Dc		Apiaceae	Herb	-	Animal feed
Pinus roxburghii Sarg.	Salla	Pinaceae	Tree	LC	Construction
Pistacia khinjuk Socks.	Kakarsingi	Anacardiaceae	Tree	LC	Timber
Plantago depressa Willd		Plantaginaceae	Herb	-	Medicinal
Plantago major L.	Vrantank	Plantaginaceae	Herb	LC	Animal feed
Plumbago zeylanica L.	Chitrak	Plumbaginaceae	Shrub	-	Medicinal
Polygonatum verticillatum (L) All.	Kantula	Liliaceae	Herb	-	Medicinal
Polygonum capitatum Buc.-Ham.	Ratnyaule jhar	Polygonaceae	Herb	-	Medicinal
Polygonum nepalensis (Meisner) H. Gross.	Kangany	Polygonaceae	Herb	-	Animal feed
Pongamia pinnata (L.) Pierre	Karanjua	Fabaceae	Tree	LC	Ornamental
Populus ciliata Wall. ex Royle	Poplar	Salicaceae	Tree	LC	Construction
Potentilla fulgens Wall.	Bajradanti	Rosaceae	Herb	-	Medicinal
Potentilla supina L.		Rosaceae	Herb	LC	Medicinal
Pouzolzia hirta Blume ex Hassk.	Atinna	Urticaceae	Herb	-	Medicinal
Prinsepia utilis Royle	dhatila	Rosaceae	Shrub	-	Medicinal
Psidium guajava L.	Amrood	Myrtaceae	Tree	-	fruit edible
Pteris vittata L.	Fern	Pteridaceae	Fern	LC	Oranmental
Pteris vittata L.	Fern	Pteridaceae	Fern	-	Ornamental
Pterocarpus marsupium Roxb.	Bijesar	Fabaceae	Tree	NT	Ornamental
Pyracantha crenulata (Roxb. ex D.Don) M.Roem.	Ghingharu	Rosaceae	Shrub	-	Medicinal
Pyrrosia adnascens (Sw.)Ching		Polypodiaceae	Herb	-	Animal feed
Pyrus pashia Buch.-Ham. ex D. Don – Kainth	Kainath	Rosaceae	Tree	LC	Edible
Quercus incana	Ban	Fagaceae	Tree	LC	Timber

Botanical name	Local name	Family	Habit	IUCN Red list	Uses
Bartram					
Ranunculus diffusus DC.	Maardi Jhaar	Ranunculaceae	Herb	-	Medicinal
Ranunculus hirtellus Royle	sanjay	Ranunculaceae	Herb	-	Medicinal
Ranunculus sceleratus L.	Jal dhaniyaa	Ranunculaceae	Herb	LC	Medicinal
Rauvolfia serpentina (L.) Benth. ex Kurz	Sarpgandha	Apocynaceae	Shrub	-	Medicinal
Reinwardtia indica Dumort.	Pyoli	Linaceae	Herb	-	Medicinal
Rhamnus virgata Roxb.	Chaitula	Rhamnaceae	Tree	LC	Construction
Rhododendron arboreum Sm.	Burans	Ericaceae	Tree	LC	Ornamental
Rhus parviflora Roxb.	Tung	Anacardiaceae	Shrub	-	Firewood
Ribes uva-crispa L.	Caktu	Grossulariaceae	Shrub	-	Medicinal
Ricinus communis L.	Inde	Euphorbiaceae	Shrub	-	Medicinal
Robinia pseudoacacia L.	Pahari kikar	Fabaceae	Tree	LC	Ornamental
Rosa moschata Herrm.	Kunja	Rosaceae	Shrub	-	Medicinal
Rubia cordifolia L.	Majethi	Rubiaceae	Climber	-	Medicinal
Rubia manjith Roxb. ex Fleming	Manjith	Rubiaceae	Climber	-	Medicinal
Rubus ellipticus Sm.	Lalanchu	Rosaceae	Shrub	-	Medicinal
Rubus niveus Thunb.	Kala Hinsalu	Rosaceae	Shrub	-	Medicinal
Rubus niveus Thunb.	kala hinsalu	Rosaceae	Herb		Medicinal
Rubus paniculatus Sm.	Kadula	Rosaceae	Climber	-	Medicinal
Rumex hastatus D.Don	Chalmore	Polygonaceae	Herb	-	Animal feed
Saccharum spontaneum L.	Kans Grass	Gramineae	Herb	LC	Animal feed
Saccharum spontaneum L.	Kans	Gramineae	Grass	LC	Animal feed
Salix denticulata Andersson	Garbainsh	Salicaceae	Tree	-	Timber
Sapindus mukorossi Gaertn.	Reetha	Sapindaceae	Tree	-	Constrution
Sarcococca pruniformis Lindl.	Tiliari	Euphorbiaceae	Shrub	-	-
Saussurea auriculata (DC.) Sch.Bip.	Kushtha	Asteraceae	Herb	-	Medicinal
Scutellaria angulosa Benth.	Paani Jhaar	Lamiaceae	Herb	-	Medicinal

Botanical name	Local name	Family	Habit	IUCN Red list	Uses
Selenium vaginatum (Edgew) CB Clarke	Bhutberi	Apiaceae	Herb	-	Medicinal
Senecio nudicaulis Buch.-Ham. ex D.Don	Turakya	Asteraceae	Herb	-	Medicinal
Senna occidentalis (L.) Link	Kasondi	Caesalpiniaceae	Tree	-	Construction
*Shorea robusta*Gaertn.	Sal	Dipterocarpaceae	Tree	LC	Construction
Sida cordifolia L.	Balu	Malvaceae	Herb	-	Medicinal
Silene indica (Roxb.) Roxb. ex Otth		Caryophyllaceae	Herb	-	Medicinal
Solanum anguivi Lam.	Kandyari	Solanaceae	Shrub	-	Medicinal
Solanum lasiocarpum Dunal	Chitrika	Solanaceae	Shrub	-	Medicinal
Solanum violaceum Ortega	Brahati	Solanaceae	Shrub	-	Medicinal
Solena heterophylla Lour.	Gulakhar	Cucurbitaceae	Climber	-	Fruit edible
Sonchus oleraceus (L.) L.	Dudhi, Pathari	Asteraceae	Herb	-	Medicinal
Sorbus cuspidata (Spach) Hedl.		Rosaceae	Tree	-	Timber
Sphaeranthus indicus L.	Tapasvini	Asteraceae	Herb	LC	Medicinal
Symplocos racemosa Roxb.	Ladha	Symplocaceae	Shrub	-	Medicinal
Syzygium cumini (L.) Skeels.	Jamun	Myrtaceae	Tree	LC	Fruit Edible
Tanacetum nubigenum Wall. ex DC.		Asteraceae	Herb	-	Incense
Taraxacum officinale (L.) Weber ex F.H.Wigg.	Pitachumki	Asteraceae	Herb	-	Edible
Taxus baccata L.	Thuner	Taxaceae	Tree	LC	Timber
Tecomella undulata (Sm.) Seem.	Rohitaka	Bignoniaceae	Tree	-	Ornamental
Tephrosia purpurea (L.)Pers.	Sarphonk	Fabaceae	Herb	LC	Medicinal
Terminalia bellirica (Gaerth.)Roxb.	Bahera	Combretaceae	Tree	-	Timber
Terminalia chebula Retz.	Harad	Combretaceae	Tree	-	Constrution
Thalictrum foliolosum DC.	Mamiri	Ranunculaceae	Herb	-	Medicinal
Thymus serpyllum L.	Jangli ajwain	Lamiaceae	Herb	-	Medicinal
Tinospora sinensis (Lour.) Merr.	Gurjya bel	Menispermaceae	Climber	-	Medicinal
Toona ciliata M.Roem.	Toon	Meliaceae	Tree	LC	Construction
Trifolium repens L.	Garila	Fabaceae	Herb	-	Medicinal

Botanical name	Local name	Family	Habit	IUCN Red list	Uses
Triumfetta rhomboidea Jacq.	Ban okra	Malvaceae	Shrub	-	Medicinal
Urena lobata L	Aramina	Malvaceae	Shrub	LC	Medicinal
Urtica dioica L.	Siyoon	Urticaceae	Shrub	LC	Medicinal
Urtica parviflora Roxb.	Kandali	Urticaceae	Shrub	-	Medicinal
Valeriana jatamansi Jones.	Sumaya	Valeriancaceae	Herb	-	Medicinal
Vallaris solanacea (Roth) Kuntze	Dudhi Bel	Apocynaceae	Climber	-	Medicinal
Vanda tessellata (Roxb.) Hook. ex G.Don	Badang	Orchidaceae	Epiphyte	LC	Medicinal
Vanda tessellata (Roxb.) Hook. ex G.Don	Badang	Orchidaceae	Epiphyte	LC	Medicinal
Verbascum thapsus L.	Mullein	Scrophulariaceae	Herb	-	Medicinal
*Veronica persic*a Poir.		Plantaginaceae	Herb	-	Medicinal
Viburnum nervosum D.Don	Asaraa	Viburnaceae	Shrub	-	Medicinal
Viola canescens Wall.	Banafsha	Violaceae	Herb	-	Medicinal
Vitex negundo L.	Siwain	Verbenaceae	Shrub	LC	Firewood
Woodfordia fruticosa (L.) Kurz	Dhuinya	Lythraceae	Shrub	LC	Firewood
Youngia japonica (L.) DC.	Dudhi	Asteraceae	Herb	-	Medicinal
Zanthoxylum armatum DC.	Timur	Rutaceae	Shrub	LC	Firewood
Ziziphus mauritiana Lam.	Ber	Rhamnaceae	Shrub	LC	Fruit Edible

3.4.1.5 Quantitative Analysis of commonly characteristics at various sampling sites

(I) Dam site

Trees

In Dam site, a total of 29 tree species (≥ 5 cm dbh or ≥16 cm GBH) was recorded in the VPHE Project, Uttarakhand during post-monsoon season. The density of tree species recorded was 170 individuals ha $^{-1}$ **(Table-3.18).** In terms of density *Alnus nepalensis* (16 individuals ha $^{-1}$), *Pinus roxburghii* (16 individuals ha $^{-1}$), *Toona ciliate* (16 individuals ha $^{-1}$) followed by *Rhododendron arboreum* (12 individuals ha $^{-1}$) *Neolitsea pallens* (8 individuals ha $^{-1}$) was the dominant species. The total basal area of all tree species recorded was 49.54 m^2 ha $^{-1}$ in the Dam site. In terms of basal area, *Rhododendron arboreum* has more basal area as compare to other tree species. In terms of importance value index (IVI), *Pinus*

roxburghii was the dominant tree species (IVI= 30.44) followed by *Alnus nepalensis* (IVI= 25.41) *Toona ciliate* (IVI= 25.09). The details are given in **Table-3.18.**

Table-3.18: Frequency, density, basal area, IVI, volume and abundance of tree species recorded at the dam site of VPHE Project, Uttarakhand during post monsoon season

Botanical name	Frequency (%)	Density (individuals ha $^{-1}$)	Basal area (m ^{2} ha $^{-1}$)	IVI	Volume (m^{3})	Abundance
Aesculus indica (Wall. ex Cambess.) Hook	12	8	2.24	13.51	0.17	1.33
Albizia lebbeck (L.) Benth.	8	4	1.16	7.55	0.10	1
Alnus nepalensis D.Don	24	16	3.68	25.41	0.35	1.33
Bauhinia variegata L.	4	2	0.54	3.70	0.05	1
Boehmeria rugulosa Wedd.	4	2	0.56	3.74	0.05	1
Callicarpa arborea Roxb.	8	4	1.12	7.47	0.11	1
Cedrus deodara (Roxb. ex D.Don) G.Don	8	4	1.88	9.00	0.18	1
Celtis australis L.	4	2	0.7	4.02	0.07	1
Cupressus torulosa C.Don	8	6	2.16	10.75	0.25	1.5
Dalbergia sissoo DC.	12	6	1.98	11.81	0.22	1
Delonix regia (Hook.) Raf.	8	4	0.88	6.99	0.06	1
Falconeria insignis Royle	4	2	0.48	3.57	0.04	1
Ficus religiosa L.	8	4	0.96	7.15	0.09	1
Grewia oppositifolia Roxb. ex DC.	8	4	0.68	6.58	0.04	1
Juniperus communis L.	4	4	1.28	6.37	0.13	2
Melia azedarach L.	4	4	1.36	6.53	0.12	2
Neolitsea pallens (D. Don) Momiy. & H. Hara	12	8	1.92	12.87	0.15	1.33
Pinus roxburghii Sarg.	20	16	6.88	30.44	0.83	1.6
Populus ciliata Wall. ex Royle	8	6	1.14	8.69	0.11	1.5
Pterocarpus marsupium Roxb.	8	4	1.16	7.55	0.10	1
Pyrus pashia Buch.-Ham. ex D. Don – Kainth	12	6	2.04	11.93	0.16	1
Quercus incana Bartram	8	4	1	7.23	0.10	1
Rhamnus virgata Roxb.	12	6	1.14	10.12	0.10	1
Rhododendron arboreum Sm.	16	12	4.44	21.74	0.44	1.5
Salix denticulata Andersson	8	4	1.52	8.28	0.13	1
Sorbus cuspidata (Spach) Hedl.	8	4	0.88	6.99	0.08	1
Syzygium cumini (L.) Skeels.	12	6	1.74	11.33	0.17	1
Terminalia chebula Retz.	4	2	0.5	3.61	0.04	1
Toona ciliata M.Roem.	24	16	3.52	25.09	0.26	1.33
Total	**280**	**170**	**49.54**	**300.00**	**4.69**	**34.43**

Shrubs

A total of only 34 shrub, bamboo and climber were recorded from dam site during study post-monsoon season of VPHE Project in 2020. The density of shrub species was recorded to be 276 individuals ha $^{-1}$ **(Table-5).** In terms of density, *Lantana camara*, *Debregeasia saeneb* (28 individuals ha $^{-1}$) followed by *Clerodendrum infortunatum* (16 individuals ha $^{-1}$)

Boehmeria macrophylla, Callicarpa macrophylla, Justicia adhatoda, *Solanum anguivi*, *Woodfordia fruticosa* (12 individuals' ha $^{-1}$) was the dominant shrub layer species in the shrub canopy layer. Other species density is less and recorded limited in number. In terms of importance value index (IVI), *Lantana camara, Debregeasia saeneb* was the dominant shrub species (IVI= 16.27) followed by *Clerodendrum infortunatum* (IVI= 11.92). The details are given in **Table-3.19.**

Table-3.19: Frequency, density, IVI and abundance of shrub species recorded at the dam site of VPHE Project, Uttarakhand during post monsoon season

Botanical name	Frequency (%)	Density (individuals ha $^{-1}$)	IVI	Abundance
Abrus precatorius L.	4	4	3.49	1
Boehmeria macrophylla Hornem.	8	12	8.43	1.50
Brucea javanica (L.) Merr.	4	8	4.94	2
Callicarpa macrophylla Vahl.	8	12	8.43	1.5
Carissa spinarum L.	4	4	3.49	1
Celastrus paniculatus Willd	4	8	4.94	2
Cissampelos pareira L.	4	4	3.49	1
Clematis buchananiana DC.	4	8	4.94	2
Clerodendrum infortunatum L.	12	16	11.92	1.33
Coriaria nepalensis Wall.	4	4	3.49	1
Cotoneaster microphyllus Wall. ex Lindl.	8	8	6.98	1
Debregeasia saeneb (Forssk.) Hepper & J.R.I.Wood	12	28	16.27	2.33
Erythrina suberosa Roxb.	4	8	4.94	2
Gaultheria fragrantissima Wall.	8	8	6.98	1
Hemidesmus indicus (L.) R. Br. ex Schult.	4	4	3.49	1
Hypericum oblongifolium Choisy	8	8	6.98	1
Hyssopus officinalis L.	4	4	3.49	1
Inula cappa (Buch.-Ham. ex D.Don) DC.	4	4	3.49	1
Ipomoea purpurea (L.) Roth	4	8	4.94	2
Justicia adhatoda L.	8	12	8.43	1.5
Lantana camara L.	12	28	16.27	2.33
Lonicera angustifolia Wall. ex DC.	8	8	6.98	1
Operculina turpethum (L.) Silva Manso	4	4	3.49	1
Plumbago zeylanica L.	4	4	3.49	1
Pyracantha crenulata (Roxb. ex D.Don) M.Roem.	4	4	3.49	1
Rhus parviflora Roxb.	4	4	3.49	1
Rubus niveus Thunb.	4	4	3.49	1
Sarcococca pruniformis Lindl.	4	4	3.49	1
Solanum anguivi Lam.	8	12	8.43	1.50
Urtica dioica L.	4	8	4.94	2
Urtica parviflora Roxb.	4	4	3.49	1
Viburnum nervosum D.Don	4	4	3.49	1
Woodfordia fruticosa (L.) Kurz	8	12	8.43	1.5

Botanical name	Frequency (%)	Density (individuals ha $^{-1}$)	IVI	Abundance
Zanthoxylum armatum DC.	4	4	3.49	1
Total	**196**	**276**	**200.00**	**45.50**

Herbs

A total of only 57 herb, grass, epiphyte and fern were recorded from submergence area during study post-monsoon season of VPHE Project in 2020. The density of shrub species was recorded to be 67600 individuals ha $^{-1}$ **(Table-3.20).** In terms of density, *Ageratina adenophora* (4800 individuals ha $^{-1}$) followed by *Euphorbia hirta*, *Galinsoga parviflora* (2400 individuals' ha $^{-1}$) were the dominant herbaceous species. In terms of importance value index (IVI), *Ageratina adenophora* (IVI=13.14), was the dominant herbaceous species followed by *Euphorbia hirta* (IVI=5.14). The details are given in Table-3.20.

Table-3.20: Frequency, density, IVI and abundance of herb species recorded at the dam site of VPHE Project, Uttarakhand during post monsoon season

Botanical name	Frequency (%)	Density (individuals ha $^{-1}$)	IVI	Abundance
Achyranthes aspera L.	12	2000	5.54	1.67
Ageratina adenophora (Spreng.) R.M.King & H.Rob.	28	4800	13.14	1.71
Ageratum conyzoides (L.) L.	12	2000	5.54	1.67
Agrimonia pilosa Ledeb.	4	400	1.45	1.00
Althaea officinalis L.	8	800	2.91	1.00
Arisaema flavum (Forssk.) Schott	4	800	2.05	2.00
Artemisia nilagirica (C.B.Clarke) Pamp.	8	1200	3.50	1.50
Astragalus condolleanus Royle	8	1200	3.50	1.50
Barleria cristata L.	12	1200	4.36	1.00
Bistrota amplexicaulis Greene	4	800	2.05	2.00
Calendula officinalis L.	8	1600	4.09	2.00
Cassia absus Sesse & Moc.	8	800	2.91	1.00
Celosia argentea L.	8	800	2.91	1.00
Chromolaena odorata (L.) R.M.King & H.Rob.	8	800	2.91	1.00
Cirsium arvense (L.) Scop.	8	800	2.91	1.00
Cynodon dactylon (L.) Persoon	8	1200	3.50	1.50
Delphinium denudatum Wall. ex Hook. f. & Thomson	8	1200	3.50	1.50
Echinops echinatus Roxb.	8	1600	4.09	2.00
Elephantopus scaber L.	16	2000	6.41	1.25
Erigeron bellidioides (Buch.-Ham. ex D.Don) Benth. ex C.B.Clarke	4	800	2.05	2.00
Eulaliopsis binata (Retz.) C.E.Hubb.	4	1200	2.64	3.00
Euphorbia hirta L.	12	2400	6.14	2.00
Evolvulus alsinoides (L.) L.	8	2000	4.68	2.50
Fumaria indica (Haussk.)Pugsley	4	800	2.05	2.00
Galinsoga parviflora Cav.	16	2400	7.00	1.50
Galium aparine L	4	800	2.05	2.00

Botanical name	Frequency (%)	Density (individuals ha $^{-1}$)	IVI	Abundance
Lespedeza sericea (Thunb.) Miq.	12	1200	4.36	1.00
Leucas lanata Benth.	8	1200	3.50	1.50
Lindenbergia indica Vatke	12	1200	4.36	1.00
Lobelia nicotianifolia Roth ex Schult.	8	1200	3.50	1.50
Malva verticillata L.	4	800	2.05	2.00
Mentha longifolia (L.)L.	4	800	2.05	2.00
Morina longifolia Wall. ex DC.	8	800	2.91	1.00
Nepeta podostachys Benth	12	2000	5.54	1.67
Oxalis corniculata L.	4	400	1.45	1.00
Panicum miliaceum L.	8	800	2.91	1.00
Parthenium hysterophoru L.	8	800	2.91	1.00
Pimpinella diversifolia Dc	12	1600	4.95	1.33
Plantago major L.	4	800	2.05	2.00
Polygonatum verticillatum (L) All.	8	800	2.91	1.00
Polygonum capitatum Buc.-Ham.	4	400	1.45	1.00
Potentilla fulgens Wall.	8	800	2.91	1.00
Potentilla supine L.	8	800	2.91	1.00
Pouzolzia hirta Blume ex Hassk.	8	800	2.91	1.00
Pteris vittata L.	4	400	1.45	1.00
Ranunculus diffuses DC.	4	800	2.05	2.00
Reinwardtia indica Dumort.	8	800	2.91	1.00
Rumex hastatus D.Don	4	400	1.45	1.00
Saccharum spontaneum L.	4	1600	3.23	4.00
Selenium vaginatum (Edgew) CB Clarke	4	800	2.05	2.00
Senecio nudicaulis Buch.-Ham. ex D.Don	12	2000	5.54	1.67
Sida rhombifolia L	8	1200	3.50	1.50
Silene indica (Roxb.) Roxb.ex otth	12	1600	4.95	1.33
Taraxacum campylodes G.E. haglund.	8	1200	3.50	1.50
Thymus serpyllum L.	4	800	2.05	2.00
Trifolium repens L.	8	800	2.91	1.00
Verbascum thapsus L.	12	1600	4.95	1.33
Total	**464**	**67600**	**200.00**	**86.63**

(II). Submergence area Trees

In submergence area, a total of 27 tree species (≥ 5 cm dbh or ≥16 cm GBH) was recorded in the VPHE Project, Uttarakhand during post-monsoon season. The density of tree species recorded was 166 individuals ha $^{-1}$ **(Table-3.21)**. In terms of density *Pinus roxburghii* (20 individuals ha $^{-1}$) followed by *Sapindus mukorossi* (14 individuals ha $^{-1}$) *Rhododendron arboreum* (12 individuals ha $^{-1}$) was the dominant species. The total basal area of all tree species recorded was 54.54 m^2 ha $^{-1}$ in the submergence area. In terms of basal area, *Pinus roxburghii* has more basal area as compare to other tree species. In terms of importance value index (IVI), *Pinus roxburghii* was the dominant tree species (IVI= 36.17) followed by

Sapindus mukorossi (IVI= 26. 51) *Rhododendron arboreum* (IVI= 22.44). The details are given in **Table-3.21**.

Table-3.21: Frequency, density, basal area, IVI, volume and abundance of tree species recorded at the Submergence area of VPHE Project, Uttarakhand during post monsoon season

Botanical name	Frequency (%)	Density (individuals ha $^{-1}$)	Basal area (m ^{2} ha $^{-1}$)	IVI	Volume (m^{3})	Abundance
Abies pindrow (Royle ex D.Don) Royle	12	8	3.04	15.85	0.33	1.33
Aesculus indica (Wall. ex Cambess.) Hook	8	6	1.38	9.78	0.13	1.50
Azadirachta indica A. Juss	4	4	1.64	7.23	0.17	2.00
Boehmeria rugulosa Wedd.	4	4	0.88	5.84	0.06	2.00
Callicarpa arborea Roxb.	8	4	1.12	8.10	0.10	1.00
Cedrus deodara (Roxb. ex D.Don) G.Don	8	8	3.44	14.76	0.41	2.00
Cupressus torulosa C.Don	4	4	1.4	6.79	0.15	2.00
Delonix regia (Hook.) Raf.	8	4	0.76	7.44	0.04	1.00
Ficus benghalensis L.	4	2	0.94	4.75	0.10	1.00
Ficus religiosa L.	8	6	1.86	10.66	0.20	1.50
Gmelina arborea Roxb.	4	2	0.58	4.09	0.05	1.00
Grewia oppositifolia Roxb. ex DC.	8	6	1.44	9.89	0.12	1.50
Juniperus communis L.	8	4	1.8	9.35	0.21	1.00
Maesa indica (Roxb.) A.DC.	4	4	0.76	5.62	0.06	2.00
Mallotus philippensis (Lam.) Müll.Arg.	12	10	3.2	17.35	0.27	1.67
Neolitsea pallens (D. Don) Momiy. & H. Hara	8	4	1.12	8.10	0.08	1.00
Phoenix humilis (L.) Cav.	8	6	1.74	10.44	0.17	1.50
Pinus roxburghii Sarg.	20	20	8.2	36.17	0.82	2.00
Populus ciliata Wall. ex Royle	8	6	1.74	10.44	0.13	1.50
Psidium guajava L.	4	4	1.08	6.21	0.06	2.00
Quercus incana Bartram	4	2	0.48	3.90	0.04	1.00
Rhododendron arboreum Sm.	16	12	3.24	20.44	0.28	1.50
Salix denticulata Andersson	8	4	1.12	8.10	0.10	1.00
Sapindus mukorossi Gaertn.	20	14	4.9	26.51	0.54	1.40
Sorbus cuspidata (Spach) Hedl.	4	4	0.76	5.62	0.06	2.00
Taxus baccata L.	8	8	3.76	15.35	0.41	2.00
T*oona ciliata* M.Roem.	8	6	2.16	11.21	0.23	1.50
Total	**220**	**166**	**54.54**	**300.00**	**5.33**	**40.90**

Shrubs

A total of only 38 shrub, bamboo and climber were recorded from submergence area during study post-monsoon season of VPHE Project in 2020. The density of shrub species was

recorded to be 376 individuals ha $^{-1}$ **(Table-3.22)**. In terms of density, *Opuntia monacantha* (28 individuals ha $^{-1}$) followed by *Brucea javanica* (24 individuals ha $^{-1}$), *Dendrocalamus strictus*, *Phragmites australis* (20 individuals' ha $^{-1}$) was the dominant shrub layer species in the shrub canopy layer. Other species density is less and recorded limited in number. In terms of importance value index (IVI), *Brucea javanica* was the dominant shrub species (IVI= 13.33) followed by *Clerodendrum infortunatum* (IVI= 13.00). The details are given in **Table-3.22**.

Table-3.22: Frequency, density, IVI and abundance of shrub species recorded at the Submergence area of VPHE Project, Uttarakhand during post monsoon season

Botanical name	Frequency (%)	Density (individuals ha $^{-1}$	IVI	Abundance
Bidens pilosa L.	16	16	9.81	1
Boehmeria macrophylla Hornem.	4	4	2.45	1
Brucea javanica (L.) Merr.	20	24	13.33	1.2
Callicarpa macrophylla Vahl.	4	4	2.45	1
Celastrus paniculatus Willd	4	4	2.45	1
Cissampelos pareira L.	8	12	5.97	1.5
Coriaria nepalensis Wall.	12	12	7.36	1
Debregeasia saeneb (Forssk.) Hepper & J.R.I.Wood	12	12	7.36	1
Dendrocalamus strictus (Roxb.) Nees	4	20	6.71	5
Embelia ribes Burm.f.	12	12	7.36	1
Erythrina suberosa Roxb.	4	8	3.52	2
Hemidesmus indicus (L.) R. Br. ex Schult.	12	12	7.36	1
Hypericum oblongifolium Choisy	8	8	4.91	1
Hyssopus officinalis L.	12	16	8.42	1.33
Inula cappa (Buch.-Ham. ex D.Don) DC.	4	4	2.45	1
Isodon coetsa (Buch.-Ham. ex D.Don) Kudô	8	8	4.91	1
Leptadenia reticulata (Retz.) Wight & Arn.	4	4	2.45	1
Lonicera angustifolia Wall. ex DC.	8	12	5.97	1.5
Operculina turpethum (L.) Silva Manso	4	8	3.52	2
Opuntia monacantha Haw.	16	28	13.00	1.75
Phragmites australis (Cav.) Trin. ex Steud.	8	20	8.10	2.5
Plumbago zeylanica L.	4	4	2.45	1
Prinsepia utilis Royle	8	8	4.91	1
Pyracantha crenulata (Roxb. ex D.Don) M.Roem.	4	8	3.52	2
Rhus parviflora Roxb.	8	8	4.91	1
Rosa moschata Herrm.	4	8	3.52	2
Rubia manjith Roxb. ex Fleming	4	4	2.45	1
Rubus niveus Thunb.	8	8	4.91	1
Rubus paniculatus Sm.	4	4	2.45	1
Sarcococca pruniformis Lindl.	4	4	2.45	1
Solena heterophylla Lour.	4	4	2.45	1

Botanical name	Frequency (%)	Density (individuals ha $^{-1}$	IVI	Abundance
Symplocos racemosa Roxb.	4	4	2.45	1
Tinospora sinensis (Lour.) Merr.	8	8	4.91	1
Triumfetta rhomboidea Jacq.	12	12	7.36	1
Urtica dioica L.	8	12	5.97	1.5
Urtica parviflora Roxb.	4	8	3.52	2
Viburnum nervosum D.Don	8	8	4.91	1
Zanthoxylum armatum DC.	8	16	7.03	2
Total	**288**	**376**	**200.0**	**52.28**

Herbs

A total of only 68 herb, grass,epiphyte and fern were recorded from submergence area during study post-monsoon season of VPHE Project in 2020.The density of shrub species was recorded to be 87600 individuals ha $^{-1}$ **(Table-3.23)**. In terms of density, *Ageratina adenophora* (4400 individuals ha $^{-1}$) followed by *Aerva sanguinolenta*, *Galinsoga parviflora* (2800 individuals' ha $^{-1}$) were the dominant herbaceous species. In terms of importance value index (IVI), *Ageratina adenophora* (IVI=8.23), was the dominant herbaceous species followed by *Ageratum conyzoides* (IVI=5.94). The details are given in **Table-3.23.**

Table-3.23: Frequency, density, IVI and abundance of herb species recorded at the Submergence area of VPHE Project, Uttarakhand during post monsoon season

Botanical name	Frequency (%)	Density (individuals ha $^{-1}$	IVI	Abundance
Achillea millefolium L.	8	800	2.20	1.00
Achyranthes aspera L.	12	1600	3.75	1.33
Adiantum caudatum L.	12	2000	4.21	1.67
Aerva sanguinolenta (L.) Blume	16	2800	5.76	1.75
Ageratina adenophora (Spreng.) R.M.King & H.Rob.	20	4400	8.23	2.20
Ageratum conyzoides (L.) L.	20	2400	5.94	1.20
Agrimonia pilosa Ledeb.	8	1200	2.65	1.50
Althaea officinalis L.	8	1200	2.65	1.50
Anaphalis busua (Buch.-Ham.)DC.	8	800	2.20	1.00
Argemone mexicana L.	12	2000	4.21	1.67
Arisaema flavum (Forssk.) Schott	4	1200	2.01	3.00
Artemisia nilagirica (C.B.Clarke) Pamp.	12	1600	3.75	1.33
Astragalus condolleanus royle	8	1200	2.65	1.50
Bacopa monnieri (L.)Wettst	8	1600	3.11	2.00
Barleria cristata L.	8	800	2.20	1.00
Bergenia ciliata (Haw.) Sternb.	12	1600	3.75	1.33
Boerhavia diffusa Kuntze	4	800	1.55	2.00
Calendula officinalis L.	8	2000	3.57	2.50
Campanula pallida Wall	4	800	1.55	2.00
Canna indica L.	8	1600	3.11	2.00
Capsella bursa-pastoris (L.) Medik.	8	800	2.20	1.00
Cassia absus Sesse &Moc.	8	1200	2.65	1.50
Celosia argentea L.	8	1200	2.65	1.50

Botanical name	Frequency (%)	Density (individuals ha $^{-1}$	IVI	Abundance
Chromolaena odorata (L.) R.M.King & H.Rob.	8	800	2.20	1.00
Cirsium arvense (L.) Scop.	4	800	1.55	2.00
Commelina benghalensis L.	4	800	1.55	2.00
Cynodon dactylon (L.) persoon	12	1200	3.29	1.00
Delphinium denudatum Wall. Ex Hook.f. & Thomson	12	1200	3.29	1.00
Desmodium heterocarpon (L.) DC	16	2000	4.85	1.25
Dryopteris species	4	800	1.55	2.00
Echinops echinatus Roxb.	4	1600	2.47	4.00
Elephantopus scaber L.	12	2000	4.21	1.67
Eriophrum comosum (Wall.) Nees	12	1600	3.75	1.33
Euphorbia hirta L.	8	2000	3.57	2.50
Evolvulus alsinoides (L.) L.	12	1600	3.75	1.33
Fragaria nubicola (Lindl. ex Hook.f.) Lacaita	4	800	1.55	2.00
Galinsoga parviflora Cav.	16	2800	5.76	1.75
Geranium rotundifolium L	8	800	2.20	1.00
Acomastylis elata var. elata	8	800	2.20	1.00
Heychium spicatum Sm.	8	1200	2.65	1.50
Hyoscyamus niger L.	4	800	1.55	2.00
Lespedeza sericea (Thunb.) Miq.	8	800	2.20	1.00
Leucas lanata Benth.	8	800	2.20	1.00
Lindenbergia indica Vatke	12	1200	3.29	1.00
Lobelia nicotianifolia Roth ex Schult.	12	1600	3.75	1.33
Mentha longifolia (L.)L.	12	1600	3.75	1.33
Morina longifolia Wall. ex DC.	8	800	2.20	1.00
Nepeta podostachys Benth.	12	1200	3.29	1.00
Oenothera rosea L. Her. ex Aiton	4	400	1.10	1.00
Panicum miliaceum L.	8	800	2.20	1.00
Parthenium hysterophoru L.	12	1600	3.75	1.33
Plantago depressa Willd	4	800	1.55	2.00
Plantago major L.	8	800	2.20	1.00
Potentilla supine L.	4	800	1.55	2.00
Pteris vittata L.	8	1200	2.65	1.50
Pyrrosia adnascens (Sw.)Ching	8	800	2.20	1.00
Ranunculus hirtellus Royle	8	800	2.20	1.00
Reinwardtia indica Dumort.	12	1200	3.29	1.00
Rumex hastatus D.Don	16	2000	4.85	1.25
Saccharum spontaneum L.	16	2000	4.85	1.25
Saussurea auriculata (DC.) Sch.Bip.	8	800	2.20	1.00
Silene indica var. edgeworthii (Bocquet) Y.J. Nasir	12	1200	3.29	1.00
Sonchus oleraceus (L.) L.	8	800	2.20	1.00
Sphaeranthus indicus L.	4	800	1.55	2.00
Tanacetum nubigenum Wall. ex DC.	8	800	2.20	1.00
Thalictrum foliolosum DC.	12	1200	3.29	1.00
Vanda tessellata (Roxb.) Hook. ex G.Don	4	400	1.10	1.00
Verbascum thapsus L.	8	1200	2.65	1.50
Total	**624**	**87600**	**200.0**	**100.32**

(III). Catchment area (Helong village and surrounding area)

Tree

In catchment area, a total of 33 tree species (≥ 5 cm dbh or ≥16 cm GBH) was recorded in the VPHE Project, Uttarakhand during post-monsoon season. The density of tree species recorded was 340 individuals ha $^{-1}$) **(Table-3.24)**. In terms of density *Pinus roxburghii* (22 individuals ha $^{-1}$) followed by *Sapindus mukorossi* (18 individuals ha $^{-1}$) *Rhododendron arboreum* (14 individuals ha $^{-1}$), *Mallotus philippensis* (14 individuals ha $^{-1}$), was the dominant species. The total basal area of all tree species recorded was 102.86 m^2 ha $^{-1}$ in the catchment area. In terms of basal area, *Pinus roxburghii* has more basal area as compare to other tree species. In terms of importance value index (IVI), *Pinus roxburghii* was the dominant tree species (IVI= 22.93) followed by *Sapindus mukorossi* (IVI= 13.94) *Cedrus deodara* (IVI= 13.66). The details are given in **Table-3.24.**

Table-3.24: Frequency, density, basal area, IVI, volume and abundance of tree species recorded at the catchment area of VPHE Project, Uttarakhand during post monsoon season

Botanical name	Frequency (%	Density (individuals ha $^{-1}$)	Basal area (m^2 ha $^{-1}$	IVI	Volume (m^3)	Abundance
Acacia nilotica (L.) Delile	12	8	2.88	7.72	0.26	1.33
Aesculus indica (Wall. ex Cambess.) Hook	16	10	2.8	9.08	0.21	1.25
Alnus nepalensis D.Don	20	12	3.24	10.95	0.28	1.2
Betula utilis D.Don.	12	8	2.32	7.17	0.27	1.33
Bombax malabaricum DC	8	6	1.44	4.87	0.14	1.5
Callicarpa arborea Roxb.	12	6	1.62	5.90	0.16	1
Cedrus deodara (Roxb. ex D.Don) G.Don	16	14	6.3	13.66	0.66	1.75
Celtis australis L.	12	10	2.8	8.23	0.27	1.67
Cupressus torulosa C.Don	12	10	4.7	10.07	0.42	1.67
Dalbergia sissoo DC.	12	10	3.5	8.91	0.33	1.67
Delonix regia (Hook.) Raf.	16	12	2.52	9.40	0.21	1.5
Diploknema butyracea (Roxb.) H.J.Lam	16	8	2.48	8.18	0.26	1
Falconeria insignis Royle	12	8	2.64	7.48	0.29	1.33
Ficus benghalensis L.	12	8	2.48	7.33	0.29	1.33
Ficus religiosa L.	16	10	2.7	8.98	0.26	1.25
Grewia oppositifolia Roxb. ex DC.	12	10	2.4	7.84	0.24	1.67
Juniperus communis L.	12	6	1.02	5.32	0.07	1
Lannea coromandelica (Houtt.) Merr.	12	8	1.76	6.63	0.18	1.33
Mallotus philippensis (Lam.) Müll.Arg.	16	14	3.78	11.21	0.38	1.75
Myrica esculenta Buch.-Ham. ex D. Don	16	12	2.28	9.16	0.17	1.5

Botanical name	Frequency (%	Density (individuals ha $^{-1}$)	Basal area (m ^{2} ha $^{-1}$	IVI	Volume (m^{3})	Abundance
Neolitsea pallens (D. Don) Momiy. & H. Hara	12	8	2.24	7.09	0.16	1.33
Phoenix humilis (L.) Cav.	16	14	3.78	11.21	0.32	1.75
Pinus roxburghii arg.	28	22	10.78	22.93	1.40	1.57
Pistacia khinjuk Socks.	4	4	1.16	3.16	0.10	2
Prunus persica (L.) Batsch.	16	10	3.1	9.37	0.31	1.25
Pterocarpus marsupium Roxb.	12	8	1.44	6.32	0.12	1.33
Pyrus pashia Buch.-Ham. ex D. Don – Kainth	4	4	1.24	3.24	0.14	2
Quercus incana Bartram	12	6	1.68	5.96	0.15	1
Rhamnus virgata Roxb.	4	6	1.26	3.84	0.13	3
Rhododendron arboreum Sm.	16	14	6.02	13.39	0.57	1.75
Salix denticulata Andersson	4	4	1.16	3.16	0.10	2
Sapindus mukorossi Gaertn.	20	18	4.5	13.94	0.45	1.8
Sorbus cuspidata (Spach) Hedl.	4	4	0.76	2.77	0.06	2
Syzygium cumini (L.) Skeels.	8	4	0.84	3.70	0.07	1
Taxus baccata L.	8	6	2.28	5.69	0.19	1.5
Terminalia chebula Retz.	8	4	1.04	3.90	0.10	1
Toona ciliata M.Roem.	20	14	3.92	12.20	0.33	1.4
Total	**468**	**340**	**102.86**	**300.0**	**10.04**	**55.72**

Shrubs

A total of only 53 shrub, bamboo and climber were recorded from catchment area during study post-monsoon season of VPHE Project in 2020. The density of shrub species was recorded to be 832 individuals ha $^{-1}$ **(Table-3.25)**. In terms of density, *Debregeasia saeneb, Ricinus communis, Ephedra gerardiana, Lantana camara*, *Murraya koenigii and Ziziphus mauritiana* (28 individuals ha $^{-1}$) followed by *Woodfordia fruticosa, Solanum anguivi* (24 individuals ha $^{-1}$), *Bidens pilosa, Dendrocalamus strictus*, Dendrocalamus strictus, *Indigofera heterantha*, *Leptadenia reticulate*, *Solanum violaceum Vitex negundo* and Zanthoxylum armatum (20 individuals' ha $^{-1}$) was the dominant shrub layer species in the shrub canopy layer. Other species density is less and recorded limited in number. In terms of importance value index (IVI), *Lantana camara* was the dominant shrub species (IVI= 7.29) followed by *Ricinus communis, Murraya koenigii* (IVI= 6.62). The details are given in **Table-3.25.**

Table-3.25: Frequency, density, IVI and abundance of shrub species recorded at the catchment area of VPHE Project, Uttarakhand during post monsoon season

Botanical name	Frequency (%)	Density (individuals ha $^{-1}$)	IVI	Abundance
Berberis aristata DC.	12	16	3.88	1.33

Botanical name	Frequency (%)	Density (individuals ha $^{-1}$)	IVI	Abundance
Bidens pilosa L.	12	20	4.36	1.67
Boehmeria macrophylla Hornem.	12	20	4.36	1.67
Brucea javanica (L.) Merr.	4	8	1.62	2
Carissa spinarum L.	8	12	2.75	1.5
Celastrus paniculatus Willd	8	12	2.75	1.5
Clerodendrum infortunatum L.	12	16	3.88	1.33
Coriaria nepalensis Wall.	12	16	3.88	1.33
Cotoneaster microphyllus Wall. ex Lindl.	4	12	2.10	3
Cryptolepis dubia (Burm.f.) M.R.Almeida	4	4	1.13	1
Datura metal L.	12	12	3.40	1
Debregeasia saeneb (Forssk.) Hepper & J.R.I.Wood	12	28	5.33	2.33
Dendrocalamus strictus (Roxb.) Nees	12	20	4.36	1.67
Dioscorea bulbifera L.	8	8	2.27	1
Ephedra gerardiana Wall. ex Stapf	12	28	5.33	2.33
Erythrina suberosa Roxb.	12	12	3.40	1
Gaultheria fragrantissima Wall	8	12	2.75	1.5
Hemidesmus indicus (L.) R. Br. ex Schult.	12	20	4.36	1.67
Hypericum oblongifolium Choisy	4	4	1.13	1
Hyssopus officinalis L.	12	16	3.88	1.33
Indigofera heterantha Brandis	12	20	4.36	1.67
Ipomoea purpurea (L.) Roth	12	12	3.40	1
Isodon coetsa (Buch.-Ham. ex D.Don) Kudô	4	4	1.13	1
Jasminum humile L.	16	16	4.54	1
Lantana camara L.	24	28	7.29	1.17
Lawsonia inermis L.	8	8	2.27	1
Leptadenia reticulata (Retz.) Wight & Arn.	12	20	4.36	1.67
Leptodermis lanceolata Wall.	12	20	4.36	1.67
Murraya koenigii (L.) Spreng.	20	28	6.63	1.4
Operculina turpethum (L.) Silva Manso	16	16	4.54	1
Opuntia monacantha Haw.	8	8	2.27	1
Phragmites australis (Cav.) Trin. ex Steud.	12	20	4.36	1.67
Rauvolfia serpentina (L.) Benth. ex Kurz	12	12	3.40	1
Ricinus communis L.	20	28	6.63	1.4
Rosa moschata Herrm.	12	12	3.40	1
Rubia cordifolia L.	8	8	2.27	1
Rubus niveus Thunb.	8	12	2.75	1.5
Rubus paniculatus Sm.	8	8	2.27	1
Sarcococca pruniformis Lindl.	16	16	4.54	1
Solanum anguivi Lam.	20	24	6.15	1.2
Solanum violaceum Ortega	12	20	4.36	1.67
Solena heterophylla Lour.	4	4	1.13	1
Triumfetta rhomboidea Jacq.	12	16	3.88	1.33
Urena lobata L	12	12	3.40	1
Urtica dioica L.	12	16	3.88	1.33
Urtica parviflora Roxb.	8	8	2.27	1
Vallaris solanacea (Roth) Kuntze	12	16	3.88	1.33
Viburnum nervosum D.Don	16	20	5.02	1.25

Botanical name	Frequency (%)	Density (individuals ha $^{-1}$)	IVI	Abundance
Vitex negundo L.	12	20	4.36	1.67
Woodfordia fruticosa (L.) Kurz	16	24	5.50	1.5
Zanthoxylum armatum DC.	12	12	3.40	1
Zanthoxylum armatum DC.	16	20	5.02	1.25
Ziziphus mauritiana Lam.	16	28	5.98	1.75
Total	**612**	**832**	**200.00**	**72.58**

Herbs

A total of only 84 herb, epiphyte, grass and fern were recorded from catchment area during study post-monsoon season of VPHE Project in 2020.The density of shrub species was recorded to be 133200 individuals ha $^{-1}$ **(Table-3.26)**. In terms of density, *Ageratina adenophora* (4800 individuals ha $^{-1}$) followed by *Elephantopus scaber and Eulaliopsis binata* (3200 individuals' ha $^{-1}$) were the dominant herbaceous species. In terms of importance value index (IVI), *Ageratina adenophora* (IVI= 6.89), was the dominant herbaceous species followed by *Eulaliopsis binata* (IVI= 4.75). The details are given in **Table-3.26.**

Table-3.26: Frequency, density, IVI and abundance of herb species recorded at the catchment area of VPHE Project, Uttarakhand during post monsoon season

Botanical name	Frequency (%)	Density (individuals ha $^{-1}$)	IVI	Abundance
Achyranthes aspera L.	12	2000	2.91	1.67
Adiantum caudatum L.	12	2000	2.91	1.67
Aerva sanguinolenta (L.) Blume	8	2400	2.74	3.00
Ageratina adenophora (Spreng.) R.M.King & H.Rob.	28	4800	6.89	1.71
Ageratum conyzoides (L.) L.	12	2000	2.91	1.67
Agrimonia pilosa Ledeb.	12	2000	2.91	1.67
Ajuga parviflora Benth.	12	1200	2.31	1.00
Allium wallichii Kunth	12	1600	2.61	1.33
Althaea officinalis L.	16	2800	3.98	1.75
Aquilegia pubiflora Wall. ex Royle	12	2000	2.91	1.67
Argemone mexicana L.	8	2400	2.74	3.00
Arisaema flavum (Forssk.) Schott	12	2400	3.21	2.00
Artemisia nilagirica (C.B.Clarke) Pamp.	8	1200	1.84	1.50
Astragalus condolleanus Royle	12	2400	3.21	2.00
Bacopa monnieri (L) Wettst	8	2000	2.44	2.50
Barleria cristata L.	12	1600	2.61	1.33
Bergenia ciliata Sternb.	8	1200	1.84	1.50
Bistrota amplexicaulis Greene	8	2000	2.44	2.50
Calendula officinalis L.	8	1600	2.14	2.00
Canna indica L.	8	1600	2.14	2.00
Capsella bursa-pastoris (L.) Medik.	12	2000	2.91	1.67
Cassia absus Sesse & Moc.	12	2800	3.51	2.33
Celosia argentea L.	8	1200	1.84	1.50

Botanical name	Frequency (%)	Density (individuals ha $^{-1}$)	IVI	Abundance
Chromolaena odorata (L.) R.M.King & H.Rob.	8	1200	1.84	1.50
Cirsium arvense (L.) Scop.	8	2000	2.44	2.50
Cynodon dactylon (L.) Persoon	8	1200	1.84	1.50
Delphinium denudatum Wall. ex Hook. f. & Thomson	12	2800	3.51	2.33
Echinops echinatus Roxb.	8	1600	2.14	2.00
Elephantopus scaber L.	16	3200	4.28	2.00
Eragrostis viscosa (Retz.) Trin	8	2000	2.44	2.50
Erigeron bellidioides (Buch.-Ham. ex D.Don) Benth. ex C.B.Clarke	4	800	1.07	2.00
Eulaliopsis binata (Retz.) C.E.Hubb.	20	3200	4.75	1.60
Euphorbia hirta L.	12	2000	2.91	1.67
Evolvulus alsinoides (L.) L.	12	2000	2.91	1.67
Fragaria nubicola (Lindl. ex Hook.f.) Lacaita	4	800	1.07	2.00
Fumaria indica (Haussk.)Pugsley	4	800	1.07	2.00
Galinsoga parviflora Cav.	12	2800	3.51	2.33
Galium aparine L.	8	800	1.54	1.00
Heychium spicatum Sm.	12	800	2.01	0.67
Hyoscyamus niger L.	8	800	1.54	1.00
Lespedeza sericea (Thunb.) Miq.	12	1200	2.31	1.00
Leucas lanata Benth.	8	1200	1.84	1.50
Lindenbergia indica Vatke	12	1200	2.31	1.00
Lobelia nicotianifolia Roth ex Schult.	8	1200	1.84	1.50
Malva verticillata L.	4	800	1.07	2.00
Mentha longifolia (L.)L.	16	2000	3.38	1.25
Micromeria biflora (Buch.Ham. ex D. Don) Benth.	8	1200	1.84	1.50
Morina longifolia Wall. ex DC.	8	800	1.54	1.00
Nepeta podostachys Benth.	4	400	0.77	1.00
Oenothera rosea L.Her. ex Aiton	4	800	1.07	2.00
Oxalis corniculata L.	12	2400	3.21	2.00
Panicum miliaceum L.	8	800	1.54	1.00
Parthenium hysterophoru L.	8	800	1.54	1.00
Pimpinella diversifolia Dc	12	1600	2.61	1.33
Plantago depressa Willd	8	1200	1.84	1.50
Plantago major L.	20	2000	3.85	1.00
Polygonatum verticillatum (L) All.	8	800	1.54	1.00
Polygonum capitatum Buc.-Ham.	12	1200	2.31	1.00
Polygonum nepalensis (Meisner) H.Gross.	12	1600	2.61	1.33
Potentilla fulgens Wall.	8	800	1.54	1.00
Potentilla supine L.	12	1200	2.31	1.00
Pouzolzia hirta Blume ex Hassk.	8	800	1.54	1.00
Pteris vittata L.	12	2000	2.91	1.67
Pyrrosia adnascens (Sw.) Ching	8	800	1.54	1.00
Ranunculus diffuses DC.	12	2000	2.91	1.67
Ranunculus hirtellus Royle	12	1600	2.61	1.33
Ranunculus sceleratus L.	12	1200	2.31	1.00
Reinwardtia indica Dumort.	8	800	1.54	1.00

Botanical name	Frequency (%)	Density (individuals ha $^{-1}$)	IVI	Abundance
Rubus niveus Thunb.	8	800	1.54	1.00
Rumex hastatus D.Don	12	2000	2.91	1.67
Saccharum spontaneum L.	4	1600	1.67	4.00
Saussurea auriculata (DC.) Sch.Bip.	4	400	0.77	1.00
Selenium vaginatum (Edgew) CB Clarke	8	800	1.54	1.00
Senecio nudicaulis Buch.-Ham. ex D.Don	12	2000	2.91	1.67
Sida rhombifolia L	12	2800	3.51	2.33
Silene indica (Roxb.) Roxb. ex Otth	12	1600	2.61	1.33
Tanacetum nubigenum Wall. ex DC.	8	1200	1.84	1.50
Taraxacum officinale (L.)Weber ex F.H. Wigg.	12	1600	2.61	1.33
Thalictrum foliolosum DC.	8	800	1.54	1.00
Thymus serpyllum L.	8	800	1.54	1.00
Trifolium repens L.	12	2000	2.91	1.67
Valeriana jatamansi Jones.	12	1200	2.31	1.00
Verbascum thapsus L.	12	2000	2.91	1.67
Viola canescens Wall.	8	1200	1.84	1.50
Total	**852**	**133200**	**200.00**	**133.48**

(IV). Downstream of dam site (Jainsal Village and surrounding areas)

Tree

In Downstream of dam site, a total of 34 tree species (≥ 5 cm dbh or ≥16 cm GBH) was recorded in the VPHE Project, Uttarakhand during post-monsoon season. The density of tree species recorded was 220 individuals ha $^{-1}$) **(Table-3.27)**. In terms of density *Pinus roxburghii* (18 individuals ha $^{-1}$) followed by *Alnus nepalensis* (14 individuals ha $^{-1}$), *Toona ciliata* (12 individuals ha $^{-1}$) was the dominant species. The total basal area of all tree species recorded was 67.3 m^2 ha $^{-1}$ in the Downstream of dam site. In terms of basal area, *Pinus roxburghii* has more basal area as compare to other tree species. In terms of importance value index (IVI), *Pinus roxburghii* was the dominant tree species (IVI= 24.14) followed by *Toona ciliata* (IVI= 18.18) *and Alnus nepalensis* (IVI= 17.04). The details are given in **Table-3.27.**

Table-3.27: Frequency, density, basal area, IVI, volume and abundance of tree species recorded at the downstream of dam site of VPHE Project, Uttarakhand during post monsoon season

Botanical name	Frequency (%)	Density (individuals ha $^{-1}$)	Basal area (m ^{2} ha $^{-1}$)	IVI	Volume (m^3)	Abundance
Aesculus indica (Wall. ex Cambess.) Hook	12	10	2.3	11.76	0.22	1.67
Alnus nepalensis D.Don	16	14	3.78	17.04	0.42	1.75
Bauhinia variegata L.	8	6	1.8	7.93	0.18	1.50

Botanical name	Frequency (%)	Density (individuals ha $^{-1}$)	Basal area (m ^{2} ha $^{-1}$)	IVI	Volume (m^{3})	Abundance
Boehmeria rugulosa Wedd.	4	4	1.48	5.28	0.16	2.00
Bombax malabaricum DC	8	6	1.5	7.49	0.12	1.50
Callicarpa arborea Roxb.	8	6	1.68	7.76	0.15	1.50
Cassia fistula L.	8	6	1.74	7.84	0.15	1.50
Cedrus deodara (Roxb. ex D.Don) G.Don	8	4	1.24	6.19	0.09	1.00
Celtis australis L.	12	6	2.22	9.82	0.18	1.00
Citrus medica L.	8	4	1.16	6.07	0.06	1.00
Dalbergia sissoo DC.	8	8	1.68	8.66	0.18	2.00
Delonix regia (Hook.) Raf.	8	6	1.38	7.31	0.11	1.50
Euphorbia candelabrum Trémaux ex Kotschy	8	4	0.84	5.60	0.06	1.00
Ficus palmata Forssk.	4	4	1.32	5.05	0.12	2.00
Ficus racemosa L.	8	4	1.24	6.19	0.15	1.00
Ficus benghalensis L.	8	4	1.32	6.31	0.14	1.00
Gmelina arborea Roxb.	8	6	1.44	7.40	0.14	1.50
Juglans regia L.	8	4	1.08	5.95	0.09	1.00
Juniperus communis L.	12	10	3.2	13.10	0.32	1.67
Mangifera indica L.	8	6	2.46	8.91	0.23	1.50
Neolitsea pallens (D. Don) Momiy. & H. Hara	12	10	3.3	13.25	0.30	1.67
Phoenix humilis (L.) Cav.	8	8	4.08	12.23	0.35	2.00
Pinus roxburghii Sarg.	20	18	6.48	24.14	0.71	1.80
Pistacia khinjuk Socks.	8	2	0.48	4.15	0.04	0.50
Pongamia pinnata (L.) Pierre	8	6	1.5	7.49	0.15	1.50
Populus ciliata Wall. ex Royle	8	4	0.72	5.42	0.06	1.00
Prunus persica (L.) Batsch.	8	6	1.62	7.67	0.15	1.50
Pyrus pashia Buch.-Ham. ex D. Don – Kainth	12	6	1.86	9.29	0.19	1.00
Syzygium cumini (L.) Skeels.	16	10	2.9	13.92	0.25	1.25
T*axus baccata* L.	12	8	2.4	11.00	0.26	1.33
Tecomella undulata (Sm.) Seem.	8	4	0.96	5.78	0.08	1.00
Terminalia bellirica (Gaerth.)Roxb.	4	2	0.56	3.01	0.06	1.00
Terminalia chebula Retz.	4	2	0.42	2.80	0.04	1.00
Toona ciliata M.Roem.	16	12	5.16	18.18	0.49	1.50
Total	**316**	**220**	**67.3**	**300.00**	**6.39**	**46.63**

Shrubs

A total of only 52 shrub, bamboo and climber were recorded from Downstream of dam site during study post-monsoon season of VPHE Project in 2020. The density of shrub species was recorded to be 556 individuals ha $^{-1}$ **(Table-3.28)**. In terms of density, *Woodfordia fruticosa* (36 individuals ha $^{-1}$) followed by *Ziziphus mauritiana* (24 individuals ha $^{-1}$), *Debregeasia saeneb*, *Justicia adhatoda, Lantana camara and Solanum anguivi* (20

individuals' ha $^{-1}$) was the dominant shrub layer species in the shrub canopy layer. Other species density is less and recorded limited in number. In terms of importance value index (IVI), *Woodfordia fruticosa and Ricinus communis* was the dominant shrub species (IVI= 11.19) followed by *Ziziphus mauritiana* (IVI= 9.03), *Solanum anguivi* (IVI= 7.37). The details are given in **Table-3.28.**

Table-3.28: Frequency, density, IVI and abundance of shrub species recorded at the downstream of dam site of VPHE Project, Uttarakhand during post monsoon season

Botanical name	Frequency (%)	Density (individuals ha $^{-1}$)	IVI	Abundance
Aloe vera (L.) Burm.f.	8	12	4.05	1.5
Berberis aristata DC.	8	12	4.05	1.5
Brucea javanica (L.) Merr.	4	8	2.38	2
Callicarpa macrophylla Vahl.	8	8	3.33	1
Carissa spinarum L.	8	12	4.05	1.5
Celastrus paniculatus Willd	4	4	1.66	1
Cissampelos pareira L.	4	4	1.66	1
Clematis buchananiana DC.	12	16	5.71	1.33
Clerodendrum infortunatum L.	8	12	4.05	1.5
Coriaria nepalensis Wall.	8	12	4.05	1.5
Cotoneaster microphyllus Wall. ex Lindl.	8	8	3.33	1
Cryptolepis dubia (Burm.f.) M.R.Almeida	8	8	3.33	1
Datura metal L.	12	12	4.99	1
Debregeasia saeneb (Forssk.) Hepper & J.R.I.Wood	12	20	6.43	1.67
Dioscorea bulbifera L.	4	4	1.66	1
Embelia ribes Burm.f.	8	8	3.33	1
Erythrina suberosa Roxb.	8	8	3.33	1
Gaultheria fragrantissima Wall	8	12	4.05	1.5
Hemidesmus indicus (L.) R. Br. ex Schult.	4	8	2.38	2
Hypericum oblongifolium Choisy	8	8	3.33	1
Hyssopus officinalis L.	8	8	3.33	1
Ipomoea purpurea (L.) Roth	4	4	1.66	1
Isodon coetsa (Buch.-Ham. ex D.Don) Kudô	4	4	1.66	1
Isodon coetsa (Buch.-Ham. ex D.Don) Kudô	8	8	3.33	1
Jatropha curcas L.	8	8	3.33	1
Justicia adhatoda L.	16	20	7.37	1.25
Lantana camara L.	12	20	6.43	1.67
Lawsonia inermis L.	8	12	4.05	1.5
Lonicera angustifolia Wall. ex DC.	8	12	4.05	1.5
Murraya koenigii (L.) Spreng.	12	12	4.99	1
Phragmites australis (Cav.) Trin. ex Steud.	8	12	4.05	1.5
Plumbago zeylanica L.	4	8	2.38	2
Rauvolfia serpentina (L.) Benth. ex Kurz	12	12	4.99	1
Ricinus communis L.	20	36	11.19	1.8
Rosa moschata Herrm.	8	8	3.33	1
Rubus ellipticus Sm.	8	12	4.05	1.5
Rubus niveus Thunb.	4	8	2.38	2
Rubus paniculatus Sm.	4	8	2.38	2

Botanical name	Frequency (%)	Density (individuals ha $^{-1}$)	IVI	Abundance
Rubus paniculatus Sm.	8	4	2.61	0.5
Sarcococca pruniformis Lindl.	4	4	1.66	1
Solanum anguivi Lam.	16	20	7.37	1.25
Solanum lasiocarpum Dunal	8	12	4.05	1.5
Solena heterophylla Lour.	4	4	1.66	1
Tinospora sinensis (Lour.) Merr.	4	4	1.66	1
Triumfetta rhomboidea Jacq.	8	8	3.33	1
Urtica parviflora Roxb.	8	8	3.33	1
Viburnum nervosum D.Don	8	12	4.05	1.5
Vitex negundo L.	4	4	1.66	1
Woodfordia fruticosa (L.) Kurz	20	36	11.19	1.8
Zanthoxylum armatum DC.	4	8	2.38	2
Ziziphus mauritiana Lam.	20	24	9.03	1.2
Total	**424**	**556**	**200.00**	**66.47**

Herb

A total of only 66 herb, epiphyte, grass and fern were recorded from Downstream of dam site during study post-monsoon season of VPHE Project in 2020. The density of shrub species was recorded to be 92400 individuals ha $^{-1}$ **(Table-3.29)**. In terms of density, *Ageratina adenophora* (4800 individuals ha $^{-1}$) followed by *Achyranthes aspera* (2800 individuals' ha $^{-1}$) were the dominant herbaceous species. In terms of importance value index (IVI), *Ageratina adenophora* (IVI= 9.46), was the dominant herbaceous species followed by *Achyranthes aspera* (IVI= 4.86). The details are given in **Table-3.29.**

Table-3.29: Frequency, density, IVI and abundance of herb species recorded at the downstream of dam site of VPHE Project, Uttarakhand during post monsoon season

Botanical name	Frequency (%)	Density (individuals ha $^{-1}$)	IVI	Abundance
Achillea millefolium L.	12	1200	3.13	1.00
Achyranthes aspera L.	12	2800	4.86	2.33
Ageratina adenophora (Spreng.) R.M.King & H.Rob.	28	4800	9.46	1.71
Ageratum conyzoides (L.) L.	12	2000	3.99	1.67
Agrimonia pilosa Ledeb.	4	400	1.04	1.00
Althaea officinalis L.	8	800	2.09	1.00
Anaphalis busua L.	12	2000	3.99	1.67
Arisaema flavum (Forssk.) Schott	8	800	2.09	1.00
Artemisia nilagirica (C.B.Clarke) Pamp.	8	1200	2.52	1.50
Astragalus condolleanus Royle	8	1200	2.52	1.50
Barleria cristata L.	12	2000	3.99	1.67
Bistrota amplexicaulis Greene	4	800	1.48	2.00
Calendula officinalis L.	8	1600	2.95	2.00
Campanula pallida Wall.	8	800	2.09	1.00
Cassia absus Sesse & Moc.	8	800	2.09	1.00
Celosia argentea L.	12	1600	3.56	1.33

Botanical name	Frequency (%)	Density (individuals ha $^{-1}$)	IVI	Abundance
Chromolaena odorata (L.) R.M.King & H.Rob.	8	800	2.09	1.00
Cirsium arvense (L.) Scop.	8	800	2.09	1.00
Commelina benghalensis L	8	1600	2.95	2.00
Cynodon dactylon (L.) Persoon	8	2000	3.38	2.50
Delphinium denudatum Wall. ex Hook. f. & Thomson	16	1600	4.17	1.00
Desmodium heterocarpon (L.) DC.	12	1200	3.13	1.00
Duchesnea indica (Jacks) Focke	12	800	2.70	0.67
Echinops echinatus Roxb.	16	1600	4.17	1.00
Elephantopus scaber L.	16	2000	4.60	1.25
Erigeron bellidioides (Buch.-Ham. ex D.Don) Benth. ex C.B.Clarke	4	800	1.48	2.00
Eriophorum comosum (Wall.) Nees	12	2000	3.99	1.67
Eulaliopsis binata (Retz.) C.E.Hubb.	8	1200	2.52	1.50
Euphorbia hirta L.	12	2800	4.86	2.33
Evolvulus alsinoides (L.) L.	12	2000	3.99	1.67
Galinsoga parviflora Cav.	12	2000	3.99	1.67
Galium aparine L	8	1200	2.52	1.50
Geranium rotundifolium L	16	2000	4.60	1.25
Acomastylis elata var. elata	12	1600	3.56	1.33
Lespedeza sericea (Thunb.) Miq.	12	1200	3.13	1.00
Leucas lanata Benth.	8	1200	2.52	1.50
Lindenbergia indica Vatke	12	1200	3.13	1.00
Lobelia nicotianifolia Roth ex Schult.	8	1200	2.52	1.50
Malva verticillata L.	4	400	1.04	1.00
Mentha longifolia (L.) L.	8	1200	2.52	1.50
Morin longifolia Wall. ex DC.	8	800	2.09	1.00
Nepeta podostachys Benth.	8	800	2.09	1.00
Oxalis corniculata L.	4	400	1.04	1.00
Panicum miliaceum L.	4	800	1.48	2.00
Parthenium hysterophoru L.	8	800	2.09	1.00
Phragmites communis Trin	12	1200	3.13	1.00
Pimpinella diversifolia Dc	8	1600	2.95	2.00
Plantago major L.	4	800	1.48	2.00
Polygonum capitatum Buc.-Ham.	8	2000	3.38	2.50
Potentilla fulgens Wall.	8	2000	3.38	2.50
Potentilla supine L.	12	1200	3.13	1.00
Pouzolzia hirta Blume ex Hassk.	8	800	2.09	1.00
Pteris vittatus L.	12	2000	3.99	1.67
Ranunculus diffuses DC.	12	1600	3.56	1.33
Reinwardtia indica Dumort.	8	800	2.09	1.00
Rumex hastatus D.Don	12	2000	3.99	1.67
Saccharum spontaneum L.	4	1600	2.34	4.00
Scutellaria angulosa Benth.	8	800	2.09	1.00
Selenium vaginatum (Edgew) CB Clarke	8	800	2.09	1.00
Senecio nudicaulis Buch.-Ham. ex D.Don	16	2000	4.60	1.25
Sida rhombifolia L	4	400	1.04	1.00
Silene indica (Roxb.) Roxb. ex otth	16	1600	4.17	1.00
Taraxacum officinale (L.) Weber ex F.H.	12	2000	3.99	1.67

Botanical name	Frequency (%)	Density (individuals ha $^{-1}$)	IVI	Abundance
Wigg.				
Thymus serpyllum L.	8	800	2.09	1.00
Trifolium repens L.	16	2000	4.60	1.25
Verbascum thapsus L.	12	1600	3.56	1.33
Total	**656**	**92400**	**200.00**	**95.38**

(V). Power house site and surrounding areas

Tree

In Power house site, a total of 27 tree species (≥ 5 cm dbh or ≥16 cm GBH) was recorded in the VPHE Project, Uttarakhand during post-monsoon season. The density of tree species recorded was 168 individuals ha $^{-1}$ **(Table-3.30)**. In terms of density *Pinus roxburghii* (22 individuals ha $^{-1}$) followed by *Alnus nepalensis* (10 individuals ha $^{-1}$), *Mallotus philippensis* (10 individuals ha $^{-1}$), *Toona ciliata* (10 individuals ha $^{-1}$) was the dominant species. The total basal area of all tree species recorded was 46.09 m^2 ha $^{-1}$ in the Power house site. In terms of basal area, *Pinus roxburghii* has more basal area as compare to other tree species. In terms of importance value index (IVI), *Pinus roxburghii* was the dominant tree species (IVI= 38.81) followed by *Toona ciliata* (IVI= 17.22) *and Mallotus philippensis* (IVI= 17). The details are given in **Table-3.30.**

Table-3.30: Frequency, density, basal area, IVI, volume and abundance of tree species recorded at the power house site of VPHE Project, Uttarakhand during post monsoon season

Botanical name	Frequency (%)	Density (individuals ha $^{-1}$)	Basal area (m^2 ha $^{-1}$)	IVI	Volume (m^3)	Abundance
Acacia nilotica (L.) Delile	12	6	1.38	11.11	0.13	1
Aesculus indica (Wall. ex Cambess.) Hook	12	8	1.76	13.13	0.16	1.33
Albizia lebbeck (L.) Benth.	4	2	0.56	3.92	0.06	1
Alnus nepalensis D.Don	16	10	1.9	16.14	0.16	1.25
Bombax malabaricum DC	8	4	1.24	8.10	0.12	1
Callicarpa arborea Roxb.	8	8	2.24	12.65	0.20	2
Cedrus deodara (Roxb. ex D.Don) G.Don	12	6	2.1	12.67	0.21	1
Celtis australis L.	12	6	1.86	12.15	0.13	1
Dalbergia sissoo DC.	12	6	1.62	11.63	0.18	1
Ficus racemosa L.	4	2	0.58	3.96	0.06	1
Ficus religiosa L.	4	2	0.41	3.60	0.04	1
Gmelina arborea Roxb.	8	4	0.96	7.49	0.10	1
Grevillea robusta A.Cunn. ex R.Br.	8	4	0.76	7.06	0.07	1
Grewia oppositifolia Roxb.ex DC.	4	2	0.36	3.49	0.03	1

Botanical name	Frequency (%)	Density (individuals ha $^{-1}$)	Basal area (m ^{2} ha $^{-1}$)	IVI	Volume (m^{3})	Abundance
Maesa indica (Roxb.) A.DC.	8	4	0.88	7.32	0.07	1
Mallotus philippensis (Lam.) Müll.Arg.	16	10	2.3	17.00	0.23	1.25
Neolitsea pallens (D. Don) Momiy. & H. Hara	8	4	0.68	6.89	0.06	1
Pinus roxburghii Sarg.	20	22	8.36	38.81	0.92	2.2
Pongamia pinnata (L.) Pierre	16	8	2.48	16.20	0.22	1
P*opulus ciliata* Wall. ex Royle	12	8	1.92	13.47	0.19	1.33
Rhododendron arboreum Sm.	8	4	1.08	7.75	0.10	1
S*enna occidentalis* (L.) Link	12	8	2.48	14.69	0.26	1.33
Shorea robusta Gaertn.	8	6	1.68	10.25	0.15	1.5
Taxus baccata L.	4	6	1.86	9.12	0.16	3
Tecomella undulata (Sm.) Seem.	8	4	1.16	7.93	0.12	1
Terminalia chebula Retz.	4	4	1.08	6.24	0.10	2
Toona ciliata M.Roem.	16	10	2.4	17.22	0.20	1.25
Total	**264**	**168**	**46.09**	**300.00**	**4.43**	**34.45**

Shrub

A total of only 25 shrub, bamboo and climber were recorded from Power house site during study post-monsoon season of VPHE Project in 2020. The density of shrub species was recorded to be 316 individuals ha $^{-1}$ **(Table-3.31)**. In terms of density, *Justicia adhatoda* (32 individuals ha $^{-1}$) followed by *Lantana camara* (28 individuals ha $^{-1}$), *Carissa spinarum*, *Solanum violaceum and Phragmites australis* (20 individuals' ha $^{-1}$) was the dominant shrub layer species in the shrub canopy layer. Other species density is less and recorded limited in number. In terms of importance value index (IVI), *Justicia adhatoda* was the dominant shrub species (IVI= 17.40) followed by *Lantana camara* (IVI= 14.32), *Carissa spinarum and Solanum violaceum* (IVI= 13.60). The details are given in **Table-3.31.**

Table-3.31: Frequency, density, IVI and abundance of shrub species recorded at the power house site of VPHE Project, Uttarakhand during post monsoon season

Botanical name	Frequency (%)	Density (individuals ha $^{-1}$)	IVI	Abundance
Boehmeria macrophylla Hornem.	8	12	7.43	1.50
Brucea javanica (L.) Merr.	12	16	10.52	1.33
Callicarpa macrophylla Vahl.	8	12	7.43	1.50
Carissa spinarum L.	16	20	13.60	1.25
Celastrus paniculatus Willd	4	4	3.08	1.00
Clematis buchananiana DC.	8	8	6.17	1.00
Coriaria nepalensis Wall.	4	4	3.08	1.00
Embelia ribes Burm.f.	8	16	8.70	2.00
E*rythrina suberosa* Roxb.	8	12	7.43	1.50
Hemidesmus indicus (L.) R. Br. ex Schult.	8	8	6.17	1.00

Botanical name	Frequency (%)	Density (individuals ha $^{-1}$)	IVI	Abundance
Inula cappa (Buch.-Ham. ex D.Don) DC.	12	12	9.25	1.00
Justicia adhatoda L.	16	32	17.40	2.00
Lantana camara L.	12	28	14.32	2.33
Leptadenia reticulata (Retz.) Wight & Arn.	8	8	6.17	1.00
Prinsepia utilis Royle	4	4	3.08	1.00
Pyracantha crenulata (Roxb. ex D.Don) M.Roem.	4	4	3.08	1.00
Rhus parviflora Roxb.	4	4	3.08	1.00
Ribes uva-crispa L.	8	12	7.43	1.50
Rosa moschata Herrm.	8	8	6.17	1.00
Solanum lasiocarpum Dunal	4	12	5.62	3.00
Solanum violaceum Ortega	16	20	13.60	1.25
Triumfetta rhomboidea Jacq.	8	12	7.43	1.50
Urena lobata L	8	12	7.43	1.50
Urtica parviflora Roxb.	4	4	3.08	1.00
Viburnum nervosum D.Don	12	12	9.25	1.00
Phragmites australis (Cav.) Trin. ex Steud.	8	20	9.97	2.50
Total	**220**	**316**	**200.00**	**36.67**

Herbs

A total of only 48 herb, epiphyte, grass and fern were recorded from Power house during study post-monsoon season of VPHE Project in 2020. The density of shrub species was recorded to be 64800 individuals ha $^{-1}$ **(Table-3.32)**. In terms of density, Silene indica (3200 individuals ha $^{-1}$) followed by *Ageratum conyzoides, Euphorbia hirta, Pteris vittatus, Rumex hastatus*, *Sida rhombifolia* (2800 individuals' ha $^{-1}$) were the dominant herbaceous species. In terms of importance value index (IVI), Silene indica (IVI= 9.70), was the dominant herbaceous species followed by *Ageratum conyzoides* (IVI= 9.08), *Rumex hastatus* (IVI= 8.13). The details are given in **Table-3.32.**

Table-3.32: Frequency, density, IVI and abundance of herb species recorded at the power house site of VPHE Project, Uttarakhand during post monsoon season

Botanical name	Frequency (%)	Density (individuals ha $^{-1}$)	IVI	Abundance
Ageratum conyzoides (L.) L.	20	2800	9.08	1.40
Agrimonia pilosa Ledeb.	8	1200	3.76	1.50
Althaea officinalis L.	8	800	3.14	1.00
Artemisia nilagirica (C.B.Clarke) Pamp.	8	1200	3.76	1.50
Barleria cristata L.	12	1600	5.33	1.33
Bistrota amplexicaulis Greene	4	400	1.57	1.00
Calendula officinalis L.	8	1600	4.37	2.00
Cassia absus Sesse & Moc.	8	800	3.14	1.00
Celosia argentea L.	4	800	2.19	2.00
Chromolaena odorata (L.) R.M.King & H.Rob.	8	800	3.14	1.00
Cirsium arvense (L.) Scop.	8	800	3.14	1.00

Botanical name	Frequency (%)	Density (individuals ha $^{-1}$)	IVI	Abundance
Cynodon dactylon (L.) Persoon	8	1200	3.76	1.50
Delphinium denudatum Wall.ex Hook. f. & Thomson	4	800	2.19	2.00
Echinops echinatus Roxb.	8	1600	4.37	2.00
Elephantopus scaber L.	16	2000	6.90	1.25
Erigeron bellidioides (Buch.-Ham. ex D.Don) Benth. ex C.B.Clarke	4	800	2.19	2.00
Eulaliopsis binata (Retz.) C.E.Hubb.	4	1200	2.80	3.00
Euphorbia hirta L.	16	2800	8.13	1.75
Evolvulus alsinoides (L.) L.	8	2000	4.99	2.50
Galinsoga parviflora Cav.	12	1600	5.33	1.33
Galium aparine L	8	1200	3.76	1.50
Lespedeza sericea (Thunb.) Miq.	8	800	3.14	1.00
Leucas lanata Benth.	8	1200	3.76	1.50
Lindenbergia indica Vatke	4	800	2.19	2.00
Lobelia nicotianifolia Roth ex Schult.	8	1200	3.76	1.50
Malva verticillata L.	4	800	2.19	2.00
Morina longifolia Wall. ex DC.	8	800	3.14	1.00
Nepeta podostachys (Benth.)	8	1200	3.76	1.50
Oenothera rosea L. Her. ex Aiton	8	800	3.14	1.00
Oxalis corniculata L.	4	400	1.57	1.00
Panicum miliaceum L.	4	400	1.57	1.00
Parthenium hysterophoru L.	8	800	3.14	1.00
Plantago major L.	4	800	2.19	2.00
Polygonum capitatum Buc.-Ham.	12	2000	5.94	1.67
Potentilla fulgens Wall.	8	800	3.14	1.00
Pouzolzia hirta Blume ex Hassk.	8	800	3.14	1.00
Pteris vittatus L.	16	2800	8.13	1.75
Ranunculus sceleratus L.	12	2000	5.94	1.67
Reinwardtia indica Dumort.	8	800	3.14	1.00
Rumex hastatus D.Don	16	2800	8.13	1.75
Saccharum spontaneum L.	4	1600	3.42	4.00
Selenium vaginatum (Edgew) CB Clarke	4	800	2.19	2.00
Senecio nudicaulis Buch.-Ham. ex D.Don	12	2000	5.94	1.67
Sida rhombifolia L.	12	2800	7.18	2.33
Silene indica (Roxb.) Roxb. ex otth	20	3200	9.70	1.60
Taraxacum campylodes G.E. Haglund	8	2000	4.99	2.50
Trifolium repens L.	8	800	3.14	1.00
Verbascum thapsus L.	12	1600	5.33	1.33
Total	**420**	**64800**	**200.00**	**76.33**

(VI). TRT Outlet (Durgapur, Birahi Village and surrounding areas)

Tree

In TRT Outlet, a total of 32 tree species (≥ 5 cm dbh or ≥16 cm GBH) was recorded in the VPHE Project, Uttarakhand during post-monsoon season. The density of tree species recorded was 148 individuals ha $^{-1}$ **(Table-3.33).** In terms of density *Pinus roxburghii* (18 individuals ha $^{-1}$) followed by *Alnus nepalensis, Phoenix humilis, Pongamia pinnata, Toona ciliata* (10 individuals ha $^{-1}$) was the dominant species. The total basal area of all tree species recorded was 46.68 m^2 ha $^{-1}$ in the TRT Outlet. In terms of basal area, *Pinus roxburghii* has more basal area as compare to other tree species. In terms of importance value index (IVI), *Pinus roxburghii* was the dominant tree species (IVI= 38.95) followed by *Toona ciliata* (IVI= 20.30) *and Alnus nepalensis* (IVI=18.63). The details are given in **Table-3.33.**

Table-3.33: Frequency, density, basal area, IVI, volume and abundance of tree species recorded at the TRT outlet site of VPHE Project, Uttarakhand during post monsoon season

Botanical name	Frequency (%)	Density (individuals ha $^{-1}$)	Basal area (m ^{2} ha $^{-1}$)	IVI	Volume (m^3)	Abundance
Alnus nepalensis D.Don	12	10	2.9	18.63	0.25	1.67
Bauhinia variegata L.	4	4	0.92	6.56	0.09	2
Boehmeria rugulosa Wedd.	4	2	0.54	4.39	0.05	1
Callicarpa arborea Roxb.	4	2	0.56	4.44	0.05	1
Callistemon species	8	2	0.44	6.07	0.03	0.5
Cassia fistula L.	4	4	0.76	6.22	0.05	2
Cedrus deodara (Roxb. ex D.Don) G.Don	8	6	2.7	13.61	0.20	1.5
Celtis australis L.	4	4	1.16	7.07	0.10	2
Cinnamomum tamala (Buch.-Ham.) T.Nees & Eberm.	4	2	0.7	4.74	0.07	1
Cupressus torulosa C.Don	8	6	2.58	13.35	0.26	1.50
Diploknema butyracea (Roxb.) H.J.Lam	4	4	1.44	7.67	0.14	2.00
Ficus racemosa L.	4	2	1.02	5.42	0.11	1.00
Ficus benghalensis L.	8	4	2.12	11.02	0.23	1.00
Gmelina arborea Roxb.	4	2	0.48	4.27	0.04	1
Grevillea robusta A.Cunn. ex R.Br.	4	2	0.78	4.91	0.08	1
Grewia oppositifolia Roxb. ex DC.	4	2	0.48	4.27	0.04	1
Juniperus communis L.	4	4	1.64	8.10	0.16	2
Lannea coromandelica (Houtt.) Merr.	8	4	0.88	8.36	0.08	1
Lyonia ovalifolia (Wall.) Drude	4	2	0.38	4.05	0.03	1
Maesa indica (Roxb.) A.DC.	4	4	1.28	7.33	0.13	2
Moringa pterygosperma Gaertn	4	4	0.76	6.22	0.06	2
Phoenix humilis (L.) Cav.	12	10	2.9	18.63	0.25	1.67
Pinus roxburghii Sarg.	20	18	8.1	38.95	0.77	1.80
Pistacia khinjuk Socks.	8	4	1.16	8.96	0.09	1
Pongamia pinnata (L.) Pierre	12	10	2.4	17.56	0.19	1.67
Prunus persica (L.) Batsch.	8	6	1.26	10.53	0.13	1.50
Pterocarpus marsupium Roxb.	8	4	1.12	8.88	0.10	1

Botanical name	Frequency (%)	Density (individuals ha $^{-1}$)	Basal area (m ^{2} ha $^{-1}$)	IVI	Volume (m^{3})	Abundance
Robinia pseudoacacia L.	4	2	0.38	4.05	0.04	1
Senna occidentalis (L.) Link	4	4	1.12	6.99	0.10	2
Sorbus cuspidata (Spach) Hedl.	4	2	0.38	4.05	0.03	1
Terminalia bellirica (Gaerth.)Roxb.	4	2	0.54	4.39	0.05	1
Toona ciliata M.Roem.	16	10	2.8	20.30	0.22	1.25
Total	**212**	**148**	**46.68**	**300.00**	**4.20**	**44.05**

Shrubs

A total of only 42 shrub, bamboo and climber were recorded from TRT outlet site during study post-monsoon season of VPHE Project in 2020. The density of shrub species was recorded to be 296 individuals ha $^{-1}$ **(Table-3.34)**. In terms of density, Debregeasia saeneb (28 individuals ha $^{-1}$) followed by *Lantana camara* (20 individuals ha $^{-1}$), Boehmeria macrophylla, Clerodendrum infortunatum, Justicia adhatoda (12 individuals' ha $^{-1}$) was the dominant shrub layer species in the shrub canopy layer. Other species density is less and recorded limited in number. In terms of importance value index (IVI), Debregeasia saeneb was the dominant shrub species (IVI= 14.82) followed by *Lantana camara* (IVI= 14.32), Lantana camara (IVI= 12.11). The details are given in **Table-3.34.**

Table-3.34: Frequency, density, IVI and abundance of shrub species recorded at the TRT outlet site of VPHE Project, Uttarakhand during post monsoon season

Botanical name	Frequency (%)	Density (individuals ha $^{-1}$	IVI	Abundance
Bidens pilosa L.	4	8	4.49	2
Boehmeria macrophylla Hornem.	8	12	7.63	1.50
Brucea javanica (L.) Merr.	4	4	3.14	1
Callicarpa macrophylla Vahl.	4	4	3.14	1
Celastrus paniculatus Willd	4	8	4.49	2
Clerodendrum infortunatum L.	4	12	5.84	3
Coriaria nepalensis Wall.	8	8	6.27	1
Cotoneaster microphyllus Wall. ex Lindl.	4	4	3.14	1
Cryptolepis dubia (Burm.f.) M.R.Almeida	4	4	3.14	1
Datura metal L.	8	8	6.27	1.00
Debregeasia saeneb (Forssk.) Hepper & J.R.I.Wood	12	28	14.82	2.33
Dioscorea bulbifera L.	4	4	3.14	1
Embelia ribes Burm.f.	4	4	3.14	1
Hypericum oblongifolium Choisy	4	8	4.49	2
Hyssopus officinalis L.	4	4	3.14	1
Indigofera heterantha Brandis	4	4	3.14	1
Lantana camara L.	12	20	12.11	1.67
Isodon coetsa (Buch.-Ham. ex D.Don)	8	8	6.27	1

Botanical name	Frequency (%)	Density (individuals ha $^{-1}$	IVI	Abundance
Kudô				
Jatropha curcas L.	4	4	3.14	1.00
Justicia adhatoda L.	4	12	5.84	3
Lawsonia inermis L.	8	8	6.27	1
Leptadenia reticulata (Retz.) Wight & Arn.	4	4	3.14	1
Leptodermis lanceolata Wall.	4	4	3.14	1
Lonicera angustifolia Wall. ex DC.	4	4	3.14	1
Operculina turpethum (L.) Silva Manso	4	4	3.14	1
Opuntia monacantha Haw.	4	4	3.14	1
Prinsepia utilis Royle	8	8	6.27	1
Pyracantha crenulata (Roxb. ex D.Don) M.Roem.	4	8	4.49	2
Rhus parviflora Roxb.	4	8	4.49	2
Rosa moschata Herrm.	4	4	3.14	1.00
Rubia cordifolia L.	4	4	3.14	1
Rubia manjith Roxb. ex Fleming	4	4	3.14	1
Solanum lasiocarpum Dunal	4	4	3.14	1
Solanum violaceum Ortega	4	4	3.14	1
Symplocos racemosa Roxb.	8	8	6.27	1
Triumfetta rhomboidea Jacq.	8	8	6.27	1
Urena lobata L	4	4	3.14	1
Urtica parviflora Roxb.	4	4	3.14	1
Viburnum nervosum D.Don	4	8	4.49	2.00
Vitex negundo L.	8	8	6.27	1
Zanthoxylum armatum DC.	4	8	4.49	2
Ziziphus mauritiana Lam.	8	8	6.27	1.00
Total	**224**	**296**	**200.00**	**55.50**

Herbs

A total of only 50 herb, grass, epiphyte and fern were recorded from TRT outlet during study post-monsoon season of VPHE Project in 2020. The density of shrub species was recorded to be 68000 individuals ha $^{-1}$ **(Table-3.35)**. In terms of density, *Ageratina adenophora* (4400 individuals ha $^{-1}$) followed by *Cynodon dactylon, Evolvulus alsinoides* (2800 individuals' ha $^{-1}$) were the dominant herbaceous species. In terms of importance value index (IVI), *Ageratina adenophora* (IVI= 10.86), was the dominant herbaceous species followed by *Evolvulus alsinoides* (IVI= 7.63), *Rumex hastatus* (IVI= 8.13). The details are given in **Table-3.35.**

Table-3.35: Frequency, density, IVI and abundance of herb species recorded at the TRT outlet site of VPHE Project, Uttarakhand during post monsoon season

Botanical name	Frequency (%)	Density (individuals ha $^{-1}$)	IVI	Abundance
Achillea millefolium L.	8	1200	3.52	1.50
Achyranthes aspera L.	12	2000	5.57	1.67
Aerva sanguinolenta (L.) Blume	4	800	2.05	2.00
Ageratina adenophora (Spreng.) R.M.King & H.Rob.	20	4400	10.86	2.20
Ageratum conyzoides (L.) L.	8	1200	3.52	1.50
Agrimonia pilosa Ledeb.	8	1200	3.52	1.50
Ajuga parviflora Benth.	4	400	1.47	1.00
Allium wallichii Kunth	8	800	2.93	1.00
Althaea officinalis L.	8	800	2.93	1.00
Anagallis busua L.	16	2400	7.04	1.50
Argemone mexicana L.	12	1200	4.40	1.00
Artemisia nilagirica (C.B.Clarke) Pamp.	8	1200	3.52	1.50
Bacopa monnieri (L.) Wettst	4	800	2.05	2.00
Barleria cristata L.	8	800	2.93	1.00
Bergenia ciliata (Haw.) Sternb.	12	1600	4.98	1.33
Boerhavia diffusa Kuntze	8	800	2.93	1.00
Calendula officinalis L.	12	2000	5.57	1.67
Canna indica L.	8	1200	3.52	1.50
Capsella bursa-pastoris (L.) Medik.	12	1200	4.40	1.00
Cassia absus Sesse & Moc.	12	2000	5.57	1.67
Chromolaena odorata (L.) R.M.King & H.Rob.	8	1200	3.52	1.50
Cirsium arvense (L.) Scop.	4	800	2.05	2.00
Commelina benghalensis L.	12	1600	4.98	1.33
Cynodon dactylon (L.) Persoon	12	2800	6.75	2.33
Evolvulus alsinoides (L.) L.	16	2800	7.63	1.75
Galinsoga parviflora Cav.	8	800	2.93	1.00
Galium aparine L.	8	800	2.93	1.00
Heychium spicatum Sm.	12	1600	4.98	1.33
Hyoscyamus niger L.	4	400	1.47	1.00
Leucas lanata Benth.	12	2000	5.57	1.67
Malva verticillata L.	4	800	2.05	2.00
Morina longifolia Wall.ex DC.	4	400	1.47	1.00
Oxalis corniculata L.	8	800	2.93	1.00
Plantago major L.	12	2000	5.57	1.67
Polygonatum verticillatum (L) All.	8	1600	4.11	2.00
Pteris vittata L.	8	1200	3.52	1.50
Ranunculus hirtellus Royle	4	800	2.05	2.00
Reinwardtia indica Dumort.	8	800	2.93	1.00
Rumex hastatus D.Don	8	1200	3.52	1.50
Saccharum spontaneum L.	12	2000	5.57	1.67
Saussurea auriculata (DC.) Sch.Bip.	8	1200	3.52	1.50
Silene Indica (Roxb.) Roxb. ex otth	12	2000	5.57	1.67
Solidago virgaurea L.	12	1600	4.98	1.33
Sonchus oleraceus (L.) L.	8	1200	3.52	1.50
Sphaeranthus indicus L.	8	800	2.93	1.00
Tanacetum nubigenum Wall. ex DC.	8	800	2.93	1.00
Tephrosia purpurea (L.)Pers.	4	800	2.05	2.00

Botanical name	Frequency (%)	Density (individuals ha $^{-1}$)	IVI	Abundance
Thalictrum foliolosum DC.	8	1200	3.52	1.50
Trifolium repens L.	12	2000	5.57	1.67
Youngia japonica (L.) DC.	12	2000	5.57	1.67
Total	**456**	**68000**	**200.00**	**73.62**

3.4.1.6.1 Total density

The overall density of plant community recorded at different study sites of VPHE Project, Uttarakhand during post- monsoon season is given in Table-3.36. The graphical analysis of tree, shrub and herb density at different study area of VPHE Project during post monsoon seasons is shown in **Figure-3.9 & Figure-3.10** respectively.

Table-3.36: Density of plant community recorded at different study sites of VPHE Project, Uttarakhand during post- monsoon season

Study area	Tree density	Shrub density	Herb density
Dam site	170	276	67600
Submergence area (Haat Village and surrounding areas)	166	376	87600
Catchment area (Helong village and surrounding areas)	340	832	133200
Downstream of dam site (Jainsal Village and surrounding areas)	220	556	92400
Power house site and surrounding areas	168	316	64800
TRT Outlet site(Durgapur, Birahi Village and surrounding areas)	148	296	68000

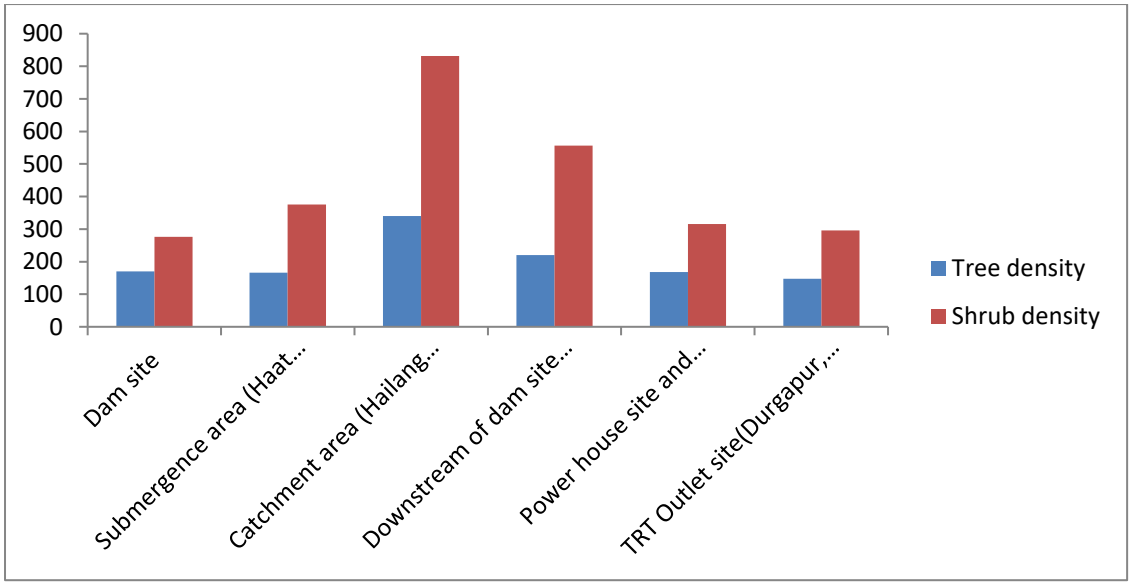


Figure-3.9: Graphical analysis of tree and shrub density at different study area of VPHE Project during post monsoon seasons

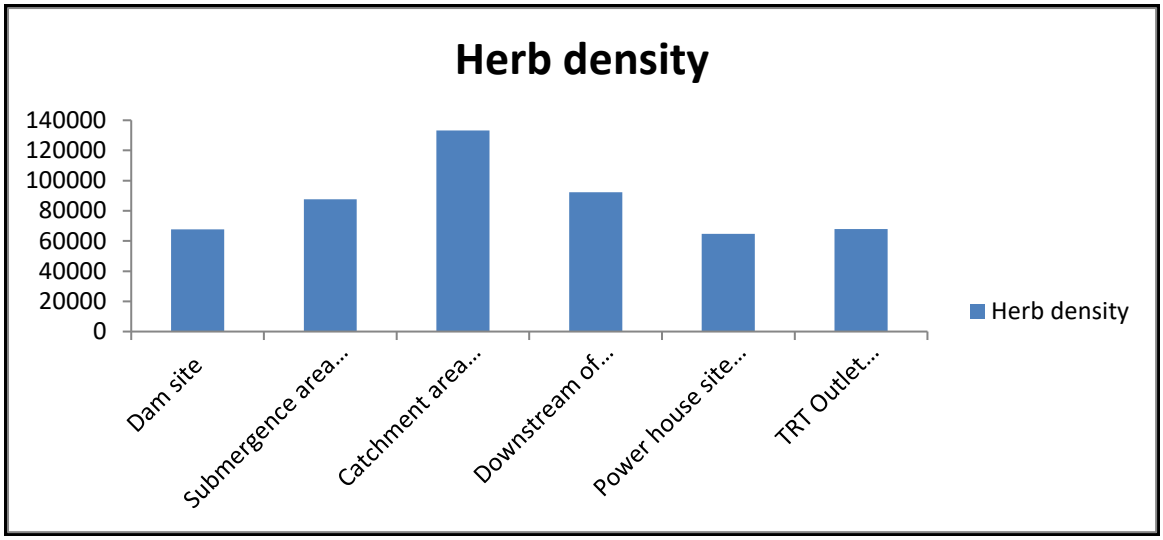


Figure-3.10: Graphical analysis of Herb density at different study area of VPHE Project during post monsoon seasons

3.4.1.6.2 Diversity index

Species diversity index can be considered as a measure of environmental quality and indicates the well-being of any ecosystem. To assess diversity of floral elements and structure of the plant community in different study sites, various diversity indices were computed. A diversity index is mathematical measures of species diversity in a community. They provide more information about community composition than simply species richness (i.e., the number of species present); they also take the relative abundances of different species into account. Three species diversity indices viz., Shannon index of general diversity (H), dominance index (D) and Evenness index (e) were computed using PAST software. The species diversity index values of plants at different sampling sites for studies conducted in post-monsoon season in 2020 are given below.

3.4.1.6.1.I. Shannon-Wiener Diversity Index

Table-3.37: Shannon-Wiener Diversity Index recorded in post-monsoon season for tree, shrub and herb community at different project sites of VPHE Project, Uttarakhand.

Shannon-Wiener Diversity Index			
PROJECT SAMPLING SITE	**TREE**	**SHRUB**	**HERB**
Dam site	3.17	3.319	3.905
Submergence area	3.128	3.478	4.111
Catchment area (Helong village and surrounding areas)	3.516	3.874	4.325
Downstream of dam site (Jainsal Village and surrounding areas)	3.4	3.766	4.074
Power house site and surrounding areas	3.132	3.095	3.736
TRT Outlet (Durgapur, Birahi Village and surrounding areas)	3.243	3.578	3.786

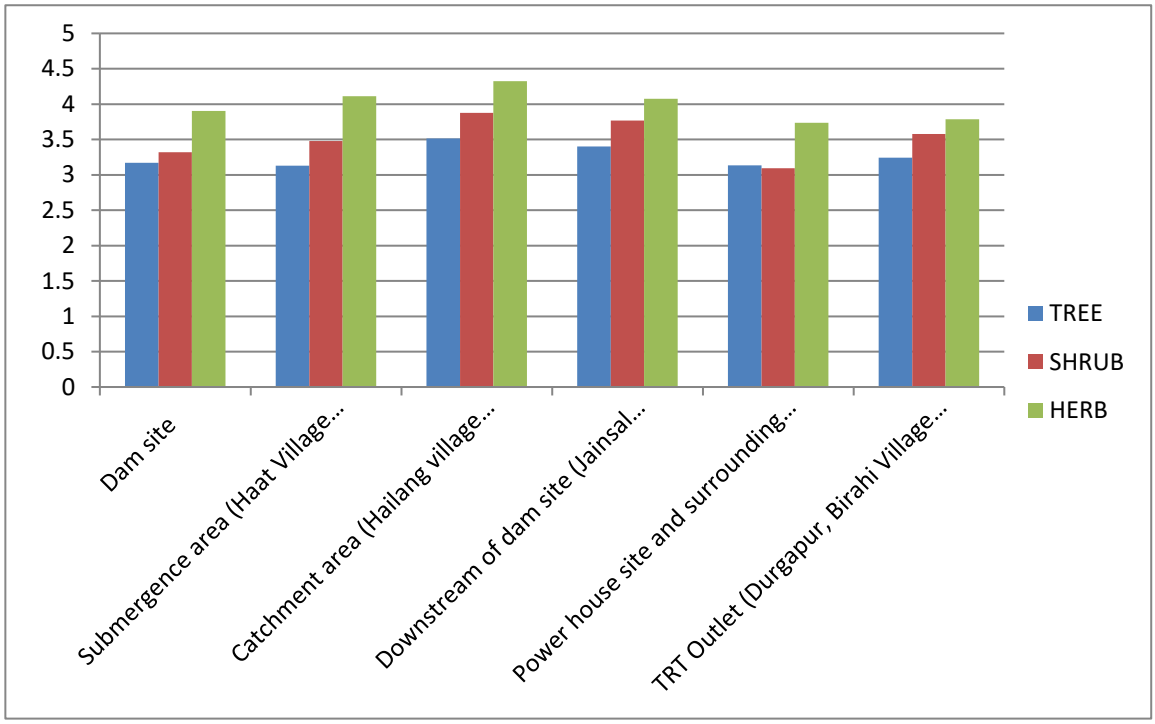


Figure-3.10: Graphical analysis of Shannon-Wiener Diversity Index at different study area of VPHE Project, Uttarakhand during post-monsoon season

3.4.1.6.1. II. Dominance index

Table-3.38: Dominance index recorded in post-monsoon season for tree, shrub and herb community at different project sites of VPHE Project, Uttarakhand.

Dominance index			
PROJECT SAMPLING SITE	**TREE**	**SHRUB**	**HERB**
Dam site	0.0508	0.4516	0.02363
Submergence area	0.05211	0.03554	0.01845
Catchment area (Helong village and surrounding areas)	0.03239	0.0233	0.01458
Downstream of dam site (Jaisal Village and surrounding areas)	0.03769	0.02748	0.01902
Power house site and surrounding areas	0.05187	0.05175	0.0269
TRT Outlet (Durgapur, Birahi Village and surrounding areas)	0.04894	0.03397	0.02574

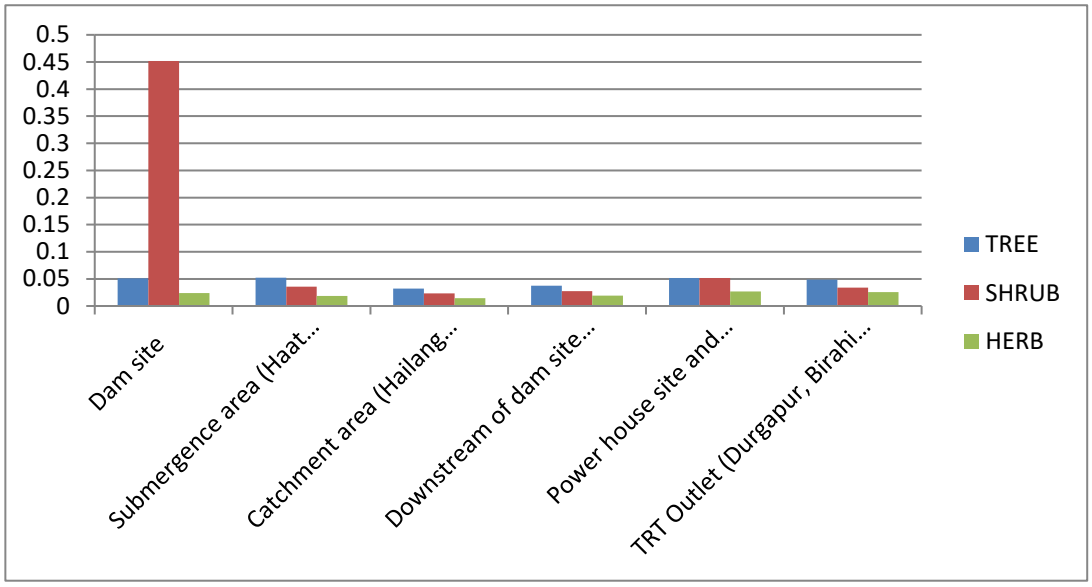


Figure-3.11: Graphical analysis of Dominance Diversity Index at different study area of VPHE Project, Uttarakhand during post-monsoon season

3.4.1.6.1.III. Buzas and Gibson's evenness index

Table-3.39: Buzas and Gibson's evenness index recorded in post-monsoon season for tree, shrub and herb community at different project sites of VPHE Project, Uttarakhand

Buzas and Gibson's evenness index			
PROJECT SAMPLING SITE	**TREE**	**SHRUB**	**HERB**
Dam site	0.8211	0.8129	0.8707
Submergence area	0.8458	0.8528	0.8971
Catchment area (Helong village and surrounding areas)	0.9098	0.9078	0.8994
Downstream of dam site (Jaisal Village and surrounding areas)	0.881	0.8471	0.8912
Power house site and surrounding areas	0.8488	0.8493	0.8733
TRT Outlet (Durgapur, Birahi Village and surrounding areas)	0.8007	0.8523	0.8812

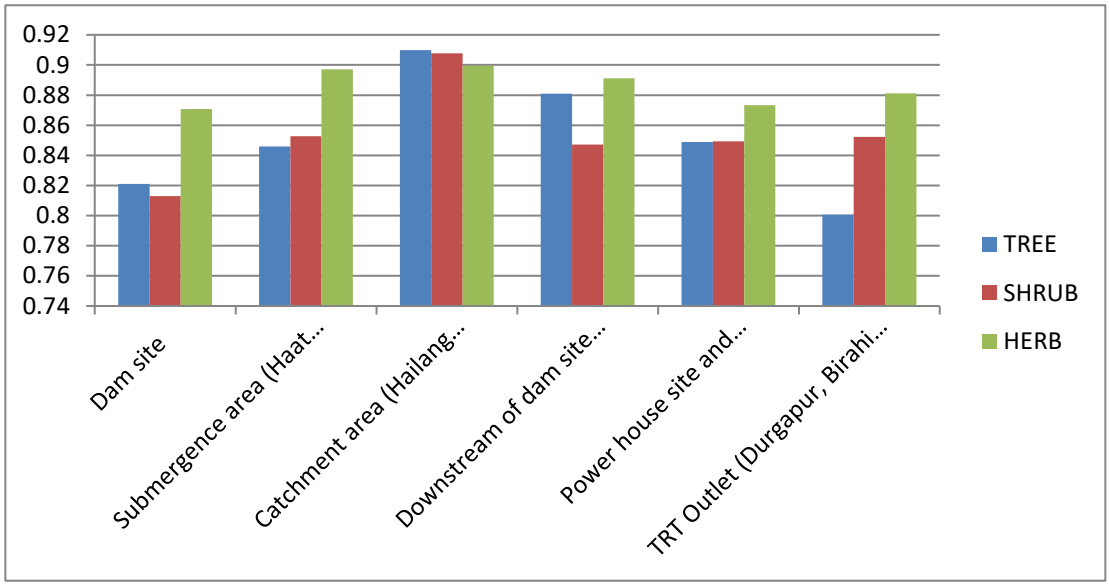


Figure-3.12: Graphical analysis of Buzas and Gibson's evenness index at different study area of VPHE Project, Uttarakhand during post-monsoon season

3.4.1.7 Lower Plant Diversity

3.4.1.7.1. Lichen

A number of non-vascular epiphytes lichens covered considerable space on the barks of the trees in the forest. In the study area *Parmotrema perlatum*, *Heterodermia hypoleuca*, *Usnea lognissima*, *Lecanora subfuseescens*, *Sarcogyne privigna*, *Arthonia impolitella*, *Acarospora fusca*, *Acarospora oxytona* and *Parmelina carporrhizans* are common lichens found in the study area of VPHE Project, Uttarakhand during post-monsoon season 2020.

3.4.1.8 Faunal Diversity (WildLife) in and around VPHE Project, Uttarakhand

The wild animals were identified by direct observation during field survey and signs of their pellets, scats, pugmarks and claw marks were also considered. A binocular (10 X 50) was used for bird watching and the important features were noted. The identification of avian fauna was made on the basis of available literature (Ali 1962, Gasten; 1978 and Grimmett et al. 2000). Interviews with the villagers and local people were also made to generate information about wild animals and avian fauna. The secondary data and reported list of wildlife were also consulted. On the basis of on-site observations as well as secondary data, a check list of wild animals was prepared. The ecological status of the wild animals was categorized following IUCN Red Data Book, 1994. The terrestrial fauna in the VPHE Project, Uttarakhand are represented by mammals, birds, reptiles, butterflies and amphibians.

The boundary of Kedarnath Wildlife Sanctuary and Project componets is shown in Figure-3.13. The Dam site of the project is at horizontal distance of 5.2 Km away from the boundary of the Kedarnath Wildlife Sanctuary and is approximately 1900 m above the dam site. The horizontal distance of the powerhouse from sanctuary border is approximately 2 km. The elevation of the sanctuary is about 2000m above Power house site. However, the

impact of VPHEP on the KWLS is not significant. This has been inferred due to use of TBM technique for construction of HRT and the location of the sanctuary w.r.t. to the project facilities.

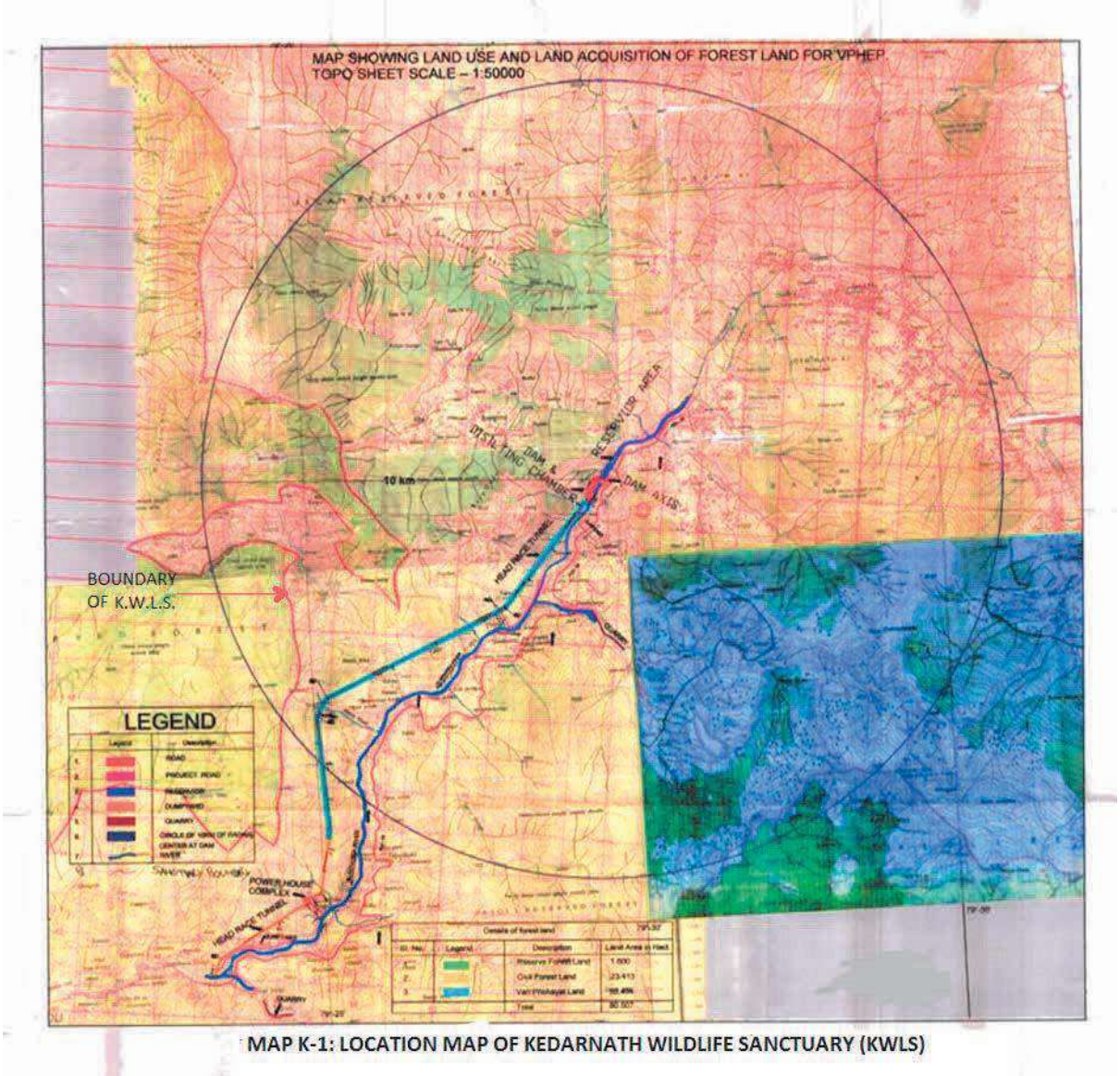


Figure-3.13: Boundary of Kedarnath Wildlife Sanctuary and Project componets of VPHEP

3.4.1.8.1. Avian-fauna

Avian fauna are regarded as important indicators of a country's environmental health (Collar and Andrew, 1988) and their high and low diversities are directly related with the environmental condition of the area. Avian-fauna or Birds are one of the most popular life forms on the planet, and their diversity leads to a richness of life and beauty. Apart from this, birds have always fascinated mankind with their intrinsically beautiful plumage, melodious songs, and artistic behavior. Besides this, birds are valuable for many aspects; that is, they

are a sensitive indicator of pollution and also play great role in pest control. List of avian fauna recorded from VPHE Project, Uttarakhand give in **Table-3.40**.

Table-3.40: Inventory of avian fauna reported from VPHE Project, Uttarakhand at study site during Post-monsoon season

Common name	Zoological name	Family	IUCN Red list
Indian Myna	*Acridotheres tristis*	Sturnidae	LC
Indian Cuckoo	*Cuculus micropterus*	Cuculidae	LC
Chukor Patridge	*Alectoris chukar*	Phasianidae	LC
House Crow	*Corvus splendens*	Corvidae	LC
Black Drongo	*Dicrurus adsimilis*	Dicruridae	LC
Black Kite	*Milvus migrans*	Accipitridae	LC
Wood pecker	*Dendrocopos himalayensis*	Picidae	LC
Grey Shrike	*Lanius excubitor*	Laniidae	LC
Pariah Kite	*Milvus migrans*	Accipitridae	LC
Large pied wagtail	*Motacilla maderaspatensis*	Motacillidae	LC
Fork-tailed Swift	*Apus pacificus*	Apodidae	LC
House Sparrow	*Passer domesticus*	Passeridae	LC
Eurasian Tree Sparrow	*Passer montanus*	Passeridae	LC
Red vented Bulbul	*Pycnonotus cafer*	Pycnonotidae	LC
Indian Robin	*Saxicoloides fulicatus*	Muscicapidae	LC
Magpie Robin	*Copsychus saularis*	Muscicapidae	LC
Spotted dove	*Streptopelia orientalis*	Columbidae	LC
Common babbler	*Turdoides caudatus*	Leiothrichidae.	LC
Blackbird	*Turdus merula*	Turdidae	LC

3.4.1.8.2. Ambhibians

Amphibians, the ancestors of modern reptiles and mammals, first evolved in Devonian era and flourished throughout Carboniferous period. This unique group of kingdom animalia provides an evolutionary link between aquatic and terrestrial mode of life. Amphibians are a class of cold-blooded vertebrates made up of frogs, toads, salamanders, newts, and caecilians (worm like animals with poorly developed eyes). All amphibians spend part of their lives in water and part on land, which is how they earned their name—"amphibian" comes from a Greek word meaning "double life. List of ambhibians reported from VPHE Project, Uttarakhand is given in **Table-3.41**.

Table-3.41: List of amphibians recorded during post-monsoon season from VPHE Project, Uttarakhand

Common name	Zoological name	Family	IUCN Red list
Toad	Bufo himalayanus	Bufonidae	LC
Frog	Rana species	Ranidae	LC
Ornamented Pygmy Frog	Microhyla ornata	Microhylidae	LC
Common Toad	Duttaphrynus melanostictus	Bufonidae	LC

LC- Least concern

3.4.1.8.3. Reptiles

Reptiles are air-breathing and cold blooded vertebrates covered in special skin made up of scales, bony plates, or a combination of both. They have crawls or moves on its belly (such as a snakes) or on a small short legs (such as a lizards). They include crocodiles, snakes, lizards, and turtles. All regularly shed the outer layer of their skin. Their metabolism depends on the temperature of their environment. While investigating during post-monsoon season VPHE Project, Uttarakhand reptiles documented which is presented in **Table-3.42**.

Table-3.42: List of reptiles recorded during post-monsoon season from VPHE Project, Uttarakhand

Common name	Zoological name	Family	IUCN Red list
Asian house Gecko	*Hemidactylus frenatus*	Gekkonidae	LC
Common Indian Lizard	*Varanus bengalensis*	Varanidae	LC
Indian giant squirrel	*Ratufa indica*	Sciuridae	LC
Green Pit Viper	*Trimeresurus albolabris*	Viperidae	LC
Himalayan Pit Viper	*Gloydius himalayanus*	Viperidae	NA
Cobra	*Bungarus caeruleus*	Elapidae	NA

LC- Least concern

3.4.1.8.4. Mammals

Mammals include humans and all other animals that are warm-blooded vertebrates (vertebrates have backbones) with hair. They characterized by the presence of mammary glands which in females produce milk for feeding (nursing) their young, a neocortex (a region of the brain), fur or hair, and three middle ear bones, list of mammals encountered while surveying and discussion with the local people. While investigating VPHE Project, Uttarakhand, several mammals documented which is presented in **Table-3.43**.

Table-3.43: List of Mammals recorded during post-monsoon season from VPHE Project, Uttarakhand.

Common name	Zoological name	Family	IUCN Red list
Jackal	*Canis aureus*	Canidae	LC
Rhesus monkey	*Macaca mulatta*	Cercopithecidae	LC
Serow	*Capricornis sumatraensis*	Bovidae	VU
Sambar	*Cervus unicolor*	Cervidae	VU
Himalayan Marten	*Martes flavigula*	Mustelidae	LC
Himalayan Musk Deer	*Moschus chrysogaster*	Moschidae	EN
Himalayan Hoary bellied squirrel	*Callosciurus pygerythrus*	Sciuridae	LC
Barking Deer	*Muntiacus muntjak*	Cervidae	LC
Jungle cat	*Felis chaus*	Felidae	LC
Himalayan Goral	*Nemorhaedus goral*	Bovidae	NA
Leopard	*Panthera pardus*	Felidae	VU
Common Langur	*Presbytis entellus*	Cercopithecidae	NA
Wild Boar	*Sus scrofa*	Suidae	LC

Common name	Zoological name	Family	IUCN Red list
Brown bear	*Ursus arctos*	Ursidae	LC
Red Fox	*Vulpes Montana*	Canidae	NA

VU - Vulnerable, LC - Least concern NA- Not applicable and EN - Endangered

3.4.1.8.5. Butterflies

Butterflies are insects in the macro lepidopteran clade Rhopalocera from the order Lepidoptera. Butterflies make the world a little more colorful. Adult butterflies have large, often brightly coloured wings, and conspicuous, fluttering flight path lend a special touch of beauty to nature. They also help flowers pollinate. Butterflies are attracted to bright flowers and need to feed on nectar. When they do this their bodies collect pollen and carry it to other plants. This helps fruits, vegetables and flowers to produce new seeds. The majority of plants need pollinators like butterflies to reproduce. List of butterflies encountered in **Table-3.44**.

Table-3.44: List of butterflies recorded during post-monsoon season from VPHE Project, Uttarakhand

S.No	Common name	Zoological name	Status
1	Tailed Punch	*Dodona eugenes*	Common
2	Silverstripe	*Lathe baladeva*	Common
3	Golden Emperor	*Dilipa morgiana*	Common
4	Pale Green Sailor	*Neptis zaida*	Common
5	Broadstick Sailor	*Neptis narayana*	Common
6	Himalayan Sailor	*Neptis mahendra*	Common
7	Himalayan Jeste	*Symbrenthia brabira*	Common
8	Pale Himalayan Oak Blue	*Amblypodia dodonaea*	Common
9	Dull Green Hairstreak	*Esakiozephyrus incana*	Common
10	Wonderful Hairstreak	*Thecla ataxus*	Common
11	White-Spotted Hairstreak	*Thecla ziha*	Common
12	Great Black Vein	*Aporia agathon*	Common
13	Dull Green Hairstreak	*Esakiozephyrus incana*	Common

3.4.1.9 Aquatic life

Periphyton comprises of organisms living on submerged surfaces including both the attached forms and the organisms associated there with. Periphyton is an extremely heterogenous and complex association of organisms on sub-aquatic natural and artificial substrates. The group consists of algae and filamentous bacteria, attached protozoans, bryozoans, rotifers and also the free swimming, creeping or lodging among the attached forms. Thus, the group is composed of three principle types of living Organism's producers, consumers and reducers (Pandit, 2002). Periphyton community includes phytoplankton, zooplankton, phytobenthos and macro-invertebrates. Algae (phytoplankton and phytobenthos) are common and important inhabitant of aquatic ecosystems and it plays an important role as a primary producer. Algae are a diverse group of simple plants ranging from unicellular to multicellular form and are considered as the first autotrophic plants of the

planet. They are very small, single-celled to complex multicellular forms, such as the gaint kelps of the eastern Pacific Ocean that grow to more than 60 meters in the length and form dense marine forests. The physico-chemical characteristics of the water may have influence on the algal spectrum represented by certain algae due to its periodical addition at a particular time while elimination of the other species at the same time. Certain algae respond quickly to any change in the quality of water and assume the role like a “sensor” in evaluation of water pollution either by retarding and preventing algal growth while others stimulate growth resulting into their bloom. Zooplankton, phytoplankton, macro-zooplankton were selected to assess the aquatic biodiversity of the study area. The composition of phytoplankton and zooplankton of a particular aquatic ecosystem are indicators of environmental stress. The phytoplankton’s constitute bulk of primary producers and are the base of food chains in any water body.

Methodology

In order to collect the samples standard methods were followed. Random sampling technique has been applied in to study aquatic ecology collection procedure. The samples were collected from the different habitats of the study area. Aquatic community specimens growing on moist cemented walls, stones, bark of trees, soil, and sand, in temporary and permanent water bodies like ditches and ponds were selected for the study. The phytoplankton and zooplankton were collected by filtering 30 to 50 liters of water at each site the help of planktonic mesh net (poresize- 10 µ), while epiphytic forms were collected by squeezing the submerged plants. The residue left in the sieve was collected in a 50 ml vial. Three replicates were taken for each community and pooled for further analysis. Phytoplankton samples were preserved using Lugol’s solution. The samples were stored in sterile plastic bottles, and recorded with GPS points. On return to the laboratory, they were washed thoroughly with water. No preservative were added in zooplankton samples.

Benthos samples were collected from each site by scraping the boulder surfaces of known quadrat area (5cm x 5cm). These samples were then preserved and analyzed in the same way as described for the plankton. The macro-invertebrates were obtained with the help of a square feet Surber sampler. The substrate, mainly stones are disturbed and immediately transferred to a bucket kept under water and later rinsed thoroughly to dislodge all the attached macro-invertebrates. For macro-invertebrates three replicates for each community were obtained and pooled for further analysis. Further analysis was conducted in laboratory. The volume of zooplankton and phytoplankton were made up to 100 ml. The total density of zooplankton and phytoplankton were calculated using ‘Drop-count’ method, described by Adoni (1983). Macro-zoobenthos samples retrieved from the sampling sites were brought to the laboratory all individuals were counted. The final densities of macro-invertebrates were

expressed in the individuals per m^2. The relative abundance of algal species was calculated as:

$$\text{Relative abundance} = \frac{\text{Number of cells of a species}}{\text{Total number of cells counted}} * 100$$

Semi-permanent slides were prepared from each sample for the identification of various taxa and observed under trinocular research microscope. The samples are acid digested, centrifuged and thoroughly rinsed to get the cleared samples. For treatment of samples, the standard method was followed (APHA, 2005). The permanent slides were prepared by mounting the medium in Euparol. These slides were examined using standard literature (Lange- Bertalot & amp; Krammer, 2000, 2001, 2002; Hustedt and Jenson, 1985; Sarod and Kamat, 1983). Relative abundance of each species of phytoplankton and phytobenthos was calculated at each site. Average value of relative abundance of each species was calculated for each stretch for final presentation. To count and identify the macro-invertebrate Pennak (1953) and Edmondson (1959) were followed.

3.4.1.9.1 Phytoplankton

Phytoplankton species of different groups of community were recorded to be growing in the study area is Bacillariophyceae, Chlorophycaeae and Myxophyceae. Phytoplanktonwere recorded in the study area while investigating VPHE, Uttarakhand project during post-mansoon season is presented in **Table-3.45**.

Table-3.45: Phytoplankton diversity recorded during post- monsoon season from VPHE Project, Uttarakhand

S. No.	Scientific Name	Family
1	*Tabellaria fenestris*	Bacillariophyceae
2	*Fragillaria inflate*	Bacillariophyceae
3	*Meridion circulare*	Bacillariophyceae
4	*Nitzschia species*	Bacillariophyceae
5	*Navicula radiosa*	Bacillariophyceae
6	*Cyclotella* species	Bacillariophyceae
7	*Cocconeis placentula*	Bacillariophyceae
8	*Cymbella cistula*	Bacillariophyceae
9	*Cymbella cistula*	Bacillariophyceae
10	*Gomphonema* species	Bacillariophyceae
11	*Diatoma elongate*	Bacillariophyceae
12	*Denticula* species	Bacillariophyceae
13	*Diatoma vulgaris*	Bacillariophyceae
14	*Ulothrix zonata*	Chlorophyceae
15	*Zygnema* species	Chlorophyceae
16	*Cladophora* species	Chlorophyceae
17	*Closterium leibleinii*	Chlorophyceae
18	*Spirogyra* species	Chlorophyceae
19	*Anabaena* species	Myxophyceae
20	*Phormidium* species	Myxophyceae
21	*Oscillatoria tenuis*	Myxophyceae
22	*Oscillatoria willei*	Myxophyceae

S. No.	Scientific Name	Family
23	*Phormidium* species	Myxophyceae

3.4.1.9.2 Zooplankton diversity

Zooplankton, the free-swimming animalcules inhabiting different zones of aquatic ecosystems, provides valuable information about the ecological status of any water-body. Zooplanktons have their own peak of rise and fall seasonally, depending upon various abiotic and biotic factors governing that water-body. Taxa of zooplanktons mainly comprised of rotifers and Cladocera in the study area. *Asplanchna* species, *Epiphanes* species, *Chydorus* species, *Macrothrix* species, *Eucyclops* species were the common zooplanktons reported in the study area.

Table-3.46: Zooplanktons diversity recorded during post- monsoon season from VPHE Project, Uttarakhand.

S. No.	Taxa	Zoological Name
1	Rotifera	*Asplanchna* species
2	Rotifera	*Brachionus* species
3	Rotifera	*Cephalodella* species
4	Rotifera	*Epiphanes* species
5	Rotifera	*Dicranophorus* species
6	Rotifera	*Eicranophorus* species
7	Rotifera	*Keratella* species
8	Rotifera	*Rotaria* species
9	Rotifera	*Trichocerca* species
10	Cladocera	*Alona* species
11	Cladocera	*Alonell* species
12	Cladocera	*Chydorus* species
13	Cladocera	*Ceriodaphnia* species
14	Cladocera	*Daphnia* species
15	Cladocera	*Macrothrix* species
16	Cladocera	*Pleuroxus* species
17	Cladocera	*Simocephalus* species
18	Copepode	*Phyllodiaptomus* species
19	Copepode	*Mesocyclops* species
20	Copepode	*Microcyclops* species
21	Copepode	*Eucyclops* species
22	Copepode	*Cyclops* species

3.4.1.9.3 Macro-zoobenthos

Macro-zoobenthos were recorded in the study area while investigating VPHE, project, Uttarakhand is listed in **Table-3.47**.

Table-3.47: **Macro-zoobenthos recorded during post-mosoon season from VPHE Project, Uttarakhand.**

S. No.	Zoological name	Order
1	*Baetis muticus*	Ephemeroptera
2	*Baetis niger*	Ephemeroptera
3	*Baetis rhodoni*	Ephemeroptera

S. No.	Zoological name	Order
4	*Caenis* Cyclotella species	Ephemeroptera
5	*Centroptilum* species	Ephemeroptera
6	*Ephemerella ignita*	Ephemeroptera
7	*Ephemerella notata*	Ephemeroptera
8	*Ironodes* species	Ephemeroptera
9	*Leptophlebia* species	Ephemeroptera
10	*Psephenus* species	Ephemeroptera
11	*Glossosoma* species	Trichoptera
12	*Hydropsyche fulvipes*	Trichoptera
13	*Perla* species	Trichoptera
14	*Leptocella* species	Trichoptera
15	*Limnephilous* species	Trichoptera
16	*Philopotamus montanus*	Trichoptera
17	*Rhyacophila* species	Trichoptera
18	*Antocha saxicola*	Diptera
19	*Atherix* species	Diptera
20	*Chironomus* species	Diptera
21	*Simulium* species	Diptera
22	*Tendipes* species	Diptera
23	*Perla* species	Plecoptera
24	*Isogenus* species	Plecoptera
25	*Corydalus* species	Neuropterans

3.4.1.9.4 Fish

A typical fish is ectothermic, has a streamlined body for rapid swimming, extracts oxygen from water using gills or uses an accessory breathing organ to breathe atmospheric oxygen, has two sets of paired fins, usually one or two (rarely three) dorsal fins, an anal fin, and a tail fin, has jaws, has skin that is usually covered with scales, and lays eggs.

Methodology

Surveys and samplings of ichthyo fauna in influence area of VPHEP, Uttarakhand during Post-mansoon was carried out in the study area. The sampling was conducted in the surrounding areas of project component sites of VPHEP in the study area. The surveys were carried out using fishing efforts and fishing was done with the help of local fishermen using cast net. Secondary data were also included for this project report. The data was not available from study sites in particular, therefore, data was gathered from nearby areas, which are anticipated to inhabit present study areas. All the parameters studied are within the permissible limits. For fish diversity and identification study used standard literature in the form of books, research articles and also taken the help of Fishery Department of Chamoli district, Uttarakhand. While investigating VPHE Project, Uttarakhand, several Fish's documented this is listed in **Table-3.48**.

Table-3.48: Fish diversity recorded during post-monsoon season from VPHE, project, Uttarakhand

Common name	Zoological name	Family	IUCN Red list
Maseen	*Schizothorax richardsonii* Gray	Cyprinidae	VU
Chongu	*Schizothoraichthys progastus* McClelland	Cyprinidae	LC
Dansulu	*Tor tor* Hamilton	Cyprinidae	DD
Dansulu	*Tor putitora* Hamilton	Cyprinidae	EN
Sunhera	*Crossocheilus latius latius* Hamilton	Cyprinidae	NA
Gondal	*Garra gotyla gotyla* Gray	Cyprinidae	NA
Gondal	*Garra lamta* Hamilton	Cyprinidae	LC
Fulra	*Barilius bendelisis* Hamilton	Cyprinidae	LC
Fulra	*Barilius bola* Hamilton	Cyprinidae	NA
Fulra	*Barilius barna* Hamilton	Cyprinidae	LC
Fulra	*Puntius sophore* Hamilton	Cyprinidae	LC
Fulra	*Puntius chelynoides* McClelland	Cyprinidae	VU
Nau	*Glyptothorax pectinopterus* McClelland	Sisoridae	LC
Nau	*Glyptothorax madraspatanum* Day	Sisoridae	NA
Mungria	*Pseudecheneis sulcatus* McClelland	Sisoridae	NA
Gadiya	*Nemacheilus montanus* McClelland	Nemacheilidae	NA
Gadiya	*Noemacheilus bevani* Gunther	Nemacheilidae	NA
Gadiya	*Nemacheilus multifasciatus* Day	Nemacheilidae	LC
Gadiya	*Nemacheilus zonatus* McClelland	Nemacheilidae	NA

VU - Vulnerable, LC - Least concern, DD - Data deficient, NA - Not applicable and EN - Endangered

View of Forest during post-monson season from study area of VPHE Project, Uttarakhand

View of pine forest during VPHE Project, Uttarakhand (post-monsoon season)

Expert surveying the floral diversity of VPHE Project, Uttarakhand (post-monson season)

Discussion with local people for collecting information on ethnobotany and wildlife during post-monson season from study area of VPHE Project, Uttarakhand

View of cultivable land during post-monson season from study area of VPHE Project, Uttarakhand

Mangifera indica

Pinus roxburghii

Sapindus mukorossi

Phoenix humilis

Psidium guajava

Moringa pterygosperma

Phyllanthus emblica

Cedrus deodara

Common trees recorded in the study area of VPHE Project, Uttarakhand in the Post-mosoon season.

Ocimum species

Ephedra gerardiana

Echinops echinatus

Mirabilis jalapa

Galinsoga parviflora

***Pteris* species**

Parthenium hysterophoru

Elephantopus scaber

Common herbs recorded in the study area of VPHE Project, Uttarakhand in the Post-mosoon season.

Lantana camara

Ziziphus mauritiana

Ageratina adenophora

Boehmeria macrophylla

Urtica parviflora

Aerva sanguinolenta

Ricinus communis

Shrubs recorded in the study area of VPHE Project, Uttarakhand in the Post-mosoon season.

Lichen recorded in the study area of VPHE Project, Uttarakhand in the Post-mosoon season.


Birds diversity recorded in the study area of VPHE Project, Uttarakhand in the Post-mosoon season.


Rhesus monkey(*Macaca mulatta*) **Langur(*Presbytis entellus*)**

Animals diversity recorded during post-monsoon season from study area of VPHE Project, Uttarakhand.

3.5 SOCIO-ECONOMIC ASPECTS

Profile of Project District Chamoli

District Chamoli is a part of Garhwal Himalaya North, one of the three divisions of sub-region Uttarakhnad Himalaya of the region namely the Northern Mountains of the country. It lies in the middle north of Uttarakhand state in the rugged Himalayan terrain; Tibet forms Northern boundary, on the south-east side the district is bounded by the Almora & Garhwal, on the east by Almora, Bageshwar & Pithoragarh and on west side by district of Rudraprayag & Uttarkashi.

With regards to Sex Ratio in Chamoli, it stood at 1019 per 1000 male compared to 2001 census figure of 1016. The average national sex ratio in India is 940 as per latest reports of Census 2011 Directorate.

The district lies between 29°55'37" to 31°27'3" N and 78º54'3" to 80º2'3" E. After carvation of Rudra Prayag from Chamoli district, the overall sprawl of the district comes to 8,030 sq. km. The district in present form occupies over 15% of the total area of the State, but contains only about 4% of state's population.

The District Map of Chamoli is presented as Figure-3.14.

Figure-3.14: District Map of Chamoli

Demographic Details of the Project District

The demographic details of the project District are presented as below

Table-3.49: Demographic features of project District

S No.	Particulars	District Chamoli (as per Census 2001)	District Chamoli (as per Census 2011)
1.	Area (Sq Km)	8030	8030
2.	Households	77381	88383
3.	Total Population	370359	391605
4.	Total Male Population	183745	193991
5.	Total Female Population	186614	197614
6.	Total SC Population	67539	79317
7.	Total ST Population	10484	12260
8.	Population Density (Per Sq. Km)	45.85	49

**Source: Census of India*

In 2011, Chamoli had population of 391,605 of which male and female were 193,991 and 97,614 respectively. In 2001 census, Chamoli had a population of 370,359 of which males were 183,745 and remaining 186,614 were females.

Scheduled Castes

Table-3.50: Decadal Change in Scheduled Castes Population (2001-2011)

District	2001			2011			Difference	Decadal Variation (%)
	P	M	F	P	M	F		
Chamoli	67539	33991	33548	79317	39718	39599	11778	17.43

**Source: Census of India*

From the Table-3.51 we depicts that as per Census 2011, Chamoli district total Scheduled Castes decadal variation is 17.43percent.

Scheduled Tribes

Table-3.51: Decadal Change in Scheduled Tribes Population (2001-2011)

District	2001			2011			Difference	Decadal Variation (%)
	P	M	F	P	M	F		
Chamoli	10484	5083	5401	12260	6021	6239	1776	16.94

**Source: Census of India*

From Table-3.52 we depict that as per Census 2011, Chamoli district total Scheduled Tribes decadal variation is 16.94%.

Literacy Level

In the district about 83% population is literate. The literacy is about 92% in urban areas and about 81% in rural areas. Average literacy rate of Chamoli in 2011 were 82.65 compared to 75.43 of 2001. If things are looked out at gender wise, male and female literacy were 93.40 and 72.32 respectively, however for 2001 census, same figures stood at 89.66 and 61.63 in Chamoli District.

Table-3.53: Literacy level in project District

S No.	Particulars	District Chamoli (as per Census 2001)	District Chamoli (as per Census 2011)
1.	Total No. of Literates	237354	280556
2.	No. of Male Literates	138934	155395
3.	No. of Female Literates	98420	125161
4.	Total Literacy Rate (%)	75.43	82.65
5.	Male Literacy Rate (%)	89.66	93.40
6.	Female Literacy rate (%)	61.63	72.32

**Source: Census of India*

Work Participation

In the total population of the district of 391,605 as much as 51.9 % are workers and rest of 48.1 % are non-worker. Among workers 63.6 % are main workers and rest of 36% are marginal workers. In absolute terms males outnumber females as main worker but females outnumber greatly the males as marginal workers.

Table-3.54: Work Participation in project District

S No.	Particulars	District Chamoli (as per Census 2001)	District Chamoli (as per Census 2011)
1.	Main Workers	96900	115115
2.	Marginal Workers	67829	65825
3.	Total Workers	164729	180940

**Source: Census of India*

Demographic Profile of the Study Villages

The project affected villages fall under two blocks of Chamoli District namely Dasholi Block (Chamoli Tehsil) and Joshimath Block (Joshimath Tehsil). The socio-economic and demographic features of the project area villages are presented at the block level.

Population

The distribution of population and demographic profile is outlined in Table-3.55. The male and female population comprises about 53.53% and 46.47% of the total population respectively. The sex-ratio of Chamoli district is around 1019 compared to 963 which is average of Uttarakhand state. The Demographic Profile of the area is shown in Figure-3.15.

Table-3.55: Demographic Profile of Study Area

S. No	Name	Area (in Sq. Km)	Total Households	Total Population	Total Male	Total Female	Population<6 years	Total Male	Total Female
Tehsil- Dasholi (District: Chamoli)									
1.	**Hat**	155.62	79	306	149	157	26	16	10
2.	**Jainsal**	152.21	45	181	98	83	12	6	6

S. No	Name	Area (in Sq. Km)	Total Households	Total Population	Total Male	Total Female	Population<6 years	Total Male	Total Female
3.	**Batula**	224.31	170	796	422	374	98	53	45
4.	**Naurakh**	328.24	309	1574	879	695	157	75	82
5.	**Tundli Chak Haat**	11.08	8	36	22	14	10	7	3
6.	**Guniyala**	56.18	15	83	39	44	15	7	8
7.	**Math Jadetha**	271.41	112	518	254	264	79	37	42
8.	**Baula (Durgapur)**	159.29	106	493	239	254	72	41	31
9.	**Gadi**	210.65	125	559	352	207	49	19	30
Subtotal (A)		**1568.99**	**969**	**4546**	**2454**	**2092**	**518**	**261**	**257**
Tehsil- Joshimath (District: Chamoli)									
10.	**Gulabkoti**	147.18	81	356	179	177	48	25	23
11.	**Langsi**	131.24	102	395	218	177	48	22	26
12.	**Tapon**	110.21	24	92	51	41	11	7	4
13.	**Dwing**	85.26	30	127	62	65	17	8	9
14.	**Noligwar**	118.03	25	112	54	58	17	6	11
15.	**Palla**	252.88	72	369	180	189	57	26	31
16.	**Hailang**	122.79	121	528	307	221	70	36	34
17.	**Paini**	270.05	153	664	369	295	87	51	36
18.	**Thaing**	384.78	165	806	405	401	90	40	50
19.	**Salna**	56.58	31	128	69	59	22	12	10
Subtotal (B)		**1679**	**804**	**3577**	**1894**	**1683**	**467**	**233**	**234**
Total (A+B)		**3247.99**	**1773**	**8123**	**4348**	**3775**	**985**	**494**	**491**

**Source: Census of India'2011*

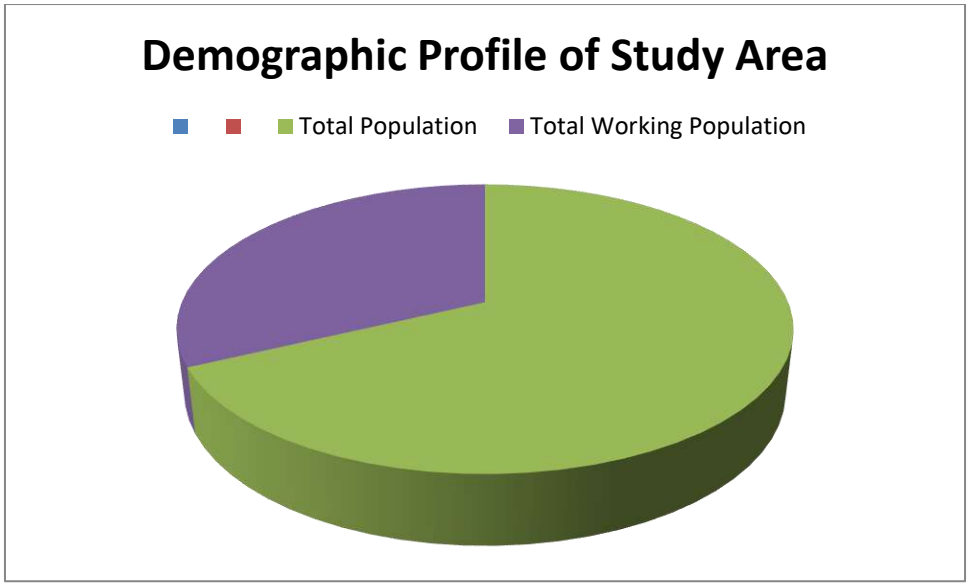


Fig-3.15: Demographic Profile of Study Area

Caste Profile

The distribution of population in study area on the basis of caste is summarized in Table-3.56. It is observed that Others/ General caste is dominant caste in the study area accounting for (70.99%) of the total population followed by Scheduled Caste (25.45%) and Scheduled Tribe (3.56%). The caste profile in the study area is presented in Figure-3.16.

Table-3.56: Caste Profile in the Study Area

S.No	Name	Total Population	Scheduled Caste Population	Scheduled Tribe Population	Others/ General caste
Tehsil- Dasholi (District: Chamoli)					
1.	**Hat**	306	133	15	158
2.	**Jainsal**	181	0	0	181
3.	**Batula**	796	135	83	578
4.	**Naurakh**	1574	492	36	1046
5.	**Chanduli Chak Haat**	36	24	0	12
6.	**Guniyala**	83	0	0	83
7.	**Math Jhadeta**	518	96	0	422
8.	**Baunla (Durgapur)**	493	171	60	262
9.	**Gadi**	559	67	0	492
Subtotal (A)		**4546**	**1118**	**194**	**3234**
Tehsil- Joshimath (District: Chamoli)					
10.	**Gulabkoti**	356	176	0	180

S.No	Name	Total Population	Scheduled Caste Population	Scheduled Tribe Population	Others/ General caste
11.	**Langsi**	395	66	8	321
12.	**Tapon**	92	4	0	88
13.	**Dwing**	127	0	0	127
14.	**Noligwar**	112	87	0	25
15.	**Palla**	369	152	0	217
16.	**Hailang**	528	282	0	246
17.	**Paini**	664	42	80	542
18.	**Thaing**	806	140	1	665
19.	**Salna**	128	0	6	122
Subtotal (B)		**3577**	**949**	**95**	**2533**
Total (A+B)		**8123**	**2067**	**289**	**5767**

**Source- Census of India'2011*

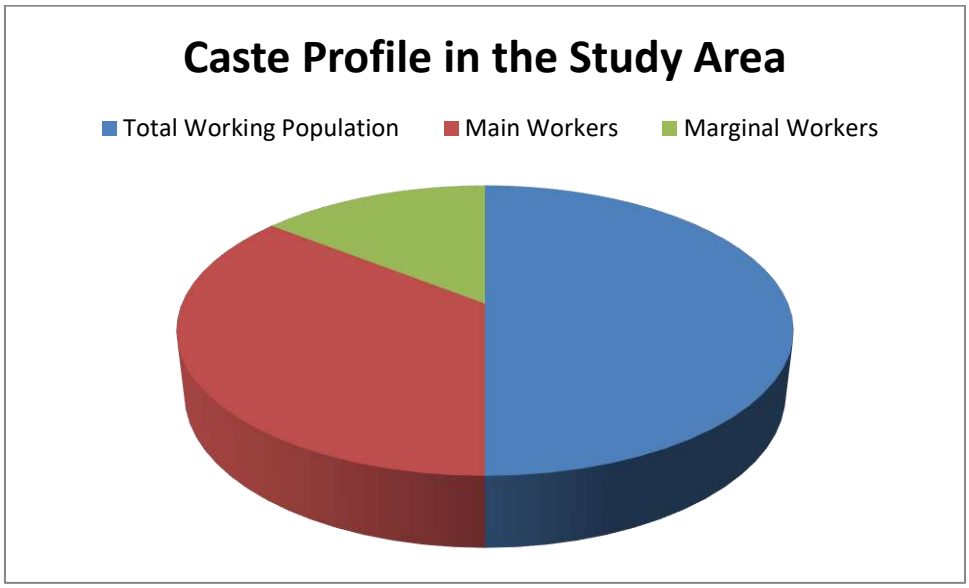


Fig-3.16: Caste Profile in the Study Area

Literacy Level

The details of literate and illiterate population amongst the total population of study area are presented in Table-3.57. It is observed that about 74.53% of the total population in the study area is literate, while about 25.47% population is illiterate. The male and female literacy rates are 59.38% and 40.62% respectively. The Distribution of literate and illiterate population in the study area is shown in Figure-3.17.

Table-3.57: Distribution of literate and illiterate population in the Study Area Villages

S.No	Village Name	Total Population	Total Literates	Male	Female	Total Illiterates
Tehsil- Dasholi (District: Chamoli)						
1.	**Hat**	306	240	129	111	66
2.	**Jainsal**	181	150	88	62	31
3.	**Batula**	796	605	340	265	191
4.	**Naurakh**	1574	1301	785	516	273
5.	**Chanduli Chak Haat**	36	17	12	5	19
6.	**Guniyala**	83	58	31	27	25
7.	**Math Jhadeta**	518	343	190	153	175
8.	**Baunla (Durgapur)**	493	355	192	163	138
9.	**Gadi**	559	419	300	119	140
Subtotal (A)		**4546**	**3488**	**2067**	**1421**	**1058**
Tehsil- Joshimath (District: Chamoli)						
10.	**Gulabkoti**	356	239	131	108	117
11.	**Langsi**	395	281	177	104	114
12.	**Tapon**	92	70	42	28	22
13.	**Dwing**	127	105	52	53	22
14.	**Noligwar**	112	72	38	34	40
15.	**Palla**	369	228	141	87	141
16.	**Hailang**	528	414	262	152	114
17.	**Paini**	664	528	312	216	136
18.	**Thaing**	806	542	323	219	264
19.	**Salna**	128	87	50	37	41
Subtotal (B)		**3577**	**2566**	**1528**	**1038**	**1011**
Total (A+B)		**8123**	**6054**	**3595**	**2459**	**2069**

**Source- Census of India'2011*

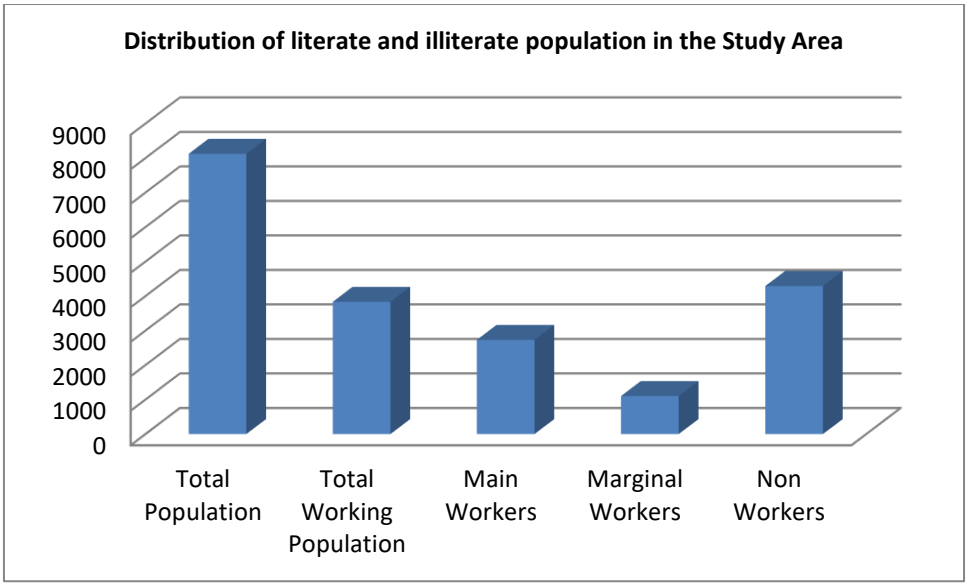


Fig- 3.17: Distribution of literate and illiterate population in the Study Area

Occupational Profile

The details on occupational profile in the study area villages are given in Table-3.58. As per this table it is observed that 47.19% of the total population is engaged in some form of economically productive activity or vocational activity, and have been designated as total working population. On the other hand, Non-workers or persons who are dependent on the population which is engaged in economically productive workers accounts for about 52.81% of the total population. Amongst the working population, about 71.25% has been designated as Main workers while the remaining 28.75% are designated as Marginal workers. The Occupational profile in the Study Area is shown in Figure-3.18

Table-3.58: Occupational Profile in the Study Area

S. No	Village Name	Total Population	Total Working Population	Main Workers	Marginal Workers	Non Workers
Tehsil- Dasholi (District: Chamoli)						
1.	**Hat**	306	177	48	129	129
2.	**Jainsal**	181	80	80	0	101
3.	**Batula**	796	355	179	176	441
4.	**Naurakh**	1574	500	250	250	1074
5.	**Chanduli Chak Haat**	36	8	3	5	28
6.	**Guniyala**	83	18	18	0	65
7.	**Math Jhadeta**	518	88	76	12	430
8.	**Baunla (Durgapur)**	493	261	259	2	232

S. No	Village Name	Total Population	Total Working Population	Main Workers	Marginal Workers	Non Workers
9.	**Gadi**	559	369	353	16	190
Subtotal (A)		**4546**	**1856**	**1266**	**590**	**2690**
Tehsil- Joshimath (District: Chamoli)						
10.	**Gulabkoti**	356	229	63	166	127
11.	**Langsi**	395	227	133	94	168
12.	**Tapon**	92	59	11	48	33
13.	**Dwing**	127	47	15	32	80
14.	**Noligwar**	112	56	14	42	56
15.	**Palla**	369	187	187	0	182
16.	**Hailang**	528	187	122	65	341
17.	**Paini**	664	412	350	62	252
18.	**Thaing**	806	496	493	3	310
19.	**Salna**	128	77	77	0	51
Subtotal (B)		**3577**	**1977**	**1465**	**512**	**1600**
Total (A+B)		**8123**	**3833**	**2731**	**1102**	**4290**

**Source- Census of India'2011*

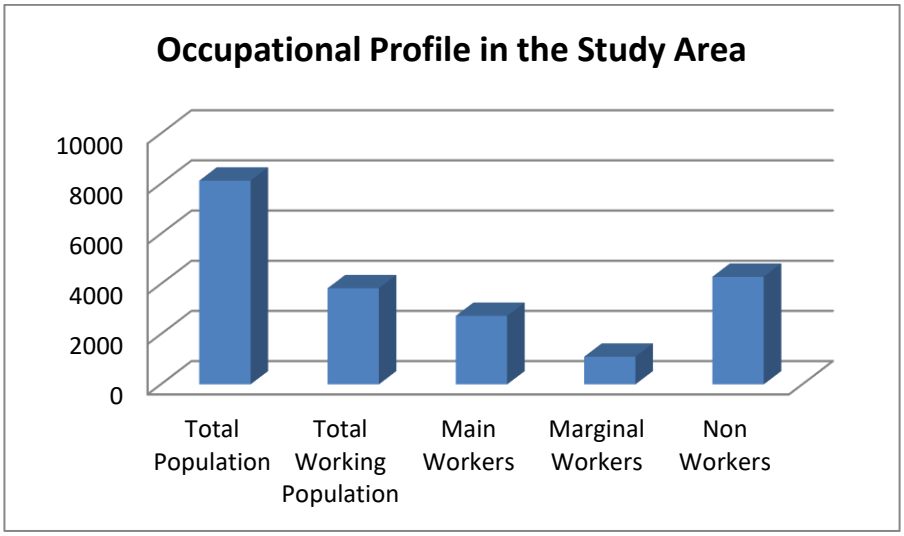


Fig-3.18: Occupational Profile in the Study Area

Availability of different amenities in CD Block Joshimath and Dasholi

Tables presented below deals with the distribution of villages according to the availability of different amenities like education, medical, improved drinking water, telephone, transport, communications, approach by pucca road and power supply within the village.

Total Inhabited Villages: 202

Table 3.59: Distribution of villages according to Availability of Different Amenities

S No.	Name of CD Block	Number of Inhabited Villages	Type of Amenity Available						
			Education	Medical	Drinking Water	Post Office	Telephone	Transport/ communication	Bank
1	Joshimath	90	86 (95.56%)	23 (25.56%)	90 (100%)	36 (40%)	90 (100%)	24 (26.67%)	2 (2.22%)
2	Dasholi	112	105 (93.75%)	46 (41.07%)	108 (96.43%)	36 (32.14%)	112 (100%)	22 (19.64%)	9 (8.04%)
Total		**202**	**191 (94.55%)**	**69 (34.16%)**	**198 (98.02%)**	**72 (35.64%)**	**202 (100%)**	**46 (22.77%)**	**11 (5.45%)**

- *Source: Census of India'2011*

Table 3.60: Distribution of villages according to Availability of Different Amenities

S No.	Name of CD Block	Number of Inhabited Villages	Type of Amenity Available		
			Agricultural Credit Societies	Appraoch by Pucca Road	Power Supply
1	Joshimath	90	2 (2.22%)	11 (12.22%)	90 (100%)
2	Dasholi	112	7 (6.25%)	26 (23.21%)	109 (97.32%)
Total		**202**	**9 (4.45%)**	**37 (18.32%)**	**199 (98.51%)**

- *Source: Census of India'2011*

Land and land use pattern of district

The variety of the land comprises undulating and rugged terrain. It requires persistent efforts and hard labour to terrace the steep hill. In the river valleys, land is fertile. According to statistics available for agriculture as appears in Statistical Bulletin 2008-09 the total area available remained 851764 hectares. Out of these 59.42% were under forests, cultivable waste 8.34%, fallow and other fallow land 0.11%, Usar and unfit for agriculture 8.35 percent, land put to other uses 7.18%, orchards and fodder 3.27% and net area sown to the limit of 3.89%. Looking into the size of land holdings it was found that 10% of the total holdings were 0.5 hectare, 15.7% holdings of 0.5 to 1 hectare, 31.26% of 1 to 2 hectares, 29.7% between 2 and 4 hectares, 12.1% holdings of the size 4 to 10 hectares and lastly1.13% of the land holdings in size of 10 or more hectares.

Table- 3.61: Land and land use Pattern (in Hectare)

Name	Year	Total Area	Forest	Cultivable Waste	Fallow land	Other fallow land	Usar & Unfit for Agriculture	Other Uses
Chamoli	2009-10	851764	506100	71100	210	566	10280	61209
	2010-11	851764	506100	71095	82	87	9203	61211
	2011-12	851764	506100	71101	3314	116	9233	61216
	2012-13	851764	506100	10999	280	1668	72228	60920
	2013-14	851764	506100	10997	580	1756	72226	60924
	2014-15	851764	506100	10992	776	1760	72226	60935
	2015-16	851764	506100	11006	151	1035	72226	60937
	2016-17	851764	506100	11019	252	1034	72224	60940
	2017-18	851764	506100	11566	696	1027	90813	11841

**Source: District Statistics Book '2019*

Land Requirement

Vishnugad Pipalkoti Hydro Electric Project as envisaged is purely a run of the river scheme without having any storage except upstream poundage up to EL 1267 m to facilitate diversion of water into the water conveyance system. Thus the land requirement for the project is primarily for accommodating different project components and other

allied works. The estimated land requirement for different project components is presented in Table-3.60

Table-3.62: Activity wise Total Land Requirement

S No.	Activity	Area Acquired (Ha.)	% to Total area
1.	Dam Area	9.722	6.87
2.	Approach Area	31.192	22.04
3.	Quarry Area	11.712	8.27
4.	Dumping Area	5.037	3.56
5.	Colony Area	8.836	6.24
6.	Power House Area	27.35	19.32
7.	Reservoir Area	20.231	14.29
8.	Underground Works	23.13	16.34
9.	Electrical Works	4.3435	3.07
	Total	**141.5535**	**100.00**

**Source: RAP, VPHEP, THDC*

Land Acquisition

A total of 141.55 hectares (ha) of land is required to create the necessary facilities and infrastructure and other activities under VPHEP. Of the total 141.55 Hectare land comprising 31.639 Hectare of Private land across 7 Villages, 100.390 Hectare of Forest / Van Panchyat / Civil Soyam Land from 22 Revenue Villages & 9.539 Hectare of PWD Land has been acquired / Diverted for VPHE Project. The Project has taken over the possession of total land.

Social Impact

Since the VPHEP is a run-of-river project, it has comparatively limited land acquisition impacts. However, the inhabitants of Haat – the village most affected by land acquisition for the powerhouse, a surge shaft and access roads – demanded relocation and rehabilitation of the entire village citing continuous disturbance and pollution during construction stage as the reason. In November 2007, THDC agreed to purchase all private land in and around the village on a willing-seller-willing-buyer basis supplemented by the provisions of THDC's Resettlement Policy.

Table-3.63: Project affected families (Private Land)

S No.	Village	Land Acquired (Ha.)	Title Holders	Total PAFs	Total PAPs
1	Haat	20.337	253	375	750
2	Jaisaal	6.878	113	188	463
3	Gulabkoti	3.394	48	79	204
4	Batula	0.542	49	92	277
5	Guniyala	0.197	25	38	100
6	Tenduli Chak Haat	0.170	04	08	35
7	Naurakh	0.121	67	115	320
Total		**31.639**	**559**	**895**	**2149**

** Source: RAP, VPHEP, THDC*

Socio-Economic Profile of the Affected Population

A detailed socio-economic survey was conducted in conjunction with the census and verification of the affected persons to profile the impacted project area and provide a baseline against which mitigation measures and support will be measured. For this purpose, comprehensive information related to PAP's assets, income, socio-cultural and demographic indicators and other sources of support such as common property resources were collected. The detail land ownership records were collected for the land proposed for acquisition from the concerned revenue. Then accordingly verification was conducted in the affected villages where in the details of the affected land along with ownership, usage of the land, structures affected and structure particulars, number of titleholders, non- titleholders, place of residence, dependents on the land and others was taken.

Impact on Structures

A total of 139 private structures and 31 community properties were acquired under the project. Of the private structures, 99 were residential, 5 were residential and commercial, 3 were only commercial, and the remaining 32 were cattle shed or dilapidated structures. Of the families losing their houses, three are non-titleholders, who will nevertheless receive the minimum land compensation of INR 100,000. Of the 104 residential and residential / commercial houses acquired, 94 are in Haat, and the remaining are in the villages of Jaisal (6) and Batula (4). All the families resettling have chosen to move to locations of their own choice. In addition to the house compensation –which the case of Haat equals the agreed selling price - all the relocating households that are resident in the houses acquired (including the non-titleholders) will receive the additional INR 1 million for self- resettlement to substitute for the infrastructure they would have access to in a resettlement site.

Details of Structures Affected under the Project

Table-3.64: Usage of Structure

S No.	Name of the Village	Residential	Commercial	Residential+ Commercial	Others	Total
1.	Haat	91	0	3	22	116
2.	Jaisal	5	0	1	7	13
3.	Batula	3	1	1	3	8
4.	Naurakh	0	0	0	0	0
5.	Tenduli Chak Haat	0	0	0	0	0
6.	Guniyala	0	2	0	0	2
7.	Gulabkoti	0	0	0	0	0
Total		**99**	**3**	**5**	**32**	**139**

**Source: RAP, VPHEP, THDC*

Table-3.65: Type of Structure

S No.	Name of the Village	Permanent	Semi-Permanent	Kutcha	Total	CPR
1.	Haat	63	0	53	116	31
2.	Jaisal	4	7	2	13	0
3.	Batula	3	1	4	8	0
4.	Naurakh	0	0	0	0	0
5.	Tenduli Chak Haat	0	0	0	0	0
6.	Guniyala	0	2	0	2	0
7.	Gulabkoti	0	0	0	0	0
Total		**70**	**10**	**59**	**139**	**31**

**Source: RAP, VPHEP, THDC*

Impact on Livestock

Villagers use both government land and Van Panchayat land for grazing and fodder collection. Van Panchayats were formed from 1921 onwards for the use and management of forest and grazing land by village communities. A total of 11 villages will lose access to an average of 2.5% of the government forest land that they use at present for grass collection and grazing, and a total of 8 villages lose access to an average of 0.9% of the Van Panchayat land they use for grazing and collection of grass and firewood. Of these villages, 3 lose access to both government forest and Van Panchayat land.

Impact on Vulnerable People

444 vulnerable people are affected by the project. The details are presented in Table-3.61 below.

Table-3.66: Details of village wise number of affected vulnerable persons

Vulnerable	Haat	Batula	Naurakh	Guniyala	Jaisal	Gulabkoti	Tenduli Chak Haat	Total
Disabled	2	4	0	3	6	0	0	15
Widow	17	17	9	4	22	7	1	77
Unmarried	26	17	5	4	23	11	1	87
>50 years	36	59	13	8	56	16	1	189
BPL (HHs)	24	10	2	0	16	22	2	76
Total	**105**	**107**	**29**	**19**	**123**	**56**	**5**	**444**

**Source: RAP, VPHEP, THDC*

Mitigation Measures

Site selection for construction of infrastructure and other facilities were done in such-as manner which involved minimal land acquisition of private land. Mitigation measures suggested to minimize the adverse impacts of the project are given below:

THDCIL has developed Resettlement and Rehabilitation Policy. The R&R Policy is based on The National Rehabilitation and Resettlement Policy (NRRP), 2007 and experience gained over the years. The policy recognizes the need to support restoration of livelihoods of

adversely affected people and lays down norms for rehabilitating the affected people and broadly outlines an approach and institutional framework to achieve its objectives.

Social Scenario till date

Status of R & R

The Implementation of Rehabilitation Action Plan (RAP) and R&R related Activities are presently under progress. Compensation has been provided by SLAO to PAFs whose land, assets etc has been acquired for the project under LA Act 1894. Additional R&R grants / Assistance have been provided by THDCIL as per the approved R&R policy.

Around 94% of Compensation amount has been disbursed by Special Land Acquisition Officer (SLAO) and approx. 88% R&R grant have been disbursed by THDCIL.

Haat Status

Of the 07 affected Villages, only 1 village i.e. Haat is getting relocated comprising of 140 PAFs & the status is as under;

- **Resident HHs** – 81 nos (Agreement signed – 77, House constructed- 76, shifted- 76, House demolished-61)
- **Non Resident HHs** – 50 nos (Agreement signed – 38, House demolished- 36)
- **ST Families** – 9 nos (Agreement signed – 9, House Constructed – 9, House demolished – 2)

The 7 ST families have constructed their houses on the 8 Naali (1600 Sq. M.) land purchased by them on Kauria - Haat road. Development of Area including providing necessary infrastructure facilities at above relocation site has since been completed by THDCIL.

Social Responsibilities

Construction of CPR

In addition to the compensation / Grants provided by SLAO/ THDCIL, common property resources like Pathways, Drinking water facility, Street Light, Primary School, Panchayat Ghar, Anganwari Kendra etc has been constructed at self resettlement sites.

Loss of Fuel and Fodder

Each entitled house hold in the affected habitation is being paid 100 days of Minimum Agriculture Wages per year for a period of 5 yrs. On the recommendations of the World Bank, THDCIL has increased disbursement of Fuel & Fodder Grants from 5 years to 8 years. The amount is paid as a grant / assistance towards the loss of fuel and fodder. Around 2700 households are getting benefited through this assistance.

Community Development Works

Under Community development various works have been taken up in the Project affected villages ie; construction of Pathways, Waiting shelters, Community buildings, Road widening,

Hill side slope protection works, Solar street lights for villages, furniture & sports kits for community, water supply schemes, Teaching aids & furniture to schools, Construction of additional classrooms & toilets, promotion of sports & cultural activities, awareness camps on social & environmental aspects, health camps & awareness camps on HIV AIDS, Pulse Polio etc.

Livelihood Activities

Various activities have also been taken up to create livelihood opportunities. These are Dairy Development, Poultry, Tailoring & Stitching, Wool Knitting, Bee Keeping, Mushroom cultivation, vermin composting to promote organic farming, plantation etc. Awareness programs for Project affected people are also organized with the help of various State Govt. Deptts ie; Horticulture, Agriculture, Tourism, Animal Husbandry etc to give awareness on various schemes, subsidies, technical assistance etc to convince local youth to opt for self employed income generation activities. Around 500 beneficiaries are benefited through these programs.

On the recommendations of the World Bank M/s Mirda Renergy & Development Pvt. Ltd. New Delhi has been awarded the works towards “Engagement of Specialized Agency to help prepare Livelohood Development/ Employment Generation Plan & its Implementation in relation to VPHEP”. The baseline survey has been completed & Draft Baseline Report is been submitted by the agency.

Vocational Trainings

Apart from above, Vocational Trainings in hotel management, Excavator operator, Electrician, Fitter, Refrigerating & Air Conditioning and other skill enhancement activities, etc. are also undertaken, in coordination with various institutes like GMR Foundation, Dr. Reddy Foundation, and Industrial Training Institutes in nearby areas. Around 300 beneficiaries are benefited through these programs.

Education

To promote Education the Project has undertaken various activities ie; Scholarship to Project affected Meritorious/Poor/ Girls students, Construction of additional class rooms & toilets, providing teaching aids & uniform, Assistance for getting admission in ITIs, assistance to schools for cultural activities etc. Around 1400 students having approx. 800 girls have been benefitted through scholarship program of THDCIL till Academic year 2018-19. The above assistance has been kept on hold as the schools are presently closed due to COVID-19 pandemic.

Health

The project is helping PAPs by facilitating them to THDCILs Dispensaries (Allopathy & Homeopathy) established in the Project Campus. OPD / IPD facility including medicines is given free of cost to PAPs. In addition to this Medical health camps are organized in project affected villages and Ambulance facility is also provided to the needy PAPs free of cost.

One Hopper Dumper Tipper TATA ACE 1.8 CUM has been handed over to Nagar Panchyat, Pipalkoti, District Chamoli. The vehicle is used for transportation of Garbage to Disposal sites under their control.

Employment

Keeping in view that the Hydro Projects are capital intensive with the State of the Art Technology and therefore do not offer much employment opportunity, particularly in unskilled category, the option of providing job with THDCIL as per policy is not considered as a rehabilitation option. However, as on date around 1118 persons have been provided direct / indirect employment opportunities in Project HCC / THDCIL / Contractors / Hiring of vehicles / Lease land for various purposes etc.

CHAPTER-4
ANTICIPATED ENVIRONMENTAL IMPACTS AND MITIGATION MEASURES

CHAPTER-4

ANTICIPATED ENVIRONMENTAL IMPACTS AND MITIGATION MEASURES

4.1 GENERAL

Based on the project details and the baseline environmental status, potential impacts as a result of the construction and operation of the under construction Vishnugad Pipalkoti Hydro Project (VPHEP) have been identified. This Chapter addresses the basic concepts and methodological approach for conducting a scientifically based analysis of the potential impacts likely to accrue as a result of the VPHEP project. The Environmental Impact Assessment (EIA) for quite a few disciplines is subjective in nature and cannot be quantified. Wherever possible, the impacts have been quantified and otherwise, qualitative assessment has been undertaken. This Chapter deals with the anticipated positive as well as negative impacts due to construction and operation of the VPHEP. The construction and operation phase comprise of various activities each of which is likely to have an impact on environment. Thus, it is important to understand and analyze each activity so as to assess its impact on environment.

The potential environmental impacts on various environmental parameters due to various project activities have been identified and Scoping Matrix for EIA study for the Vishnugad Pipalkoti Hydro-Electric Project is outlined in Table- 4.1.

Table-4.1: Scoping Matrix for EIA study for the Vishnugad Pipalkoti Hydro-Electric Project

Aspects of Environment	Likely Impacts
A. Land Environment	
Construction phase	- Increase in soil erosion from various construction and quarry sites - Pollution by construction spoils - Acquisition of land for construction of project appurtenances labour camps/ colonies cause land use pattern - Solid waste generated from labour camps/colonies
Operation phase	- Solid waste generated from colonies
B. Water Resources & Water Quality	
Construction phase	- Impact on water quality of receiving water body due to disposal of runoff from construction Sites carrying high sediment level. - Degradation of water quality due to disposal of effluent from labour, camps/colonies
Operation phase	- Modification of hydrologic regime due to diversion of water for hydropower generation
C. Aquatic Ecology	
Construction phase	- Increased pressure on riverine fisheries as a result of indiscriminate fishing by the Immigrant labour population.

Aspects of Environment	Likely Impacts
	- Reduced productivity due to increase in turbidity levels as a result of disposed-off waste water from construction sites and labour Camps/ colonies.
Operation phase	- Impacts on spawning & breeding grounds in the stretch downstream of dam site to Tail race disposal site. - Degradation of riverine ecology - Impacts on migratory fish species - Impact on aquatic ecology due to reduction in flow downstream of the dam site upto tail race disposal site.
D. Terrestrial Ecology	
Construction phase	- Increased pressure from labour to meet their fuel wood requirements during project construction phase - Adverse impacts on flora and fauna due to increased accessibility in the area and increased level of human interferences - Loss of forest due to siting of various project appurtenances
Operation phase	- Impacts on wildlife movement due to the project - Impacts on wildlife habitats due to acquisition of forest land for various project appurtenances.
E. Socio-Economic Aspects	
Construction phase	- Increased employment potential during project construction phase, Development of allied sectors leading to greater employment - Pressure on existing infrastructure facilities. - Cultural conflicts and law and order issues due to migration of labour population
Operation phase	- Loss of community properties, if any - Impacts on archaeological and cultural monuments, if any - Impacts on mineral reserves, if any
F. Air Pollution	
Construction Phase	- Impacts due to emission as a result of fuel combustion in various construction equipment - Impacts due to emission as a result of increased vehicular movement for transportation of men and material during project construction phase - Fugitive envisions from various sources - Impacts due to emissions from DG set
G. Noise Pollution	
Construction Phase	- Noise due to operation of various construction equipment - Noise due to increased vehicular movement - Noise due to blasting - Increased noise levels due to operation of DG set
H. Public Health	
Construction Phase	- Increased incidence of water related diseases - Transmission of diseases by immigrant labor population
Operation phase	- Increased incidence of vector- borne diseases

Based on the Scoping Matrix, the environmental baseline data has been collected. The project details have been superimposed on environmental baseline conditions to understand the beneficial and deleterious impacts due to the construction and operation of the Vishnugad Pipalkoti Hydro Electric Project.

The Project is under construction and present status is given in the following paragraphs.

Civil & Hydro-Mechanical Works:

- River Diversion has been completed.
- Construction of U/S Coffer Dam has been completed.
- Open excavation in Dam area including plunge pool - 40% has been completed.
- Heading of all 3 De-silting Chambers has been completed and benching 40% completed.
- HRT by DBM - 77% Heading excavation completed
- Intake tunnel - 1, 2 and 3 - Excavation 100% completed. First phase of Overt concrete lining has been completed, 100 % in Intake Tunnel-1 & 2 and 80.50% in Intake Tunnel-3. Invert concrete lining in Intake Tunnel-1 has been 94% completed.
- TBM has been commissioned. During operation of TBM in the RBM zone, big boulders have been encountered, which has hampered TBM operation. To overcome this problem two Approach Adits are being constructed to reach the cutter head. One Adit has been completed 23m out of 36m.
- In Machine Hall, crown excavation has been completed and strengthening of geologically weak section with steel rib supports is in progress.
- In Transformer Hall, pilot tunnel completed 100% and 70% crown excavation completed. Balance in progress along with stabilization with steel rib supports.
- In TRT, heading excavation 14.40% completed.
- At TRT outlet area, 80% slope stabilization work has been completed.

Electro - Mechanical Works:

Design and Engineering is in progress. Model testing of Turbine has been successfully completed in BHEL. Supply of EM equipment amounting to Rs. 167.60 cr has been completed. The overall physical and financial progress is 51.50% and 58.0% respectively.

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

- Impacts on Land Environment
- Impacts on Water Environment
- Impacts on Air Environment
- Impacts on Noise Environment
- Impacts on Biological Environment
- Impacts on Socio-Economic Environment

4.2 IMPACTS ON LAND ENVIRONMENT

4.2.1 Construction Phase

The impacts on land environment due to construction of the project have been evaluated and it was found that terrain around project site is going to have permanent and temporary changes in the landscape.

4.2.1.1 Impacts due to acquisition of land

Vishnugad Pipalkoti Hydro Electric Project as envisaged is a run of the river scheme without having any storage except upstream pond age up to EL 1267 m to facilitate diversion of water into the water conveyance system. Thus, land requirement for the project shall be limited for accommodating different project components and other allied works. A total of 141.568 ha of land required to create the necessary facilities and infrastructure and other activities under VPHEP is in the possession of THDCIL. Of the total land required, 100.39 ha (including 23.13 ha for underground works, 20.231 ha for reservoir area) is forest land and 9.539 ha belongs to PWD (road/pathways etc.) that are transferred to project. The private land of 31.621 ha has been acquired for the project.

The construction of dam and intake structure involves stripping of the banks but due to good quality rocks the river banks after stripping shall still be sufficiently stable, however, at places where joints and weak seams are encountered rock bolting/fiber link guniting shall be resorted too. In the submergence zone the stability of the land slide prone zone shall be strengthened by adapting to engineering and biological measures.

Due to submergence, major impacts will be on river regime which will change from riverine to lacustrine state, which implies that the area of water body shall increase. The existing private settlements, forest, etc. within submergence shall change to water body. But as the project is a Run-off the river scheme, only 20.231 ha of forest land (along the river flood plain) with little or no vegetation has been acquired for reservoir area and therefore the impacts are neither significant nor critical as compared to storage based HEP's.

4.2.1.2 Quarrying operations

A project of this magnitude would require significant amount of construction material. The quarrying operations are semi-mechanized in nature. Both fine and coarse aggregates are to be processed from the river shoals located near the power house site and rock material required for construction are from the quarry area near the dam site. Quarry sites were identified for the project are at Patalganga quarry (5 km from dam site), Gadi quarry (Birahi quarry) 5 km from power house site. Generally, a permanent scar is likely to be left, once quarrying activities are over in most of the quarries. With the passage of time, the rock from the exposed face of the quarry under the action of wind and other erosion forces, get slowly weathered and after some time, they (slopes)may become a potential source of landslide. Thus, it is necessary to implement appropriate slope stabilization measures to prevent the possibility of soil erosion.

Similarly, the construction project would require significant amount of fine material, which can be met either by crushing the aggregates or by excavation from borrow areas. In the project, large quantity of fines shall be required, which would entail excavation from borrow pits. Normally,

such sites are left untreated after excavation of the construction material. The pit so created impedes the natural drainage, increases the potential for soil erosion and stores rain water and runoff. These pools of water can serve as habitats for proliferation of mosquitoes, which can lead to increased incidence of vector-borne diseases.

Mitigation Measures

A. Restoration Plan for Quarries

Reclamation of Quarry area will be undertaken under the project. Both the quarries selected for VPHEP are of river-bed mining type and therefore are supposed to be restored each year during the monsoon period. However, for the temporary infrastructure expected to be developed (e.g. Approach road etc.) after closure of quarry operations shall be restored back, filled and covered with soil cover and, if possible/permitted, developed into garden/ tourist spot / playground etc. as per the location of the site.

Restoration plan of quarries is a part of mining plan which is an essential compliance condition for obtaining the mining license and Environmental clearance from state government. The quarry restoration plan of Gadi quarry is enclosed at Annexure-VIII Apart from above, following measures may be taken into consideration if required.

Diversion of run off

Effective drainage system will be provided to avoid the infiltration of run-off and surface waters into the ground of quarry sites. Garland drains around quarry site shall be constructed to capture the runoff and divert the same to the nearest natural drain.

Filling of depressions

Removal of rocks from quarry sites for different construction works will result in the formation of depression and/or craters. These will be filled by the dumping materials consisting of boulders, rock, gravel and soil from nearby plant/working sites.

Construction of retaining walls

Retaining walls will be constructed at the filled-up depressions of quarry sites to provide necessary support particularly where there are moderately steep slopes. In addition, concrete guards shall be constructed to check the soil erosion of the area.

Rocks for landscaping

After quarrying activities are over, these sites will be splattered with the leftovers of rocks and boulders. These boulders and rocks can support the growth of mosses and lichens, which will act as ecological pioneers and initiate the process of succession and colonization. The boulders of moderate size will be used to line the boundary of a path.

Laying of the top soil

The depressions/craters filled-up with rock aggregates will be covered with top soil. Fungal spores naturally present in top soil will aid plant growth and natural plant succession. The top soil

will be further enriched by organic manure and Vesicular-Arbuscular Mycorrhizal (VAM) fungi. This will help in the process of soil reclamation and the early establishment of juvenile seedlings.

Barbed wire fencing

The periphery of the area of rock quarry site will be fenced to prevent entry of animals in the quarry area and to protect the plantation from grazing and to enhance natural regeneration.

Re-vegetation

The work plan formulated for re-vegetation of the dumping sites through 'Integrated Biological and Biotechnological Approach' would be based upon the following parameters:

- Evaluation of rock material for their physical and chemical properties to assess the nutrient status to support vegetation.
- Formulation of appropriate blends of organic waste and soil to enhance the nutrient status of rhizosphere.
- Isolation and screening of specialized strains of mycorrhizal fungi, rhizobium, azotobacter and phosphate solubilizers (bio-fertilizers inoculums) suitable for the mined out sites.
- Mass culture of plant specific biofertilizer and mycorrhizal fungi to be procured from different institutions/organizations which are engaged in the phyto-remediation activity of degraded areas.
- Plantation at quarry sites/areas using identified blend and bio fertilizer inoculums.

B. Landscaping and Restoration of Construction Areas

Area for landscaping

The working area of dam site, power house, and colony area has been selected for beautification of the project area after construction is over there is a need to construct benches for sitting, development of resting sheds and footpath. The beautification would be carried out by developing flowering beds for plantation ornamental plant and flower garden.

There would be sufficient open space in power house complex and colony area. Forested area in the power house complex would provide aesthetic view and add to natural beauty. The beautification in the colony area would be carried out by development of flowering beds for plantation of ornamental plant, creepers, flower garden and a small park, construction of benches for sitting, resting sheds, walk way and fountain.

The construction of the project is expected to lead to certain changes in the area, as the construction of the project requires excavations. Also approach roads have been proposed to excess these construction areas. Although, no major alteration of the area is expected, still measures have been recommended for landscaping and restoration of construction sites.

A garden with local ornamental plants and trees will also be created in the empty area left after the construction activities. All plants will be properly labeled with scientific and/or common names.

4.2.1.3 Impacts due to muck disposal

In the project, muck generation is envisaged during excavation of project components such as Dam, Power house, TRT, Adits, Pressure shaft etc. worked out. The project would involve

excavation of earth and rock generating muck in large quantum. Out of the 40.00 L cum (lakh cubic meter) of the total muck likely to be generated from the construction works of the project at least 14.00 L cum will be utilized for construction purposes of different project components, filling works and other infrastructure works. For dumping of the remaining muck of i.e. 31.20 Lcum, four dump yards areas viz. (i) Haat, (ii) Jaisaal, (iii) Gulabkoti and (iv) Siyasain, have been earmarked adjacent to project components and are operational. In these 4 identified sites dumping will be done and further they will be restored and revegetated with proper landscaping. The capacity and location of disposal areas are given in **Table 4.2.**

Table 4.2: Details of Muck Disposal Sites

Dumping Location	Capacity of Disposal Yard (in Lack cum)
Gulabkoti (Disposal Yard 1)	12.3
Haat (Disposal Yard 2)	12.65
Siyasain (Disposal Yard 4)	5.47
Jaisal (Disposal Yard 5)	1.28
Total	**31.7**

Muck, if not securely transported and dumped at pre-designated sites, can have serious environmental impacts, such as:

- Muckmay get washed away into the main river which can cause negative impacts on the aquatic ecosystem of the river.
- Muck disposal may lead to impacts on various aspects of environment. Normally, the land is cleared before muck disposal. During clearing operations, trees are cut, and undergrowth perishes as a result of muck disposal.
- In many of the sites, muck is stacked without adequate stabilization measures. In such a scenario, the muck moves along with runoff and creates landslide like situations. Many a times, boulders/large stone pieces enter the river/water body, affecting the benthic fauna, fisheries and other components of aquatic biota.
- Normally muck disposal is done at low lying areas, which get filled up due to stacking of muck. This can sometimes affect the natural drainage pattern of the area leading to accumulation of water or partial flooding of some area which can provide ideal breeding habitat for mosquitoes.

Mitigation Measures

A. Muck disposal Plan

It is proposed to dispose muck, after creating terraces. Suitable retaining walls shall be constructed to develop terraces so as to support the muck on vertical slope and for optimum space utilization. Loose muck would be compacted layer wise. The muck disposal area will be developed in a series of terraces of boulder crate wall and masonry wall to protect the area/muck from flood water during monsoons. In-between the terraces, catch water drain will be provided.

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

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

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

Various activities proposed as a part of the management plan are given as below:

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

For stabilization of muck dumping areas following engineering and biological measures are being executed at dump site-

Engineering Measures

- Wire crate wall
- Boulder crate wall
- R.C.C
- Catch water Drain
- Gabion retaining wall

Biological Measures

- Plantation of suitable tree species and soil binding species
- Plantation of ornamental plants
- Barbed wire fencing
- Plantation of vegetation
- Vetivar grass (Chrysopogon Zizanioides)

Muck generally lacks nutrients and therefore, is difficult to re-vegetate. However, if no attempts to vegetate the slopes are made, the muck could slide lower down during rain and may eventually wash off the check dams also. Since, top soils are not available in large quantities in Himalayas, it may not be possible to apply a thin layer of soil over the muck. It is proposed to use Bio-fertilizer technique in the proposed project for stabilization of muck disposal sites. As a part of this technique, unused excavated material is piled and stacked with proper slopes at the designated muck disposal sites. The slopes are broken up by creating benches across them. This is done to provide stability to the slopes and also to provide ample space for planting of trees that would further help in holding and consolidating biotechnological approach. The traditional methods of afforestation of these areas would be supplemented with the use of fungus, i.e. Vesicular Arbuscular Mycorrizae (VAM) and nitrogen fixing bacteria that form partnership with plant roots. These grow on plant roots and provide water and nutrition especially phosphorus to plants at faster rate. The seeding of plants would be inoculated with VAM and nitrogen fixing bacteria before planting. It has been found that plants inoculated with bio-fertilizers grow at faster rate especially in the medium where the soil/rock is devoid of nutrients.

The afforestation with suitable plant species shall be done. About 1000-1200 trees/ha shall be planted.

The unused excavated material shall be piled and stacked with proper slopes at the designated muck disposal sites. The slopes are broken up by creating benches across them. This is done to provide stability to the slopes and also to provide ample space for planting of trees that would further help in holding and consolidating biotechnological approach.

Some of the muck disposal sites shall be used for temporary infrastructure works during construction phase. On completion of construction activities, the same shall be used for Greenbelt Development.

4.2.1.4 Changes in land stability, erosion and sedimentation

During construction phase a large quantity of construction material like stones, pebbles, gravel and sand would be needed. Significant amount of material is available in the riverbed. It is proposed to extract construction material from borrow areas in the riverbed. The extraction of construction material will lead to formation of pits. Normally, deposition of material takes place at sites where velocity reduces on account of flattening of slopes, increase in cross-sectional area. Such sites are used for extraction of construction material. The pits at sites after extraction of construction material will be under constant erosion in high flows and deposition under low flows. These pits with passage of time will be stabilized due to settlement of silt and sediments in the pits created on the riverbed. Thus, no major impacts are anticipated on this account.

The runoff from the construction sites will have a natural tendency to flow towards river or its tributaries. For some distance downstream of major construction sites, such as dam, powerhouse, etc. there is a possibility of increased sediment levels which will lead to reduction in light penetration, which in turn could reduce the photosynthetic activity to some extent of the aquatic plants as it depends directly on sunlight. This change is likely to have an adverse impact on the primary biological productivity of the affected stretch of river Alkananda. Quantum of rainfall is very low in term of flow in river Alaknanda.

4.2.1.5 Solid waste generation from labour camps

During construction phase, labour, clerical staff and technical personnel are likely to congregate. The increase in population is expected to be of the order of 3200 during the peak construction phase. The average per capita solid waste generated would be of the order of 425 gm/day/person. The solid waste likely to be generated from labour camps will about 3.5 tonnes/day. For solid waste collection, 30 number of masonry storage vats, each of 2 m^3capacity will be constructed at appropriate locations in various labour camps. These vats will be emptied at regular intervals and the collected waste can then be transported to disposal site.

The chemical characteristics of solid waste generated are given in Table-4.3 The composition of various waste materials is in the municipal refuse is detailed in Table-4.4.

Table-4.3: Chemical characteristics of municipal waste

Component	Percentage by weight(%)
Moisture	19.52
Organic matter	25.14
Nitrogen (as Total Nitrogen)	0.66
Phosphorous (as P_2O_S)	0.56
Potassium (as K_2O)	0.69

The composition of various waste materials is in the municipal refuse is detailed in Table-4.5.

Table-4.4: Composition of waste material in municipal refuse

Ingredient	Percentage by weight (%)
Paper	4.71
Rubber, Leather and synthetics	0.71
Glass	0.46
Metals	0.49
Total compostable matter	38.95
Inert matter	44.73
Others/ plastic	9.95
Total	**100**

Mitigation Measures

A. Solid Waste Management Plan

A sufficient number of garbage bins and containers will be made available at the worker camps, the areas of planned and spontaneous resettlement and at the main work sites.

Garbage and other waste will be regularly collected and be transported to a designated waste disposal site. Two covered trucks to collect the solid waste from common collection point and transfer it to the disposal site. The solid waste management plan of VPHEP has been integrated with Joshimath and Chamoli Municipal parishad.

Suitable sanitary and solid waste collection and disposal facilities or systems will be provided at all camps, workshops, stores, offices, main work sites and personnel will be provided to operate and maintain the systems. Various aspects of solid waste management include:

- Reuse/Recycling
- Refuse storage
- Collection and Transportation
- Disposal

Reuse/Recycling

In order to reduce quantum of waste generated, project will reuse significant quantity of Muck (generated due to excavations) for backfilling, form work (in civil work) wherever possible and will also reuse the packing materials received with packages etc.

Project proponent will explore opportunity to recycle the waste generated at the project site. In this context project will identify authorized vendors and send used batteries, used oil, and used oil filters for recycling.

Bio-degradable waste will be disposed by composting and the manure generated will be given to local community for cultivating vegetables and flowers.

Refuse storage

In the construction project, labour camps shall have provisions to separately store the degradable and non-degradable solid waste.

Two different colored bins shall be supplied to each labour family, who will segregate the waste generated by their family. Green and Biodegradable waste is to be deposited in one container and non-biodegradable waste in another container. In case of canteens, kitchens also, two different colored dust-bins suitable to deposit the Biodegradable and non-biodegradable waste generated in their unit shall be provided. A sustained awareness programme will be conducted to educate workers about the segregation of degradable and bio-degradable wastes.

Collection of Household Waste

Every day the trolleys will collect the waste at the door of each unit of labour camp and colonies. The trolleys will be provided with two compartments for depositing segregated waste separately. Each worker will be allotted at a fixed area. The collection will be on regular pre-informed timings and the arrival will be informed through blowing a whistle/horn. The solid waste so collected shall be disposed at a common storage point. Two trucks will be commissioned to collect the solid waste and dispose the same at sites designated for disposal of solid waste.

Segregation of waste

The awareness programmes shall be organized for waste segregation. Residents of labour camps shall be apprised of the benefits of waste segregation. Regular meeting shall be conducted with representative of residents of colonies where good upkeep shall be recognized and rewarded.

Disposal

Degradable component

The degradable portion of the solid waste would be disposed-off by composting. The degradable portion is taken as about 38.9%. Thus, (0.389*0.67) about 0.26 t/day of degradable portion of solid waste expected to be generated. An electronic composting machine of capacity around 250kg/day has been procured and being used for the composting of the bio-degradable waste (mainly food waste) from the colony and camps.

Non-Degradable component

The non- degradable portion such as plastic bottles, cans, etc. shall be segregated and stored in the solid waste management facility developed at the project. The non-biodegradable waste so collected is transported to municipal facilities in Chamoli and Joshimath.

Impacts due to Construction of Roads

The construction of roads can lead to the following impacts:

- The topography of the project area has steep slope, which descends rapidly into narrow valleys. The conditions can give rise to erosion hazards due to net downhill movement of soil aggregates.
- Removal of trees on slopes and re-working of the slopes in the immediate vicinity of roads can encourage landslides, erosion gullies, etc. With the removal of vegetal cover, erosive action of water gets pronounced and accelerates the process of soil erosion and formation of deep gullies. Consequently, the hill faces are bared of soil vegetative cover and enormous quantities of soil and rock can move down the rivers, and in some cases, the road itself may get washed out.
- Construction of new roads increases the accessibility of a hitherto undisturbed areas resulting in greater human interferences and subsequent adverse impacts on the ecosystem.
- Increased air pollution during construction phase.

Mitigation Measures

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

Construction

- Area for clearing shall be kept minimum subject to the technical requirements of the road. The clearing area shall be properly demarcated to save desirable trees and shrubs and to keep tree cutting to the minimum.
- Where erosion is likely to be a problem, clearing operations shall be so scheduled and performed that grading operations and permanent erosion control of features can follow immediately thereafter, if the project conditions permit; otherwise temporary erosion control measures shall be provided between successive construction stages. Under no circumstances, however, should very large surface area of erodible earth material be exposed at any one time by clearing.
- The method of balanced cut and fill formation shall be adopted to avoid large difference in cut and fill quantities.

The treatment for cut slope failure of rock mass s depicted in **Figure-4.1.**

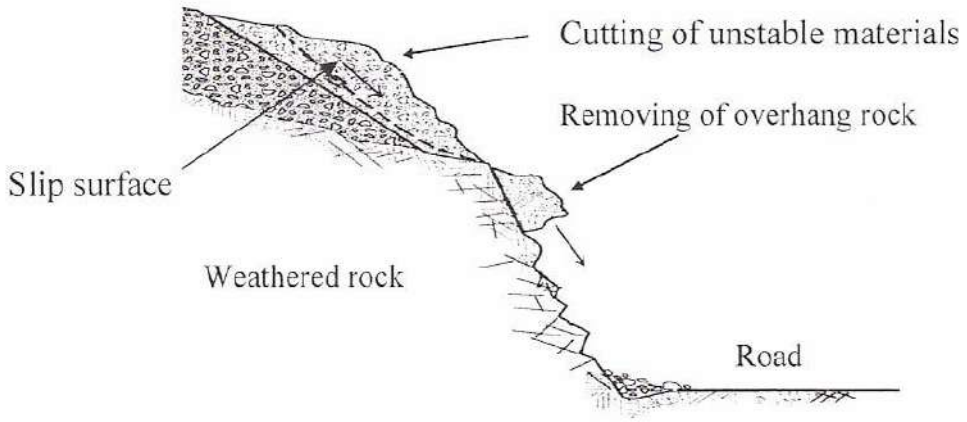


Figure-4.1: Treatment for Cut Slope Failure of Rock Mass

The cut slopes shall be suitably protected by breast walls, provision of flat stable slopes, construction of catch water and intercepting drains, treatment of slopes and unstable areas above and underneath the road, etc**. (Refer Figure-4.2).**

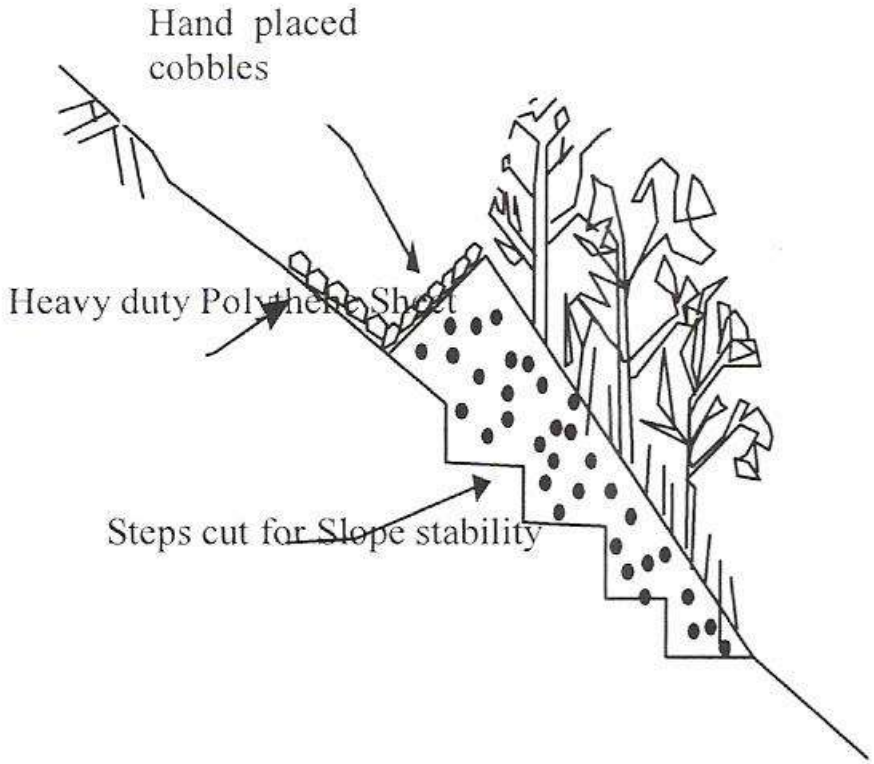


Figure-4.2: Protection of slopes

- Landslide prone areas shall be treated with location specific engineering protection measures.
- Where rock blasting is involved, controlled blasting techniques shall be adopted to avoid over-shattering of hill faces.
- Excavated material should not be thrown haphazardly but dumped duly dressed up in a suitable form at appropriate places where it cannot get easily washed away by rain, and such spoil deposits may be duly trapped or provided with some vegetative cover.

Drainage

- Drainage of the water from hill slopes and road surface is very important. All artificial drains shall be linked with the existing natural drainage system.
- Surface drains shall have gentle slopes. Where falls in levels are to be negotiated, check dams with silting basins shall be constructed and that soil is not eroded and carried away by high velocity flows.
- Location and alignment of culverts should also be so chosen as to avoid severe erosion at outlets and siltation at inlets.

Grassing and Planting

- Tree felling for road construction/works should be kept bare minimum and strict control must be exercised in consultation with the Forest Department. Equivalent number of new trees should be planted as integral part of the project within the available land and if necessary, separate additional land may be acquired for this purpose.

- Depending on the availability of land and other resources, afforestation of roadside land should be carried out to a sufficient distance on either side of the road.

Various measures recommended in this chapter shall be included in the contract document of the contractor involved in construction activities. The implementation of these measures shall be monitored by the project proponents. However, the site for disposal of solid waste shall be identified in consultation with district administration.

4.2.1.6 Landslides

The landslide at Pipalkoti, Pakhi, Tangri, Patal Ganga, Langsi, Gulabkoti and Helong are observed along the road section, fall on the left side of the river. Most of the project activities desiltation chamber, Head Race Tunnel, Power House and Tail Race Tunnel are located in the right bank of the river.

Occurrence of land slide due to road cutting may take place on either side. Since the dam and surge shaft area come under the low hazardous zone while the TRT outfall area come under the moderate hazardous zone the triggering of landslide due to project activities is likely to be insignificant or moderate.

Mitigation measures

- The very low hazard and low hazard zones are considered safe for development schemes.
- The moderate hazard zones may contain some local vulnerable zones of instability, which could be controlled with appropriate slope protection measures such as rock bolting, geo-grid etc.
- Wherever required check dams spurs and vegetative measures must be undertaken.
- Wherever, high hazard and very high hazard zones present it could be avoided. Drainage must be provided along roads.
- Plantation must be carried along the approach roads.
- Green belt development program may be undertaken, vegetation tends to reduce surface water runoff and thus reduce the potential for erosion thus enhancing stability of slope. The barren and sparsely vegetated areas show faster erosion and greater instability.

4.3 WATER QUALITY

4.3.1 Construction phase

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

- Sewage from labour camps/colonies.
- Effluent from crusher/batching plants.
- Effluents from TBM

4.3.1.1 Sewage from labour camps

The peak strength likely to be employed during project construction phase is about 2000 labour and 600 technical staff. The employment opportunities in the area are limited. Thus, during the project construction phase, some of the locals may get employment. It has been observed during construction phase of many of the projects; the major works are contracted out, who bring their own skilled labour. However, it is only in the unskilled category, that locals get employment.

The construction phase shall also lead to mushrooming of various allied activities to meet the demands of the immigrant labour population in the project area.

Based on experience of similar projects and above referred assumptions, the increase in the population as a result of migration of labour population during construction phase is expected to be of the order of 3200.

The domestic water requirement has been estimated as 70 lpcd. Thus, the total water requirements work out to 0.22 mld. It is assumed that about 80% of the water supplied will be generated as sewage. Thus, total quantum of sewage generated is expected to be of the order of 0.18 mld. The BOD load contributed by domestic sources will be about 144 kg/day

Mitigation Measures

The water quality of the river Alaknanda requires to be maintained to desired standard for river as specified by Uttarakhand State Pollution Control Board. In case the natural sources get dried up alternative sources may be explored or the river water can be utilized.

There is need to be meaningful consultation with local communities so that management measures are culturally appropriate locally and have community support. Discharge of waste from construction/ labour camp into water bodies must be strictly prohibited. Adequate drainage system to dispose storm water drainage from the labour colonies should be provided. Labour camps are located at away from water bodies and local settlements to the extent possible. Malaria control measures which aim at destroying the habitat and interrupting the life cycle of mosquitoes by mechanical or biological or chemical means need to be implemented. The anti-malarial operations can be coordinated by various Primary Health Centers (PHC) in the nearby villages and Hospital at District Headquarters in association with the project proponents. Silt fencing may be provided near water bodies to avoid spillage of construction material. Water quality monitoring will be conducted during construction phase. In operation phase proper waste and water management plan must be prepared for the colony area. Discharge of waste directly into the water body is strictly prohibited. A sewage plant has been constructed at project colony and the sewage of labour camps is being treated through septic tank and soak pit.

4.3.1.2 Effluent from crusher/batching plants

Crusher and batching plants are irreplaceable part of a construction project of this magnitude.

Crusher and batching plants both use water for their operation and often the effluent (highly turbid) from these plants may find its way to the water bodies causing undesirable impacts upon the water quality of the water body.

during construction phase, at least one crusher is to be commissioned at the quarry site by the contractor involved in construction activities. It was proposed only crushed material would be brought at construction site. The total capacities of the two crushers are likely to be of the order of 120-150 tph. Water is required to wash the boulders and to lower the temperature of the

crushing edge. About 0.1 m^3 of water is required per tonne of material crushed. The effluent from the crusher would contain high-suspended solids. About 12-15 m^3/hr of wastewater is expected to be generated from each crusher. The effluent, if disposed without treatment can lead to marginal increase in the turbidity levels in the receiving water bodies. The natural slope in the area is such that, the effluent from the crushers will ultimately find its way in river Alaknanda. This amounts to a discharge of 0.0033 to 0.0042 cumec. Even the lowest 10-day minimum flow in river Alaknanda is10.69cumec. The effluent from crusher will have suspended solids level of 3000-4000 mg/l. On the other hand, suspended solids as observed at various sampling locations, during water quality monitoring studies was observed to be <0.1 mg/l. The composite value of suspended solids would increase by 0.25 mg/l, which is insignificant. Thus, no adverse impacts, are anticipated due to small quantity of effluent and large volume of water available in river Alkanada for dilution. Even then, it is proposed to treat the effluent before disposal so to ameliorate even the marginal impacts likely to accrue on this account.

4.3.1.3 Effluent due to tunneling operations

During tunneling work the ground water flows into the tunnel along with construction water, which is used for various works like drilling, concreting, etc. The effluent thus generated in the tunnel contains high suspended solids. It is recommended to construct a settling tank of adequate size to settle the suspended impurities. Thus, effluents are expected to be generated from these locations. The sludge from the various settling tanks can be collected once in 15 days and disposed at the site designed for disposal of municipal solid wastes. The sludge after drying could also be used as cover material for landfill disposal site.

4.3.1.5 Effluent from Fabrication Units and Workshops

The fabrication units and workshops which shall be functional during construction phase will generate effluents with high suspended solids and oil and grease. It is proposed to treat the effluent from fabrication units and workshops in a oil and grease separater unit prior to disposal.

4.2.2 Operation phase

4.3.2.1 Effluent from project colony

During project operation phase, due to absence of any large-scale construction activity, the cause and source of water pollution will be much different. Since, only a small number of O&M staff will reside in the area in a well-designed colony with sewage treatment plant and other infrastructure facilities, the problems of water pollution due to disposal of sewage are not anticipated.

In the operation phase, about 100 families (total population of 500) will be residing in the project colony. About 0.23 to 0.27 mld of sewage will be generated. The total BOD loading will be order of 68 to 81 kg/day. It was proposed to provide biological treatment facilities including secondary treatment units for sewage so generated from the BOD load after treatment will reduce to 10 to

12 kg/day. It shall be ensured that sewage from the project colony be treated in a sewage treatment plant so as to meet the disposal standards for effluent. Thus, with commissioning of facilities for sewage treatment, no impact on receiving water body is anticipated. Thus, no impacts are anticipated as a result of disposal of effluents from the project colony.

Mitigation Measures

In the project operation phase, a plant colony with 50 quarters is already constructed. It was recommended to provide a suitable Sewage Treatment Plant (STP) to treat the sewage generated from the colony. The cost required for construction of sewage STP in the project colony has already been covered in the budget earmarked for construction of the project colony. Hence, the cost for the same has not been included in the cost for implementing EMP.

4.4 IMPACTS DUE TO SEDIMENTATION

There will be significant modification in hydrologic regime of river Alaknanda due to diversion of water for hydropower generation and storage of water in the reservoir. The discharge in the intervening stretch downstream of dam site upto tail race disposal site would be reduced from the pre-project level to the spills/releases from the reservoir. In addition, there will be contribution from the intervening catchment as well.

The construction of the reservoir would reduce the velocity of flowing water converting a lentic system to lotic system. The reduction in velocity would lead to sedimentation at the dam site. Increased levels of soil erosion are not anticipated at the dam site due to the project.

Sediment will be fed abruptly to the reservoir when landslides will occur in these areas due to bank erosion. Besides this, changes in land use practices in the upper catchment area may also contribute to increased sediment yields over the longer term since the project has also cultivated and fragile areas.

The construction of the dam will stop the sediment flow from the dam site to the downstream river reaches. The change in the hydraulic regime will affect normal erosion and sediment transport patterns along the banks and riverbeds.

When a river flows along a steep gradient, it could carry a significant amount of sediment load, depending on the degradation status of the catchment. When a hydraulic structure is built across the river, it creates a reservoir, which tends to accumulate the sediment, as the suspended load settles down due to decrease in flow velocity.

Mitigation Measures

The project is based on Run off the River Scheme and at regular intervals, flushing will be done to clear out the sediments. Catchment Area Treatment and Eco-restoration Plan (refer Chapter-10) is prepared to address the issue of sedimentation in the dam.

4.5 IMPACTS ON DOWNSTREAM USERS

The diversion of water for hydropower generation will lead to drying or reduction of flow in the river stretch of about 2.69 km. The effect will be more pronounced in the lean season, however minimum flow will maintained by the joining of tributary and release of e-flow; as notified by Ministry Of Jal Shakti vides its notification dated 09.10.2018. There are no major users of water in the intervening stretches, as river flows through a gorge No major adverse impacts are anticipated on downstream water users. There are no major sources of water pollution in the intervening stretch. Thus, no adverse impacts on water quality is anticipated.

The project is based on Run of the River Scheme. Water will be diverted through a tunnel for power generation and the tail race discharge outfall in Alaknanda river about 2.69 km downstream from the diversion site. The river stretch downstream of the diversion site upto the confluence point of tailrace discharge (about 2.69 km) will have reduced flow. The flow will be augmented by contribution of flow by release of adequate quantum of Environmental Flows for sustenance of riverine ecology.

The reduction in flow or drying of the river in the intervening stretch is not likely to have any adverse impact on the downstream users. This is mainly because of the fact that settlements/ villages within this dry stretch are not dependent on the water of river Alaknanda, as the villagers use water of small streams or nallahs flowing adjacent to their habitation.

Mitigation Measures

Environmental Flows shall be released for ensuring water supply for downstream users.

4.6 IMPACTS ON AIR ENVIRONMENT

4.6.1 Construction Phase

4.6.1.1 Pollution due to fuel combustion of various equipment

The operation of various construction equipment requires combustion of fuel. Normally, diesel is used in such equipment. The major pollutant which gets emitted as a result of combustion of diesel is SO_2. The SPM emissions are minimal due to low ash content in diesel. The short-term increase in SO_2, even assuming that all the equipment are operating at a common point, is quite low, i.e. of the order of less than 1$\mu g/m^3$. Hence, no major impact is anticipated on this account on ambient air quality.

4.6.1.2Emissions from crushers

The operation of the crusher during the construction phase is likely to generate fugitive emissions, which can move even up to 1 km in predominant wind direction. During construction phase, one crusher each is likely to be commissioned near dam and power house sites. During crushing operations, fugitive emissions comprising mainly the suspended particulate will be generated. Since, there are no major settlements close to the barrage and power house, hence, no major adverse

impacts on this account are anticipated.

During the layout design, care should be taken to ensure that the labour camps, colonies, etc. are located on the leeward side and outside the impact zone (say about 2 km on the wind direction) of the crushers.

4.6.1.3 Fugitive Emissions from various sources

During construction phase, there will be increased vehicular movement. Lot of construction material like sand, fine aggregate are stored at various sites, during the project construction phase. Normally, due to blowing of winds, especially when the environment is dry, some of the stored material can get entrained in the atmosphere. However, such impacts are visible only in and around the storage sites. The impacts on this account are generally, insignificant in nature.

4.6.1.4 Blasting Operations

Blasting will result in vibration, which shall propagate through the rocks to various degrees and may cause loosening of rocks/boulders. The overall impact due to blasting operations will be restricted well below the surface and no major impacts are envisaged at the ground level.

During tunneling operations, dust will be generated during blasting. ID blowers will be provided with dust handling system to capture and generated dust. The dust will settle on vegetation, in the predominant down wind direction. Appropriate control measures have been recommended to minimize the adverse impacts on this account.

4.6.1.5 Pollution due to increased vehicular movement

During construction phase, there will be increased vehicular movement for transportation of various construction materials to the project site. Similarly, these will be increased traffic movement on account of disposal of muck or construction waste at the dumping site. The maximum increase in vehicle is expected to 50 vehicles per hour. Large quantity of dust is likely to be entrained due to the movement of trucks and other heavy vehicles. Similarly, marginal increase in Hydrocarbons, SO_2 and NOx levels are anticipated for a short duration. Modelling studies for hydrocarbon emissions were conducted and the results are given in Table-4.5.

Table-4.5: Increase in hydrocarbon concentration due to vehicular movement

Distance (m)	Increase in HC concentration (µg/m^3)
10	5.00
20	2.50
30	1.67
40	1.25
50	1.00
60	0.83
70	0.71
80	0.63
90	0.56
100	0.50

The increase in vehicular density is not expected to significant. In addition, these ground level emissions do not travel for long distances. Thus, no major adverse impacts are anticipated on this account.

4.6.1.6 Dust emission from muck disposal

The loading and unloading of muck is one of the source of dust generation. Since, muck will be mainly in form of small rock pieces, stone, etc., with very little dust particles. Significant amount of dust is not expected to be generated on this account. Thus, adverse impacts due to dust generation during muck disposal are not expected.

Mitigation Measures

A. Control of Emissions

Minor air quality impacts will be caused by emissions from construction vehicles, equipment and DG sets, and emissions from transportation traffic. Frequent truck trips will be required during the construction period for removal of excavated material and delivery of select concrete and other equipment and materials. The following measures are recommended to control air pollution:

- The contractor will be responsible for maintaining properly functioning construction equipment to minimize exhaust.
- Construction equipment and vehicles will be turned off when not used for extended periods of time.
- Unnecessary idling of construction vehicles to be prohibited.
- Effective traffic management to be undertaken to avoid significant delays in and around the project area.
- Road damage caused by sub-project activities will be promptly attended to with proper road repair and maintenance work.

B. Air Pollution control due to DG sets

The Central Pollution Control Board (CPCB) has issued emission limits for generators upto 800 KW. The same are outlined in Table-4.6, and are recommended to be followed.

Table-4.6: Emission limits for DG sets prescribed by CPCB

Parameter	Emission limits (gm/kwhr)
NOx	9.2
HC	1.3
CO	2.5
PM	0.3
Smoke limit*	0.7

Note: * Light absorption coefficient at full load (m^{-1})

The above standards need to be followed by the contractor operating the DG sets.

C. Dust Control

The project authorities will work closely with representatives from the community living in the vicinity of project area to identify areas of concern and to mitigate dust-related impacts effectively (e.g., through direct meetings, utilization of construction management and inspection program,

and/or through the complaint response program). To minimize issues related to the generation of dust during the construction phase of the project, the following measures have been identified:

- Identification of construction limits (minimal area required for construction activities).
- When practical, excavated soils will be removed as the contractor proceeds along the length of the activity.
- When necessary, stockpiling of excavated material will be covered or staged offsite location with muck being delivered as needed during the course of construction.
- Excessive soil on paved areas will be sprayed (wet) and/or swept and unpaved areas will be sprayed and/or mulched. The use of petroleum products or similar products for such activities will be strictly prohibited.
- Contractors will be required to cover stockpiled soils and trucks hauling soil, sand, and other loose materials (or require trucks to maintain at least two feet of freeboard).
- Contractor shall ensure that there is effective traffic management at site. The number of trucks/vehicles to move at various construction sites to be fixed. Three personnel will be earmarked for this purpose.
- Dust sweeping - The construction area and vicinity (access roads, and working areas) shall be swept with water sweepers on a daily basis or as necessary to ensure there is no visible dust. Five sweepers will be earmarked for this purpose

4.6.2 Operation Phase

In a water resources project, air pollution occurs mainly during project construction phase. During operation phase, no major impacts are envisaged.

4.7 IMPACTS ON NOISE ENVIRONMENT

4.7.1 Construction phase

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

4.7.1.1 Impacts due to operation of construction equipment

The noise level due to operation of various construction equipment is given in Table-4.7.

Table-4.7: Noise level due to operation of various construction equipment

Equipment	Noise level dB(A)
Earth moving	
Compactors	70-72
Loaders and Excavator	72-82
Dumper	72-92
Tractors	76-92
Scrappers, graders	82-92
Pavers	86-88
Truck	84-94
Material handling	
Concrete mixers	75-85
Movable cranes	82-84
Stationary	
Pumps	68-70
Generators	72-82

Equipment	Noise level dB(A)
Compressors	75-85
Others	
Vibrators	69-81
Saws	74-81

Under the worst-case scenario, considered for prediction of noise levels during construction phase, it has been assumed that all these equipment generate noise from a common point. The increase in noise levels due to operation of various construction equipment is given in Table-4.8.

Table-4.8: Increase in noise levels due to operation of various construction equipment

Distance (m)	Ambient noise levels dB (A)	Increase in noise level due to construction activities dB(A)	Increased noise level due to construction activities dB(A)	Increase in ambient noise level due to construction activities dB(A)
100	44	74	74	30
200	44	69	69	25
500	44	65	65	21
1000	44	61	61	17
1500	44	58	58	14
2000	44	54	54	10

It would be worthwhile to mention here that in absence of the data on actual location of various construction equipment, all the equipment have been assumed to operate at a common point. This assumption leads to over-estimation of the increase in noise levels. Also, it is a known fact that there is a reduction in noise level as the sound wave passes through a barrier. The transmission loss values for common construction materials are given in Table-4.9.

Table-4.9: Transmission loss for common construction materials

Material	Thickness of construction material (inches)	Decrease in noise level dB(A)
Light concrete	4	38
	6	39
Dense concrete	4	40
Concrete block	4	32
	6	36
Brick	4	33
Granite	4	40

Thus, the walls of various houses will attenuate at least 30 dB(A) of noise. In addition there are attenuation due to the following factors.

- Air absorption
- Rain
- Atmospheric inhomogeneities.
- Vegetal cover

Thus, no increase in noise levels is anticipated as a result of various activities, during the project construction phase. The noise generated due to blasting is not likely to have any effect on

habitations. However, blasting can have adverse impact on wildlife, especially along the alignment of the tunnel portion. It would be worthwhile to mention that no major wildlife is observed in and around the project site. Hence, no significant impact is expected on this account.

4.7.1.2 Impacts due to increased vehicular movement

During construction phase, there will be significant increase in vehicular movement for transportation of construction material. At present, there is negligible vehicular movement near the Dam site. During construction phase, the increase in vehicular movement is expected to increase upto a maximum of 10 to 12 trucks/hour.

As a part of EIA study, impact on noise level due to increased vehicular movement was studied using Federal Highway Administration model. The results of modelling are outlined in Table-4.10.

Table-4.10: Increase in noise levels due to increased vehicular movement

Distance (m)	Ambient noise level dB(A)	Increase in noise level due to increased vehicular movement dB(A)	Noise levels due to increased vehicular movement dB(A)	Increase in ambient noise level due to increased vehicular movement dB(A)
10	44	72	72	28
20	44	67	67	23
50	44	61	61	17
100	44	57	57	13
200	44	52	53	9
500	44	46	48	4
1000	44	42	46	2

As mentioned earlier, there will be significant attenuation due to various factors, e.g. absorption by construction material, air absorption, atmospheric in homogeneities, and vegetal cover. Thus, no significant impact on this account is anticipated. Appropriate measures have been suggested as a part of Environmental Management Plan (EMP) report to minimize impacts.

4.7.1.3 Impacts on labour

The effect of high noise levels on the operating personnel, has to be considered as this may be particularly harmful. It is known that continuous exposures to high noise levels above 90 dB(A) affects the hearing acuity of the workers/operators and hence, should be avoided. To prevent these effects, it has been recommended by Occupational Safety and Health Administration (OSHA) that the exposure period of affected persons be limited as per the maximum exposure period specified in Table-4.11.

Table-4.11: Maximum Exposure Periods specified by OSHA

Maximum equivalent continuous Noise level dB(A)	Unprotected exposure period per day for 8 hrs/day and 5 days/week
90	8
95	4
100	2
105	1

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

4.7.1.4 Noise generated due to drilling

The noise levels monitored at a 10 m distance from the source and operator's cabin is given in Table-4.12.

Table-4.12: Noise generated due to drilling

Equipment	Noise level at source dB(A)
Standing idle (inside cabin)	70-72
Standing idle (10 m radius)	72-74
On load (inside cabin)	78-80
On load (10 m radius)	82-84

The noise levels during various construction activities have been compared to various standards prescribed by Occupational Safety and Health Administration (OSHA), which are being implemented in our country through rules framed under Factories Act. It can be observed (Refer Table-4.21) that for an 8 hour duration, equivalent noise level exposure should be less than 90 dB(A).

The Director General of Mines Safety in its circular no. DG(Tech)/18 of 1975, has prescribed the noise level in mining operations for workers in 8 hour shift period with unprotected ear as 90 dB(A) or less. Similar norms can be considered for construction phase of the project as well. The workers who are expected to be exposed to noise levels greater than 90 dB(A), should not work in these areas beyond 6 to 8 hours. In addition, they also need to be provided with ear plugs. Thus, increased noise levels due to drilling are not expected to adversely affect the workers operating the drill or involved in other mining activities closely.

4.7.1.5 Noise generated due to blasting

Noise generated by blasting is instantaneous, site specific and depends on type, quantity of explosives, dimension of drill hole, degree of compaction of explosives in the hole and rock. Noise levels generated due to blasting have been monitored at various sites and the results have been summarized in Table-4.13.

Table-4.13: Noise generation due to blasting

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

It can be observed from Table-4.21, that noise level due to blasting operations are expected to be of the order of 75-86 dB(A). Since, the nearest settlement are about 0.8 to 1.0 km away, the incremental noise due to blasting is expected to be 50-60 dB(A). As the blasting is likely to last for 4 to 5 seconds depending on the charge, noise levels over this time would be instantaneous and short in duration. Considering attenuation due to various sources, even the instantaneous increase in noise level is not expected to 60 dB(A). Hence, noise level due to blasting is not expected to cause any significant adverse impact.

Mitigation Measures

A. Noise Control Measures

- The contractors will be required to maintain properly functioning equipment and comply with occupational safety and health standards. The construction equipment will be required to use available noise suppression devices and properly maintained mufflers.
  - Vehicles to be equipped with mufflers recommended by the vehicle manufacturer.
  - Staging of construction equipment and unnecessary idling of equipment within noise sensitive areas to be avoided whenever possible.
  - Use of temporary sound fences or barriers to be evaluated.
  - Notification will be given to residents within 300 feet (about 90 m) of major noise generating activities. The notification will describe the noise abatement measures that will be implemented.
  - Monitoring of noise levels will be conducted during the construction phase of the project. In case of exceeding of pre-determined acceptable noise levels by the machinery will require the contractor(s) to stop work and remedy the situation prior to continuing construction.
- Provision with ear muffs or plugs for the workers, so as to attenuate the noise level near the crusher by at least 15 dB(A).
- Working hours of the laborers working on dredgers will decided considering the guidelines of Occupational Safety and Health Administration (OSHA)
- To prevent other psychological and physiological impacts as mentioned in literature, the exposure period of affected persons be limited as recommended by OSHA limits in the Table-4.20.

B. Noise Control Measures for DG sets

- The following Noise Standards for DG sets are recommended for the running of DG sets during the construction:
  - The maximum permissible sound pressure level for new diesel generator sets with rated capacity upto 1000 KVA shall be 75 dB(A) at 1 m from the enclosure surface.
  - Noise from the DG set should be controlled by providing an acoustic enclosure or by treating the enclosure acoustically.
  - The Acoustic Enclosure should be made of CRCA sheets of appropriate thickness and structural/ sheet metal base. The walls of the enclosure should be insulated with fire retardant foam so as to comply with the 75 dB(A) at 1m sound levels specified by CPCB, Ministry of Environment & Forests. The acoustic enclosure/acoustic treatment of the room should be designed for minimum 25 dB(A) Insertion Loss or for meeting the ambient noise standards, whichever is on the higher side.
  - The DG set should also be provided with proper exhaust muffler with insertion loss of minimum 25 dB(A).
  - Proper efforts to be made to bring down the noise levels due to the DG set, outside its premises, within the ambient noise requirements by proper siting and control

measures. A proper routine and preventive maintenance procedure for the DG set should be set and followed in consultation with the DG set manufacturer which would help prevent noise levels of the DG set from deteriorating with use.

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

4.7.2 Operation Phase

In a water resources project, noise pollution occurs mainly during project construction phase. During project operation phase, no major impacts are envisaged.

4.8 IMPACTS ON BIOLOGICAL ENVIRONMENT

4.8.1 Construction phase

4.8.1.1 Impacts on Terrestrial Flora

The direct impact of construction activity of any water resource project in a Himalayan terrain is generally limited in the vicinity of the construction sites only. As mentioned earlier, a large population including technical staff, workers and other group of people are likely to congregate in the area during the project construction phase. It can be assumed that the technical staff will be of higher economic status and will live in a more urbanized habitat, and will not use wood as fuel, if adequate alternate sources of fuel are provided. However, workers and other population groups residing in the area may use fuel wood, if no alternate fuel is provided for whom alternate fuel could be provided. There will be an increase in population by about 3200 of which about 2400 are likely to use fuel wood. On an average, the fuel wood requirements will be of the order of (1.0 x 365 x 2400 x 10^{-3}) 876m^3. The wood generated by cutting tree is about 2 to 3 m^3. Thus every year fuel wood equivalent to about 400-500 trees will be cut, which means every year on an average about 1-2 ha of forest area will be cleared for meeting fuel wood requirements, if no alternate sources of fuel are provided. Hence to minimize impacts, community kitchens have been recommended. These community kitchens shall use LPG or diesel as fuel.

The other major impact on the flora in and around the project area would be due to increased level of human interferences. The workers may also cut trees to meet their requirements for construction of houses and other needs. Thus, if proper measures are not undertaken, adverse impacts on terrestrial flora is anticipated. Since, labour camps are proposed to be constructed by the contractor along with necessary facilities, such impacts are not envisaged. The stage-I & Stage-II forest clearance has receive on 03.06.2011 & 28.05.2013 respectively.

Mitigation Measures

A. Provision of Free Fuel

The project proponents, i.e. THDCL in association with district administration shall make necessary arrangements for supply of kerosene/LPG. The fuel would be supplied at subsidized rates to the local/contract labour for which provision should be kept in the cost estimate.

4.8.1.2 Acquisition of forest land

During project construction phase, land will be required for location of construction equipment, storage of construction material, muck disposal, widening of existing roads and construction of new project roads. The total forest land to be acquired for the project shall be 100.3 ha. The normally in a dense forest, tree density is of the order of 1000-1200 trees/ha. Thus, in land to be acquired for the project, the tree density is low to moderate.

No Rare, Endangered, Threatened species is reported in the land to be acquired for the project.

Mitigation Measures

A. Compensatory Afforestation

The Indian Forest Conservation Act (1980) stipulates:

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

Compensatory afforestation is proposed in lieu of acquisition of this land. It is proposed to afforest the degraded forest patches and as per Forest Conservation Act (1980).In order to compensate diversion of forestland i.e. 100.39 ha (includes 23.13 ha land for underground works) for establishment of various project units, compensatory afforestation plan proposed to be on 201 ha as per the Forest (conservation) Act (1980). The compensatory afforestation will be carried out by the Forest Department. Local species must be preferred for plantation under compensatory afforestation.

The clearing of project sites for construction requires felling of trees, a total number of 6153 trees are be felled. The trees consist of plantation in forest land and van panchayat land. All the species are commonly distributed throughout the project immediate influence as well as project influence area hence, the impact will be insignificant. The Compensatory Afforestation Would be carried to compensate the loss of trees. Double no. of trees 12,306 trees may be planted in lieu of trees felled. The copy of Stage-I & Stage-II forest clearance is given in **Annexure-IX.**

B. Biodiversity Conservation Plan

As a part of Biodiversity Conservation Plan, the following measures are proposed:

- Afforestation
- Soil stabilization measures & improving water regime,
- Sustenance of Livelihoods
- Establishment of botanical gardens for conservation and propagation of RET species.
- Anti-poaching measures

The activities proposed as a part of Biodiversity Conservation Plan are described in the following paragraphs:

Afforestation

Area under forest and tree cover will be expanded through systematic planning and implementation of afforestation and rehabilitation programme in degraded and open forests and available non forest lands.

Regeneration of felled areas will be ensured in a time bound manner and productivity of plantations will be increased through use of improved seeds and planting stock. The indigenous fruit bearing plants, vital from wildlife point of view are proposed to be planted so as to enrich the habitat & ensure the sufficient availability of food. Monoculture will be discouraged and mixed plantations of broad-leaved fodder, fuel wood and wild fruit species will be promoted. This activity will increase forest cover and will provide habitat to the animals. Afforestation programme in the degraded Forest Compartments, is proposed to be carried out and species for this shall be finalized by the Forest Department.

Eco-Development Works

The Eco-development Committees and Village Conservation Committees (VCCs) can be constituted for this purpose which will help State Forest Department in capacity building and micro planning of the various eco-developmental activities formulated for community development. The activities under this programme are aimed at improvement of livelihood of people living in the project area. Under this programme, number of activities have been proposed and are described in the following paragraphs.

Compensation: Ex-gratia payment to the victims of crop damage, cattle lifting and human life loss/injury:

Ex-gratia payment to the victims of crop damage, cattle lifting and human life loss/injury is also a management tool for conserving the wild animals. The compensation to the owners for loss of their crop / livestock by wildlife, if any, is proposed under this scheme on humanitarian grounds.

Publicity and Awareness

- Under this programme, the following activities are proposed:
- Training should be imparted to the school teachers in the project area for introduction of environmental education among the school children and exchange to knowledge on environment and ecology between the monastic and village schools.
- Publishing of research documents, pamphlets, brochures, hoardings
- Opening of biodiversity register in every village
- Advertisement of hazardous effect of fire through press, sign boards and public meetings will form the important activities under this component.

Establishment of Botanical Gardens

For conservation & propagation of local species, development of Botanical and Herbal garden was proposed at suitable place in consultation with State Forest Department. These gardens

would function as repositories and would catalyze the biodiversity conservation, scientific research, education and environmental awareness in the area.

It was proposed to develop nursery at appropriate location preferably in the Gram Panchayat. Self-help groups formed by women shall be involved for the promotion of herbal drugs from the kitchen stock and rare medicinal plants.

4.9 IMPACTS ON TERRESTRIAL FAUNA

The major factor affecting the distribution of animals in entire area is found to be forest types, altitudinal variation, interference of human activities and forest cover. Impacts on fauna are categorized as direct, indirect, cumulative and induced impacts.

Impacts of Wildlife of Nanda Devi Biosphere Reserve (NDBR)

The project is located 37km away from the core zone of the Nanda Devi Biosphere Reserve (NDBR). The project is also located outside the transition zone, and at its closest touches the boundary of the transition zone (at the dam site). No legal or regulatory restriction therefore applies to the project. Other than the NDBR, the protected area closest to the project is the Kedarnath Wildlife Sanctuary, 72km away from the project. The development of the project will not have any impact on the Core and Buffer zone of the NDBR. The Impact in the transitional zone NDBR of is not significant. The project sites are located along the river course. The area along the river consists of steep rockyslopes with scattered pine forest.

Impacts of Wildlife of Kedarnath Wildlife Sanctuary (KWLS)

The project consists of three major construction activities - Dam, Head Race Tunnel and Powerhouse. The distance of the dam site is about 5.20 Km from Kedarnath Wild Life Sanctuary (KWLS) boundary. There is no acquisition of land or tree cutting within the sanctuary area. The foundation of the dam is at 1205 msl and the elevation of the sanctuary boarder is approximately 1900m above the dam at an elevation of 3100 msl, The proposed HRT layout is overlain by rock up to depth about 1000m. The major portion (12 Km) of HRT is proposed to be constructed using Tunnel Boring Machine (TBM) from the power house site. The horizontal distance of the powerhouse from sanctuary border is approximately 2 km. However, the elevation of the sanctuary is about 2000m above Power house site. The power house foundation is at 1010 msl and the sanctuary border is at 2974 msl.

Even though the sanctuary is inaccessible from project site and virtually no direct impact is predicting, Potential impacts of the project on the Sanctuary have been assessed and suitable mitigation measures for probable issues such as influx of labor and the impacts of blasting on wildlife has been considered such as provision of watch tower to check the entry of labour in the KWLS and the controlled blasting technique that has been employed at site.

The entire wildlife protection measures have been kept under the Eco-restoration plan (ERP) which is to be executed by the Forest department. The DFO, Badrinath Forest Division, Gopeshwar is the nodal implementing agency who will be the Nodal officer in charge of Project Management Cell (PMC). The responsibility of implementing the ERP in Kedarnath Division will lie with the concerned DFO who will be responsible for implementing the prescribed works. The project will be monitored in terms of physical, financial progress and quality by Conservator of Forests, Garhwal, Pauri & Conservator of Forest/Director, Nanda Devi Biosphere Reserve, Gopeshwar.

The wildlife clearance from wildlife board is received on 20.12.2012 and copy is given as **Annexure-X.**

4.9.1 Construction Phase

4.9.1.1 Impacts due to Labour Population and construction activities

During construction phase, large number of machinery and construction workers shall be mobilized, which may create disturbance to wildlife population in the vicinity of project area. The operation of various equipment will generate significant noise, especially during blasting which will have adverse impact on fauna of the area. The noise may scare the fauna and force them to migrate to other areas. Likewise, siting of construction plants, workshops, stores, labour camps etc. could also lead to adverse impact on fauna of the area. However, The wildlife inhabits the forest areas mostly at higher elevations away from settlement. The project affected area is mostly open/plantation area with settlements, the wildlife move in the area during night-time. The project activities are likely to disturb the normal peace of the wildlife and they are likely to move in other areas.

During construction phase, accessibility to area will lead to influx of workers and the people associated with the allied activities from outside will also increase, which can lead to illegal hunting and poaching. The increase in human interference could have an impact on terrestrial ecosystem.

4.9.1.2 Impacts due to Blasting

The other major impact could be the blasting to be carried out during construction phase. This impact needs to be mitigated by adopting controlled blasting and strict surveillance regime and the same is proposed to be used in the project. This will reduce noise level and vibrations due to blasting to a great extent. Likewise, sitting of construction equipment, godowns, stores, labour camps, etc. may generally disturb the fauna in the area. However, no large-scale fauna is observed in the area. Thus, impacts on this account are not expected to be significant. However, few stray animals sometimes venture in and around the project site. Thus, to minimize any harm due to poaching activities from immigrant labour population, strict anti-poaching surveillance measures need to be implemented, especially during project construction phase.

Mitigation Measures

A. Wildlife Protection Plan

For the improvement of vigilance and measures to check poaching, number of measures described below would be undertaken.

During construction phase in and around the main construction areas, i.e. the barrage site, powerhouse site, etc. where construction workers congregate, some disturbance to the wildlife population may occur. The terrain is hilly & difficult, therefore, the wildlife protection force adequately equipped with watch towers, wildlife personnel and other necessary equipment be deployed to prevent poaching in the area. The measures proposed for wildlife protection are outlined in the following paragraphs:

Purchase of anti-poaching kits: To capture and translocate wild animals out of human habitations or agricultural lands, various trapping equipment's pertaining to anti-poaching activities are needed.

Infrastructure Development: This includes anti-poaching huts, rock shelters development and residential quarters for forest guards. For effective monitoring, one watch tower is also proposed to be established at an identified place having high pressure of biotic interference. The basic amenities for the field staff shall be provided to enable them to do effective patrolling in the areas.

Purchase of Survey equipment and Vehicles: In order to improve network and vigilance it is required to procure communication equipment like walkie talkie, IT infrastructure to document and develop a database, altimeters, G.P.S., binoculars, video as well as digital still cameras are essential. Purchase of field vehicle will help in increased vigilance. For better communication and purchase of survey equipment, an amount of Rs. 75.0 lakh has been earmarked.

Construction of Check posts: To improve vigilance for illegal logging/loping, anti-poaching, better protection, enforcement for control grazing practices, control-grazing-cum-anti poaching check posts are proposed to be constructed.

B. Monitoring of Biodiversity Conservation & Management Plan

Monitoring is an important part of the Biodiversity Management Plan. All the activities of Biodiversity Management Plan will be closely and regularly monitored in terms of physical, financial progress and quality by the project proponent and officers of Forest Department.

The State Government shall set up a Biodiversity Conservation Committee (BCC) under the chairmanship of the Principal Chief Conservator of Forests, Govt. of Uttrakhand. The committee shall review and oversee the conservation work to be undertaken.

4.9.1.3 Loss of habitats of rare/endangered/endemic wildlife

Most of the features of the proposed project have been designed to be located underground. The major construction works for dam, tunnel, portal, muck disposal, quarry, link road and staff

quarter will take place in forest and private owned agriculture land. Therefore, direct impact of construction activity on protected faunal species is not anticipated. However, during the occasional movement of wildlife around the project area, local people and construction workers may illegally hunt these animals.

The aggregation of labour force in the project area might result in enhancement in indiscriminate fishing including use of explosives. The use of explosive material to kill fishes in the river in the project area would result in complete loss of fishes and other aquatic life making a river stretch completely barren. Indiscriminate fishing will reduce fish stock availability for commercial and sport fishermen.

4.9.1.4 Impacts on Avi-Fauna

The damming of the river will create quiescent/tranquil conditions. The reservoir banks will have wet environment throughout the year which can lead to proliferation of vegetation e.g. grass, etc. along the reservoir banks. Such conditions are generally ideal for various kinds of birds, especially, water birds. This is expected to increase the avi-faunal population of the area.

Mitigation Measures

Forests are vital for the survival, foraging, breeding and nesting of avifauna. Natural forests provide a variety of food materials to the birds not only in the form of nectar of flowers, fruits, seeds etc. in the trees, shrubs, herbs and grasses but they also contain a large number of insects eaten by birds. In the forests, food is always available for the faunal component. Although most floral species flower during spring through summer but fruit maturation and seed ripening takes place in them throughout the year. Therefore, first strategy of improvement of habitat for birds is avoiding nest predation or brood parasitism through maintenance of large contiguous forest tract. These areas have the ability to support the largest number of forest interior birds and will also be more likely to provide habitat for area sensitive species. It is more practicable to protect the existing forest area rather than creating new forest area.

Another measure for habitat improvement for avifauna is to be installation of artificial nest boxes in the influence zone and catchment area of the project after consultation with the forest department as well as local NGOs. These nest boxes has been found to be quite beneficial for attracting hole nester birds. The size and capacity of boxes vary from one species to another.

Feature of a Nest Box:

The characteristic features of nest box are listed below and shown in Figure-4.3.

- Untreated wood (Jamun, mango, pine, cedar or fir)
- Thick walls (at least ¾ inches)
- Extended, sloped roof
- Rough or grooved interior walls
- Recessed floor, coated with primer and paint
- Drainage holes

- Ventilation holes
- Easy access for monitoring and cleaning
- Sturdy construction
- No outside perches

The entrance hole should have a 2-inch diameter and 6 inch depth from entrance hole. Nest boxes are placed on trees at height from 10-12 ft. Such nest boxes designs have been used with success.

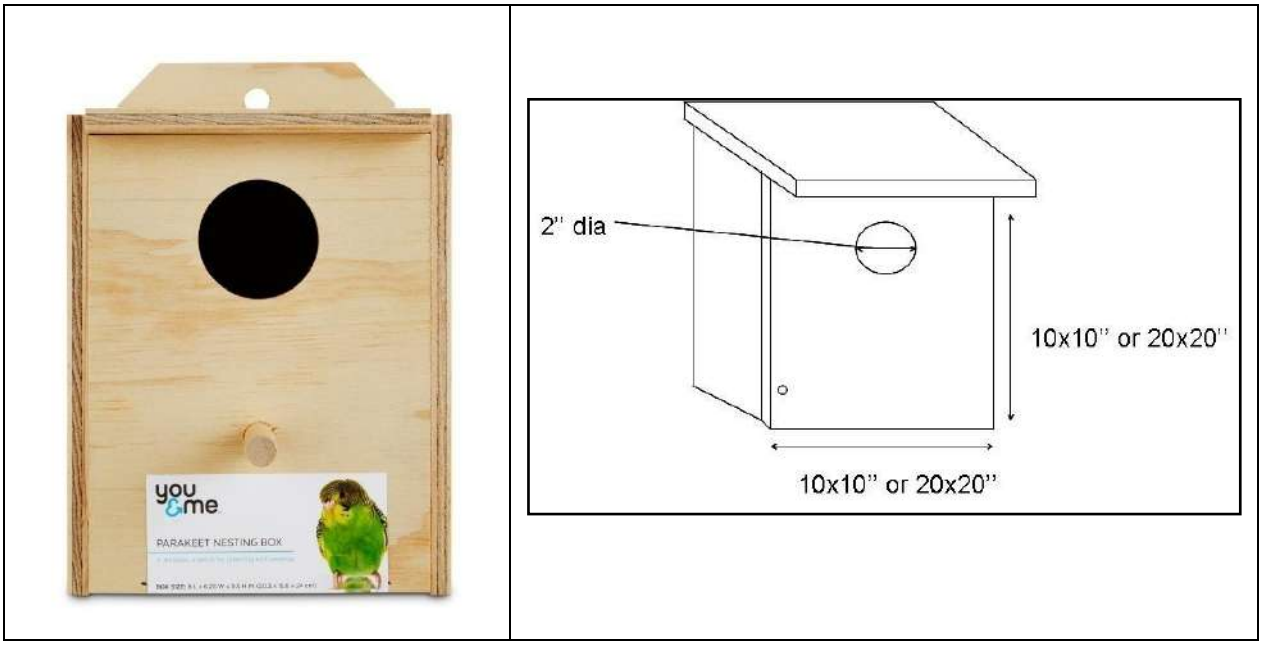


Figure-4.3: Nest Box

4.9.1.5 Impacts on Nanda Devi Biosphere Reserve (NDBR)

The NDBR comprise of Chamoli, Bageshwar and Pithoragarh district. It is divided into Core zone -712.12 km^2, Buffer Zone- 5,148.57 km^2 and Transitional Zone -546.34 km^2. The buffer zone is inhabited by 47 villages whereas the transition zone is inhabited by 52 villages. The core zone consists of Valley of Flowers and Nanda Devi National Park. The Valley of flowers is a trek of about 16 km from Govindghat which is about 25 km from Joshimath. The Nanda Devi National Park is situated at a distance of 25 km from Joshimath, the territory starts at a distance of 9 km trek from the Village Lata.

The project is located 37km away from the core zone of the NDBR. The project is also located outside the transition zone, and at its closest touches the boundary of the transition zone (at the dam site). No legal or regulatory restriction therefore applies to the project. Other than the NDBR, the protected area closest to the project is the Kedarnath Wildlife Sanctuary, 72km away from the project.

The development of the project will not have any impact on the Core and Buffer zone of the NDBR. The Impact in the transitional zone NDBR of is not significant. The project sites are located along the river course. The area along the river consists of steep rocky slopes with scattered pine forest.

- Although there is no direct impact of the project on the protected areas, the EA assessed the potential of indirect impacts on the transition and buffer zones of the Nanda Devi Biosphere Reserve (NDBR) and determined that such impacts are not significant, during construction or operation. Nevertheless, interventions to enhance the quality and the management of buffer zone, are provided even if the project's impacts are not significant. The acts which are likely to occur on transitional zone of NDBR due to the project activities are:
- Construction work is likely to increase the noise level in the area however the impact will be intermittent and temporary and localized.
- Ambient air quality is likely to be affected due to generation of dust and fugitive emission. The impact will be temporary and limited to construction phase.
- Cutting of trees and clearing of land. No rare/endangered and threatened species located in the area. The Dam site consists of panchayat forest areas which consist of plantation. The project entails likely to affect the top flora and fauna.
- No impact on fauna of the area as no fragmentation of habitat and there is no dense forest in this zone. Hence no habitat issue occurring in the area.
- Influx of labour population is likely to occur which may impart pressure on the local resources of the area.

Mitigation Measures

The project area does not fall in Core zone of the NDBR, The core zone consists of Valley of Flowers and Nanda Devi National Park. The Valley of flowers is a trek of about 16 km from Govindghat which is about 25 km from Joshimath. The Nanda Devi National Park is situated at a distance of 25 km from Joshimath. Joshimath town is approx 12 km upstream from the Dam site. As per the guidelines and The proformae of MoEF for Protection, Development, Management and Research in Biosphere Reserves in India (Oct 2007) only the core zone secure legal protection and management and must be kept free of human pressure. The project does not fall in core zone of NDBR hence does not attract any legal obligation.

- The machineries, vehicles and equipment use in construction shall strictly confirm to CPCB standard. All vehicles equipment machinery used in construction shall be fitted by exhaust silencers. Blasting shall be carried out as per the statutory laws, regulation and rules pertaining to acquisition, transport, storage, handling and use of explosives.
- Plants,machineryandequipmentshallbehandledsoastominimizegeneration of dust
- All earth work shall protected to minimize dust generation by using regular water sprinklers.
- Compensationmustbegiventovanpanchayatforthelandandstandingcrop.Fruit bearingtreesmaybecompensatedincludingcostoffruityieldof5years.Cuttingof trees should be strictly prohibited outside construction site. Timely implementation of Compensatory Afforestation plan.
- Wildlife monitoring must be established in association with Forest Dept. in the project area and hunting /poaching must be strictly banned.
- Labours must be provided fuel- kerosene LPG by contractor. No felling of trees must bed one byl abour for fuel and shelter.Labour camps must be located away from forest area.Local people must be given preference for skilled and unskilled jobs in the project.
- Awareness program must be undertaken by THDC on environmental importance and natural resources.

4.9.2 Operation phase

4.9.2.1 Increased accessibility

During the project operation phase, the accessibility to the area will improve due to construction of roads, which in turn may increase human interferences leading to marginal adverse impacts on the terrestrial ecosystem.

4.10 IMPACTS ON AQUATIC FLORA

4.10.1 Construction phase

During construction phase wastewater mostly from domestic source will be discharged mostly from various camps of workers actively engaged in the project area. Around 0.22 mld of water is required for the workers during the peak construction phase out of which 80% (i.e. about 0.18 mld) will be discharged back to the river as wastes, more or less as a point sources from various congregation sites where workers will reside. Sufficient water for dilution will be available to keep the DO of the river to significantly high levels. However, the sewage will be treated prior to disposal.

4.10.2 Operation phase

4.10.2.1 Impacts due to development of reservoir

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

4.10.2.2 Loss of aquatic habitats

The aquatic environment of River VishnugadPipalkoti Hydro-Electric Projectis expected to be affected during construction due to following project activities:

- Removal of river bed/bank materials may destruct the spawning ground; it may also interrupt the migratory route.
- Excavation and related activities will pollute the river by increase in turbidity.
- Spillage of oil, chemicals, and construction materials may pollute the water of river and riverbank.

Thus, the aquatic habitat of fish and other organisms will be disturbed due to one or the combination of above activities. On the other hand, due to increase in the human population in

the construction area, there will be increased demand of fish. The construction workforce including their families as well as the local people may get involved in fishing. This will eventually bring serious depletion of fish population in the river.

During construction phase, wastewater will be discharged from various camps of workers actively engaged in the project area. Around 0.49 mld of water is required for the workers during the peak construction phase out of which 80% (i.e. about 0.39 mld) will be discharged back to the river as wastes, more or less as a point sources from various congregation sites where workers will reside. Sufficient water for dilution will be available in river Vishnugad Piptokeep the DO of the river to significantly high levels.

During the construction phase a large quantity of construction material like stones, pebbles, gravel and sand would be needed. Significant amount of material is available in the riverbed. It is proposed to extract construction material from borrow areas in the riverbed. The extraction of construction material may affects the river water quality due to increase in the turbidity levels. This is mainly because the dredged material gets released during one or all the operations mentioned below:

- Excavation of material from the riverbed
- Loss of material during transport to the surface
- Overflow from the dredger while loading
- Loss of material from the dredger during transportation

The cumulative impact of all the above operations is increase in turbidity levels. Good dredging practices can however, minimize turbidity. It has also been observed that slope collapse is the major factor responsible for increase in the turbidity levels. If the depth of cut is too high, there is possibility of slope collapse, which releases a sediment cloud. This will further move outside the suction radius of dredged head. In order to avoid this typical situation, the depth of cut should be restricted to:

$$\gamma H/C < 5.5$$

Where,

γ - unit weight of the soil

H - depth of soil

C - Cohesive strength of soil

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

The second important impact is on the spawning areas of fishes. Almost all the cold water fish breed in the flowing waters. The spawning areas of these fish species are found amongst pebbles, gravel, sand etc. The eggs are sticky in nature and remain embedded in the gravel and subsequently hatch. Any disturbance of stream bottom will result in adverse impacts on fish eggs. Even increase in fine solids beyond 25 ppm will result in deposition of silt over the eggs, which would result in asphyxiation of developing embryo and also choking of gills of young newly emerged fry. Thus, if adequate precautions during dredging operations are not undertaken, then significant adverse impacts on aquatic ecology are anticipated.

4.11 IMPACTS ON AQUATIC FAUNA

4.11.1 Construction phase

4.11.1.1 Impacts due to Construction Activities

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

4.11.2 Operation phase

4.11.2.1 Impacts on Fish Fauna

Among the aquatic animals, it is the fish life, which would be most affected. The migratory fish species, are likely to be adversely affected due to obstruction created by the dam.

With the completion of dam, flow in the downstream stretch of the river would be reduced considerably more so during the lean period. The most important changes, which can be expected, are:

- Reduced flow rate
- Increase in water temperature
- Reduction in availability of steno-thermal aquatic animals
- Increase in population of euro-thermal species.

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

4.11.2.2 Impediment to movement of migratory fish species by the Dam

Fish populations are highly dependent upon the characteristics of the aquatic habitat which supports all their biological functions. This dependence is most marked in migratory fish which require discrete environment for the main phases of their life cycle which are reproduction, production of juveniles, growth and sexual maturation. The fish composition in the project area is represented by potadromous species. The building of a dam generally has an adverse impact on fish population, their migration, which can be stopped. The commissioning of the dam would adversely affect the migratory route of fisheries.

Construction of the Vishnugad Pipalkoti Hydro-Electric Project would hamper the upward and downward migratory movement of various fish species in summer and winter seasons. Likewise, migration of fish species from tributaries to river, would be affected on account of creation of reservoirs due to construction of Vishnugad Pipalkoti Hydro-Electric Project. Thus, the project will lead to adverse impact on migratory fish species. The fish migration would be restricted in the following stretches:

- Upstream of dam site of Vishnugad Pipalkoti Hydro-Electric Project
- Downstream of dam site of Vishnugad Pipalkoti Hydro-Electric Project
- Tributaries out falling in river Alaknanda between dam site and tail race disposal site of project.

Mitigation Measures

A. General Measures

- Use of good dredging equipment that can considerably reduce the turbidity and nutrient/contaminant addition to the water for the benefit of aquatic life.
- Adopting controlled blasting and strict surveillance regime to reduce noise level and vibrations from blasting to great extent.
- Contractor/s shall be responsible to provide subsidized kerosene/LPG to their workers which will in turn discourage them from illegal tree felling and removal of fuel wood and timber from the adjoining forests
- Appropriate sewage treatment measures to be taken for the discharge of wastewater so as to avoid adverse impacts on riverine ecology.
- Wildlife Protection force to be adequately equipped with necessary equipment to prevent poaching in the area.
- Compensatory afforestation of the forest area utilized for the construction purpose.
- Compensatory plantation is to be established on degraded forest lands, which must be twice the forest area affected or lost.
- Fodder and wild fruit plantation for wild animals and for roosting, breeding and hiding cover for migratory birds etc.

B. Fisheries Management Plan

I. Provision of minimum flow

The construction of the project will lead to reduction in flow, especially during dry months, in the intervening stretch between the diversion site and the tail race disposal point. Such a situation will

adversely affect the benthic communities and fish.

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

The Environmental flow (E-flow) at VPHEP shall be governed by the latest Gazette Notification dated 09th Oct 2018 of GoI, regarding maintaining a minimum environmental flow in River Ganga up to Unnao, (UP). As per the notification the environmental is given in Table-4.14.

Table-4.14: Environmental Flows for Vishnugad Pipalkoti HEP

Season	Months	% age of average flow of preceding 10 daily period
Dry	Nov to March	20
Lean	Oct, April and May	25
High flow	June to September	30

Sources: Gazette Notification dated 09th October 2018

The e-flow based on the above will vary based upon the real time inflow data to be observed during the operation stage of the project. Therefore, the values of actual environmental flows cannot be calculated/fixed at the moment. However, based on the inflow data series of 42 years, used for the design of the project, the highest and lowest e-flows works out be 238.7 and 1.7 cumecs (corresponding to heighest and minimum recorded inflows) respectively and accordingly the provisions to release the e-flow are being made in the design of the structures. A dual combination operative mechanism of 2 MS pipes of 1.5m dia each with suitable control valves and part opening of lower level sluice gate is being contemplated to allow for the desired riparian flows. The valves will be synchronized with the gate opening (through SCADA etc) so that the dual combination operative mechanism is automated and hassle free. The value of e-flow prior to issue of this Gazette Notification was 15.65 cumecs.

II. Sustenance of fisheries

The stocking program shall comprise of the following:

- Acclimatization stocking (a new fish species is introduced in a water course)
- Supplementary stocking (a species already living in a water body)
- Transfer stocking (transportation of mature fish from one water body to another)
- Repetitive stocking (species which do not propagate in natural conditions).

To carry out the stocking programme on annual basis, suitable aquaculture facilities have to be created in river Alaknanda to meet the requirements of fingerlings. The endemic stocks in Alaknanda river are the Trout. The proposed aquaculture facilities have to meet the requirements of fingerlings of the Trout. The proposed aquaculture facilities have to be in flow through system facility for Trout species.

Commercial fishing is not in vogue in the project area. The dam site on river Alaknanda to be

developed as a part of the project will act as a barrier to the free movement of fish species. Since, *Schizothoraxrichardsonii*(Snow trout)is categorized as vulnerable species amongst the threatened fishes of India, scientific management of the existing stock needs to be adopted. It is proposed to implement supplementary stocking programmes for the project area. In addition to reservoir area, it is proposed to stock river Alaknanda for a length of 10 km each on the upstream and the downstream side of the diversion site. The rate of stocking is proposed as 100 fingerlings of about 30 mm size per km. For reservoir area, the rate of stocking could be 200 fingerlings of about 30 mm size per ha. The stocking can be done annually by the Fisheries Department, Government of Uttrakhand.

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

4.12 INCREASED INCIDENCE OF WATER-RELATED DISEASES

4.12.1 Construction Phase

4.12.1.1 Increased incidence of water-related diseases

The VPHEP project is under construction and it is envisaged that further 5 years required to complete the construction activities.

The construction phase of a water resources project, could lead to increased incidence of various water-borne and vector-borne diseases, if adequate precautions or control measures are not undertaken.

The health risks specific to water resources projects emanate from congregation of labour at various construction sites. During construction phase, new groups come and go constantly keeping the human population in a flux. These groups are usually housed in temporary dwellings without proper sanitary conditions and water supply. In the final stages, colonies for project maintenance, townships are built. During construction phase or for permanent settlement, if adequate precautions are not taken, the vector-borne disease epidemiology may show sudden or long lasting change. Many of the immigrant population could be reservoir of infection for various communicable diseases. Once they settle in labour camps/colonies, there could be increased incidence of various diseases. This aspect needs to be looked into with caution, and efforts must be made to ensure that a thorough check up of the labour population congregating in the area is conducted. Those affected by any ailments need to be properly quarantined depending on the ailment with which they are suffering.

Population migration induced by actual or possible opportunities for work can aggravate problems

as a result of housing difficulties, over-crowding, rise in cost of living and some unpredicted social problem, as well as the introduction of new sources of diseases or new diseases or immigrants immunologically susceptible to the endemic diseases prevalent in the areas of development. The overcrowding could lead to increased incidence of respiratory infection and tuberculosis. The scarcity of water in the houses and the absence of sanitary facilities in labour camps could be responsible for increased prevalence of gastero-enteritis and other water-borne diseases.

Mitigation Measures

- Measures to be taken for provision of adequate drinking and sanitation facilities for the labour population and their families.
- Borrow areas for excavation material would be under river bed, hence it would prevent formation of mosquitoes breeding ground.
- Adequate measures for supply of potable water and sewage treatment have been recommended as a part of Environmental Management Plan.
- A proper surveillance, immunization schedule and medical facilities would be provided for the labour population migrating into the project area.

Development of medical facilities

Health Facilities at Construction sites

A first aid post is to be provided at major construction sites, so that workers are immediately attended to in case of an injury or accident.

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

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

The first-aid post can be housed in temporarily erected structure and should be managed by one Health Assistant and assisted by one dresser/first aid attendant. Doctors from the dispensary can attend First Aid post regularly every day at a fixed time. Communication link between the dispensary and then first-aid post shall be established, so as to enable doctors from dispensary to reach the work site in case of an emergency. The first aid post shall have facilities such as fire-fighting equipment, telephone connection, one vehicle or ambulance van for effective functioning.

For maintaining community health program may be framed such as

- Augment existing health program
- Health education for local project workers and community
- Vaccination programs - meningitis, tuberculosis tetanus etc.
- Specific HIV/ AIDS prevention activities may be carried such as
- HIV/STD/ AIDS awareness centres
- Peer education program within workers
- Technical and material support for STD clinic.
- Integration of HIV/ AIDS into thematic projects (eg. emergency training)
- Voluntary counselling and testing
- Medical aid policies for workers

Health Extension Activities

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

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

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

The costs estimated as follows are approximate and indicate the order of expenditure likely to accrue.

4.12.2 Operation Phase

4.12.2.1 Increased incidence of water-related diseases

Health risks include diseases hazards due to lack of sanitation, (lack of potable water, inadequate human waste disposal facilities) and hazards due to local carriers. Mitigation measures include provision of adequate sanitary health care and human waste disposal facilities near the construction sites and labour camp.

The association between irrigation development and the incidence of water related diseases such as malaria, etc. is well established. Malaria is a common vector borne disease in the project area. The preferred environmental setting for vectors is fresh water open to sunshine or moderate shade. The habitats for larvae growth are permanent or semi-permanent standing fresh water such as small ponds, pools, standing agricultural water, permanent or semi-permanent fresh water such as open stretches or canals. Thus, the project may create favorable conditions for breeding of new pathogens or vectors such as mosquitoes, etc. Most of the water borne diseases can largely be prevented by adequate hygiene. The experience of various project confirms the above mentioned hypothesis. In the project area, a sudden spurt in the incidence of malaria is expected, if adequate control measures are not taken up.

Improvement in availability of water for various uses, increased agricultural production, availability of diversified food, strengthening of educational and health facilities significantly improves public health in the project area. On the other hand, water resources development also has negative impacts,

since, it could increase the habitat of certain vectors like mosquitoes. Thus, poorly planned and managed water resources projects could increase the prevalence of vector-borne diseases like malaria and filariasis. The factors are responsible for increased incidence of vector-borne diseases are described in the following paragraphs:

4.12.2.2 Rain Pools

Collection of rain water in roadside ditches, clogged drainage and other natural depressions, expected to partial or full sunlight could serve as breeding habitats for mosquitoes. This can lead to increased incidence of malaria. The water-borne diseases are common in the command area. The overall picture does not indicates whether there will be rise in the number of cases because of the project. With the increased water availability, the quality of water being supplied is expected to improve, leading to reduction in incidence of water-borne diseases. However, adequate measures in the form of strict public health measures are required.

4.12.2.3 Water washed diseases

The water washed diseases occur mainly due to scarcity of water and with the improvement of water availability, the incidence of these diseases is reduces in a water resources project. This impact is envisaged in the project as well.

4.12.2.3 Increased incidence of vector-borne diseases due to excavations

The excavation of earth from borrow pits etc. is one of the major factor for the increase in prevalence of malaria. After excavation of construction material, the depressions are generally left without treatment where water gets collected. These pools of water, then serves as breeding grounds for mosquitoes. However, in the present case, the borrow areas are within the river bed, which in any case remain under water. Thus, no additional habitat for mosquito breeding is created due to excavation.

The quarry areas after excavation shall from stagnant pools of water during monsoons, which can serve as breeding sites for mosquitoes. The flight of mosquito is generally limited up to 1 to 2 km from the breeding sites. The residential areas is located within 1 km from the reservoir periphery, or stagnant pool of water will be vulnerable to increased incidence of malaria. Similarly, labour camps, etc. could be vulnerable to increased incidence of malaria, if proper measures for siting drainage and mosquito control are not undertaken.

4.13 IMPACTS ON SOCIAL ENVIRONMENT

4.13.1Construction Phase

It is expected that a lot of labour force will be deployed at the project site during the construction phase and the total increase in population during peak construction has been estimated to the tune of 3200. Together with the work force many business establishment will take place which will attract people from other places. Influx of labour population might lead to number of social,

cultural, economic and security related problems. However, it is evident that the local residents will have an upper hand in the establishments of any business ventures.

The VPHEP project is under construction and it is envisaged that further 5 years required to complete the construction activities.

Land acquisition and population displacement/involuntary resettlement. The important adverse impact during construction phase will be that, pertaining to land acquisition. About 141.55 ha of land is to be acquired for the Vishnugad Pipalkoti Hydro-Electric Project. The acquisition of private land would lead to PAFs losing land in varying proportions. The details of project affected families is given in Table-4.24. The Resettlement Action Plan Approved by District Magistrate, Chamoli dated 17.11.2009 is given in **Annexure-XI** and present status of expenditure on R&R is given in Table-4.15.

Table-4.15: Details of Project Affected Families

S. No	Village	Stage	Land Acquired	Tittle Holders	Net Tittle Holders	Sons above 18 years	Total PAF	Other family members	Total PAP
1	Haat	Stage-II	1.665	141	253	122	375	375	750
		stage-III	18.672	253					
		Sub Total	20.337						
2	Jaisaal	Stage-II	2.597	106	113	75	188	275	463
		stage-III	4.281	101					
		Sub Total	6.878						
3	Gukabkoti	Stage-II	1.025		48	31	79	125	204
		stage-III	2.369						
		Sub Total	3.394						
4	Batula	Stage-II	0.542	49	49	43	92	185	277
		Sub Total	0.542						
5	Guniyala	stage-III	0.197	25	25	13	38	62	100
		Sub Total	0.197						
6	Tenduli ChakHaat	stage-III	0.170	04	04	04	08	27	35
		Sub Total	0.170						
7	Naurakh	Stage-II	0.107	49	67	48	115	205	320
		stage-III	0.014	18					
		Sub Total	0.121						
Grand Total			**31.639**	**-**	**559**	**336**	**895**	**1254**	**2149**

Table-4.25 Details Expenditures of R&R, VPHEP

S. No	Description	Amount (Rs.)
1	Option I	26851400.00
2	Option II	64905921.00
3	Special Package	111500000.00
4	Community Development	89434530.00
5	Schlorship	74309000.00
6	Fuel and Fodder	104160800.00
7	House Grant	1839216.00
8	Khoka Grant	43800.00
	Total Amount	**473044667.00**

4.13.1.1 Local employment opportunities

The construction phase will last for about 5 years. The total number of persons inhabiting the area including the service population will be about 3200. The construction phase of any project is rather an unsettled stage characterized by uncertainties and often disorders. The basic problem relates to management of large population, which migrates to the project area or near major construction sites, in search of jobs. The construction of the project would invariably create a number of direct employment opportunities. However, indirect employment opportunities would also be generated which would provide great impetus to the economy of the local area. Various types of businesses, such as shops, food-stalls, tea stalls, restaurants, workshops, etc. would invariably come-up, which would be run by the more entrepreneurial local residents. Besides, a variety of suppliers, traders, transporters, service providers, etc., are also likely to concentrate here and likely to benefit immensely, as demand for almost all types of goods and services will increase significantly. The business community as a whole would be benefited. The locals would also avail these opportunities arising from the project and increase their income levels.

The construction phase of the project will provide an impetus to the industrialization and urbanization in the area. Many of the agricultural lands or barren lands in the vicinity of the project area are likely to be put to non-agricultural uses. The project would require lot of ancillary developments like shops, restaurant, workshops, etc. which will have a significant impact on the existing land use of the area. Job opportunities will drastically improve in this area. At present most of the population sustains on agriculture and allied activities. There are no major industries or other avenues of occupation in the area.

The VPHEP project is under construction and it is envisaged that further 5 years required to complete the construction activities. The project will open a large number of jobs to the local population during project construction phase.

4.13.1.2 Business opportunities

Apart from direct employment, opportunities for indirect employment will also be generated which would provide great impetus to the economy of the local area. Various types of business like shops, food-stall, tea stalls, etc. besides a variety of suppliers, traders, transporters will concentrate here and benefit immensely as demand will increase significantly for almost all types of goods and services. The business community as a whole will be benefited. The locals will avail these opportunities arising from the project and increase their income levels. With the increase in the income levels, there will be an improvement in the infrastructure facilities in the area.

4.13.1.3Impacts due to blasting on people and structures

The construction of the project would require blasting for various operations due to tunneling, cutting of roads, quarrying, etc. This could affect the nearby structures. Normally blasting is done

in with proper safety measures and major impacts are not anticipated. However, if such impacts do take place, suitable compensation shall be paid for mitigation of adverse impacts in this account.

4.13.1.4 Construction workforce related influence on social services (Educational, Health, Communication, Water Supply, Consumer Goods, and Sanitation etc.)

During construction phase a large labour force, including skilled, semi-skilled and un-skilled labour force, is expected to immigrate into the project area. Some of the locals would also be employed to work in the project. The labour force would stay near to the project construction sites. Education will receive a shot in the arm. The advantages of education to secure jobs will quickly percolate through all sections of the population and will induce people to get their children educated. A sizeable amount of surplus generated through labour will be spent on education.

The labour force that would work in the construction phase would settle around the project site. They would temporarily reside there. This may lead to pollution, due to generation of domestic wastewater, human waste, municipal solid waste etc. Besides, other deleterious impacts are likely to emerge due to inter-mixing of the local communities with the labour force. Differences in social, cultural and economic conditions among the locals and labour force could also lead to friction between the migrant labour population and the local population.

4.13.1.5 Improved access facilities in the project area

Development of a project like Vishnugad Pipalkoti Hydro-Electric Project will have multifold beneficial impacts. The immediate beneficial impacts from the project will be improved road access which will bring food security situation and overall economic and social stability. The improved accessible road will also provide cheap, safe and fast transport of goods and services from rural areas to urban centers and vice versa.

4.13.1.6 Impacts on public health due to migrant population

About 1000 labourers, technical staff and service providers will congregate in the project area during peak construction phase. The total increase in population is expected to be of the order of 3200. Most of the labour would come from various parts of the country. The labourer would live in dormitories provided by the Contractor. Proper sanitation facilities are generally provided. Hence, a proper surveillance and immunization schedule needs to be developed for the labour population migrating into the project area.

4.13.2 Operation Phase

4.13.2.1Community health improvement

The development of infrastructure facilities in the project area will lead to easy access for the locals to the district hospital as well as project health care units. The better electrification will further enhance the facilities available at the centers.

During project construction phase, proponent will developed health care with adequate number of health workers and logistic supports primarily to provide health support services to the workers and project staff. The health facility will also be made available to local people and visitors as well.

4.13.2.2 Local employment opportunities

The operation of the project will provide some employment opportunity for the local people. The number of employees will decrease in comparison to the requirement during construction but some workers will continue during the operation phase for running the power plant. Besides direct employment opportunity, there shall be enhancement in industrial activities in the area due to availability of electricity. The construction and operation will lead to urbanization, which will also create employment opportunity indirectly.

4.13.2.3 Improved Access to social services (education, health, market etc.)

Once the construction of the project starts, significant and visible impacts will be felt in the project area. It can be assumed that economic activities will boom in settlements close to the project facility sites. During construction phase, education centers, health post, market etc. will be improved. After construction phase, there will be withdrawal of economic activities which flourished during construction phase since most of the construction related workforce will leave the project area. However, some economic activities will continue or be further promoted in these areas because of the relatively good accessibility to cities and urban areas.

4.13.2.4 Community Health Improvement

The construction of various project roads will improve the accessibility to and around the project area. At the same time, project will establish one health care units at the dam site area. Improvement the project area people will have easy access to the district hospital as well as project health care units. The better electrification (with the implementation of rural electrification program) will further enhance the facilities available at the centers.

During project construction phase, the proponent will establish two health care units (one at dam site and other at powerhouse area) with adequate number of health workers and logistic supports primarily to provide health support services to the workers and project staff. The health facility will also be made available to local people and visitors as well.

4.13.2.5 Local employment opportunities

The operation of the project will provide an impetus to the industrialization and urbanization in the area. Many of the agricultural lands or barren lands in the vicinity of the project area are likely to be put to non-agricultural uses. The project would require lot of ancillary developments like shops, restaurant, workshops, etc. which will have a significant impact on the existing land use of the area. Job opportunities will improve in this area. At present most of the population sustains

on agriculture and allied activities. There are no major industries or other avenues of occupation in the area. The project will open a large number of jobs to the local population during project operation phase.

4.14 IMPACTS ON GENDER AND CHILD ISSUES

4.14.1Gender discrimination risks

Most of the male labour population is expected to be engaged in the construction works, thereby creating shortage of male labor for agricultural and household activities. This will create additional pressure to women of agricultural and household workload of collecting fodder, firewood, grazing livestock, etc. On the other hand, the contractors/sub-contractors may be willing to employ women for low wages. Women and children particularly from poor and disadvantaged groups may be attracted to any small job offer even for low wages. Thus, wage hours need to be applied for both male and female labour population.

4.14.2Child Discrimination Risks

During construction phase large number of local as well as outsiders will be engaged directly and indirectly. But in case of Nepal children will use directly or indirectly such as teashop boys, agricultural practices, furniture factories, washing dishes in small restaurant, searching garbage for recycle etc. though, the project will have the provision of not employing children less than 16 years of age, due to poverty parents will forced to engage their children in some form of work like in tea stalls, collection of sand, aggregates etc. since there would be extra earnings, children will be attracted to help their parents in working with the project rather than going to school. This will affect the education of children of the project area. At the same time, different project activities such as drilling, blasting and other construction activities pose safety concerns to the local people especially the children. Besides these due to employment opportunity parents will not provide sufficient time for their children.

4.15 ARCHAEOLOGICAL SITES

A comprehensive Archaeological study comprise of survey of Project area surrounding 7 km of the project sites was conducted during 2009 to predict the impact of project implementation of nearby Archaeological sites. On the basis of village to village Survey (Exploration), 63 villages have been prepared in Joshimath tehsil, Distt. Chamoli. These villages falls under the area of Vishnugarh-Pipalkoti Hydro Electric Dam project area, covering an area of 7 km from river Alaknanda covering the stretch length of 28 km from Chinka village to 3 Km upstream towards Joshimath from Helong Dam site in district Chamoli tehsil Joshimath.

Impacts and Mitigation Measures

Eight villages located in the Project Influence Area have archaeological sites. These locations and archeological findings are given below.

- Dungri- Pre-historic rock-shelter site
- Amarpur- Megalithic burial site consisting the types
- Sirkot I and II- Pottery
- Mahargaon- Pottery
- Darmi- Narsimha Temple
- Haat-Lakshmi Narain Temple
- TangniMalli -Heritage building
- Pakhi- Garud Temple &GodessDurga Temple

Amarpur, Sirkot, Mahargaon, Darmi Gulabkoti, Tangni Malli and Paki villages are located on the left side of the river Alaknanda, Dungri village is located on right side of the river. The project sites - the HRT, Adits, Power house and Colony area are located on the right bank of the River. The villages on left side of the river are located above the National Highway (NH-58) at higher elevation. The distance of the archeological sites from the river are given in Table-4.16.

Table-4.16: Distance of Archaeological locations from river Alaknanda

S. No	Archaeological Site	Location from river Alaknanda	Distance from river Alaknanda, MSL of location & River
1	Pre-historic rock-shelter, Dungri	Right Hand Side	2 km, 1572 m above MSL, River level approx. 1034 m MSL
2.	Megalithic burial site Amarpur	Left Hand Side	2 km, 1353 m above MSL, River level approx.1050 m MSL
3.	Pottery site, Sirkot-1 & Sirkot-2	Left Hand Side	1 km & 0.5 km, 1307 and 1311 m above MSL, River level approx. 1050m MSL
4.	Pottery site, Mahargaon	Left Hand Side	1.5 km, 1364 m above MSL, River level approx. 1050 m MSL
5.	Narsimha Temple, Darmi	Left Hand Side	2.3 km, 1557 m above MSL, River level approx. 1245 m MSL
6.	Lakshmi Narain Temple, Haat	Left Hand Side	1 km, 1507 m above MSL, River level approx. 1245 m MSL
7.	Heritage building, TangniMalli.	Left Hand Side	1.1 km, 1547 m above MSL, River level approx. 1245 m MSL
8.	Garud Temple and Goddess Durga Temple, Pakhi	Left Hand Side	0.5 km, 1372 m above MSL, River level approx. 1234 m MSL

The project facilities such as establishment of various projects units - diversion dam, Intake structures, underground sedimentation chambers, Silt flushing tunnel, Head Race Tunnel (HRT) along the right bank of the Alaknanda river, Underground powerhouse, two number of adits , 3km long tail race tunnel and 4 approach roads are not likely to disturb or alter the archaeological sites.

The impacts which are likely to occur in the project area due to the establishment of project facilities are,

- The construction work is likely to increase the noise level in the area however the impact will be intermittent and temporary and localized.
- The Air quality is likely to be affected due to generation of dust and fugitive emission. The impact will be temporary and limited to construction phase.

- Cutting of trees and clearing of land. The project entails construction of underground tunnel which is not likely to affect the top flora and fauna.
- Influx of labour population is likely to occur which may impart pressure on the local resources of the area.

No impact is envisaged on the archaeological sites in the Project Influence Area, hence no mitigation measures are required.

Suggestions

a) The Gram Panchayat may be involved to protect and maintain the temples.

b) The prehistoric and megalithic remains in the area may be taken as separate long-term planned project by the concerned Govt authority.

4.15.2. Impact on Archaeological Sites in Project Immediate Affected Area (PIAA)

The project immediate influence area is comprised of 500m on both sides of project sites. One archaeological site is located in PIAA area at Haat- Lakshmi-Narayan temple

Mitigation Measures

No impact is envisaged on the temple by the project activity. It is suggested that possible enhancement & beautification of the temple can be undertaken as it is close to the Power House.

CHAPTER -5
ANALYSIS OF ALTERNATIVES

CHAPTER - 5
ANALYSIS OF ALTERNATIVES

5.1 DAM SITE

In 1984, Uttar Pradesh (U.P.) Irrigation Department identified Vishnugad – Pipalkoti Hydro Electric Project (VPHEP) for development with an installed capacity of 340 MW. Several alternative sites were considered in the identification report which included barrage at Helong and underground power house at Birahi on the right bank. The report also considered construction of a high dam and creation of a large storage. Two alternatives were considered. In the first case, an underground power house at Birahi on right bank was considered, and in the second alternative, a surface power house near village Haat, on the left bank, was proposed. However, no detailed investigations were carried out at the time.

In a subsequent development, the Government of Uttarakhand assigned THDC India Ltd the task of investigating and developing Vishnugad Pipalkoti site for hydro power generation.

In order to decide on a barrage or a dam, investigations were carried out by THDC India Ltd at several locations in the area. The various alternatives considered are given below. While assessing the alternatives for final site selection, a lot of emphasis was laid on environmental and social aspects. The objective was to avoid or minimize impacts on physical environment, terrestrial and aquatic biodiversity and human settlements not only due to the dam but also due to the construction and operation of HRT, spillways, power house, sedimentation chambers, tail race tunnels and other facilities like approach roads, project township, labour colony, etc. For unavoidable impacts, appropriate mitigation measures were taken into account.

a) Dam Site 1

The Pipalkoti site, as identified and suggested in the 1984 report, was investigated for construction of 202 m high concrete gravity dam, but it was found that storage is not suitable at the site due to the following reasons:

- A part of the National Highway-58, which connects Rishikesh and Joshimath, and passes through Pipalkoti, is lying below pond level at Pipalkoti. This will require realignment of NH-58 in a reach of about 20 to 30 km.
- About six villages and Pipalkoti town will be submerged due to the reservoir.
- There will be huge submergence of forest land with damage to flora and fauna.
- Geological formations are not suitable for storage dam.
- Presence of Main Central Thrust (MCT) nearby is also not suitable for such a large storage dam.

The option of having a diversion dam or a barrage near Helong was then investigated. The following alternative sites for barrage and dam were investigated:

b) Upper Barrage Site

This is in immediate downstream of the confluence of Animath nalla and Alaknanda river. A diversion structure was found feasible. This would help utilize the total head available between tail waters of Vishnuprayag Project and full reservoir level of Bowala-Nandprayag Project near the confluence of Birahiganga and Alaknanda. However, much excavation work would be required due to considerable depth of overburden.

c) Lower Barrage Site

The site is located between two bridges on Alaknanda near Helong (EL 1244 m). A 20 m high barrage was proposed to divert the water of Alaknanda through a tunnel on the right bank to an underground power house near Haat village with tail race of EL 1027 m. The geological formations appeared to be suitable for tunneling and locating underground sedimentation chamber upstream of barrage near Helong. The site falls in the vicinity of MCT. The barrage, if located here, would not be able to utilize the full head available between Vishnugad and Helong, but the discharges of Karmanasa and Kalpganga rivers would be available for power generation.

d) Dam Site 2

The site is about 120 m downstream of Upper Barrage Site (B1). There is strong possibility of rock fall here on right abutment. Depth of overburden is little over 19 m.

e) Dam Site 3

The site, located about 200 m downstream of dam site 2, was not found suitable as about 20 m thick river borne material terrace exists above water level on the left and right bank. There is also possibility of rock fall.

f) Dam Site 4

The location is about 1.5 km downstream of Upper Barrage Site (B1). Construction of a small dam was considered with head race tunnel (HRT) on right bank and underground power house near Haat village. The area above the site, at a higher level, is covered with debris and forests. There is a major shear zone upstream, but is sufficiently away from the proposed dam site. Geologically, the site reveals hard and compact quartzite and is comparatively free from the danger of rock fall. The proposed tunnel on the right bank will not have to cross MCT. Waters from Karmanasa and Kalpganga rivers will be fully utilized. Since the gorge is steep and narrow, underground sedimentation chamber will be required.

g) Dam Site 5

Taking into consideration the studies carried out by THDC India Ltd, detailed investigations were carried out by the DPR consultants. On the basis of these investigations, a new site

has been selected for construction of a diversion dam with low height spillway. This site is 50 m downstream of D-4 Site, near village Helong.

A summary of the findings of various alternatives is given in Table-5.1.

Table-5.1: Summary of findings of various Alternatives of Dam Site

Alternatives	Location	Environmental, Social & Technical issues	Remarks
D-1 site	Near Pipalkoti	• Pipalkoti town and 6 villages will submerge • Huge forestland under submergence • NH-58 below pond level, will need realignment in 20/30 km stretch • Main Central Thrust close to the site • Calcareous rock-not suitable for storage dam	Not suitable
Upper Barrage Site (B1)	Just d/s of Animath nala - Alaknada confluence	• Overburden depth too much-much excavation required	Not suitable
Lower Barrage Site	Near Helong	• Close to MCT • Full head not able to utilize	Not suitable
D-2 Site	120 m d/s of B-1	• Overburden depth too much	Not suitable
D-3 Site	200 m d/s of D-2	• Rockfall prone • 20m thick river borne material terrace above water level on both bank	Not suitable
D-4 Site	1.5 km of d/s of B-1	• Least environmental and social problem	Found suitable
D-5	50 m d/s of D-4	• Most appropriate from environmental, social and technical aspects	Finally Selected

Conclusion: On the basis of these investigations, **Alternative-D5** has been selected for construction of a diversion dam with low height spillway.

5.2 OTHER COMPONENTS

Once the dam site was finalized, location/ alignments of other project components like HRT, power house, approach road etc. were selected. Environmental and social aspects were taken into consideration while finalizing the location/ alignments of these components, as detailed below:

a) Head Race Tunnel (HRT) Alignment

The 13.4 km long 8.8 m dia circular shaped head race tunnel has been proposed on right bank of the river. The geological profile of the rock structure in the tunnel are completely folded and faulted. The alignment of the tunnel is crossed by several perennial and ephemeral nallas and Maina nadi, which is an important drainage and intersects the tunnel

at a distance of about 9 km from the dam. The alignment of the tunnel has been optimally fixed to provide adequate rock cover below the nala crossings. As the most critical stretch of the HRT passes through Maina nadi which required proper rock cover, detailed and adequate site investigations were carried out for finalizing and selecting the layout of the alignment.

The construction of HRT will not have any significant impact on environment as it is an underground tunnel. The underground HRT traverses though sparsely vegetated area with scattered Pine trees and does not involve clearing of land. Hence the flora & fauna of the area as well local community is not affected.

b) Power House

Geology and ecology of the area, availability of head and discharge in the river, as well as human habitation and density of population are some of the main issues considered for the location of the Hydro-Electric Power Project. Although the project falls outside the buffer zone of the Nanda Devi Biosphere Reserve, which is also a World Heritage Site, THDC abandoned the option of Surface Power House and opted for the proposed underground structure which is more secure and environmentally viable. The Power House site is selected inside a hill on the right bank of Alaknanda river downstream of Hat village.

The underground power house is selected as the river banks are steep and there was paucity of space for surface power house in other alternate site which was considered near Birahi Ganga confluence with Alaknanda River. In fact the hill slopes of the surrounding area are considerably steep and constructing a surface power house by excavation was also not considered practical. So the site which is located about 15 km downstream of the diversion dam was selected for the construction of underground power house.

The detailed topographical study of the area surrounding and the geological investigations carried out also revealed that the power house complex was suitable for accommodating other tunnels such as cable tunnel, ventilation tunnel, adit tunnel to penstock. Therefore, the orientation of the power house has been decided on the basis of in-situ stress and foliation direction.

The underground power house complex will comprise of two separate caverns. The main machine hall cavern is 146 m x 20.3 m x 48 m with a service bay and space for 4 units of 111 MW turbines. The transformer cavern will be 140.3 m x 15 m x 25.5 m high to accommodate transformer and Gas Insulated Switchgear (GIS) etc. The draft tubes shall be provided with a draft tube gate.

The construction of underground power house site is likely to reduce the impact on surrounding environment. The area is sparsely vegetated and floral species found at the site are common in occurrence and are found extensively throughout the degraded areas.

The site in located on right side of the river hence the traffic on NH-58 on left bank will not be impacted.

c) Spillway & Energy Dissipation

For optimal utilization of the head and water available from the different streams joining the river the site an ogee spillway with vertical gates is considered to pass the design flood of 10840 m3 /sec (One gate un-operative) corresponding to PMF. Five openings, each with clear opening of size 7.8 m (W) * 16 m (H) are proposed to cater to design flood discharge which is inclusive of one gate for additional factor of safety as per BIS Code. Radial Gates will be operated by means of hydraulic hoists. Provision of stop log gates with gantry crane has also been made.

Energy dissipation is proposed through a trajectory type of bucket which throws the feet of water through the air and into the plunge pool. Protection works in term of concrete apron are proposed immediately downstream of bucket.

d) Approach Roads

Vishnugad Pipalkoti H E Project is connected on Ghaziabad-Haridwar-Rishikesh- Srinagar-Pipalkoti-Joshimath-Mana National Highway (NH-58). The project site is about 225 km from Rishikesh.

Various approach roads covering a length of around 25.578 km length was initially proposed to be constructed in the project area to provide good accessibility to various work fronts i.e. Dam Site, Power House, Adits, Quarry & Borrow Area, Muck Disposal Sites, Pot Yard Area etc. The various components of the project are proposed to be connected by project road diverted from National Highway (NH-58). They are as follows:

i. Approach Road to dam site (Helong to Dam Site)
ii. Approach Road to Langsi Adit (Gulabkoti to Dwing)
iii. Approach Road to Maina Adit (Pipalkoti to Maina Nadi)
iv. Approach Road to Power house & colony site (Koriya to Siyasain)

These roads will cover a total area of 38 Ha. The road to dam complex will be diverted from the NH-58 and will be connected to dam top, bridge, and various work fronts up to river bed etc. and will be of permanent nature. The site does not have any rare/endangered or threatened species of flora. It traverses through the Van Panchayat area and the species found at the location are common and planted. The construction of road does not involve disturbance to any wildlife habitat and human settlement. There is no settlement located at the site hence no impact on local people due to the road construction.

Construction of approach road to Langsi Dwing Adit does not involve any road cutting on left bank. The existing PWD road which was an old road route to Badrinath will be utilized from Langsi up to the Bridge on Alaknanda. The section will be updated and connected to the adit portal opposite Patal Ganga. It will avoid cutting of trees, cutting

of hill and land acquisition on the left bank. Therefore, the impacts on environment and social aspects are minimized by the utilizing the old abandoned road.

The approach from National Highway near Pipalkoti will be diverted to the adit portals on Maina Nadi and will be of permanent nature. It will provide connectivity to the villages on the right bank Tenduli, Math and Guniyala. The villagers have to frequently/ daily walk and reach Pipalkoti for marketing, hospital, school etc. The construction of road will save time and energy of the villagers.

The approach road near Kodia village will be of permanent nature and diverted to connect power house, switch yard, surge shaft top & bottom, TRT outfall and residential/non-residential complex will be of dual carriage way. The alignment traverses through open area with some agricultural land. There is no forest present in the area. The vegetation is dominated by thorny bushes and all species found are common in occurrence.

e) Project Township and Administrative building

The project township including office is built in Siyasain near village Haat and Jaisal which is located on the right bank of Alaknanda River approx. 20 km downstream from the dam site. The township site is a flat patch of land of approx. area 13 Ha with a gentle slope. Within this township residential / non-residential buildings(office), Post office, Bank, Fire station, Guest houses, Market, Police station etc., are proposed to be provided for the officers and staff for operation and maintenance of the plant. Water treatment plant/ Sewage treatment is also planned to be provided for a clean living environment. The site falls in building Zone-V (Seismic Zoning Map of India, IS 1893 part I, 2002). All the project components will be looked after from this residential/ non-residential complex.

This site has been selected as it has good accessibility with the surrounding facility area, power house, dam site of THDC and the nearest commercial complex i.e. market, community centre, guest houses, hotels, offices etc. located at Pipalkoti. The local town of Pipalkoti is located approx. 4km away from this project township. This site has been selected because a major portion of the land is barren with a minimal covering of grass, few scattered trees, one small school and few houses of the Jaisal/Siyasain village. Major portion of this site (i.e. approx. 60 % of the total area belongs to village panchayat) and about 40% of the land is forest land.

Sites on the left bank were not considered as NH-58 transverses on the left bank of Alaknanda River. But proper approach roads for various work areas for construction and operation and maintenance of the project would be provided and diverted from National Highway at different locations by bridges across Alaknanda River for various approach roads.

f) Contractors Accommodations

The contractor's accommodation including the labour camps and construction worker's camps are located in Gulabkoti, and Batula. The contractor's accommodation, labour and construction worker's camps at Gulabkoti, and Batula are located on the left bank of the river as topography on the right bank are steep as there is paucity of space and flat land on the right bank. These sites have been selected by project authority as they have good accessibility with the surrounding facility area, power house, dam site of THDC and the nearest commercial complex.

g) Quarry and Borrow Areas

The Quarry Areas sites are located at Gulabkoti, Patalganga and Garigaon. Gulabkoti Quarry area is located around 2 km downstream of the dam site and adjacent to National Highway (NH-58). The Patalganga Quarry area with terrace deposits to be used as coarse aggregate in concrete for non-wearing surfaces is located at about 5 km downstream of the dam site. The third site of Gadi/Garigaon near Birahi River for coarse aggregate to be used in concrete for non-wearing surfaces is located at 5 km away from the power house.

All these Quarry areas have been selected as they are near the proposed construction sites for the various components of the project like Power House, Dams, Head and Tail Race Tunnels and Surge Shafts. These quarry sites also have good accessibility and are well connected with the surrounding facility areas of power house and dam site of THDC by the four approach roads from NH-58 to dam site, Pipalkoti to Maina Nadi and Koriya to Siyasain.

The Quarry sites are represented by open barren area dominated by common shrubs such as *Colebrookia oppositifolia* and *Euphorbia royleana*.

The Borrow Areas are located at Bajipur, Haat and Bhagisera villages. Koria village borrow area having fine aggregate is located at about 10 km downstream of confluence of Birahi and Alaknanda Rivers. The quarry area at Haat village with fine aggregate is located along River Alaknanda. The third site at Koria village with terrace sand deposits is located 1.5 km away from the proposed power house site.

All these Borrow areas have been selected as they fall within the construction sites for the various components of the project like Power House, Dams, Head and Tail Race Tunnels and Surge Shafts. Borrow area material sites has been selected near the construction sites for project to cut down the cost of construction and maintain the ecological balance of the area by using indigenous material found locally.

h) Muck Disposal Sites

For dumping of the muck Five Muck Disposal Sites viz. (i) Haat, (ii) Siyasain (iii) Jaisaal, (iv) Gulabkoti and iv) Maina Nadi were identified adjacent to project components in which dumping will be done and further they will be restored and re-vegetated with proper landscaping.

The identified sites of muck disposal have been selected in such a way that they are in conjunction with various characteristics viz. landscape, cost effectiveness, nearness to source of generation, groundwater/blockage to surface water, relief and scope of afforestation and erosion control/sediment arrest.

These muck disposal sites are degraded areas. The vegetation found on the area constitutes of *Eupatorium adenophorum, Colebrookia oppositifolia, Plectranthus coesta* and *Rumex hastatus. Parthenium hysterophorus* is dominant grass species occurring in the area. The impact on flora and fauna will be insignificant. No impacts on local people as the sites are away from settlement area.

CHAPTER-6
ENVIRONMENTAL MONITORING PROGRAMME

CHAPTER-6
ENVIRONMENTAL MONITORING PROGRAMME

6.1 THE NEED

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

Monitoring of environmental indicators signal potential problems and facilitate timely prompt implementation of effective remedial measures. It will also allow for validation of the assumption and assessments made in the present study.

Monitoring becomes essential to ensure that the mitigation measures planned for environmental protection function effectively during the entire period of project operation. The data so generated can also serve as a data bank for prediction of post-project scenarios in similar projects as well.

From the monitoring point of view, the important parameters are water quality, ambient air quality, noise, terrestrial and aquatic ecology incidence of water-borne and vector borne disease etc. The monitoring details are outlined in the following sections.

6.2 WATER QUALITY

6.2.1 Surface Water Quality:

Construction Phase

surface water quality is being monitored as proposed during EIA/EMP 2009 at each active construction sites i.e 1 Km U/S DAM, 3 Km D/S DAM, 1 Km D/S TRT& 3 Km D/S TRT. The frequency of monitoring is once per season. The parameters that are being analysed include pH, Biochemical Oxygen Demand, Chemical Oxygen Demand, Total Suspended Solids and Total Dissolved Solids. The total estimated cost for monitoring till construction phase works out to Rs..6.0 lakh.

Operation phase

The surface water quality of the impounded water and Alaknanda river can be monitored thrice a year. The proposed parameters to be monitored include; pH, temperature, electrical conductivity, turbidity, total dissolved solids, calcium, magnesium, total hardness, chlorides, sulphates, nitrates, DO, COD, BOD, Iron, Zinc and Manganese.

The sampling sites shall be:

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

The total cost of analysis will be **Rs. 0.90 lakh/year**. This analysis shall be done throughout the entire life of the project. The analysis work can be conducted by a reputed external agency recognized by State Pollution Control Board or the same can be done in-house by THDC.

6.2.2 Effluent Monitoring

A sewage treatment plant (STP) has been constructed to set up for treatment of effluent from the project colony. Effluent from STP is proposed to monitor once per season before discharging into river system. Also, it is proposed to monitor the surface water quality downstream from disposal point from proposed STP (if any).The parameters to be analyzed include pH, Biochemical Oxygen Demand, Chemical Oxygen Demand, Total Suspended Solids and Total Dissolved Solids. Estimated total cost for analysis in project operation works out to **Rs. 10 lakh.**

6.3 AMBIENT AIR QUALITY

Construction Phase

The ambient air quality monitoring during construction phase is being carried out by an external agency at four location near active construction sites. Every year monitoring is to be done for three seasons namely, winter, summer and Post-monsoon. The frequency of monitoring could be twice a week for four consecutive weeks at each station for each season. The parameters to be monitored are PM_{10}, $PM_{2.5,}$ SO_2 and NO_2.Till project construction phase, the total cost required shall be **Rs. 28.4 lakh.**

Operation phase

Air quality monitoring has not been recommended during project operation phase. However, indoor air quality inside power can be monitored once in a year. Budget will be allocated at appropriate stage from the project head.

6.4 METEOROLOGY

A meteorological laboratory was set up as proposed in EIA/EMP 2009 at one of the ambient air quality monitoring stations for Automatic recorders for temperature, wind speed and direction, humidity, rainfall at the site. An Additional amount of **Rs. 5.0 lakh** can be earmarked for maintenances of AWS.

6.5 NOISE

Construction Phase

Noise emissions from vehicular movement, operation of various construction equipments is being monitored as proposed in EIA/EMP 2009 during construction phase at major construction sites. The frequency of monitoring is as once every three months.

For monitoring of noise level, an integrating Sound Level Meter will be required. An amount of **Rs. 0.5 lakh** can be earmarked for this purpose.

Operation Phase

Noise quality monitoring has not been recommended during project operation phase. However, indoor noise quality inside power can be monitored twice a year.

6.6 ECOLOGY

Construction Phase

A detailed ecological survey covering forestry, fisheries, wildlife was recommended during the construction phase. The survey and monitoring is being carried by various 3rd Party agencies i.e. ICFRE, WAPCOS and DCFR. No additional monitoring plan is being proposed during construction phase.

Operation Phase

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

The parameters can be monitored within a year after commissioning of the project. Subsequently the monitoring frequency shall be increased as once in five years. The monitoring can be conducted by a reputed external agency for which an amount of Rs. 3,0 lakh/year has been earmarked.

Status of afforestation programmes, changes in migration patterns of the aquatic and terrestrial fauna species should be studied. The staff at the proposed unit of the Environmental Management Cell can undertake the work. A provision of Rs. 2.0 lakh/year has been kept for this purpose.

Additional budget provision for an amount of Rs. 10.0 lakh for the monitoring of ecological parameters.

6.7 SOIL EROSION AND SILTATION

Operation Phase

Soil erosion rates, slope stability of embankments of barrage, efficacy of soil conservation measures are being closely monitored by the staff of the proposed Environmental

Management Cell. Necessary measures are already incorporated in CAT/ECO Restoration plan of project

Following parameters like soil erosion rates, stability of bank embankment would be measured. In addition to above, soil quality at various locations in the catchment area needs to be monitored once every year. The parameters to be monitored are pH, organic matter and texture. A provision of **Rs. 1.6 lakh/year** has been made for this purpose.

6.8 INCIDENCE OF WATER-RELATED DISEASES

Construction Phase

Identification of water-related diseases, quality of drinking water, adequacy of local vector control and curative measures, status of public health are some of the parameters which is being closely monitored with the help of data maintained in the government dispensaries/hospitals.

The total cost required for monitoring over the entire project construction phases shall be **Rs. 24.4 lakh**.

Operation Phase

Increased prevalence of various vector borne diseases and adequacy of local vector control and curative measures need to be monitored. The monitoring can be done three times in a year. The monitoring can be done by State Health Department and other agencies, e.g. hospitals and dispensaries constructed by the project proponents.

6.9 LAND USE

Operation Phase

During project operation phase, it is proposed to monitor land use pattern once every year using satellite data from Web portal of NRSC (Bhuwan)/ Google Earth.

6.10 SUMMARY OF ENVIRONMENTAL MONITORING PROGRAMME

The summary of Environmental Monitoring Programmes to be implemented in project construction and operation phases is given in Tables 6.1 and 6.2 respectively.

Table-6.1: Summary of Environmental Monitoring Programme during Project Construction Phase

S. No.	Item	Parameters	Frequency	Location
1.	Effluent from STP	pH, BOD, COD, TSS, TDS	Once every season	NA
2.	Ambient Air quality	PM_{10}, $PM_{2.5,}$ SO_2 and NO_2	Once every season	At four locations
3.	Meteorological aspects	Wind speed & direction,	Throughout the construction	At one of the ambient air quality sampling

S. No.	Item	Parameters	Frequency	Location
		temperature, humidity, rainfall	period	sites
4.	Noise	Equivalent noise level (L_{eq})	Once in three months	At major construction sites
5.	Water-related diseases	Identification of water related diseases, adequacy of local vector control and curative measure, etc.	Three times a year	Labour camps and colonies
6.	Surface Water Quality	pH, Temperature, EC, Turbidity, Total Dissolved Solids, Calcium, Magnesium, Total Hardness, Chlorides, Sulphates, Nitrates, DO, COD, BOD, Iron, Zinc, Manganese	Once every season	At major construction sites
7.	Drinking Water Quality	pH, Temperature, EC, Turbidity, Total Dissolved Solids, Calcium, Magnesium, Total Hardness, Chlorides, Sulphates, Nitrates	Once every season	Labour camps and colonies

Table-6.2: Summary of Environmental Monitoring Programme during Project Operation Phase

S. No.	Items	Parameters	Frequency	Location
1.	Water Quality	pH, Temperature, EC, Turbidity, Total Dissolved Solids, Calcium, Magnesium, Total Hardness, Chlorides, Sulphates, Nitrates, DO, COD, BOD, Iron, Zinc, Manganese	Thrice a year	• 1 km upstream of reservoir • Submergence area • 1 and 3 km downstream of tailrace discharge
2.	Soil Erosion & Siltation	Soil erosion rates, stability of bank embankment, etc.	Twice a year	-
3.	Ecology	Status of afforestation programme of green belt development	Once in a year	-

S. No.	Items	Parameters	Frequency	Location
4.	Water related diseases	Identification of water related diseases, sites, adequacy of local vector control measures, etc.	Three times in a year	Villages adjacent to project sites
5.	Aquatic ecology	Phytoplanktons, zooplanktons, benthic life, fish composition	Once a year	• 1 km upstream of reservoir • Submergencear ea • 1 and 3 km downstream of tail race disharge
6.	Landuse	Landuse pattern using satellite data	Once in a year	Catchment area
7.	Soil	pH, EC, texture, organic matter	Once in a year	Catchment area

6.11 COST FOR IMPLEMENTING ENVIRONMENTAL MONITORING PRORAMME

The cost required for implementation of Environmental Monitoring programme during project construction and operation phase is **Rs. 223.1 lakh**. This amount is taken into the earlier Environmental Clearance. An amount of Rs. 31.5 lakh has been earmarked to strengthen the Environmental Monitoring Plan. The details are given in Table-6.3 and 6.4.

Table-6.3: Cost for implementing Environmental Monitoring Programme as per EIA/ EMP 2009

Items	Construction Phase					Operation Phase	Total
	I Year	II Year	III Year	IV Year	V Year		
Water Quality						90000	**215000**
Air Quality& Meteorology	568000	568000	568000	568000	568000		**2840000**
Noise Level	100000	100000	100000	100000	100000		**500000**
Water related diseases	488000	488000	488000	488000	488000		**2440000**
Effluent/ Water Quality monitoring	996000	996000	996000	996000	996000	300000	**5280000**
Aquatic ecology-Phytoplankton, Zooplankton, macrozoobenthos, fish						500000	**500000**
Soil erosion & Siltation						160000	**160000**
Environmental Expert Panel (1+5)	2100000	2100000	2100000	2100000	2100000		**10500000**
Total	**4252000**	**4252000**	**4252000**	**4252000**	**4252000**	**1050000**	**22310000**

Table-6.4: Additional Cost for implementing Environmental Monitoring Programme during construction phase.

Items	Additional Cost (Rs.)
Water Quality	600000
AWS and Noise	550000
Effluent/ Water Quality monitoring	1000000
Aquatic ecology-Phytoplankton, Zooplankton, macrozoobenthos, fish	1000000
Total	**3150000**

6.12 COMPOSITION OF ENVIRONMENTAL MANAGEMENT CELL

Two tire in-house monitoring mechanism exists in THDCIL, one at corporate level and another at project level. There exist full fledged Social & Environment (S&E) Departments at Corporate level as well as project level. Corporate S&E Deptt. oversees overall social & environment related issues of the organization including monitoring of implementation of EMP by the projects and reporting to various regulatory authorities. In addition, Corporate S&E Deptt. also act as an interface between the project and various regulatory authorities w.r.t. necessary permissions/compliances/ clarifications etc. Whereas, project S&E Deptt. is responsible for implementation & monitoring of Rehabilitation and Environment Management Plans and related conditions stipulated during various clearances at site. Efforts are made to maintain multidisciplinary nature of S&E Deptts. both at Corporate as well as Project level by sufficiently staffing them with social, life science and environmental engineering background manpower. In addition to above, the EPC contractor M/s Hindustan Construction Company (HCC) also has its own environment cell at site for execution of EMP. Composition of manpower at Corporate S&E Deptt., Project S&E Deptt. and HCC is as under:

Environmental Management Unit are given in Table-6.4.

Table-6.4: Manpower Requirement for Environmental Management Unit at Project site

S. No	Position	Number
1	Environmental Officer	1
2	Ecologist	1
3	Socio-Economist	1
4	Technical Assistant (Environmental Chemistry)	2
5	Technical Assistant (Terrestrial Ecologist)	1
6	Technical Assistant (Aquatic Ecologist/Fisheries)	1
7	Technical Assistant (Socio-Economist)	1
8.	Other Assistants (Miscellaneous Works)	2
	Total	**10**

The key tasks of the Environmental Management Unit will be to coordinate specific studies to:

- Monitor implementation of Environmental Mitigatory measures
- Coordinate activities outlined as a part on Environmental Audit
- Coordinate Environmental Monitoring Programme
- Suggestion of additional measures/studies, if any.

The Environmental Management Cell will report to the appropriate authority having adequate powers to implement the required measures. The Organization Chart of Environment management Unit is enclosed as Figure-6.1.

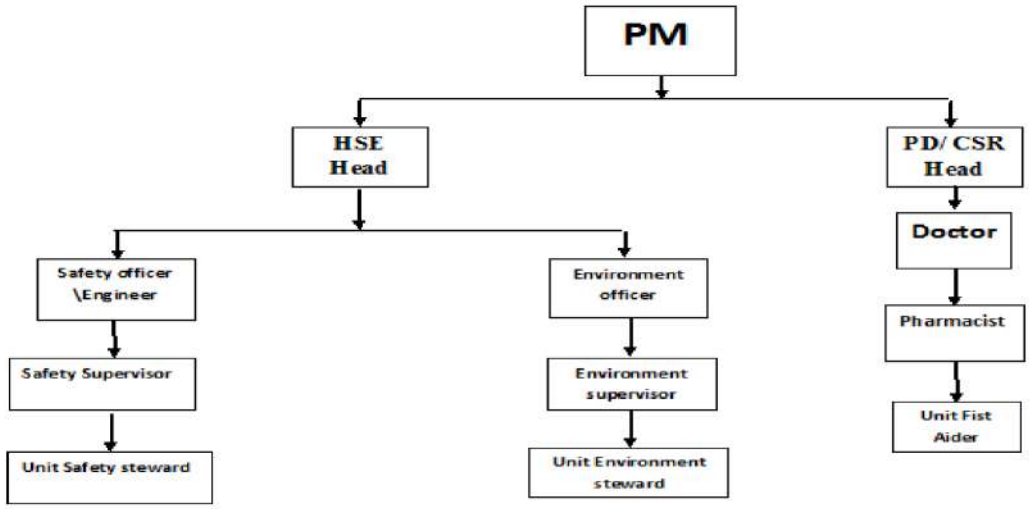


Figure-6.1: Organization Chart of Environmental Management Unit of HCC

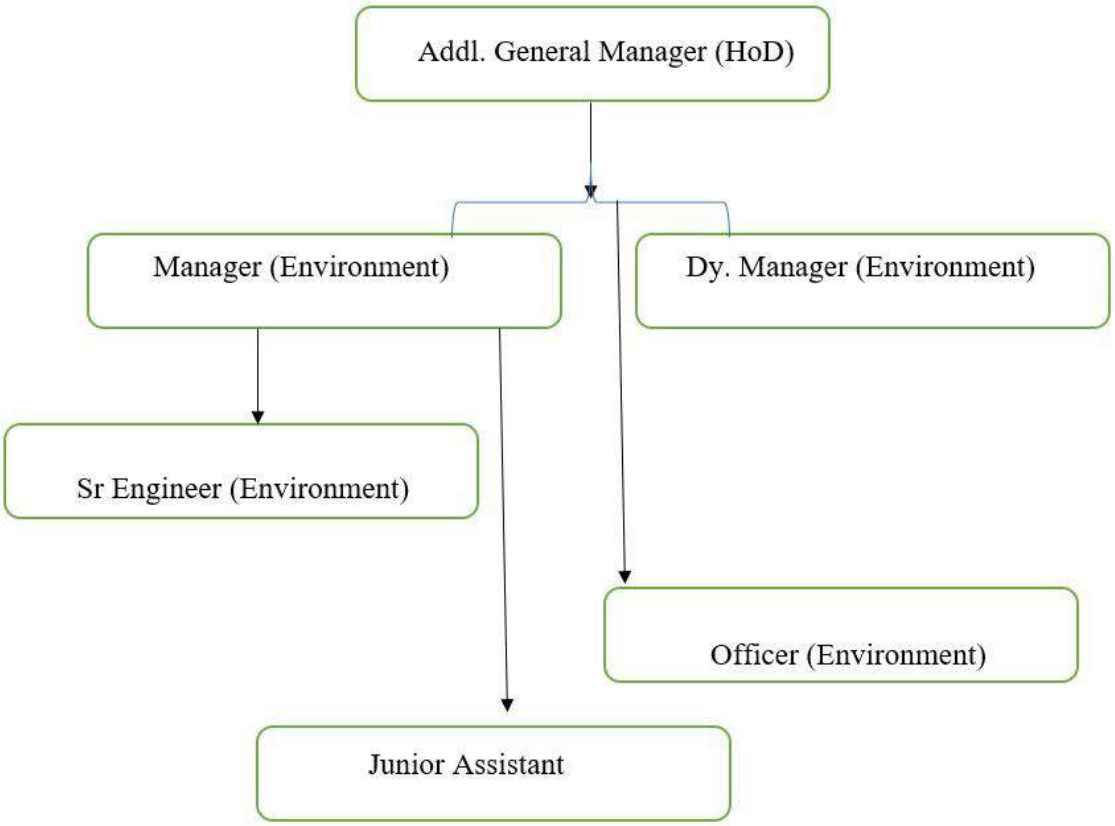


Figure-6.1.b: Organization Chart of Environmental Management Unit of VPHEP

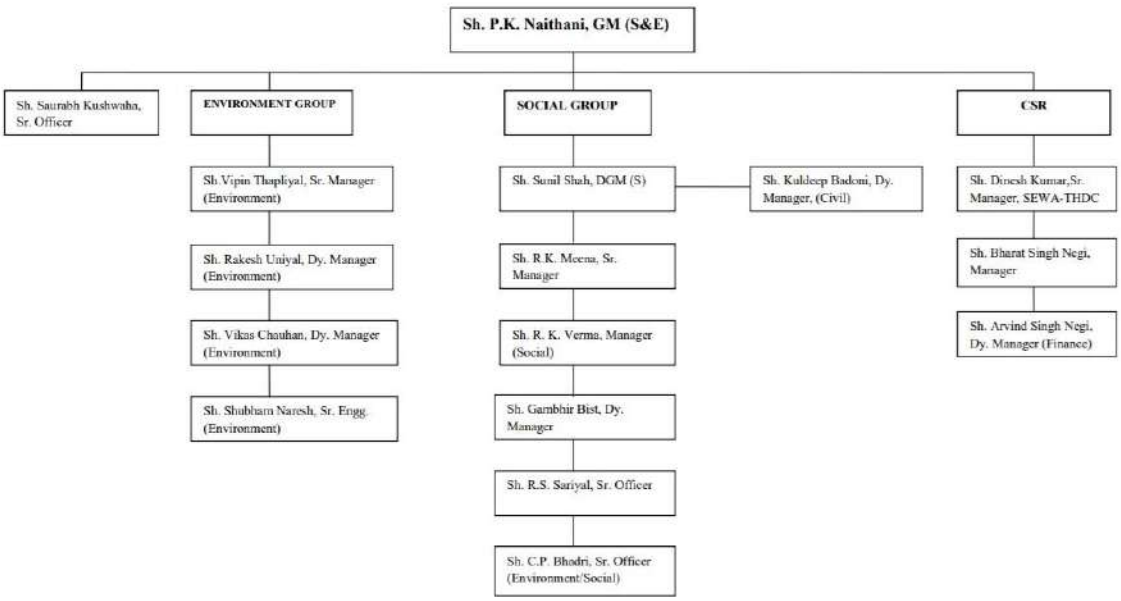


Figure-6.1.C: Organization Chart of Corporate S&E Department

6.13 CURRENT STATUS OF THE ENVIRONMENTAL MONITORING

THDCIL has developed a robust system for the monitoring plan which is framed to monitor the Environmental parameters. The details are given in Table-6.5.

Table-6.5: Details of Environment Parameters

S. No.	Items	Parameters	Frequency	No. of sample	Budget Provision (Crore)	Expenditure April 2021 (Crore)
1.	River Water Quality	pH, Temperature, EC, Turbidity, Total Dissolved Solids, Calcium, Magnesium, Total Hardness, Chlorides, Sulphates, Nitrates, DO, COD, BOD, Iron, Zinc, Manganese	Quarterly	04	2.23	0.74
2.	Water related diseases	Identification of water related diseases, sites, adequacy of local vector control measures, etc.	Monthly	NA		
3	Noise	Leq (db)	Quarterly	04		
4	Ambient Air	PM, NOX ,SO_2	Quarterly	04		
5	Drinking water	pH, Temperature, EC, Turbidity, Total Dissolved Solids, Calcium, Magnesium, Total Hardness, Chlorides, Sulphates, Nitrates	Quarterly	04		

6.14 THIRD PARTY MONITORING OF EMP, CAT PLAN AND RAP (REHABILITATION ACTION PLAN)

6.14.1 EMP Monitoring

A third-party monitoring program has been formulated to monitor the implementation of activities provided in EMP. The Environmental Management Cell (EMC) of VPHEP in association with Corporate Office is monitoring the EMP. However, a third-party monitoring for the implementation of the EMP is being conducted by an agency or a committee of experts who visit the project site, twice a year, to oversee and evaluate the EMP implementation and suggest improvements. EMP is being monitored by the M/s WAPCOS from January, 2015 to December, 2020 and further, new work has been awarded to M/s WAPCOS for post 2020 monitoring.

6.14.2 CAT Monitoring

The primary objective of this assignment is to provide information from a third party perspective to provide the information regarding the progress, quality (such as survival rate of plantation, site specific plantation, percentage of fruit bearing saplings/plants etc.), progress of physical and financial aspects along with financial expenditure of various works envisaged under the scope of the CAT Plans of Vishnu Gad Pipalkoti Hydroelectric Project (VPHEP) developed and implemented by State Forest Department. The recommendation of third party monitoring will provide information and opportunity for THDCIL and State Forest Department to review the progress and adopt appropriate on site, short term or long term correction to plan and achieve the implementation of CAT plan works on schedule and bench mark good practices. CAT plan is being monitored by third party agency Indian Council for Forestry, Research and Agriculture (ICFRE), Dehradun.

6.14.3 RAP (Rehabilitation Action Plan)

THDCIL is committed to following the basic principles of R&R as laid out in the National Policy on Resettlement and Rehabilitation (R&R) 2007 in the implementation of VPHEP. The project is being developed with World Bank funding, hence also complying with the Bank's policy guidelines on R&R. To make implementation of RAP more transparent and stakeholder friendly, a leading NGO Shri Bhuvaneshwari Ashram was also engaged to work as interface between the project proponent and the community.

Apart from in-house monitoring, independent monitoring of Rehabilitation Action Plan (RAP) is also being done for effective implementation through third party expert agencies. Initially, the Monitoring & Evaluation of RAP implementation of VPHEP was conducted through DHV India Pvt. Ltd. from Sept., 2010 to July 2013 and further from Nov, 2014 to Nov' 2019 through Ctran Consulting Pvt. Ltd.

The end term report concluded that the R&R policy of the VPHEP is very effective in adhering to the project development objectives and ground level implementation and found implementation it satisfactory & efficient as per provisions made in the policy.

CHAPTER-7
ADDITIONAL STUDIES

CHAPTER – 7
ADDITIONAL STUDIES

7.1 INTRODUCTION

The present chapter covers the following plans:

- Resettlement and Rehabilitation Plan
- Disaster Management Plan
- Public hearing Proceedings

7.2 REHABILITATION AND RESETTLEMENT PLAN

THDCIL has formulated a Rehabilitation & Resettlement policy (R&R Policy) for the Vishnugad Pipalkoti Hydro Electric Project. The Policy is based on the National Rehabilitation & Resettlement Policy 2007 (NRRP-2007) incorporating the better features considering the World Bank Guidelines. The Policy addresses the R&R issues trough proactive approach and appropriate Planning on Land Acquisition. Besides disbursement of compensation by Special Land Acquisition Officer (SLAO), the Policy envisages provisions of grants and other benefits considering the categories and the Entitlements. For effective implementation of R&R policy, Rehabilitation Action Plan (RAP) has been formulated so that after reasonable transition period, the affected families improve, at least regain their previous standard of living, earning capacity and production levels. Rehabilitation & Resettlement policy (R&R Policy) for the Vishnugad Pipalkoti Hydro Electric Project approved by Dstrict Magistrate, Chamoli is enclosed as **Annexure-.XI**

Table-7.1: Details of Project Affected Families - Private land

S. No	Village	Stage	Land Acquired	Tittle No. of Holders	Net Tittle Holders	Sons (> 18 years of age)	Total PAFs	Other family members	Total PAPs
1	Haat	Stage-II	1.665	141	253	122	375	375	750
		Stage-III	18.672	253					
		Sub Total	**20.337**						
2	Jaisaal	Stage-II	2.597	106	113	75	188	275	463
		Stage-III	4.281	101					
		Sub Total	**6.878**						
3	Gukabkoti	Stage-II	1.025		48	31	79	125	204
		Stage-III	2.369						
		Sub Total	**3.394**						
4	Batula	Stage-II	0.542	49	49	43	92	185	277
		Sub Total	**0.542**						
5	Guniyala	Stage-III	0.197	25	25	13	38	62	100
		Sub Total	**0.197**						
6	Tenduli Chak Haat	Stage-III	0.170	04	04	04	08	27	35
		Sub Total	**0.170**						
7	Naurakh	Stage-II	0.107	49	67	48	115	205	320
		Stage-III	0.014	18					
		Sub Total	**0.121**						
Grand Total			**31.639**	**-**	**559**	**336**	**895**	**1254**	**2149**

7.2.1 Present Status

At present the RAP implementation is under progress & is being monitored by the third party and the World Bank Authorities.

Land Acquisition

A total of 141.568 Ha of Land comprising of 31.639 Ha of Private land across 7 Villages, 100.390 Ha of Forest / Van Panchyat / Civil Soyam Land from 22 Revenue Villages & 9.539 Ha. of PWD Land has been acquired / Diverted for VPHE Project. The Project has taken over the possession of total land.

Status of R&R Plan Implementation of PAFs:

The Implementation of Rehabilitation Action Plan (RAP) and R&R related Activities are presently under progress. Compensation has been provided by SLAO to PAFs whose land, assets etc. has been acquired for the project under LA Act 1894. Additional R&R grants / Assistance have been provided by THDCIL as per the approved R&R policy.

Around 94% of Compensation amount has been disbursed by Special Land Acquisition Officer (SLAO) and approx. 88% R&R grant have been disbursed by THDCIL.

Haat Status:

Out of the 07 affected Villages, only 1 village i.e. Haat is getting relocated comprising of 140 PAFs & the status is as under;

- ✓ **Resident HHs –** 81 nos (Agreement signed – 77, Houses constructed- 76, shifted- 76, Houses demolished-61)
- ✓ **Non Resident HHs –** 50 nos (Agreement signed – 38, Houses demolished- 36)
- ✓ **ST Families –** 9 nos (Agreement signed – 9, Houses Constructed – 9, Houses demolished - 2. 7 ST families have constructed their houses on the 8 Naali (1600 Sq. M.) land purchased by them on Kauria - Haat road. Development of Area including providing necessary infrastructure facilities at above relocation site has since been completed by THDCIL.

Local Area Development

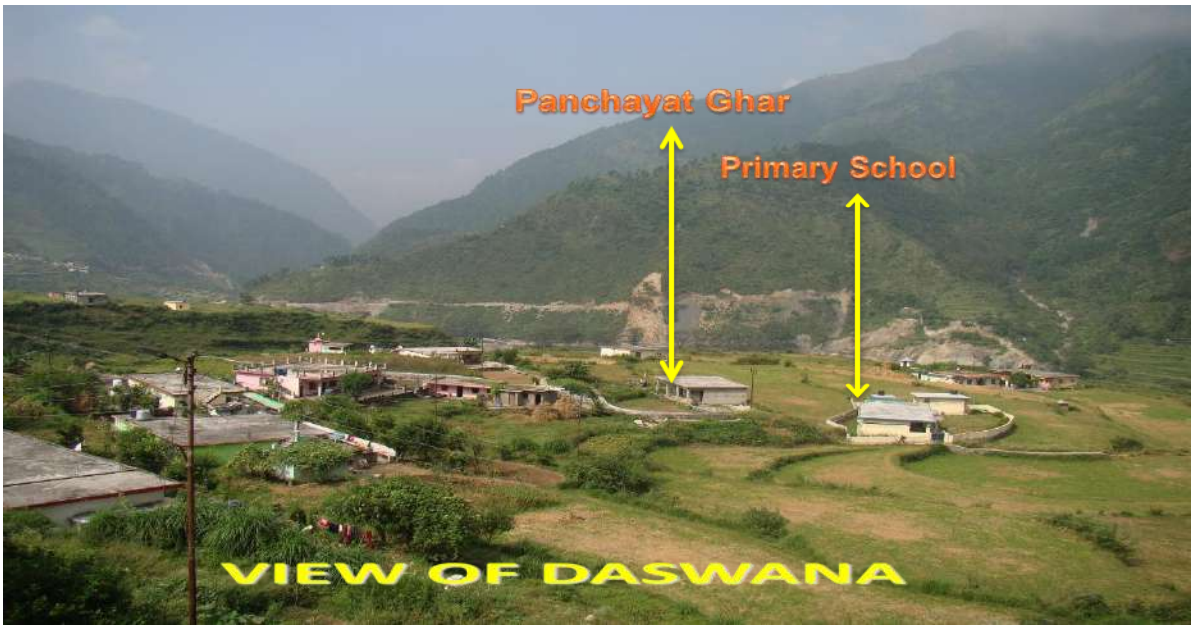
In addition to implementation of Rehabilitation Action Plan (RAP), activities were also included for socio economic upliftment of the affected population. Prominent community development activities taken up in the area includes infrastructure development works such as construction of pathways, samshan, water supply schemes, community buildings, additional class rooms in the schools, toilets, community parks, electrification works, installation of solar street lights, nala protection, construction of safety/boundary walls, promotion of sports, imparting various

livelihood & vocational skill trainings, promotion of various livelihood activities, extending allopathic and homeopathic treatment facilities, organization of multispecialty health camps, strengthening community sanitation facilities, promotion of cultural activities, scholarships to school students, providing school vehicles for students, water tanks, furniture, computer & peripherals, etc. Activities were identified based on felt needs & requirements and demand by the local population.

The total estimated cost for implementation of RAP is given at **Table 10.16: Details of Expenditure incurred under Local area development / CER**

The area/community development fund is now proposed as Rs. 19.07 Cr. in the Revised Cost Estimate (RCE) of the project prepared on Feb, 2019 price level.

Interaction with stakeholders in presence of the World Bank representatives


Panchayat Ghar
Primary School
VIEW OF DASWANA

Kitchen & Separate Toilet Blocks for Boys & Girls

Internal Pathways at Daswana & Eldana

Electrification work in villages Eldana & Daswana

Medical Camp at Urgam

Career Counseling

Skill Training-Tailoring

Livelihood Promotion

7.3 DISASTER MANAGEMENT PLAN

7.3.1 General

Dams store large amount of water, uncontrolled release of water has great potential for loss of life and damage to property in the downstream areas due to flooding. Such situations can occur due to several reasons, such as, breach of dam on account of earthquake, landslide and/or sabotage; excessive release of water on account of extreme storm events, etc. It is, therefore, necessary to have a thorough and consistent planning for any such eventuality so as to save lives and reduce property damage in areas that would be affected by dam failure or operation and putting in place action plans to cope with such an emergency. CWC issued "Guidelines for development and implementation of Emergency Action Plan (EAP) for dams" in May, 2006.

In line with the guidelines issued by CWC, EAP for VPHEP has been prepared to identify potential emergency conditions at VPHEP and specified preplanned actions to be followed to minimize property damage and loss of life. The EAP specifies actions to be taken to moderate the problems at the dam site as well as in the areas downstream of the dam. It contains procedures and information to assist THDCIL in issuing early warning and notification messages

/ request for assistance to responsible emergency management authorities, viz., District Magistrate / Collector, Armed forces, Paramilitary forces, Project Authorities and other Central/ State Agencies. It also contains inundation maps to show the emergency management authorities of the critical areas for necessary relief and rescue actions in case of an emergency.

7.3.2 Purpose and scope

EAP is intended to help officials dealing with the emergency, save lives, minimize damage to property, structure and inhabitations and also to minimize environmental impact in the event of flooding caused by large releases from the dam, dam failure or in other such events that present hazardous conditions. The EAP will guide the dam operation / supervisory personnel in identifying, monitoring, responding to and mitigating emergency situations. lt outlines "who does what, where, when and how' in an emergency situation or any unusual occurrence affecting the dams.

Certain causes such as heavy floods or dam failure may create emergency conditions at the dam site as well as in the areas downstream of the dam that will require warning, evacuation of the population at risk or other response actions. The EAP is intended to interface with the emergency operation plans of other Local, District and State agencies to ensure effective and timely implementation of response actions.

7.3.3 Hazard Area

No emergencies are expected in the area upstream of the dam because all population in the area coming under submergence up to Maximum Reservoir Level i.e. EL 1269 m has been rehabilitated. In the downstream of the dam, Alaknanda River flows in a confined valley up to Srinagar, where it merges into the reservoir of GVK Power Plant, which is under operation. After GVK power plant Srinagar, Alaknada joins, river Bhagirathi at Devprayag and after the confluence, river downstream of Deoprayag is known as Ganga. The valley is moderately narrow upto up-stream of Rishikesh and starts widening from Rishikesh. Flood plains are quite wide after Haridwar.

Therefore, in the event of release of large floods, villages and towns along river Alaknanda from downstream of dam up to reservoir of GVK Power Plant, Srinagar is likely to be affected.

7.3.4 Periodic Review, Testing, Updating of EAP and Trainings

The EAP of the Project is prepared by Operation & Maintenance Safety Department, THDCIL, Rishikesh in line with the guidelines issued by CWC. The EAP shall be revised after implementation of the Project and impoundment of reservoir to incorporate necessary changes based on inputs gathered and experience gained.

Before the impoundment of reservoir, training of personnel involved with the EAP shall be ensured by Project Disaster Management Group (PDMG) and shall be carried out every year to ensure that they are thoroughly familiar with their responsibility, all the elements of the plan and availability of equipment etc. Mock drill shall also be carried out every year to ascertain the effectiveness / preparedness of disaster mitigation measures.

7.3.5 Project Disaster Management Group (PDMG)

PDMG shall be constituted in line with the requirements of Disaster Management Act 2005. The meetings of project level group will be held twice every year (around May & Nov.) ln case of any emergency, a special meeting can also be called by Head of Project.

ln-charge (Planning), VPHEP shall be the EAP Co-ordinator for PDMG and shall prepare agenda, minutes of meeting and status of action taken on the recommendations of PDMG on quarterly basis for the appraisal of management through Head (OMS). Actions on behalf and recommendations of the PDMG shall be initiated by Planning Department, THDCIL, VPHEP, Pipalkoti.

The Project level group at VPHEP comprises of the following officers:

1. Head of the project
2. Head (Safety)
3. In-charge (Dam, Spillway & Power House)
4. In-charge (Planning)
5. In-charge (Mechanical/Hydro-mechanical)
6. In-Charge (Electric/Operation and Maintenance)
7. In-Charge (P&A and Dispensary)
8. In-charge (C&MM/CSR/Building & Roads)
9. In-Charge (Finance)

The responsibilities of the project level group are listed as below:

i) Coordinate with the State and District Administration for necessary support for medical law and order etc., and for evacuation of the likely affected area in the case of release of water from dam during emergency.
ii) Identify activities to be done for implementation of EAP
iii) Review ongoing activities related to EAP
iv) Ensure availability of resources as proposed in the EAP through availability with THDC Depts. and agencies working at Project. The shortcomings, if any, shall be fulfilled, as far as possible, through purchase/ hire /other nearby ongoing works.
v) Identify additional resources (HMV, LMV, & Fire Tender etc.) available with other nearby projects (THDC or any other Agency) and State/ Distt. Administration before monsoon which can be called on in the case of any emergency.
vi) Finalize action plan with role and responsibilities of concerned staff before monsoon.
vii) Ensure training (in house or through outside agency) of the staff to be deputed for emergency management every year, to make them aware about their role and responsibility.
viii) Ensure establishment of control room to operate round the clock during monsoon period.

ix) Conduct a critique following any emergency to discuss and evaluate, the events prior to, during and following the emergency, significant action taken by each participant and what improvements would be practicable for future emergency and all deficiencies found in procedures, materials, equipment, manpower, leadership and funding.
x) Ensure budget provision for identified activities every year
xi) Identify scope or improvement in the EAP from time to time and following a test or actual emergency in order to facilitate revision of EAP every year before monsoon by OMS, QA & Safety Deptt.

In The PDGM meeting in May/June i,e before monsoon, officers from the corporate office and representatives from State and District Administration will also attend the meeting to facilitate coordination among all the stake holders and concerned as under

1. Head (OMS, QA & Safety)
2. Head (Design-Civil)
3. Head (S&E)
4. Representative from Disaster Mitigation and Management Centre (DMMC), Dehradun.
5. Representative from District Administration, Chamoli, Rudraprayag, Tehri-Garhwal and Pauri Garhwal.

7.3.6 Budget Provision

An appropriate budget provision will be made by the Concerned Departments on account of Emergency Management activities including training programme identified by PDMG in revenue budget estimate. In-charge (Planning) will ensure that all the concerned departments make budget provision for activities related to Disaster Management.

7.3.7 Inundation Maps

For communities or significant numbers of dwellings located in the floodplains downstream of the dam, inundation maps are usually needed to develop an adequate evacuation plan. These maps show an outline of the area covered by the dam break or excessive release during flood in detail to identify dwellings and other significant features that are likely to be directly affected. Estimated flood travel time and depth at selected locations have been included on the map.

Length of river Alaknanda from Helang to downstream of Srinagar is about 105 kms Digital Elevation Model (DEM) of the entire downstream area was developed using satellite images (Cartosat Stereo) due to inaccessibility of most of the downstream areas. After completion of DEM, river cross sections were extracted. Thereafter, flood simulation studies were carried out.

7.3.8 Flood Simulation Studies for PMF and Dam Break Flood

Static and Dynamic flow studies can be carried out either i) scaled physical hydraulic models ii) mathematical simulation using a computer. A modern tool to deal with this problem is the

mathematical model, which is cost effective and approximately solves the governing flow equations of continuity and momentum by computer simulation.

In the present study, HEC-RAS version 4.1.0 model developed by Hydrologic Engineering Centre of U.S. Army Corps of Engineers has been used.

The procedure used for static flow analysis by HEG-RAS to compute water surface profiles assumes a steady, gradually varied flow scenario and is called the direct step method. The basic computation procedure is based on an iterative solution of the energy equation ($H = Z + Y + \alpha V^2 / 2g$) which states that the total energy (H) at any given location along the stream is the sum of potential and kinetic energy.

The fully dynamic HEC-RAS model for dam break study has been used. The basic theory for dynamic routing in Dam Break flow analysis consists of two well-known partial differential equations originally derived by Barre De Saint Venant in 1871 for conservation of mass (continuity) equation and conservation of momentum equations. Energy losses are evaluated by friction (Manning's equation) and contraction/ expansion (coefficient multiplied by the velocity head). The above studies were carried out by Department of Water Resources Development & Management IIT, Roorkee (Uttarakhand).

7.3.9 Preparation of Inundation Maps

Detailed inundation maps of the areas downstream of Dam to Devprayag have been prepared on the basis of results of steady flow studies correspondlnq to different release scenarios and results of dynamic flow studies for dam break. These maps clearly delineate the infrastructure and habitation likely to inundate and likely to remain free from inundation under different flood situations which will help in preparing detailed evacuation plan for any emergency situation. This study was carried out and maps were prepared by Disaster Management; & Mitigation Centre (DMMC), Dehradun Uttarakhand Govt.

The flooding due to release of PMF are given Table-7.2 and due to Dam break are given in Table-7.3.

Table-7.2: Flooding due release of PMF

S. No	Location	PMF		Lowest of Habitation	Result
		Maximum Discharge	Water Level		
1	Hat	10840	1080	1075	Partially Inundated
2	Kauriya	10840	1065	1115	Safe
3	Birahi	11124	1020	1026	Safe
4	Chinko	11124	990	1000	safe
5	Chamoli	11124	930	990	Partially Inundated
6	kothiyalsain	11124	930	990	Safe
7	Tilphara	11124	920	927	safe

S. No	Location	PMF		Lowest of Habitation	Result
		Maximum Discharge	Water Level		
8	Chapdyun	11124	880	870	Partially Inundated
9	Maithana	11124	880	875	Partially Inundated
10	Kafal khet	11124	870	880	safe
11	Mason	11124	850	860	safe
12	Near Nandprayag Bridge	12051	836	820	Fully inundated
13	Dewali	12051	796	795	Major part inundated
14	Langasu	12051	778	790	safe
15	Jilasu	12051	770	763	Partially Inundated
16	Kelcshrvar'	12051	761	748	Partially Inundated
17	Siwar Tall	12051	765	770	safe
18	Karanpraag	1463	750	730	Partially Inundated
19	Bandarkhand	1463	710	750	safe
20	Gauchar	1463	700	710	safe
21	Diauki	1463	680	745	safe
22	Nagrasu	1463	685	730	safe
23	Chhinka	1463	672	700	safe
24	Gholtir	1463	665	680	safe
25	Bhitwari	1463	685	690	safe
26	Manak Sidh	1463	655	660	safe
27	Nirwali	1463	650	670	safe
28	Odali	1463	655	665	safe
29	Ratura	1463	700	715	safe
30	Sumerpur	1463	647	665	safe
31	Tilni	1463	655	690	safe
32	Lameri	1463	690	692	safe
33	Khurar	1463	660	770	safe
34	Rudraprayag	16630	643	590	Partially Inundated
35	Gulabrai	16630	645	670	safe
36	Utyasu	16630	635	670	safe
37	Maliyasu	16630	590	608	safe
38	Hairi	16630	560	604	safe
39	Kaliasaur	16630	560	604	safe
40	Dhari	16630	555	575	safe
41	Dungri	16630	560	560	Partially Inundated
42	Margaon	16630	541	588	safe
43	Pharasu	16630	542	580	safe
44	Gandasu	16630	535	560	safe
45	Near Devprayag	18587	494.69	479	Partially Inundated

Table-7.3: Flooding due to Dam break

S. No	Location	PMF		Lowest of Habitation	Result
		Maximum Discharge	Water Level		
1	Hat	12067	1078	1075	Partially Inundated
2	Kauriya	11923.98	1065	1115	Safe
3	Birahi	11852.49	1007	1026	Safe
4	Chinko	11724.7	985	1000	safe
5	Chamoli	11329.13	944	940	Partially Inundated
6	Kothiyalsain	11316.38	922	990	Safe
7	Tilphara	11283.29	915	927	safe
8	Chapdyun	11105.18	880	870	Partially Inundated
9	Maithana	11100.18	880	875	Partially Inundated
10	Kafal khet	11068.58	860	880	safe
11	Mason	11047.97	845	860	safe
12	Near Nandprayag Bridge	11022.37	834	820	Fully inundated
13	Dewali	10891.38	795	795	Major part inundated
14	Langasu	10836.15	775	790	safe
15	Jilasu	10795.08	766	763	Partially Inundated
16	Kelcshrvar'	10424.94	756	748	Partially Inundated
17	Siwar Tall	10422.83	760	770	safe
18	Karanpraag	10387.39	740	730	Partially Inundated
19	Bandarkhand	10049.91	701	750	safe
20	Gauchar	10015.79	698	710	safe
21	Diauki	10009.23	678	745	safe
22	Nagrasu	10001.27	665	730	safe
23	Chhinka	10001.27	665	700	safe
24	Gholtir	9956.47	645	680	safe
25	Bhitwari	9946.39	675	690	safe
26	Manak Sidh	9546.82	640	660	safe
27	Nirwali	9604.86	645	670	safe
28	Odali	9592.97	640	665	safe
29	Ratura	9582.25	640	715	safe
30	Sumerpur	9570.36	649	665	safe
31	Tilni	9570.45	640	690	safe
32	Lameri	9569.88	640	692	safe
33	Khurar	9567.16	660	770	safe
34	Rudraprayag	9545.83	635	590	Partially Inundated
35	Gulabrai	9595.37	625	670	Safe
36	Utyasu	9530.34	622	670	Safe
37	Maliyasu	9512.97	578	608	Safe
38	Hairi	9432.49	555	604	Safe
39	Kaliasaur	9443.5	552	604	Safe
40	Dhari	9443.5	553	575	Safe
41	Dungri	9438.08	550	550	Partially Inundated

S. No	Location	PMF		Lowest of Habitation	Result
		Maximum Discharge	Water Level		
42	Margaon	9436.8	530	588	Safe
43	Pharasu	9432.98	527	580	Safe
44	Gandasu	9434.53	530	560	Safe
45	Near Devprayag	7097.27	484.89	479	Partially Inundated

Detailed Emergency Action Plan for Vishnugad Pipalkoti Hydro Electric Project is enclosed as **Annexure- XII.**

7.4 PUBLIC HEARING

The commitments of Project during Public Hearing on 09.01.2007 are given in Table-7.4. Also, MoEF&CC vide its letter dated 01.06.2021 grant exemption to under construction VPHEP project from any repeat Public Hearing.

Copy of letter is enclosed as **Annexure- IIB.**

Table-7.4: Commitments of Project during Public Hearing

S. No	ISSUES RAISED	STATUS AS ON APR' 2021
1	Negative impact on Environment due to Project's Activities shall not take place and provisions shall be made as per the standards and approval from competent level shall be obtained.	As per Environmental studies undertaken, no significant impacts have been noticed. However, EMP envisages precautionary measures in order to prevent occurrence of negative impacts and action is being taken accordingly.
2	Geological structures around the project area shall not be affected, In this regard, permission from concerned department shall be taken after Detailed investigations and implementation of recommendations shall be ensured.	• Work is being undertaken only in areas where approval has been accorded by concerned authorities / agencies. • No Incidence or deviation noticed during Reporting period • Work in project area is done with due precautions such as mechanical excavation, controlled blasting, vibration monitoring etc.
3	Minimum water flow shall be ensured in river Alaknanda in such a way that the aquatic fauna is not adversely affected and also there is no impact on water quality.	• Project designed has been modified for regular implementation of E-Flow as percribed in Ministry of Jal Shakti S.O. dated 09.10.2018..
4	There shall be no negative impact on Area's Forest resources, Flora, Fauna and life style of the people, due to Project's activities. In this regard, proper appropriate measures shall be taken and permission from	• Environmental Management measures are being properly taken care off. Entry of workforce is restricted in forest area. • Contractor is operating a Community mess for workforce. • Labors camps have been constructed at

S. No	ISSUES RAISED	STATUS AS ON APR' 2021
	concerned department shall be taken.	different locations and in isolation from local villagers. Meanwhile hired accommodation and community mess is being provided by contractor. • Nevertheless, awareness programmes are being conducted to safeguard flora and fauna.
5	During all stages of Project, Local people shall be given job opportunities on priority basis.	Based on the requirements, direct & indirect job opportunities are being extended among local people on priority basis at THDCIL & Contractors Level. Employment opportunities includes: • Direct/Indirect job opportunities in THDCIL & with Contractor • Award of petty Contracts • Hiring of Vehicles • Allocation of Shops Details are indicated at Annexure-A1 under Employment.
6	Arrangements as per standards/policy shall be ensured for Project Affected Persons and Complete compensation of the acquired land shall be released to the concerned in time.	Land Compensation as assessed & decided by Land Acquisition Officer is being disbursed through Special Land Acquisition Officer (SLAO) in accordance to the provisions of LA Act. About 94% PAF's have received payment from SLAO. Besides SLAO Payment, Project is extending various other benefits to the Project Affected Families in accordance to the R&R Policy of Project, framed based on NRRP-2007 & considering the World Bank Operational Policy. The Affected Families are getting cash benefits in the form of various Grants. Apart from above, Project is complying with the Social Obligation & the details are as per Annexure-A1.
7	The explosives in construction related activities shall be used only in avoidable situations in minimum required quantity.	• Explosives used in avoidable situations only & in minimum quantity. • Controlled blasting is being undertaken involving non electric delay detonation technique • Blasting is done only during day time and at pre- notified time. Blast pattern & vibration is monitored by Central Institute of Mining and Fuel Research (CIMFR), Roorkee.
8	Various facilities developed for the project shall be available for the people of the area and community	Various facilities, awareness programmes etc. under Community Development have been made available for the Project Affected Villages

S. No	ISSUES RAISED	STATUS AS ON APR' 2021
	development works shall be carried out in nearby villages.	including surrounding villages that comprises of: • Construction of Pathways, Waiting shelters, Community buildings, Road widening, Hill side slope protection works, Solar street lights for villages, furniture & sports kits for community, water supply schemes, Teaching aids & furniture to schools, Construction of additional classrooms & toilets, promotion of sports & cultural activities, awareness camps on social & environmental aspects, health camps & awareness camps on HIV AIDS, Pulse Polio etc.
9	A Comprehensive Disaster Management Plan shall be prepared for the project and the recommendations of the Plan shall be complied.	A Comprehensive Disaster Management Plan has been prepared.
10	THDC shall ensure the development of Affected villages Forest Rehabilitation, as per directions of Uttarakhand Government and with the help of Local People.	• Developmental activities, i.e, construction of pathways, minor water supply schemes etc. in affected villages are being executed through involvement of local people. • A provision for involving local population has also been earmarked under CAT plan.
11	Labors and their families, working in the construction works of the Project shall be properly vaccinated.	Medical examination of workforce is done prior to induction and properly vaccinated whenever needed. Medical camps are also organized for labors.
12	The proper development of religious places and Shamshan Ghats nearby the river bank shall be ensured.	This aspect has been covered under Community Development activities at Point No. 8 above.
13	The treatment of sewage generated by the Labors engaged in construction works of the Project shall be ensured by means of Septic Tank and soak pits.	At each camp site; One Community latrine per 20 persons was provided. Each camp is equipped with septic cum soak pits. The effluent is being disposed-off in septic cum soak tanks.
14	In order to provide all necessary Project related information to local people, a Public Information Centre shall be established and completed information shall be provided to the people.	Project has established Public Information Centers (PICs) at two locations in Project area. Necessary information related to Technical, Social & Environmental aspects are displayed and are available in PICs.
15	Complete details related to the project shall be published through Press and the views /opinions of the people shall properly solve.	Project related information is being published in local newspapers on regular basis. Grievance Redressed Mechanism has been put in plan, to resolves the issues of affected population in accordance to R&R Policy of

S. No	ISSUES RAISED	STATUS AS ON APR' 2021
		VPHEP.

ANNEXURE-A1

SOCIAL RESPONSIBILITIES

1. CONSTRUCTION OF COMMON PROPERTY RESOURCES:

In addition to the compensation / Grants provided by SLAO/ THDCIL, common property resources like Pathways, Drinking water facility, Street Light, Primary School, Panchayat Ghar, Anganwari Kendra etc. has been constructed at self-resettlement sites.

2. LOSS OF FUEL & FODDER

Each entitled house hold in the affected habitation is being paid 100 days of Minimum Agriculture Wages per year for a period of 5 years. On the recommendations of the World Bank, THDCIL has increased the period of disbursement of Fuel and Fodder Grants from 5 years to 8 years. The amount is paid as a grant / assistance towards the loss of fuel and fodder. Around 2700 households are getting benefited through this assistance.

3. COMMUNITY DEVELOPMENT WORKS

Under Community development various works have been taken up in the Project affected villages ie; construction of Pathways, Waiting shelters, Community buildings, Road widening, Hill side slope protection works, Solar street lights for villages, furniture & sports kits for community, water supply schemes, Teaching aids & furniture to schools, Construction of additional classrooms & toilets, promotion of sports & cultural activities, awareness camps on social & environmental aspects, health camps & awareness camps on HIV AIDS, Pulse Polio etc.

4. LIVELIHOOD ACTIVITIES

Various activities have also been taken up to create livelihood opportunities. These are Dairy Development, Poultry, Tailoring & Stitching, Wool Knitting, Bee Keeping, Mushroom cultivation, vermin composting to promote organic farming, plantation etc. Awareness programs for Project affected people are also organized with the help of various State Govt. Departments i,e. Horticulture, Agriculture, Tourism, Animal Husbandry etc. to give awareness on various schemes, subsidies, technical assistance etc. to convince local youth to opt for self-employed income generation activities. Around 500 beneficiaries are benefited through these programs.

On the recommendations of the World Bank, the work towards “Engagement of Specialized Agency to help Prepare Livelihood Development / Employment Generation Plan & its Implementation in relation to VPHEP” awarded on M/s Mirda Renergy & Development Pvt. Ltd, New Delhi commenced on 03.01.2020 & the Agency has submitted the Inception Report. The

agency commenced the Baseline survey & completed for around 10 villages as reported until Lockdown due to Covid-19 Pandemic w.e.f 23.03.2020 was announced. The survey activity got suspended for around 4½ Months & got resumed only on 05.08.2020. The Baseline Survey has been completed & Draft Baseline Report was submitted on 5th December 2020. Based on the Comments from THDCIL & the World Bank, the Agency has submitted the Final Baseline Report as well.

5. VOCATIONAL TRAININGS

Apart from above, Vocational Trainings in hotel management, Excavator operator, Electrician, Fitter, Refrigerating & Air Conditioning and other skill enhancement activities, etc. are also undertaken, in coordination with various institutes like GMR Foundation, Dr. Reddy Foundation, and Industrial Training Institutes in nearby areas. Around 300 beneficiaries are benefited through these programs.

6. EDUCATION

To promote Education the Project has undertaken various activities i,e Scholarship to Project affected Meritorious/Poor/ Girls students, Construction of additional class rooms & toilets, providing teaching aids & uniform, Assistance for getting admission in ITIs, assistance to schools for cultural activities etc. around 1400 students having approx. 800 girls have been benefitted through scholarship program of THDCIL till Academic year 2018-19. The above assistance has been kept on hold as the schools are presently closed due to COVID-19 pandemic.

7. HEALTH

The project is helping PAPs as they are allowed areas to THDCILs Dispensaries (Allopathy & Homeopathy) established in the Project Campus. OPD / IPD facility including medicines is given free of cost to PAPs. In addition to this Medical health camps are organized in project affected villages and Ambulance facility is also provided to the needy PAPs free of cost. The Health camps have been immensely beneficial for local population and nearby areas that include people from project affected villages of Project. Almost 18000 beneficiaries including 5000 females have been administered treatment in Allopathic dispensaries and approx. 24600 have benefited by Homeopathic dispensaries.

1 Hopper Dumper Tipper TATA ACE 1.8 CUM has been handed over to Nagar Panchyat, Pipalkoti, District Chamoli on the 9th June, 2020 through SEWA, THDCIL, Rishikesh under Corporate Social Responsibility (CSR). The vehicle is used for transportation of Garbage to

Disposal sites under their control. The Garbage generated at THDCIL, Project Complex, and VPHEP is also being addressed by Nagar Panchyat, Pipalkoti.

8. EMPLOYMENT

Keeping in view that the Hydro Projects are capital intensive with the State of the Art Technology and therefore do not offer much employment opportunity, particularly in unskilled category, the option of providing job with THDCIL as per policy is not considered as a rehabilitation option. However, as on date around 1118 persons have been provided direct / indirect employment opportunities in Project HCC / THDCIL / Contractors / Hiring of vehicles / Lease land for various purposes, etc.

CHAPTER-8
PROJECT BENEFITS

CHAPTER-8
PROJECT BENEFITS

8.1 INTRODUCTION

The present Chapter outlines the benefits likely to accrue as a result of construction and operation of the Vishnugad Pipalkoti Hydro-electric Project. Both direct as well as indirect benefits have been covered as a part of the present chapter.

8.2 POWER GENERATION

The Project will add capacity of 444 MW in the Northern Region, reducing peaking power shortage in the region. Annual Design Energy of 1657.09 MU (with 95% machine availability). The energy generated from the project will improve the quality of life of the locals. The increased energy generation shall provide impetus to industrialization and urbanization and improve the overall quality of life in the area.

8.3 INDIRECT BENEFITS

- Integrated Development of Chamoli / Garhwal region in the areas of employment, communication, education, health, tourism, development of flora & fauna etc.
- Out of 13% free power to the home state Uttarakhand, 1% shall be utilized for contribution towards local area development.

8.3.1 Tourism

The reservoir will generate an artificial lake with a water spread of about 24.5 ha can become recreational spot. Facilities for boating, water skiing and other aquatic sports can be developed.

8.3.2 Infrastructure Improvement

Infrastructure like roads, bridges, buildings etc. will be built at a large scale at the construction stage of the project which will benefit the local people also.

8.3.3 Improvement in Livestock

The improvement in the socio-economic status of the population in the command area will indirectly improve the quality of livestock. The main reasons could be improvement in the supply and availability of the veterinary services along with the betterment in the infrastructure facilities in the area.

8.3.4 Improved Access to Social Services (education, health, market, etc.)

Once the construction of the project starts, significant and visible impacts will be felt in the project area. It can be assumed that economic activities will boom in settlements close to the project facility sites. During construction phase, education centers, health post, market, etc. will be improved. After construction phase, there will be withdrawal of economic activities

which flourished during construction phase since most of the construction related workforce will leave the project area. However, some economic activities will continue or be further promoted in these areas because of the relatively good accessibility to cities and urban areas.

8.3.5 Community Health Improvement

The construction of various project roads will improve the accessibility to and around the project area. Improvement the project area people will have easy access to the district hospital as well as project health care units. The improvement in electrification status (with the implementation of rural electrification program) will further enhance the facilities available at the centers.

During project construction phase, the proponent will establish two health care units with adequate number of health workers and logistic supports primarily to provide health support services to the workers and project staff. The health facility will also be made available to local people and visitors as well.

8.3.6 Local Employment Opportunities

The construction phase of any project is rather an unsettled stage characterized by uncertainties and often disorders. The basic problem relates to management of large population, which migrates to the project area or near major construction sites, in search of jobs. The construction of the VPHEP project would invariably create a number of direct employment opportunities. However, indirect employment opportunities would also be generated which would provide great impetus to the economy of the local area. Various types of businesses, such as shops, food-stalls, tea stalls, restaurants, workshops, etc. would invariably come-up, which would be run by the more entrepreneurial local residents. Besides, a variety of suppliers, traders, transporters, service providers, etc., are also likely to concentrate here and likely to benefit immensely, as demand for almost all types of goods and services will increase significantly. The business community as a whole would be benefited. The locals would also avail these opportunities arising from the project and increase their income levels.

Status on project benefits is given at susequent Chapters.

CHAPTER-9
ENVIRONMENTAL COST BENEFIT ANALYSIS

CHAPTER-9
ENVIRONMENTAL COST BENEFIT ANALYSIS

9.1 INTRODUCTION

The environment has mainly two important components viz., physical and socio-economic. In recent years, there has been a remarkable growth of interest in environmental issues in sustainability and the management of development in harmony with the environment. Put in simple words the Environment Cost - Benefit analysis (ECBA) basically involves reducing numerous complex physical and social-economic variables of environment to easy, quantifiable components of costs and benefits. It is a useful tool to predict the damage caused to the environment by any development project in term of its impact of cost which can help management to take precautionary measure to minimize the damage and reduce the cost.

9.2 ENVIRONMENTAL COST AND BENEFITS

Essentially benefits connote an increase in human wellbeing (utility) and costs are reductions in human wellbeing. For a project or policy to qualify on cost-benefit grounds, its social benefits must exceed its social costs. The value of environmental costs and benefits are most clearly understood when represented in monetary units, and then balanced against one another. It is essential' that ecological and environmental losses and socio-economic distress caused to the people who are displaced are weighted against economic and social gains.

9.3 ENVIRONMENTAL COST BENEFIT ANALYSIS OF HYDRO PROJECT

Hydro Power projects like any power project significantly contribute to growth rate of power sector of any country and in turn demand huge financial and human resources of a country. Hydroelectric projects like most of the developmental activities have in built pollution control and mitigative measures. The society has to compulsorily bear the cost of various degradation and pollution, directly or indirectly. Hydroelectric project generally involves intervention in river thereby changing river flow regime in the submergence area and causes changes in existing land use in relation to the land forest, agriculture and barren land beside water bodies

9.4 GUIDELINES FOR DETERMINATION OF ENVIRONMENTAL COST AND BENEFITS

The MoEF&CC vide letter No. 7-69/2011-FC(Pt.), dated 1st August,2017, issued Guidelines for conducting Cost Benefit Analysis for projects involving diversion of forest land under the provisions of the Forest (Conservation) Act, 1980. These guidelines are applicable for conducting cost-benefit analysis for projects involving forest diversion, yet to a larger extent provide a broad and self-explanatory methodology for assessing ecological and environmental losses and eco-economic distress caused due to the population/families who are displaced and weighted against economic and social gains.

9.5 ENVIRONMENTAL COST

The impacts due to the project could be direct, e.g., loss of forest land and the vegetal cover over it, loss of agriculture land and agriculture produce, distress to the people due to involuntary acquisition of land assets, impact to aquatic life and reduction in diversity and population density of migratory fishes, loss of public facilities and administrative infrastructure. Apart from this there are host of indirect impacts viz., loss of animal husbandry productivity, loss of fodder, habitat fragmentation, etc.

9.5.1. Cost of Loss to Ecological Services

Forests are prime natural resource system and host a large number of endemic or endangered species that provide ecological services which cannot be substituted. They constitute not just an ecosystem, but form part of a complex social system involving a very wide range of stock holders. The diversion of forestland for non-forestry purpose certainly destabilize the existing eco-system balance. As per “Polluter Pays” policy, the agency demanding the diversion of forest land has to pay for the loss of benefits from ecological services from such land. The benefits of forests include both goods and services only some of which can be valued directly like timber, fuel wood and NTFP products at prevalent market rates.

Forestry is viewed as a community assets, which provide various benefits over an extended time of horizon. The NPV of forest land can be termed as the discounted value of benefits from the forest land net of the management costs.

As per MoEF&CC guidelines dated 1.8.2017, the economic value of loss of eco-system services due to diversion of forests shall be the net present value (NPV) of forest land being diverted as prescribed by the Central Government (MoEF& CC). In case of National Parks, NPV shall be ten (10) times the normal NPV and in case of Wildlife Sanctuary the NPV shall be five (5) times the normal NPV or otherwise prescribed by the ministry or any

other competent authority.

9.5.2 Cost of Loss of animal husbandry productivity, including loss of fodder

Forests are one of the most important sources of fodder for people involved in livelihoods associated with livestock. A significant proportion of cattle used in livestock management are grazed in forests. A recent study conducted by the Forest Survey of India (FSI) found that more than 86 million Adult Cattle Units (ACUs) are completely dependent on forests for fodder requirements (FSI 2011b). Based on standard fodder requirements for each ACU (22 kg. /ACU/day), the total consumption of fodder from forests is estimated (R. Pandey 2011).

Forests provide fodder leaves and grazing facility to the rural animals. About 20 per cent livestock population depends upon forest grazing and leaf fodder supply. Leaf fodder of several tree species is almost as nutritious as that of agricultural fodder crops. Trees provide animal fodder, enabling communities to keep livestock that provide them with nutritionally important milk and meat.

Forest provides a good landscape for shelter and breeding of wild animals, besides providing escape routes to animals. These have good forage and browse values of the habitat for wild animals. Natural generation in forest area improves the vegetal cover and grass cover. With habitat depletion of the area, the source population shall be easily targeted and will always be at the risk of being eliminated.

The diversion of forest land shall result in reduction of the grazing area for cattle of fringed villages. To meet the fodder requirement of such area, the local folks have either to seek other grazing grounds, if available nearby, or purchase fodder from other areas.

As per MoEF&CC guidelines dated 1.8.2017, this loss is to be quantified and expressed in monetary terms or 10% of NPV applicable whichever is maximum. For tropical Dry Deciduous Forests, the total value of fodder/ha @ average fodder market rate of Rs. 2000/tonne has been estimated at Rs 25070/ha.

9.5.3 Cost of Habitat Fragmentation

Reservoir triggers fragmentation of natural areas on either bank of river. The surface works like dam, intake structure, haul and project roads, exposed penstock line and surface power house also cause physical barrier and fragmentation. Habitat fragmentation bisects the landscape and leaves smaller, more isolated land for wildlife, causing local and population level changes to native flora and fauna. Fragmentation can shift habitat use and provide opportunity for invasions of non-native species. Fragmentation increases the amount of “edge” in a landscape, which can negatively impact wildlife by causing changes in abiotic (increased sunlight and higher wind speeds) and biotic (increased risk of predation and brood parasitism, invasion of non-native species) conditions, making the habitat unsuitable

for some native species (Henning's, L., and J. Soll. 2010. Wildlife corridors and permeability). Isolation of habitats can negatively impact species that require access to multiple small habitat patches to survive by reducing their access to resources. Increased isolation of habitats can lead to inbreeding, which can cause genetic abnormalities and weaknesses (Young, A., T. Boyle, and T. Brown. 1996- the population genetic consequences of habitat fragmentation for plants).

Currently, there is insufficient knowledge to predict with precision when habitat fragmentation will be ecologically consequential to many organisms. Clearly, as habitat is reduced in extent and subdivided, at some point it becomes structurally disconnected.

Habitat loss and fragmentation is a complex, multidimensional process. Consequently, the quantitative analysis of habitat loss and fragmentation is fraught with numerous difficult issues. There are many ways to model or represent landscape structure corresponding to different perspectives on habitat fragmentation. Clearly, given the number and variety of components of landscape structure affected by habitat loss and fragmentation, it is unreasonable to expect a single metric, or even a few metrics, to be sufficient (Neel et al. in prep.). Therefore, it is not possible to reliably identify the "best" measures of habitat loss and fragmentation.

There are five major spatial components to habitat loss and fragmentation: (1) habitat extent, (2) habitat subdivision, (3) patch geometry, (4) habitat isolation, and (5) habitat connectedness. Numerous landscape metrics have been developed for each of these components (e.g., Baker and Cai 1992; McGarigal and Marks 1995; Jaeger 2000, McGarigal et al. 2002). However, these categories are not discrete and many landscape metrics measure properties that relate to several components. Thus, a simple classification of metrics into these categories is not straightforward.

As per MoEF&CC guidelines dated 1.8.2017, while the relationship between fragmentation and forest goods and services is complex, for the sake of simplicity the cost due to fragmentation bas been pegged at 50% of NPV applicable as a thumb rule.

9.5.4 Compensatory afforestation & soil moisture conservation cost

Compensatory afforestation refers to the practice of ensuring that when a forested area is diverted for non-forest purposes, another area is afforested to maintain biodiversity equilibrium. It is the provision which direct to do plantation of new trees to compensate loss of trees that happened during any infrastructure or development project activity. It can be treated as a replacement cost of diverted forestland by way of either afforestation in equivalent new non-forest area or double of area diverted in a degraded forest area. The norms for raising plantation has been fixed by the MoEF&CC The actual cost of

Compensatory afforestation & soil moisture conservation and its maintenance in future at the present discounted value shall be considered as substitution cost per MoEF&CC guidelines dated 1.8.2017.

9.5.5 Loss of Public facilities and administrative infrastructure

Many a times, public infrastructure (Roads, buildings, schools, dispensaries, electric lines, railways, etc.) existing on private land or in forest land are to be lost under proposed acquisition/diversion for project works. These structures shall be relocated, the provision for which is generally made under sub-head “B-land” in the DPR. For relocation of such facilities likely to be diverted, forest land would be further required. Similarly, if located in non-forest land, these shall have to be relocated at appropriate location with the consent of stakeholders. As per MoEF&CC guidelines dated 1.8.2017, the replacement cost of such facilities has to be quantified and expressed in monetary terms as per actual cost basis at the time of diversion.

9.5.6 Possession value of forest land diverted

Forest land has value over and above the value of land itself. This re-adjustment should achieve comparability with guidelines of land valuation for other purposes, e.g., acquisition. Possession Value of land reflects the value of space provided by the diverted forest land over and above its NPV. Forest land diverted for project such as irrigation, hydropower, railways, roads and transmission lines are unlikely to be returned and remain in possession of the user agencies. As per MoEF&CC guidelines dated 1.8.2017, 30% of environmental costs (NPV) due to loss of forests or circle rate of adjoining area in the district should be added as a cost component of possession value of forestland, whichever is maximum.

9.5.7 Cost of human resettlement

For infrastructure project for public purpose land (Public and Private) invariably is to be acquired by the appropriate government either for its own use or for a requiring body as the case may be. Though the project is conceived with the sole objective of minimal displacement of people, compulsory acquisition of some extent of private land for the public purpose is necessitated. The acquisition of the land shall be in consonance with “The Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Act, 2013”, (RFCTLARRA 2013) which has come into force from 1-1-2014, notified by Government of India and conjointly with the provision of the State R&R Policy 2013, for Hydro Electric Projects for the Rehabilitation & Resettlement of displaced/project persons. Component of compensation package in respect of land acquired under the Act shall be as per First Schedule. Elements of Rehabilitation and Resettlement entitlements for all the affected families (both land owners and the families whose livelihood is primarily

dependent on land acquired) shall be as contained in Second Schedule, in addition to those provided in the First schedule. As per MoEF&CC guidelines dated 1.8.2017, the cost is to be quantified and expressed in monetary terms as per R&R Plan.

9.5.8 Cost of Loss of Agriculture Production

There shall be loss of agriculture production from acquired land as due to change in its land use it shall not be put under agriculture. The loss shall be @ average yield of 2.25 ton/ha for each crop harvested and the cost worked on the basis of current minimum support price.

9.6 ENVIRONMENTAL BENEFITS

The benefits from the project are mainly from increase in productivity attributable to the specific project, benefits to economy, economic benefits due to of direct and indirect employment due to the project, long term economic benefits due to implementation of certain management plan. The economic benefits of hydro projects are saleable electricity, employment creation during construction and post construction, and in some cases fisheries and tourism.

9.6.1 Increase in Productivity (Electric Generation)

Electricity generates public benefits and is logically considered as a public good. As per National Electricity Policy,2005 and Tariff Policy,2016 availability of electricity to consumers at reasonable and competitive rates. Electricity is a public good that attribute to the broader goals of socio- economic development. Based on CERC method for setting tariff for electricity, the estimate of annual power generation, in 90% dependable year, benefits from the project can be computed. After accounting for 12% free power being given to the home state, the annual saleable units shall be 0.88x annual generation. As per MoEF&CC guidelines dated 1.8.2017, the cost is to be quantified and expressed in monetary terms. The cost of saleable units shall be based on levelized tariff as contained in the Financial Evaluation Chapter of DPR.

9.6.2 Benefit to the State

As per State Hydro power Policy for the Development of Hydropower in Uttaranchal through Projects of Capacity of 100 MW and Larger, Twelve percent (12%) of electricity generated shall be made available free of cost to the State during the entire life of the Project. This free power will be in addition to the amounts received at the time of allotment. However, as per Policy for the Development of Hydropower in Uttarakhand through Projects of Capacity of 25 MW and Larger, on all projects governed by this policy, for the first 15 years, royalty at the rates of 12% of net energy wheeled (after deducting wheeling charges) or supplied directly without wheeling would be charged.

9.6.3 Benefits to Local Population

As per Hydro Power Policy, 2008 read with Ministry of Power Order dated 8.3.2019, an additional 1% free power from the project would be provided and earmarked for a Local Area Development Fund, aimed at providing a regular stream of revenue for income generation and welfare schemes, creation of additional infrastructure and common facilities etc. on a sustained and continued basis over the life of the project. Just as host State governments have been turned into stake-holders by stipulating that 12% of the power is given to them free cost as a royalty, there is need to turn the project affected areas and persons also into stake-holders with a continuing stake not only in the completion but also in the continued operation of the project.

9.6.4 Economic benefits

Establishment of project will facilitate the emergence of industries, trade and commerce and would bring more and more economic development in the State and Country. At present the industry sector alone consumes 42% of total consumption of the state. Since the tariff for mixed industry in the state is more than the tariff for domestic consumption the difference of tariff shall accrue as an additional income to the state.

9.6.5 Employment Generation

During peak stage of construction, employment will be generated for 1200 skilled/semi-skilled/unskilled labour. Besides this due to implementation of labour-oriented works under CAT Plan, Green Belt Development Plan and Command Area Development Plan a large number of local people are likely to be engaged. The creation of the reservoir will increase the fish production and development of pisciculture in the region. Many families will get job in the fisheries which will improve their socio-economic conditions. After completion during operation about 50 people will get employment for O&M, routine upkeep / maintenance of roads and buildings.

9.6.6 Economic benefits due to compensatory afforestation

As per MoEF&CC guidelines dated 1.8.2017, benefits from such compensatory afforestation accruing over next 50 years monetized and discounted to the present value should be included as benefits of compensatory afforestation. For benefits of CA the guidelines of the Ministry for NPV estimation may be consulted.

9.7 ENVIRONMENTAL COST AND BENEFITS

The environment cost and benefits of the project has been carried out based on the methodology and discussion made in foregoing section/sub-sections and elucidated in **Table 9.1**. It is manifest from table that the cost to environment is Rs 18020.84 lakh whereas the annual benefits are Rs 83499.83 lakh and for useful life of project these are projected as Rs 2490595.8 lakh, with benefit cost ratio of 138.20:1. The details are given in **Table-9.1**.

Table 9.1: Environment Cost and Benefits Analysis

S. No.	Environment Cost/Benefit	MoEF Guidelines for CBA of forest land diversion,2017	Parameters	Total loss (Rs. lakh)
A. Environmental Cost:				
1	Eco-system services losses due to proposed forest diversion	Economic value of loss of eco-system services due to diversion of forests shall be the net present value (NPV) of forest land being diverted	NPV of 100.36 ha forest land is Rs. 825 lakh, which is already deposited	825.00
2	Loss of animal husbandry productivity including loss of fodder	To be quantified and expressed in monetary terms or 10% of NPV applicable, whichever is maximum	100.36 ha x Rs. 25070/ha = Rs. 25.16 lakh (ii) 10% of Rs 825 lakh = Rs 82.50 lakh. (Max. of two is adopted)	82.50
3	Cost of human resettlement	To be quantified and expressed in monetary terms as per R&R Plan	R&R Plan has been prepared as per NPRR, 2007 and approved by state government.	6883.88
4	Loss of Public facilities and administrative infrastructure (Roads, buildings, schools, dispensaries, electric lines, railways, etc.) on forest land, which would require forest land if these facilities were diverted due to the project.	To be quantified and expressed in monetary terms as per actual cost basis at the time of diversion.	all the public facilities/ infrastructures were fully compensated. therefore, for the sake of calculations has already been incorporated in the cost at point 03 above)	0.00
5	Possession value of forest land diverted	30% of environmental costs (NPV) due to loss of forests or circle rate of adjoining area in the district should be added as a cost component of possession value of forestland, whichever is maximum	30% of Rs 825 lakh (NPV) = Rs. 247.5 lakh	247.50
6	Cost of sufferings to oustees	The social cost of rehabilitation of oustees (in addition to the cost likely to be incurred in providing residence, occupation and social	All the affected parties have been fully compensated w.r.t loss of income or livelihood during the rehabilitation	0.00

S. No.	Environment Cost/Benefit	MoEF Guidelines for CBA of forest land diversion,2017	Parameters	Total loss (Rs. lakh)
		services as per R&R plan) be worked out as 1.5 times of what oustees should have earned in two years had they not been shifted.	period. therefore, for the sake of calculations has already been incorporated in the cost at point 03 above).	
7	Habitat fragmentation cost	While the relationship between fragmentation and forest goods and services is complex, for the sake of simplicity the cost due to fragmentation has been pegged at 50% of NPV applicable as a thumb rule.	50% of NPV = 0.50x Rs 825.0 lakh = Rs. 412.50 lakh	412.50
8	Compensatory afforestation & soil moisture conservation cost	The actual cost of Compensatory afforestation & soil moisture conservation and its maintenance in future at the present discounted value	Cost of Compensatory Afforestation& Roadside plantation, pillar demarcation and muck management on road sides =Rs. 125 lakh + Rs. 43.81lakh + Rs. 15 lakh = Rs 183.81 lakh	183.81
9	Cost of Environmental Management Plan for avoiding, mitigating, checking the adverse impacts on various environmental components during construction and operational phase of the project.	As per cost of EMP included in EIA report avoiding the cost of losses already included in serial No.1 to 8.	Total cost of EMP after discounting cost of Compensatory afforestation plan, cost of human resettlement i.e., R&R plan, relocation cost of public facilities (old EMP & New EMP)- Compensatory Afforestation & Biodiversity Management= (10953.16-6267.51+4700)	9385.65
Total Environment Cost (A)				**18020.84**
B. Environment Benefits				
1	Increase in productivity attribute to the specific project	To be quantified and expressed in monetary terms avoiding double counting	After accounting for 12% free power to the state and 1% free power for local development of area, net annual Saleable annual energy (after accounting for 0.70% auxiliary consumption and 0.50% transmission loss)	65962.2

S. No.	Environment Cost/Benefit	MoEF Guidelines for CBA of forest land diversion,2017	Parameters	Total loss (Rs. lakh)
			= 1677.4 GWhX0.87 = 1459.34 MU. The benefit expressed in monetary terms shall be for 1459.34 MU @ average of peaking and non peaking tariff of Rs. 4.52/unit	
2	Benefits to economy due to specific projects	The incremental economic benefit in monetary terms due to the activities attributed to the specific project.	Establishment of project will facilitate the emergence of industries, trade and commerce and would bring more and more economic development in the State and Country At present the industry sector alone consumes 42% of total consumption of the state. Therefore, on a conservative estimate about 704.50 GWh shall be consumed in industry. Since the tariff for mixed load in the state is Rs. 5.45/unit which implies that the difference of Rs. 5.45-4.52 = Rs. 0.93/unit shall accrue as an additional income of Rs 14583.15 lakh to the state.	6551.85
3	Number of Populations benefit due to specific project	As per DPR	The project will directly benefit the population of the country as a whole and the population of state, due to share of 12% free power and people of the project area by 1% free power for local development of area. The benefit expressed in monetary terms shall be for 1677.4x0.13= 218.06 MU @ average tariff of Rs 4.52/unit	9856.31
4	Economic benefits due to direct and indirect employment due to	As per DPR	(i) During peak stage of construction, employment will be generated for	720.0

S. No.	Environment Cost/Benefit	MoEF Guidelines for CBA of forest land diversion,2017	Parameters	Total loss (Rs. lakh)
	the project.		2000 skilled/semi-skilled/unskilled labour. Assuming that on an average 1000 persons are employed with an average minimum wage of Rs 10000/- pm after discounting the income of Rs. 4000/pm by the person being earned before being engaged in construction, the net benefit shall be = Rs. 6000x12x1000= Rs. 720.0 lakh. (ii) After completion during operation about 100 people will get employment for O&M, routine upkeep / maintenance of roads and buildings. Average benefit shall be 100x12x30000= Rs. 360.0 lakh	360
5	Economic benefits due to compensatory afforestation	Benefits from such compensatory afforestation accruing over next 50 years monetized and discounted to the present value should be included as benefits of compensatory forestation. For benefits of CA the guidelines of the Ministry for NPV estimation may be consulted	Benefits from Compensatory afforestation in 200.72 ha @ discount rates of 6%/year of NPV =Rs 49.5 lakh)	49.5
Total Environment Benefits (B)				**83499.86**
Total benefits due for useful life of 30-year =30 (operational year) x (83499.86 - 720) + 720* 10 (construction year) = Rs. 2490595.8 Lakh				**2490595.8**
Environment Benefit Cost Ratio= 2490595.8/18020.84				**138.20:1**

CHAPTER-11
SUMMARY AND CONCLUSIONS

CHAPTER-11
SUMMARY AND CONCLUSIONS

11.1 INTRODUCTION

Vishnugad Pipalkoti Hydro Electric Project (4x111 MW) is a run-of-the-river scheme. It envisages construction of a 65 m high concrete diversion dam harnessing a gross head of 237m on river Alaknanda (a major tributary of river Ganga). The project is located in district Chamoli in the state of Uttarakhand, 225 km from Rishikesh on NH-58. A dam is to be located at village Helong in Joshimath Tehsil and an underground power house, at village Haat in Chamoli Tehsil.

River Alaknanda is originating from the glacial regions of the Himalayas. The river has tremendous scope for development of hydro-power, which needs to be harnessed to meet the ever-growing demand for power. At present, various hydropower schemes are in different stages of development on the river. Vishnugad Pipalkoti hydropower is one such scheme envisaged in this region.

11.2 CONCLUSIONS

The benefits of the underconstruction project are:

- Capacity addition of 444 MW in the Northern Region, reducing peaking power shortage in the region.
- Annual Design Energy of 1657.09 MU (with 95% machine availability).
- Integrated Development of Chamoli / Garhwal region in the areas of employment, communication, education, health, tourism, development of flora & fauna etc.
- Out of 13% free power to the home state Uttarakhand, 1% shall be utilized for contribution towards local area development.

It can be concluded that the underconstruction Vishnugad Pipalkoti HEP is likely to entail certain adverse environmental impacts. However, these impacts have been ameliorated to a large extent by implementing appropriate mitigation measures (Chapter-4). Appropriate management measures too have been suggested and delineated as a part of Environmental Management Plan (EMP) (Chapter-10).

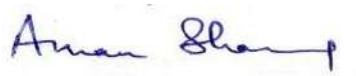
CHAPTER-12
DECLARATION BY EXPERTS CONTRIBUTING TO THE EIA

CHAPTER-12

DECLARATION BY EXPERTS CONTRIBUTING TO THE EIA

I, hereby, certify that I was a part of the EIA team in the following capacity that developed the above EIA.

EIA coordinator: Name: Dr. Aman Sharma



Signature and Date:

Period of involvement:
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S. No.	Functional Areas	Name of the experts	Signature
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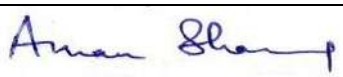
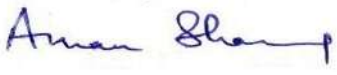
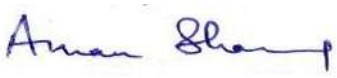
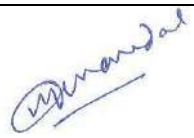
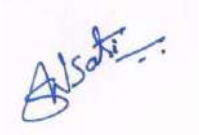
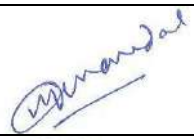
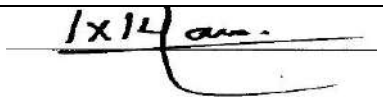
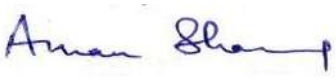
2	WP	Dr. Aman Sharma	
3	AP	Mr. A. S. Leo	
	AP	Mr. S.M. Dixit	
4	SHW	Dr. Aman Sharma	
	SW	Mr. S.M. Dixit	
5	EB	Dr. S.K. Tyagi	
6	HG	Dr. Aman Sharma	

S. No.	Functional Areas	Name of the experts	Signature
	HG	Mrs. Moumita Mondal Ghosh	
7	GEO	Dr. S.K.Sati	
8	SC	Dr. K.P.S Malik	
9	AQ	Mr. S.M. Dixit	
10	LU	Mrs. Moumita Mondal Ghosh	
11	RH	Swapan Kumar Bandopadhyay	
12	SE	Dr. K K Gaur	
13	NV	Dr. D K Pandey	
14	N	Mr. S.M. Dixit	

Declaration by the Head of the Accredited Consultant Organization/authorized person

I, Dr. Aman Sharma, hereby, confirm that the above mentioned experts prepared the EIA report entitled "Environmental Impact Assessment Study for Vishnugad Pipalkoti HEP". I also confirm that the consultant organization shall be fully accountable for any misleading information mentioned in this statement.

Signature : 

Name : Dr. Aman Sharma

Designation : Chief Executive Director (Envt., CM & Admin)

Name of the EIA consultant organization : WAPCOS Limited

NABET Certificate No.& Issue Date : NABET/EIA/1821/SA 0120 dated 20.10.2020